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Machine-Made Glass Containers and the End of Production for Mouth-Blown Bottles.[1]

ABSTRACT

Between 1880 and 1920 a major revolution in the production of glass containers transformed the glass industry and launched an ancient craft into a modern "mechanized engineering activity" (Meigh 1960:25). The number of patents for and improvements of semi-automatic and automatic bottle blowing machines in this period is very confusing. This discussion is an attempt to outline these developments with an emphasis on their chronology and impact on bottle and jar production. Although this discussion is limited to containers, it should be borne in mind that similar mechanization was occurring in other branches of the glass industry.

Introduction

During the late 19th century, improvements in the finish portion of glass containers in combination with the development of convenient, reliable closures, helped increase the demand for glass commercial containers. Two very important closures were the crown top for bottles and the Phoenix cap for jars, both patented in 1892 (Lief 1965:17–20). During this same period, automatic canning and bottling machinery was being developed, along with better knowledge of sterilization and a wider availability of refrigeration (Hampe & Wittenberg 1964:115–21). All of these developments were part of a broad change in food consumption patterns and emerging brand-name products.

Statistics illustrating the impact of these developments on glass container demand and production for Canada and England are very limited; however, in the United States, container production increased 50 per cent between 1899 and 1904, that is, before the development of the fully automatic machine (Barnett 1926:70). From 1897 to 1905 the number of hand bottle-blowers in the United States increased from 6000 to 9000, which matches the 50 per cent increase in glass container production (Barnett 1926:71). By 1919 the amount of glass containers produced was 180 per cent higher than the number produced in 1904 (Barnett 1926:70, 89). The increasing market for glass containers helped provide the capital necessary for mechanization and the drive for its success.

All glass-blowing machines (semi-automatic and automatic) that have been successfully taken into production, have involved three separate molding steps. These involve a ring mold which shapes the finish, a parison or part-size mold to give initial shape to the hot glass, and a blow or full-size mold to form the container's final shape, size and any embossed letters or designs it might have. Machine production follows these steps:

1. A gob of molten glass enters the ring and parison mold and is forced by air pressure, suction, or a plunger to take the shape of the full-sized finish mold and that of the part-sized parison mold. The role of the parison mold is to distribute the glass into the shape needed for blowing the full-sized container.
2. With the finish ring mold still attached, the parison mold is removed. In some cases, the body of the parison is allowed to elongate.
3. The full-sized or blow mold is joined to the ring mold around the parison and the bottle is blown to full size by air pressure.

While both semi-automatic and automatic machines went through the above steps, there was a fundamental difference recognized by the glass industry. Semi-automatic machines were supplied with gobs of molten glass and operated by semi-skilled laborers. Fully automatic machines, on the other hand, gathered glass directly from the furnace and all processes in molding and blowing were independent of human labor. Semi-automatics were limited in their production capacity by the speed with which the worker could feed glass to the machine and run the machine through the molding sequence. Limited production capacity and the cost of labor led to the elimination of

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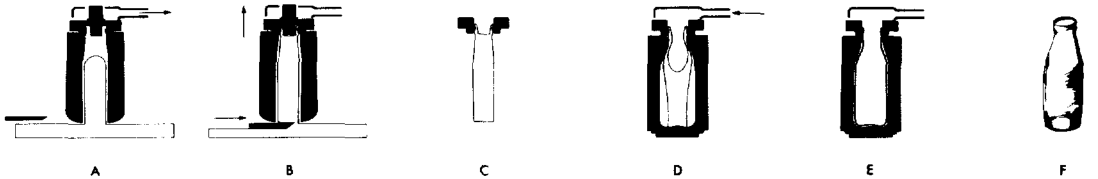

FIGURE 1. The Owens suction-and-blow process (*Drawing by S. Epps*). A. Gob sucked up into blank mold; B. Neck formed and gob sheared off at base; C. Blank (parison) shape with ring mold still attached; D. Blank shape transferred to full size mold; E. Final shape blown; F. Finished bottle

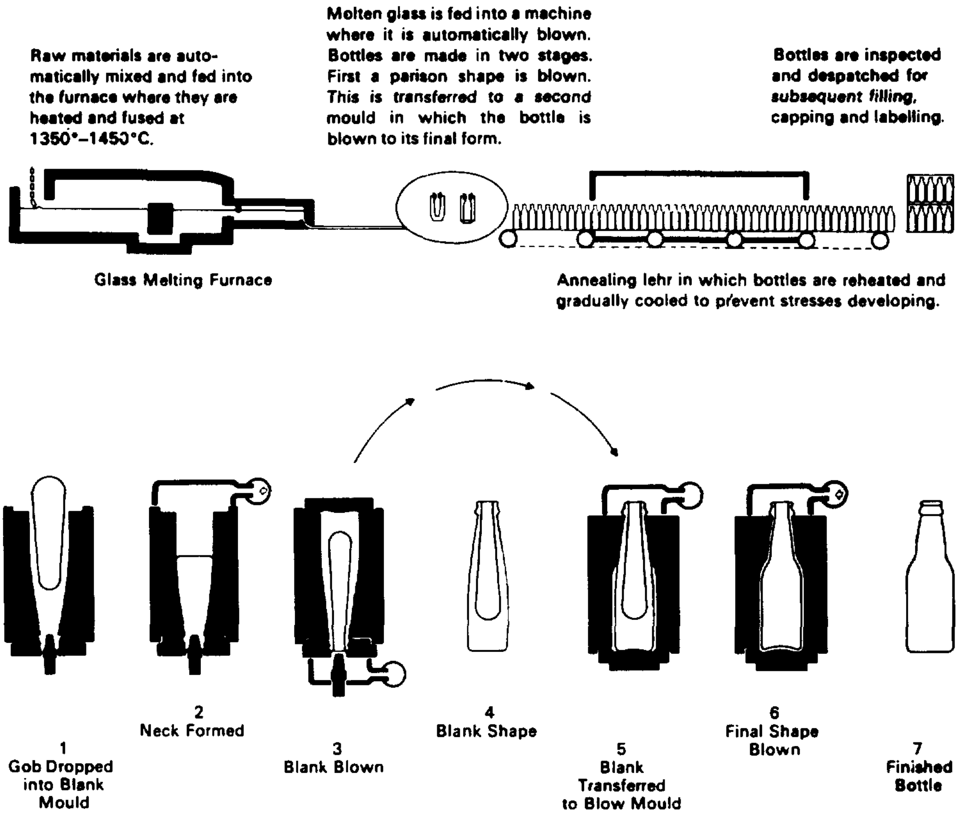

FIGURE 2. Blow-and-blow process (Published with permission of *Glass Manufacturers Federation 1973:25*).

semi-automatic machines in favor of the more productive automatic bottle-blowing machines.

In the hand-blowing process, the glass blower gathered a gob of molten glass on the blow pipe, shaped it and then blew it into shape with or without molds. After the vessel was fully blown, the bottle was disconnected from the blowpipe and then the neck was shaped. Because the mouth of the container was the last part completed, it became known as the finish. A major development

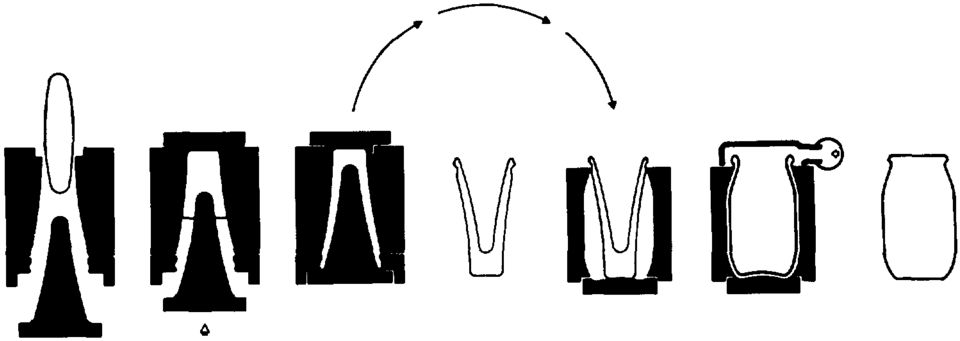

FIGURE 3. Press-and-blow process (*Glass Manufacturers Federation* 1973:25).

towards machine-made glass bottles was the recognition that the finish had to be the first part formed rather than the last. It is the finish that provides the momentary connection of the glass to the machine for blowing of the container. Two American patents, Gillender's in 1865 and Atterbury's in 1873, both described molding processes where the finish was formed as the first part of machine blowing; however, neither of these patents seems to have come into production (Barnett 1926:67).

Two semi-automatic blowing machines were developed in the 1880s—one, by Philip Arbogast, patented in 1881 in the United States, and the other, by Howard Ashley, patented in 1886 in England (Meigh 1960:26–27). Use of machines was limited by strong glass blowers' unions in their respective countries. Arbogast's machine established the principle of using a parison and a blow mold in a press-and-blow method which formed wide-mouthed containers. Use of his machine did not enter large scale production until 1893 when it was used in a non-union shop to make vaseline jars, and, later, fruit and other jars as well (Meigh 1960:27). The Ashley machine used a blow-and-blow process with a parison and full-sized mold to produce small-mouthed containers (Meigh 1960:28). Its successful application to mass production of containers did not take place until 1899 (Meigh 1960:27).

After the development of these prototypes, several other machines were developed in quick succession. These have been well described by Edward Meigh (1960) in "The development of the automatic glass bottle machine: a story of some pioneers." The 1890s was a period of revolution in glass technology; however, the new technology did not begin to cut down on the number of hand glass blowers until after 1905, because expanding demands for glass containers accommodated both the new technology and the old (Barnett 1926:71). This situation could not last forever.

In 1903 Michael Owens of the Libbey Glass Works in Toledo, Ohio, patented his fully automatic glass-blowing machine. He had been making a series of improvements towards machine-blown bottles since 1898 (Meigh 1960:29–31). The machine Owens developed was a major advance over the semi-automatic machines, and in 1903 The Owens Bottle Machine Company was organized with a capital of $3,000,000 to license rights to the machine to various glass companies for production of specific types of bottles (Walbridge 1920:67–68). By 1909 three other companies had taken up licences to use the machine and had put 46 machines into production (Scoville 1948:105, 115). Their success with the machine and further improvements by Owens increased the number of glass companies taking out licences. In the two years from September 1909 to September 1911, the number of Owens machines in production doubled from 51 to 103.

Between 1903 and 1923, Owens designed a series of 12 automatic bottle-blowing machines which increased productivity and expanded the types of containers that could be produced from three-ounce bottles to carboys (Meigh 1960:33). By 1917 half of the production of glass containers in the United States was done on Owens machines (Barnett 1926:88).

The spread of the Owens Bottle Machine to other countries was fairly rapid. In 1906 a licence from the Owens Company was issued to the Canadian Glass Manufacturing Company for a glass works in Hamilton, Ontario (King 1965:90). By 1914 there were 60 Owens machines in Europe (Barker 1968:317).

During the period when the Owens machine was being developed, semi-automatic machines were being improved and automatic feeding devices were being invented. These devices, such as the Brooke's continuous stream-feeding device and the Peiler Paddle Gob Feeder, transformed semi-automatics into automatic glass bottle-blowing machines (Meigh 1960:35–40). They were much simpler than Owens machines and much less costly to build and operate. The feeding devices took a small amount of glass to the machines, whereas the Owens device took the whole machine to the glass. Owens machines could weigh up to 120 tons and were raised and lowered by counterweights to suck up the molten glass (Walbridge 1920:93). Each arm of the Owens machine was dipped into a revolving circular tank furnace to suck glass up into the mold. Each mold-filling required the whole machine to move up and down (Figure 1). Some Owens machines had up to 15 arms and could produce 350 gross pint bottles in 24 hours, production equal to the output of 50 glass workers (Meigh 1960:33).

While the Owens machine was highly successful in large production runs, it was of limited use for short runs due to the necessity of shutting down the whole machine to change a mold on any one arm. As well, the larger the Owens machine, that is the greater the number of arms, the larger the revolving tank needed, which meant that fuel costs were higher for the more complex machines (Meigh 1960:34).

Rapid adoption of machines for manufacturing glass containers was a matter of economics. Semi-automatic and automatic glass bottle-blowing machines worked in two ways to lower the cost of glass container production. First, mechanization greatly increased the productivity of the workers making glass containers, and second, it eliminated the need for highly-skilled craftsmen. Prior to the development of bottle-blowing machines, glass blowers were very well paid, for their skills were essential to produce bottles and jars. Minimal skill was needed to operate semi-automatic machines, and the fully automatic machines almost completely replaced laborers.

In terms of productivity, the machines greatly increased output of containers per man-hour. Boris Stern's 1927 study of *Productivity of Labor in the Glass Industry* established that semi-automatic machines were between 42 and 171 per cent more productive per man-hour than hand production methods and that fully automatic machines were between 642 and 3806 per cent more productive than hand manufacture (1927:8). These ranges relate to the size of containers being produced and differences in the capacity of the various types of bottle-blowing machines.

The same study indicates that the labor cost per gross of bottles produced on the semi-automatics were from 23 to 52 per cent cheaper than hand-blown bottles. Labor costs per gross of bottles produced on fully automatic machines were between 90 and 97 per cent lower than hand-blown bottles (Stern 1927:8). Lower labor costs were of course offset by the capitalization necessary to acquire the machines.

Development of the Semi-Automatics into Automatic Bottle-Blowing Machines

Semi-automatic bottle-blowing machines which began development before the Owens machine had their significance eclipsed by the speed and efficiency of the Owens machine. The step needed to make the semi-automatic fully automatic was the development of automatic feeding devices. One of the earliest such devices to be successfully developed was the Brooke's stream feeder, patented in 1903 (Scoville 1948:182–83). Between 1911 and 1915 the Graham Glass Company adapted the stream feeder to their semi-automatic machine. When it became apparent that the Graham Glass Company had developed a workable automatic glass-blowing machine, the Owens company bought them out. However, attempts to further the production of this machine met with limited success (Scoville 1948:182–83). Brooke's feeder used a gravity flow of glass in a stream from the glass furnace. The flow was husbanded in a cup until the desired quantity was collected and it was then dumped into the mold. Cooling of the glass in the cup caused it to be stringy and often entrapped air blisters. These defects did not stop Hazel-Atlas from using a stream feeder to produce pressed jar lids (Meigh 1960:36).

The Hartford-Fairmont Feeding Devices

An engineering firm in Hartford, Connecticut, and a glass company in Fairmont, West Virginia, were incorporated in 1914 to develop an automatic feeding device to be used with semi-automatic bottle-blowing machines (Meigh 1960:36–37). The engineer who developed the feeding device was Karl E. Peiler, with an engineering background from the Massachusetts Institute of Technology rather than from the glass industry. The first successful feeder he developed used a fire clay paddle to push a gob of molten glass from the furnace onto a metal chute kept moist to create a cushion of stream for the gob to ride on into the mold (Meigh 1960:37–38). In 1915 this device was put into use for the production of milk bottles and Hartford-Fairmont began marketing it to other glass manufacturers.

The gob feeder was limited to the production of wide-mouth glass containers. To overcome this limitation, Peiler created an improved gob feeder, a Paddle-needle Feeder that came into production in 1918 (Meigh 1960:38). It had a lip on the tank furnace with a hole at its base, through which a plunger needle fed the glass. Success of Peiler's feeding devices led to their wide usage. In fact, the Owens Company entered into an agreement with Hartford-Fairmont and became a major lessee of gob feeders in 1924 (Meigh 1960:39). By 1925, in the United States, the gob feeders working with various glass bottle- and jar-blowing machines were producing approximately 8,500,000 gross of glass containers as compared to roughly 12,500,000 gross by the Owens machine (Scoville 1948:185).

Use of the gob feeders with bottle-blowing machines involved mechanical alignment of parison and blow molds, usually by means of one or two rotating tables. This complexity was simplified by the I.S. or Individual Section Machine developed by Henry Ingle of the Hartford Empire Company in 1925 (Meigh 1972:62). Instead of moving molds to the feeding device, the I.S. feeder had a bank of parison and blow molds in a straight line on a fixed-bed plate. Gobs of hot glass were delivered to each mold in sequence and any one section of the machine could be shut down to change the molds without stopping production in the other sections (Meigh 1972:62–64). This was a great advantage over other automatic machines and by 1960 there were 1250 I.S. machines in production (Meigh 1960:47).

Because the various machines with gob feeders were less expensive than the Owens machine and more versatile for small orders, they began to supersede the Owens machine during the 1920s. Sometime between 1927 and 1930, the number of glass containers produced on gob feeder machines surpassed the amount produced on the Owens machines (Meigh 1972:57). By 1947, in the United States, it is estimated that only 30 per cent of production was on the Owens machine while the gob feeders produced 67 per cent of the glass containers (Phillips 1947:188–89). Meigh estimates that over 90 per cent of world production of glass containers by the early 1970s was produced on gob feeder machinery (Meigh 1972:58). Whether any Owens machines are still in production today is not clear from the literature. In Canada the Owens machine stopped being used at Dominion Glass Company in about 1945.

Impact of the Machine-made Glass Container

The impact of automatic machine production of glass containers was extensive and rapid. Hand production of bottles and jars declined rapidly from the second decade of the 20th century. For archaeologists, two immediate questions come to mind: when did hand production stop, and what characteristics might be used to identify bottles from the various machines that came into production? Much broader than these questions is the impact of cheap glass containers on society.

The period of overlap for hand and machine production is fairly long. Types of bottles being blown by hand were continually being reduced as semi-automatic, automatic, and feeding device machines were developed. Barnett's *Chapters on Machinery and Labor* (1926) estimates the number of hand glass bottle-blowers working in the United States during the period when bottle-blowing machinery was being developed:

Year	No. of Blowers	Page Ref.
1896	6229	83
1897	6000	70
1905	9000	71
1917	2000	90
1924	1000	86

Declines in the number of bottle blowers were occurring at a time when glass container production was rapidly increasing. Once again, Barnett provides the statistics on container production used below:

Year	No. of Gross Produced	Page Ref.
1899	7,777,000	70
1904	11,942,000	89
1909	12,313,000	89
1914	19,288,000	89
1917	24,000,000 est.	89
1919	22,289,000	89
1924	18,000,000 est.	85

The drop in production reflected in the figures for 1919 and 1924 was caused by prohibition which began in 1919 in the United States. Rising glass container production from the beginning of the 20th century was of course related to increased use of semi-automatic and later fully automatic bottle-blowing machines: in 1900 there were 80 semi-automatic machines producing wide-mouthed glass containers; by 1904 when Owens machines came into production there were 200 semi-automatics in production and the number increased to a high of 459 in 1916 (Barnett 1926:69, 92). After that, the Owens machine and gob feeding devices adapted to existing machines cut into bottle production by semi-automatics. By 1924 there were only 72 semi-automatics in production (Barnett 1926:111). Impact of the automatics is reflected in a 1927 government study by Boris Stern, *Productivity of Labor in the Glass Industry*, which states that:

> In 1926, out of 25 bottle plants inspected only one plant was found using the semi-automatic to a large extent. In another plant the semi-automatic was found standing by the furnace but dismantled and ready to be displaced by an automatic. In still another plant a semi-automatic machine had recently been consigned to the scrap heap (Stern 1927:35).

Adoption of Owens machines was retarded by the leasing system used by the Owens Company. In the 1905–06 period there were only eight Owens machines in production. By 1916–17 there were 200 in production (Barnett 1926:88). It was shortly after this period that the gob-feeding devices and the Individual Section Machine began making inroads on the market serviced by Owens machines. As mentioned earlier, by 1917 the Owens machine was producing half of the glass containers made in the United States. The other half was produced by 2000 hand blowers and 2000 operators of semi-automatic machines. According to Barnett, the 12,000,000 bottles produced by glass blowers and semi-automatic machine operators in 1917 was equal to the 12,000,000 bottles produced by 9000 glass blowers and 1000 semi-automatic machine operators in 1905 (Barnett 1926:88–89). Stated as mathematical equations, these figures come out as follows:

1905

9000 blowers' production + 1000 machine workers' production = 12,000,000 gross

1917
2000 blowers' production + 2000 machine workers' production = 12,000,000 gross

Assuming that productivity for blowers remained the same and solving the above equations gives the following results:

Hand-blown		Semi-automatic	
1905	7,714,000 gross +	3,286,000 gross =	12,000,000 gross
1917	1,500,000 gross +	10,500,000 gross =	12,000,000 gross

Total 1917 production
1,500,000 gross by hand blown methods
10,500,000 gross by semi-automatics
12,000,000 gross by Owens machines

These figures are rather rough, but they suggest that hand-blown containers made up between 5 and 10 per cent of all the bottles and jars produced in the United States in 1917.

One of the myths about the Owens bottle-blowing machine is that it greatly lowered the cost of glass containers and thus expanded the demand for them. In reality, the price of bottles made on Owens machines fell only about 15 per cent from 1905 to 1914 (Barnett 1926:130). Thus, the cost of production was a marginal consideration in expanding the use of glass containers. More important was that machines could produce highly standardized, reliable finishes and sizes that could be used on the automatic machines that filled the containers. These developments combined to meet and change consumer demands for products put up in glass containers.

The types of bottles produced on the Owens machine were limited to those for which there was a fairly large demand. Stern's 1927 report sums up the machine-made bottle market as follows:

> The principle advantage of the machine lies in mass production. The high cost of making the necessary number of molds and the time required in adjusting the machine and changing molds make it uneconomical for large machines to work on orders less than 1,000 gross of bottles. Even for the smaller six-arm machines the order has to be at least 250 gross to make production economical. Hence the smaller orders, especially those below 100 gross, necessarily go to the hand plants. Among bottles of this kind the principle place is occupied by perfumery and toilet ware, individually shaped bottles being used as a means of identifying and advertising their contents.
>
> As a competitive factor in the bottle branch of the glass industry hand production is absolutely non existent. At best it fills the gaps left by the machine and must therefore be considered as supplementary to the machine rather than competitive (1927:55).

Some idea of just how costly the molds for the Owens machine were is given in B. E. Moody's *Packaging in Glass:*

> A 'single' mould, i.e., the equipment required for one head on a machine, consists of at least nine separate parts, . . . and a complete set for a six-head machine could cost well over £1000. It is clearly vital that the bottle maker should be able to obtain a long working life from the moulds; a single mould may be capable of producing something like a million bottles before it has to be scrapped (1963:21).

The minimum number for an economical run of glass containers appears to have increased between 1927 and 1963 when Moody wrote his book. He states that:

> We have seen above that it is not an economic proposition to run a bottle machine for short periods, and generally a run of about three days would be regarded as an absolute minimum. The output from a modern bottle machine might be in the region of 100 to 1200 gross per day, depending on the size of the bottle and size of machine, so the minimum number of bottles which can be made economically in a run is of the order of 1,000 gross (1963:20).

The economics of machine production changed the characteristics of bottles. Prior to machine domination of glass container production, the industry produced a wide variety of bottles and jars for small companies such as local breweries and soft drink bottlers. Through the use of plate molds, glass manufacturers made distinctive bottles for small pharmacies and medicine companies. These small-run orders were not compatible with machine production. Barnett summarizes the situation in 1926.

> Many articles put up in glass containers have a small market and the orders of the makers of these articles are for only a small number of bottles. The Owens machine is an instrument of large scale production, and the manufacturers who were using the older methods of manufacture—hand and semi-automatic—were able, therefore, to hold the orders for small lots of special bottles. This advantage has been less

> important in recent years, as the small user of glass containers, in order to secure cheaper bottles, has become willing to use standard sizes and to rely on the label for his distinctive mark (1926:91).

Hand-blown tradition for commercial containers was still going on in 1934 for "small orders and oddly-shaped bottles" (Jerome 1934:106).

World War II further consolidated the standardization of glass containers when the American federal government, with the glass manufacturers, reduced the number of types and varieties of bottles to maximize production.

> Prior to the war, there were many odd shapes and sizes of bottles. War standardization, and elimination of small sizes, provided an increased output with the same production machinery. Janssen stated in 1946 that a return to the prewar pattern would cut output by 20% in grossage, or 40% in gallonage (Holscher 1953:375).

Hand-blowing of commercial containers in the United States probably was close to non-existent by World War II, and in the period between the World Wars it was limited to odd shaped containers, perfumery, toiletware and carboys.

Machine-made Glass Containers in England

Information for countries other than the United States is not as easy to locate. In England, according to Angus-Butterworth, mechanization of the glass industry was fairly complete by 1924 (Angus-Butterworth 1948:177–78). Mechanical production of glass containers in England began with the use of the Ashley semi-automatic machine in Castleford in 1887. Further modifications produced several models, one of which, the Plank machine, had 20 units in commercial operation by 1889. A semi-automatic jar machine was in production in the early 1890s, and before the end of the 19th century, three factories had put bottle machines into operation and a further three or four had used jar machines (Turner 1938:251–52).

Shortly after the Owens automatic bottle-blowing machine was developed in the United States, the Owens Company attempted to lease rights to it in Europe. Not finding a buyer, they formed the Owens European Bottle Machine Company and built a factory at Manchester, England, which was in production by 1907 (Meigh 1960:34). Successful demonstration of the machine's capabilities in the mass production of cheap glass containers convinced the European manufacturers to speedily form a cartel, the *Europaischer Verband der Flaschen-fabriken Gesellschaft* (E.V.), to purchase the European rights to the Owens machine for 12 million gold marks (Meigh 1960:34). The English part of the cartel was the British Association of Glass Bottle Manufacturers Ltd.

The E.V. cartel was interested in minimizing the impact of the Owens machine on glass production and union resistance to it. Therefore, they set goals of 10 per cent of glass container production for the first year with an increase of 5 per cent for the following two years of each country's production (Barker 1968:317). If they had continued to increase at the rate of 5 per cent a year, then 100 per cent automation would have occurred around 1925. Angus-Butterworth suggests that by 1924 the English glass container industry was under "fairly complete mechanization" (1948:177–78). Supporting this is Meigh's statement that the English glass container industry was fully automated by the early 1920s (1960:34). However, Meigh, writing in 1934, indicates that a small number of hand-blown bottles was being produced in England for "special bottles and those used in small quantities" (1934:123–24).

One of the English companies that continued hand production on a large scale was Beatson, Clark & Company Ltd., a large manufacturer of druggists' ware. Their production in 1929 was 98 per cent mouth-blown and 2 per cent semi-automatic, with an output of 1100 gross per week (Beatson, Clark & Co. Ltd. 1952:40). While this seems like a large production, it would be less than one per cent of the British glass container production which was over eight million gross in 1928 (Meigh 1960:43). In 1929 Beatson, Clark and Co. began building a glass works capable of fully automatic production and by 1949, 80 per cent of their production was fully automatic, 19 per cent semi-automatic and less than 1 per cent mouth-blown

(Beatson, Clark & Co. Ltd. 1952:30–40). As in the United States, it was the pharmaceutical and cosmetic bottles that were the last types to be mouth-blown.

Machine-made Glass Containers in Germany

For the rest of Europe, the history of the transition to machine-made glass is much more sketchy. Germany had the largest glass container production in Europe prior to the introduction of the Owens machine and was the major shareholder in the E.V. cartel formed in 1907 to purchase European rights to the Owens machine (Barker 1968:317). Before the Owens machine came on the scene, a very successful device known as the Schiller Semi-Automatic, a press-and-blow machine, was in 1906 put into commercial use in Germany. Between 1906 and 1932, it is claimed, 1150 Schiller Semi-Automatic bottle-making machines were installed throughout Europe, 223 of them in Germany itself (Turner 1938:257).

The first Owens fully-automatic bottle-blowing machine was installed in Germany in 1907, the year the E.V. cartel was formed (Turner 1938:58). As mentioned earlier, the E.V. cartel attempted to minimize the impact of the Owens machine by limiting its production to 10 per cent of the glass containers for the year of introduction with 5 per cent increases for the following two years. If this schedule were followed by Germany, then roughly 40 per cent of German bottle production by 1914 would have been made on fully-automatic machines. In 1914, half of the 60 Owens machines authorized by the E.V. cartel were in Germany (Barker 1968:317), a higher proportion than the original agreed-upon distribution of machines based on pre-machine production for each country in the cartel. This suggests that Germany may have been ahead of England in the proportion of Owens machine-made bottles being produced. What happened to the German glass industry during World War I is not clear, and it is difficult to say when mouth-blown bottle production ended in Germany.

Machine-made Glass Containers in France

Prior to the introduction of Owens machines into Europe, the French production of glass containers almost equalled English production, making France the third largest European producer of such wares (Barker 1968:317). Like manufacturers in the United States, England, and Germany, the French had developed a successful semi-automatic bottle machine. Claude Boucher began developing his machine in 1894 and was successful by 1897 (Turner 1938:253). According to Henrivaux, the Boucher bottle machine was used in countries other than France, and he estimates world-wide production by this machine to have been in excess of 200,000 bottles in 1909 (Henrivaux 1909:395). Unfortunately, figures are not given for French production of machine-made vs. hand-made glass containers.

French glass manufacturers joined the E.V. cartel in 1907 and then withdrew from the agreement (Barker 1968:317). How long they remained outside the cartel is not clear; however, the first Owens machine was installed in France in 1910, following installations in England, Germany, Holland, Austria, and Sweden (Turner 1938:258). How fast the French industry converted to mechanized bottle production is not clear from the literature consulted.

Machine-made Glass Containers in Canada

Information on the transition of the Canadian glass industry from a craft to an automated industrial activity is very limited. For example, the available literature provides little information on the introduction of semi-automatic bottle machines into the Canadian market and no quantitative information on their output. The dramatic technological developments in the United States probably entered Canada much faster than England, due to physical proximity, the constant flow of information carried by glass workers moving between Canada and the U.S., and contact between the unions involved in setting wages in both countries.

For example, one of the early manufacturers of semi-automatic machines was Frank O'Neill (of Toledo, Ohio) who had one of his jar-lid power presses operating in Ontario by around 1901 (Scoville 1948:333 n42). Newspapers from Wallaceburg, Ontario, for 24 September, 1903, report fruit jar-making machines at the Sydenham Glass Works but unfortunately do not mention the type of machine being used (Stevens 1967:29). Among the types of semi-automatic machines documented in use in Canada are the O'Neill, Teeple-Johnson, Olean, and Lynch machines (Stevens 1967:20, 21, 54, 55, 88, 90, 91; King 1965:89; Meigh 1960:40). The relationship of Frank O'Neill with the Canadian glass manufacturers appears to have been fairly significant. After selling his United States interests in the O'Neill Machine Company in Toledo in 1912, he set up the O'Neill European Machine Company factory in Montreal (Meigh 1960:40). How much impact the semi-automatic machines had on hand-blown production of glass containers and how rapidly they spread in Canada is not documented in the literature.

Information on the introduction of the Owens machine to Canada is better documented, due to the leasing structure set up by the Owens Company, and, no doubt, also because of the great costs involved. Rights to the Owens automatic machine for Canada were secured before the European rights were leased. In 1906, for $104,900, the Canadian Glass Manufacturing Company purchased exclusive Canadian container rights on the Owens bottle machine (Scoville 1948:141, Table 14). This company was established specifically to lease Owens machines to operating glass plants in Canada. One of the prime movers in the company was George A. Grier who had acquired control of the Diamond Glass Company and changed its name to Diamond Flint Glass Company (King 1965:90). The first Owens machines in Canada were set up in the Hamilton Glass Works in 1906 (Stevens 1967:9–10).

Control of container rights for the Owens machines was instrumental in the amalgamation of Diamond Flint Glass, Sydenham Glass Company, and the Canadian Glass Company into the Dominion Glass Company in 1913 (King 1965:90). This was the dominant Canadian glass company until the founding of Consumers Glass Company in 1917 (Stevens 1967:54–55). By that time the feed-and-flow devices discussed earlier were being adapted to semi-automatics, such as the O'Neill, Hartford, and Lynch machines, which made them competitive with the Owens machine, and they were a great deal cheaper (Meigh 1960:39).

How long it took bottle-blowing machines to replace bottle blowers in Canada is not well documented. Because the Dominion Glass Company had a practical monopoly on glass production in Canada, it was not a case of hand factories competing against mechanized factories. When Dominion Glass built its new glassworks in Redcliff, Alberta, in 1913, the company combined production on the Owens machine with hand-blown shops. In 1915 the Redcliff operation had an Owens ten-arm machine, a lamp chimney machine, and three bottle shops in operation (Stevens 1967:69). The bottle shops would have produced orders that were too small for production on the Owens machine. Most likely these included such types as pharmaceutical bottles, cosmetic wares and probably demijohns. By the mid-1920s the amount of glassware being hand-blown in Canada was very small, as was the case in the United States and England. Gerald Stevens describes the declining role of glass blowers at the Redcliff plant in the 1930s:

> Mechanization was to take its toll. A jurisdictional issue arose in 1937 and the last of the glass blowers declared a lengthy strike. Eventually, they returned to work, "but things were never the same. Their time had run out and they and their skills and songs are gone." (Stevens 1967:69–70).

According to E. G. Davis, manager of the Dominion Glass Works plant at Wallaceburg, Ontario, there were no glass blowers employed in Canadian glass factories in 1959 and the last hand-blowing operation at the Wallaceburg works was in about 1942 (Stevens 1967:91).

The Owens machine in Canada began being replaced by the Individual Section Machine in the 1940s (King 1965:91).

Discussion and Chronological Summary

For the purposes of archaeology, the machine-made bottle provides an excellent, readily-identifiable time marker. Because all semi-automatic and automatic bottle-blowing machines work on the principle of forming the finish first as an attachment to the blowing machine, and the use of a parison mold followed by a full-size mold, identification of the differences between bottles made on the various machines is limited. The major exception to this is the Owens scar.

Characteristics of Machine-made Bottle Manufacture

1. A large number of mold seams, particularly related to the finish.
2. Finish seams:—horizontal mold seam encircling the neck-finish junction. This seam must appear with other machine-made characteristics; an 1860 patent for hand-blown bottles features this seam (Toulouse 1969:584).—1 or 2 horizontal mold seams around the top of the finish or lip caused by a neck-shaping plug and a collar to guide it. On beer and beverage bottles these seams have sometimes been fire-polished off, so other evidence must be sought.—continuous vertical mold seams up the side of the body and over the finish (Figures 4 and 6).
3. Body seams:—wandering vertical "ghost" mold seams on the body of the container, left by the parison mold halves, which join the full-sized mold seams at the finish. A "ghost" seam is certain proof of machine manufacture (Toulouse 1969:585) (Figure 5).
4. Base:—either cup or post bottom mold seams can appear on machine-made bottles and should not be confused with the mouth-blown versions.
—Owens scar, a distinctive, circular mark with "feathery" edges, caused by the shears that cut off the gob of glass in the suction machines. An Owens scar is usually off-center and may sometimes even extend onto the heel. It dates from 1904 until at least 1969 (Toulouse 1969:582) (Figure 8).
—valve mark. A non-symmetrical indented groove on the base, found on wide-mouthed containers and milk bottles. 1930s into 1950s (Toulouse 1969:583) (Figure 7).
—"ghost" seam from the base part of the parison mold.

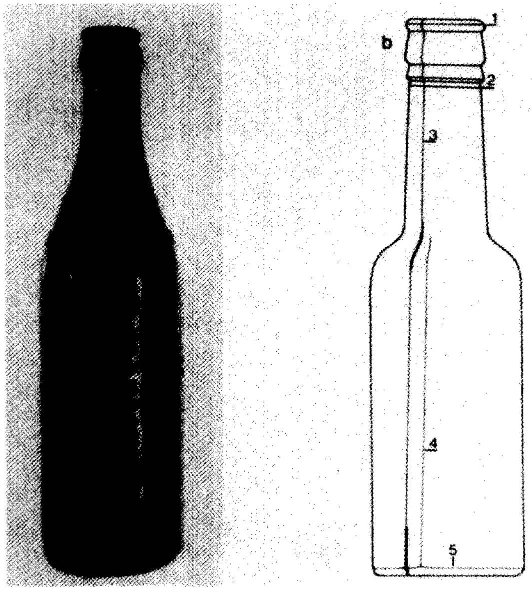

FIGURE 4. *a* & *b*. Two bottles showing typical machine-produced mold seams, including on *b* a "ghost" seam from the parison mold on the body (*Photo by R. Chan; Drawing by D. Kappler*).

The main difference between semi-automatic and automatic machines was the degree of mechanization and thus the rate of production, not the appearance of the container. Bottles produced by either method should look the same and have similar "typical" seams and evidence of manufacture.

Roughly speaking, the chronology of mechanization for production of glass containers is as follows:

FIGURE 5. Close-up view of a wandering "ghost" mold seam on the body of a container (*Photo by R. Chan*).

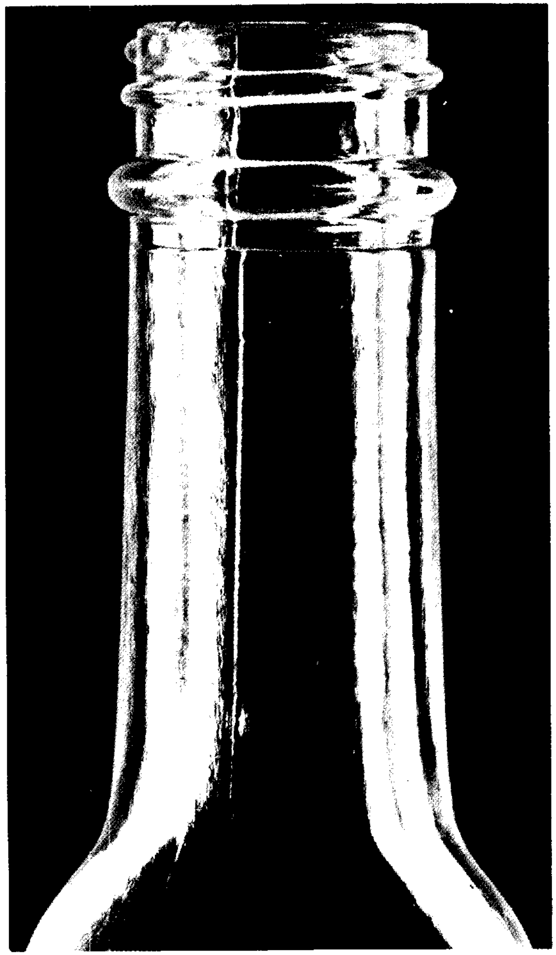

FIGURE 6. Close-up view of a container finish, showing the large number of seams left by the mold parts (*Photo by R. Chan*).

A. Semi-automatic machines for wide-mouthed containers: commercial production begins 1893, peak ca. 1917, end ca. 1926.
B. Semi-automatic machines for production of narrow-mouthed containers: commercial production begins 1889, peak ca. 1917, end ca. 1926.
C. Fully-automatic production on the Owens machine for narrow- and wide-mouth containers: commercial production begins 1904; by 1917 they were producing half of the bottles in the United States; began being replaced by feeders in the 1920s; end of production around the late 1940s or early 1950s.
D. Semi-automatic made automatic by flow-and-feed devices: introduced in 1917, continued to grow in importance and offered an inexpensive alternative to the Owens machine.
E. The Individual Section Machine: developed in 1925; by the 1940s this had become the machine most commonly used in producing bottles.

Hand-blown bottles, as discussed earlier, lasted into the 1930s but only for small run types such as pharmaceutical bottles, cosmetic wares and demi-

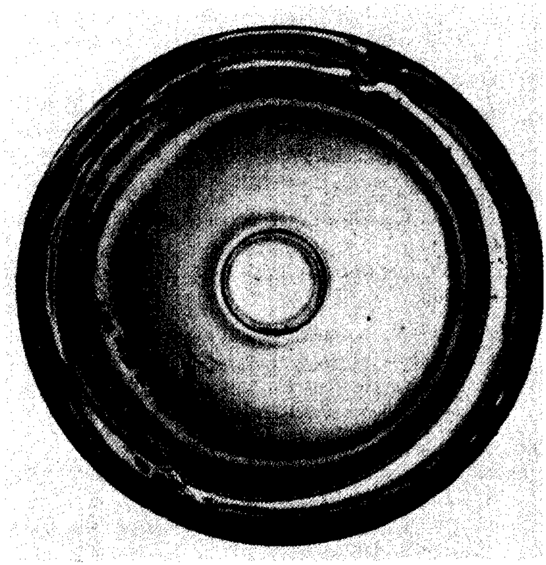

FIGURE 7. Owens suction scar caused by shearing the glass when the mold is full. The shears leave a cooled glass surface, creating a scar from the cutting action; *a* also shows the base and heel mold seams from the parison mold (*Drawing by D. Kappler; Photo by R. Chan*).

johns. Their quantities would be very small in any post-1920 archaeological assemblage.

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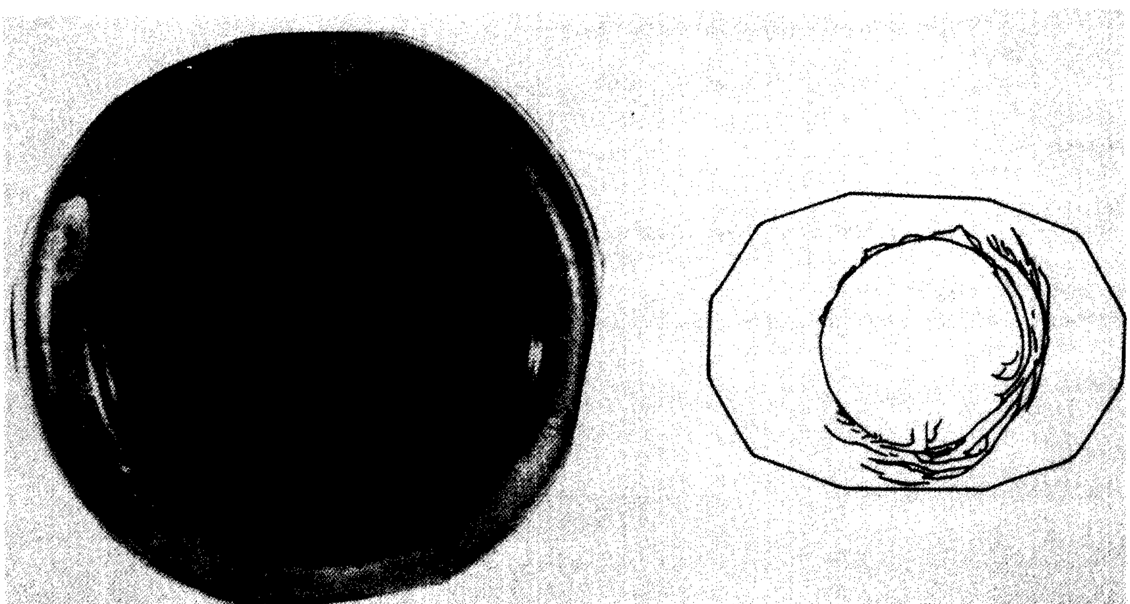

FIGURE 8. Valve mark on a bottle base. Toulouse (1969:583) says that this mark is caused by a valve that ejects the parison out of the mold so that it can be transferred to the blow mold for completion (*Photo by R. Chan*).

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