

Galss Manufacturing

By

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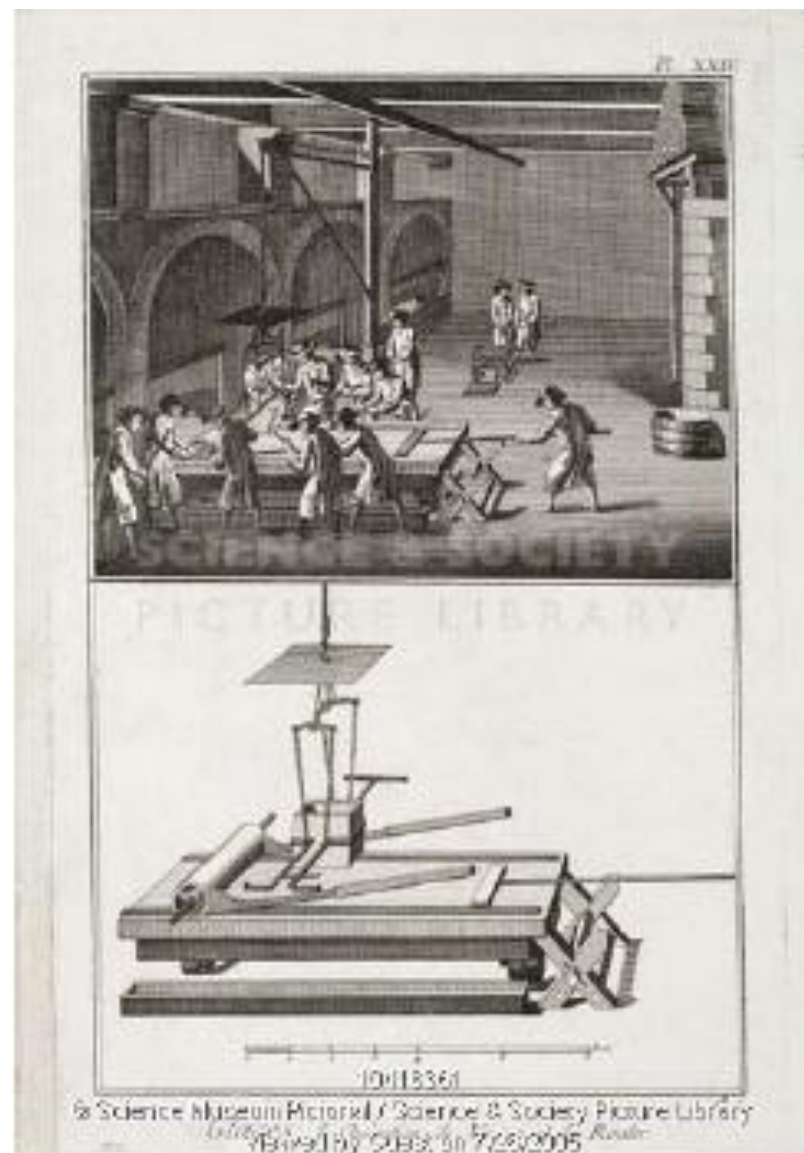
Overview

Discovered over 4,000 years ago

7th century Syrians - crown method lump of molten glass spun to flat shape

The History of Glass

- ▶ Early 20th century - sheet glass drawn vertically out of molten glass
- ▶ Plate glass - molten glass poured onto table, rolled to flatten - ground & polished into a plate
- ▶ 1959 - float glass - molten glass flows from furnace onto bath of molten tin formed to continuous ribbon of glass
- ▶ 1960's and beyond - multi-color, insulating, heat-treated glass



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Overview

- Hand glass manufacture
- Sheet glass manufacture
- Mechanical sheet glass manufacture
- Pilkington float glass process
- Bottle manufacture
 - Codd bottles
 - Ramune bottles

Rolled Glass

- Single roll

Molten glass is poured onto a metal table and a single metal roll is used to flatten it into a sheet.

- Double roll

Molten glass is passed between a pair of rotating metal rolls to form the sheet.

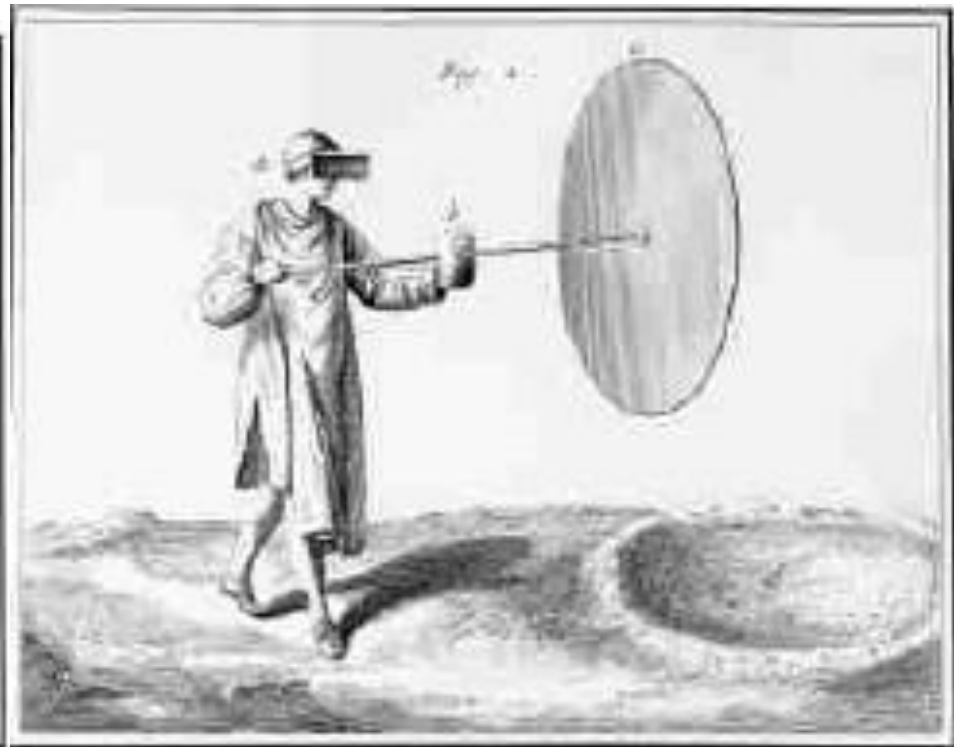
Cylinder Drawn Glass

The first mechanical method of drawing glass, 40 ft high cylinders of glass were drawn vertically from a circular tank.

The glass was annealed and then cut into 7-10ft cylinders, which were then cut lengthways, reheated and flattened.

This process was used in the UK up to the end of the 1920's.

Handglass Manufacturing

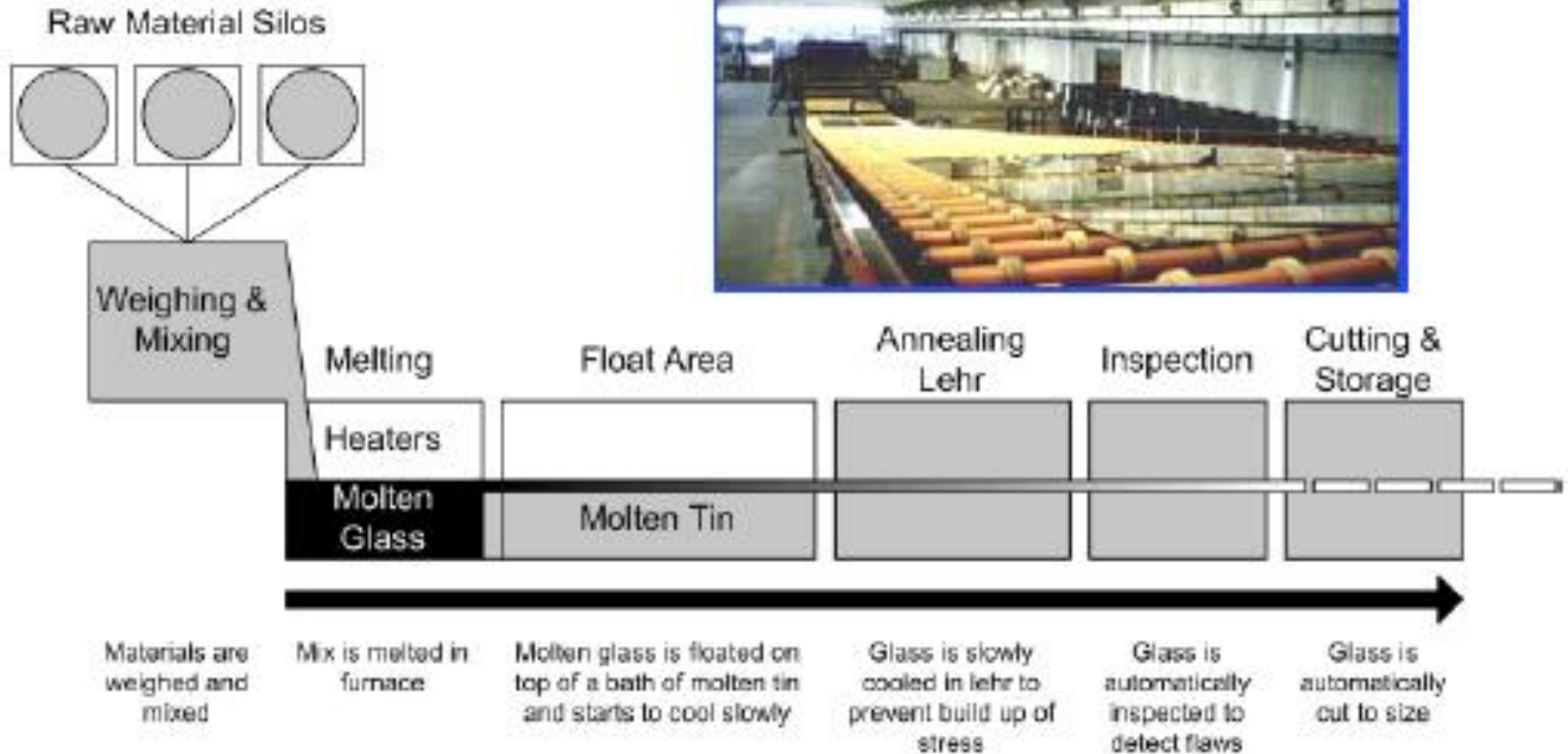


Flat Glass Manufacturing

Batch Materials

- Silica Sand (72,6%)
 - Limestone (8,4%)
 - Soda Ash (13,0%)
 - Dolomite (4,0%)
 - Alumina (1,0%)
 - Glass Cullet (1,0%)
-
- Over time, 100% of the internal cullet is recycled
 - Typically 15-30% of a given batch is cullet

Flat Glass Manufacturing



Flat Glass Manufacturing

- Molten glass is pulled vertically through a slit in a large one-piece refractory block that is floating on the glass surface.
- The annealing lehr is mounted vertically over the draw chamber.
- The glass was drawn until it cooled sufficiently to allow it to be cut.
- The Belgians invented the original process but it did not reach the UK until 1919.
- Drawn glass is generally more pristine than rolled glass because its surface has remained untouched during forming.

Flat Glass Process

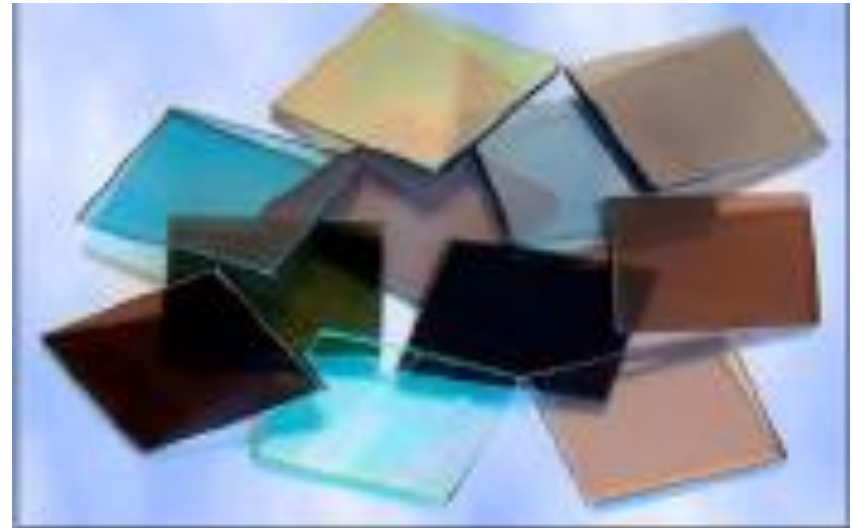
- Batch heated to 2900° F
- Natural gas is the principal means of firing the flat glass furnace in North America
- Molten mass leaves conditioning zone at 1900° F
- Annealing
Slowly cooling the ribbon of glass from 1100° F to 200 ° F

Flat Glass Manufacturing

Float line operation:

- 24 hours a day
- 7 days a week
- 365 days a year
- For 10 years +
- Typical furnace produces between 300 - 600 tons of glass per day
- In a year, a typical furnace produces enough glass that a 1 foot wide ribbon circles $3/4^{\text{th}}$ of the Earth at the equator.

- Batch materials for tinted glass substrates include selenium, cobalt, etc.
- Other trace materials can be used
 - Clear
 - Green
 - Grey
 - Bronze
 - Blue
 - Blue Green
 - Low Iron
 - High Performance Substrates
 - Low Iron Glass



Glass Tubing

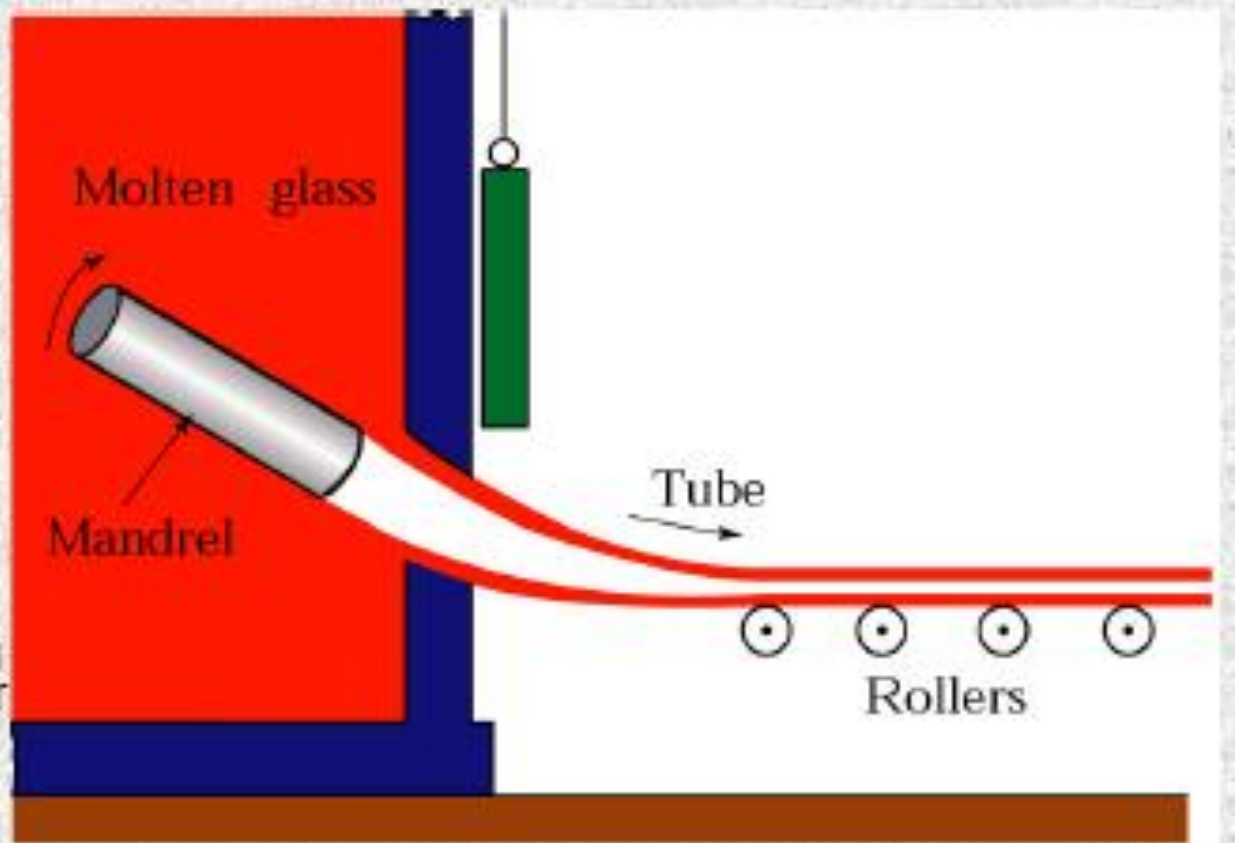


Figure 11.29 Manufacturing process for glass tubing. Air is blown through the mandrel to keep the tube from collapsing. Source: Corning Glass Works.

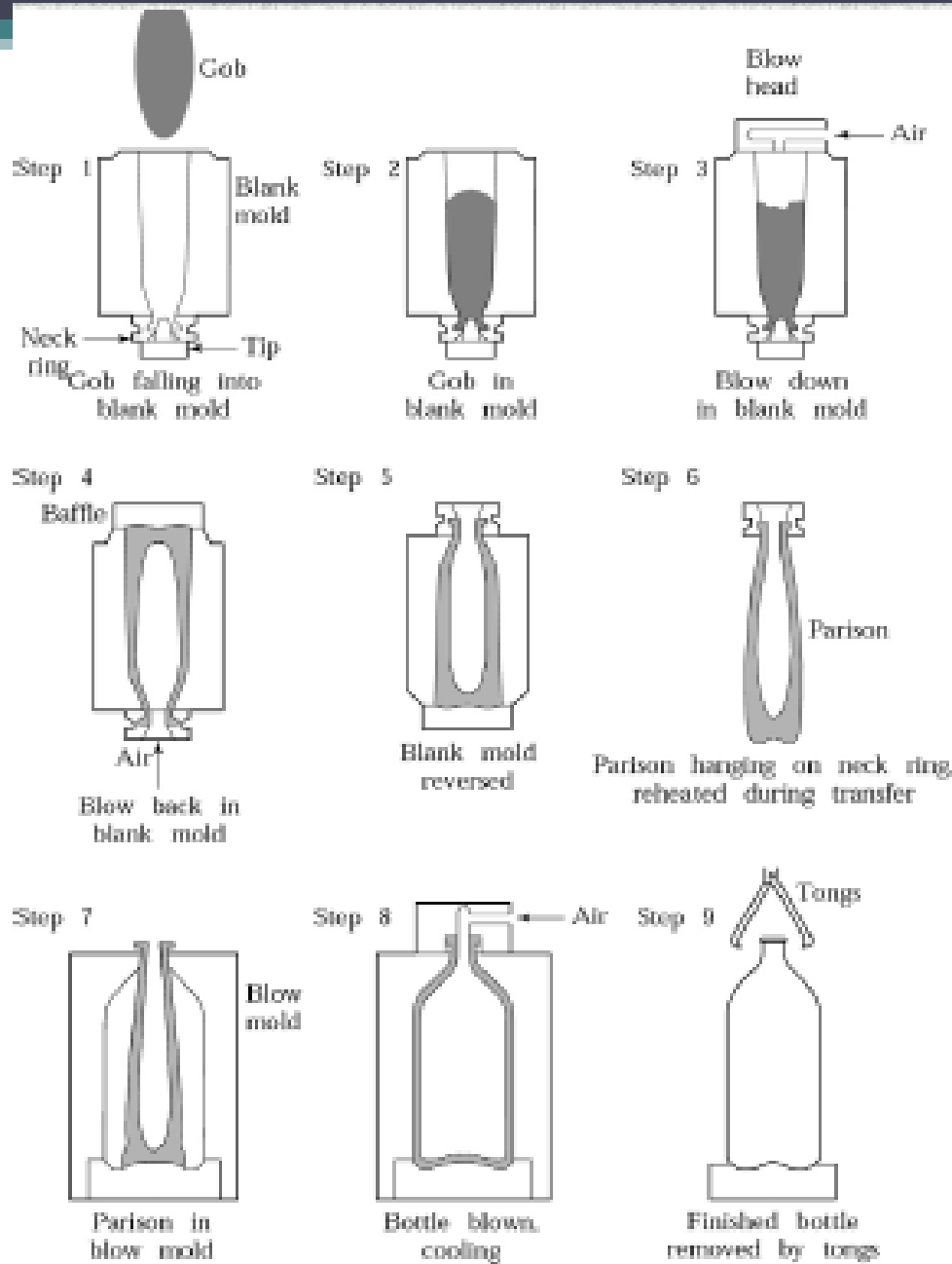


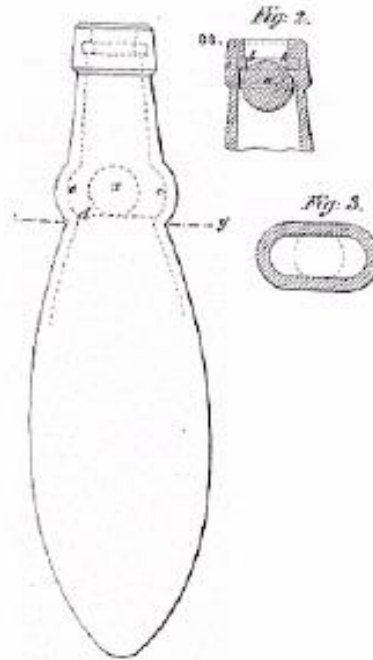
Figure 11.30 Stages in manufacturing an ordinary glass bottle. Source: F.H. Norton, *Elements of Ceramics*. Addison-Wesley Publishing Company, Inc. 1974.

Step in Manufacturing Glass Bottle

Ramune Bottles



Codd Bottles



Hiram Codd
1838-1877



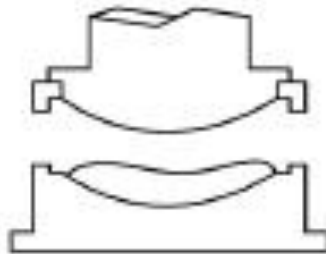
Glass Molding

Stage 1



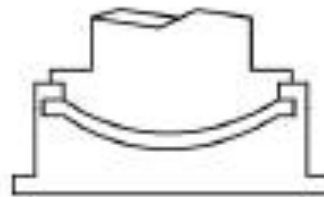
Empty mold

Stage 2



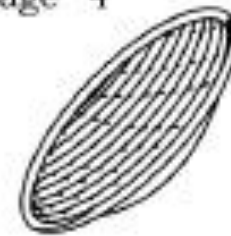
Loaded mold

Stage 3



Glass pressed

Stage 4



Finished piece

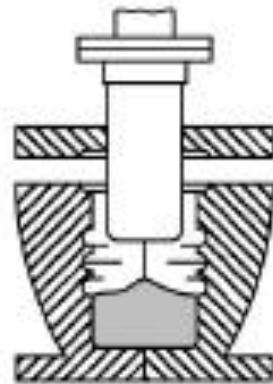
Figure 11.31 Manufacturing a glass item by pressing glass in a mold. Source: Corning Glass Works.

Step 1



Empty mold

Step 2



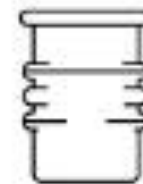
Loaded mold

Step 3



Glass pressed

Step 4

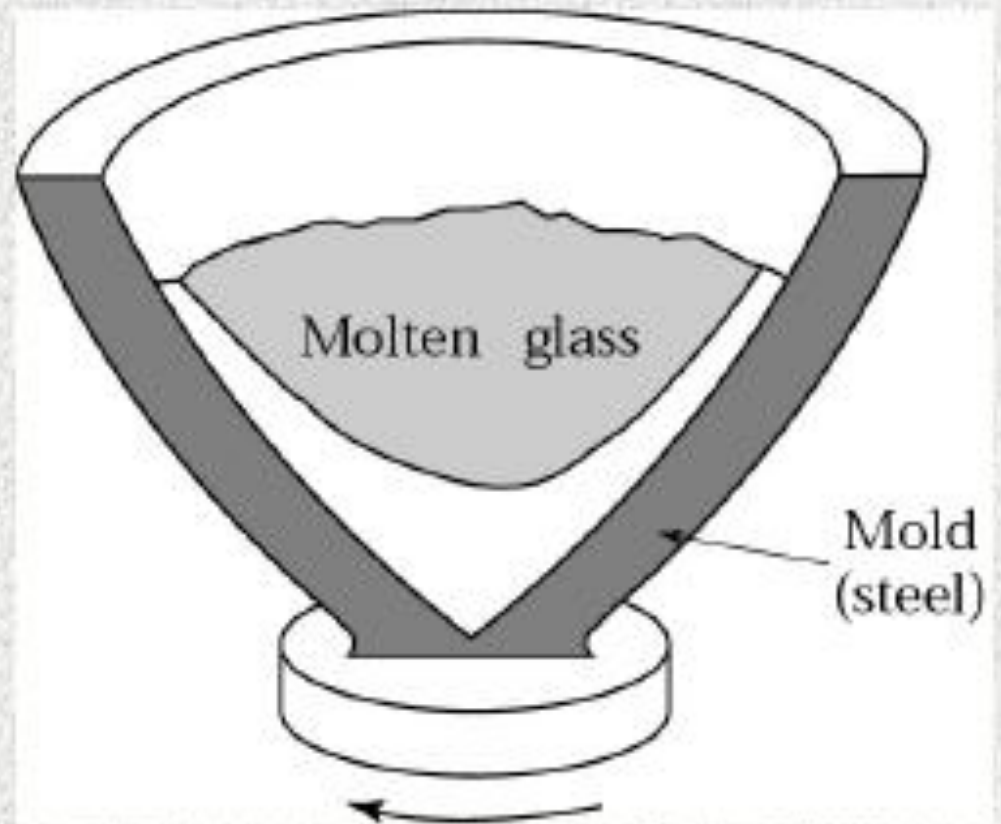


Finished product

Figure 11.32 Pressing glass in a split mold. Source: E.B. Shand, *Glass Engineering Handbook*. McGraw-Hill, 1958.

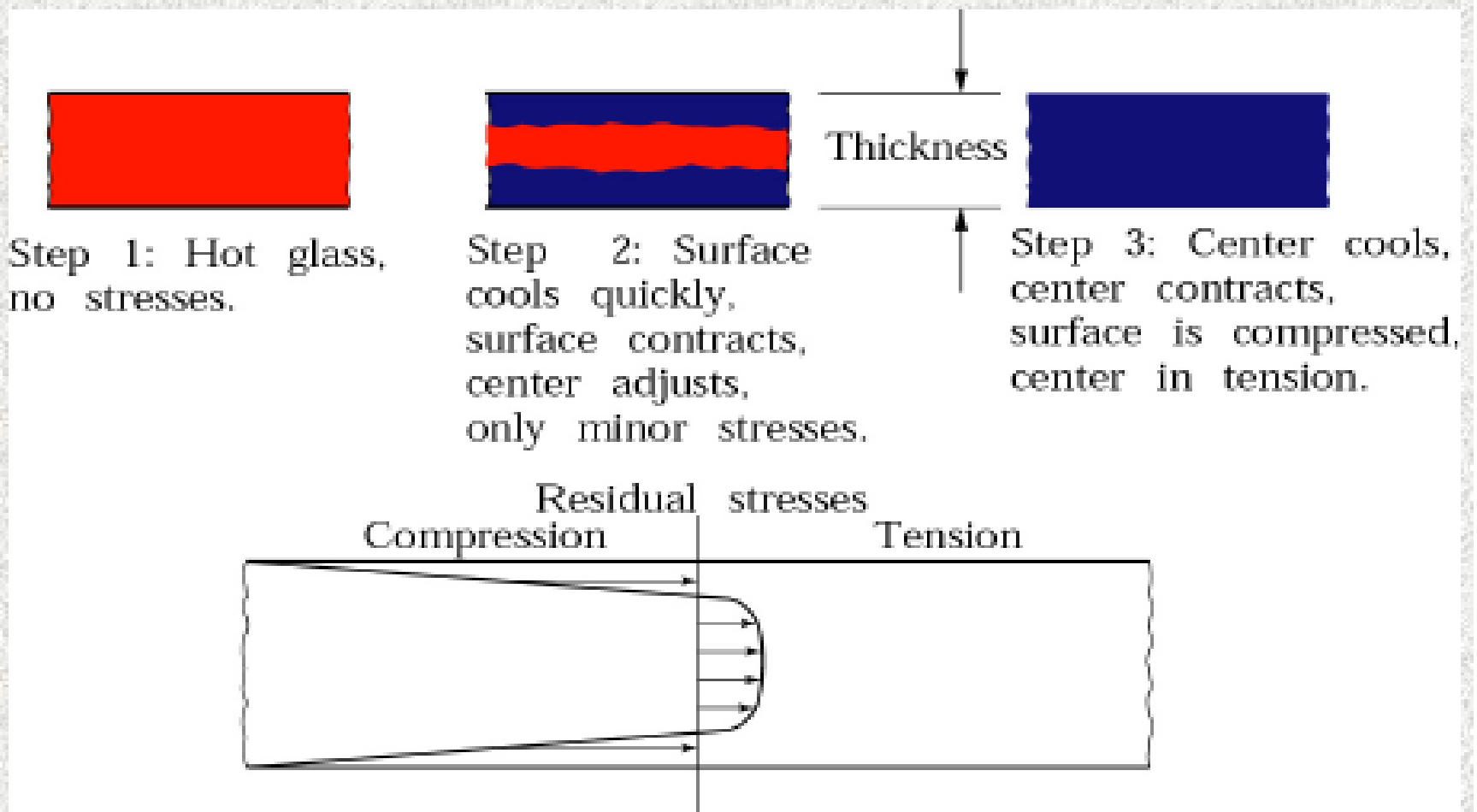
Centrifugal Glass Casting

Figure extra Centrifugal casting of glass. Television-tube funnels are made by this process. Source: Corning Glass Works.



Residual Stress

Figure 11.33 Residual stresses in tempered glass plate, and stages involved in inducing compressive surface residual stresses for improved strength.



References

- M. P. Groover, “Fundamentals of Modern Manufacturing 2/e”, 2002 John Wiley & Sons, Inc.
- Kalpakjian & Schmid, “Manufacturing Processes for Engineering Materials, 1997, Addison Wesley
- Prof. J.S. Colton , Manufacturing Processes and Engineering, Lecture note. Georgia Institute of Technology.