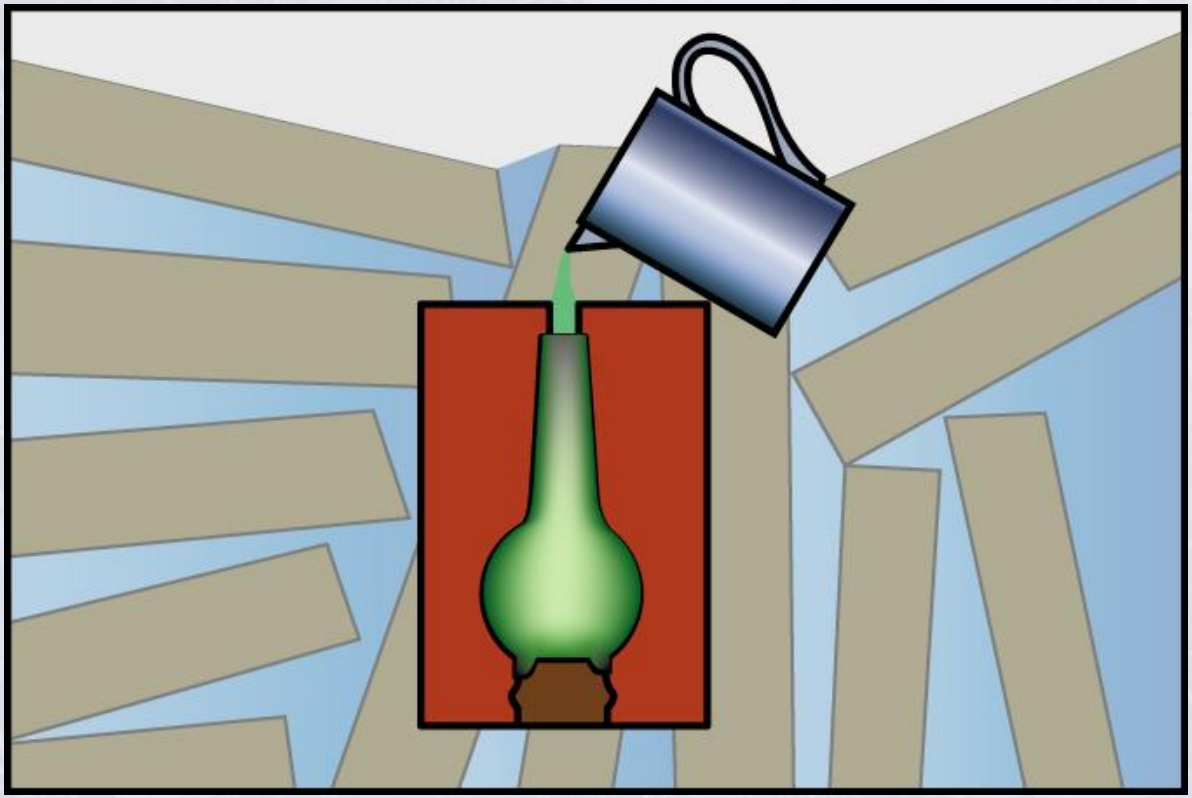
Chapter 18

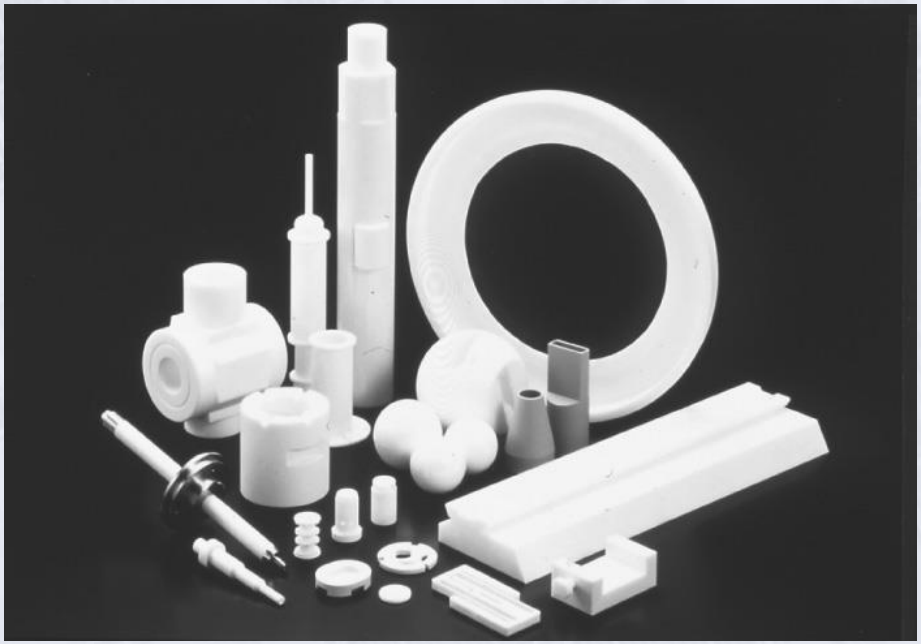
Processing of Ceramics, Glass, and Superconductors



Manufacturing, Engineering & Technology, Fifth Edition, by Serope Kalpakjian and Steven R. Schmid.
ISBN 0-13-148965-8.

Ceramic and Glass Parts

(a)



(b)

Figure 18.1 Photos of typical (a) ceramic and (b) glass parts. *Source*: Courtesy of Sanwa Components USA. (b) Courtesy of Corning Glass Works.

Characteristics of Ceramics Processing

TABLE 18.1

General Characteristics of Ceramics Processing

Process	Advantages	Limitations
Slip casting	Large parts, complex shapes, low equipment cost	Low production rate, limited dimensional accuracy
Extrusion	Hollow shapes and small diameters, high production rate	Parts have constant cross-section, limited thickness
Dry pressing	Close tolerances, high production rates (with automation)	Density variation in parts with high length-to-diameter ratios, dies require abrasive-wear resistance, equipment can be costly
Wet pressing	Complex shapes, high production rate	Limited part size and dimensional accuracy, tooling costs can be high
Hot pressing	Strong, high-density parts	Protective atmospheres required, die life can be short
Isostatic pressing	Uniform density distribution	Equipment can be costly
Jiggering	High production rate with automation, low tooling cost	Limited to axisymmetric parts, limited dimensional accuracy
Injection molding	Complex shapes, high production rate	Tooling can be costly

Steps in Making Ceramic Parts

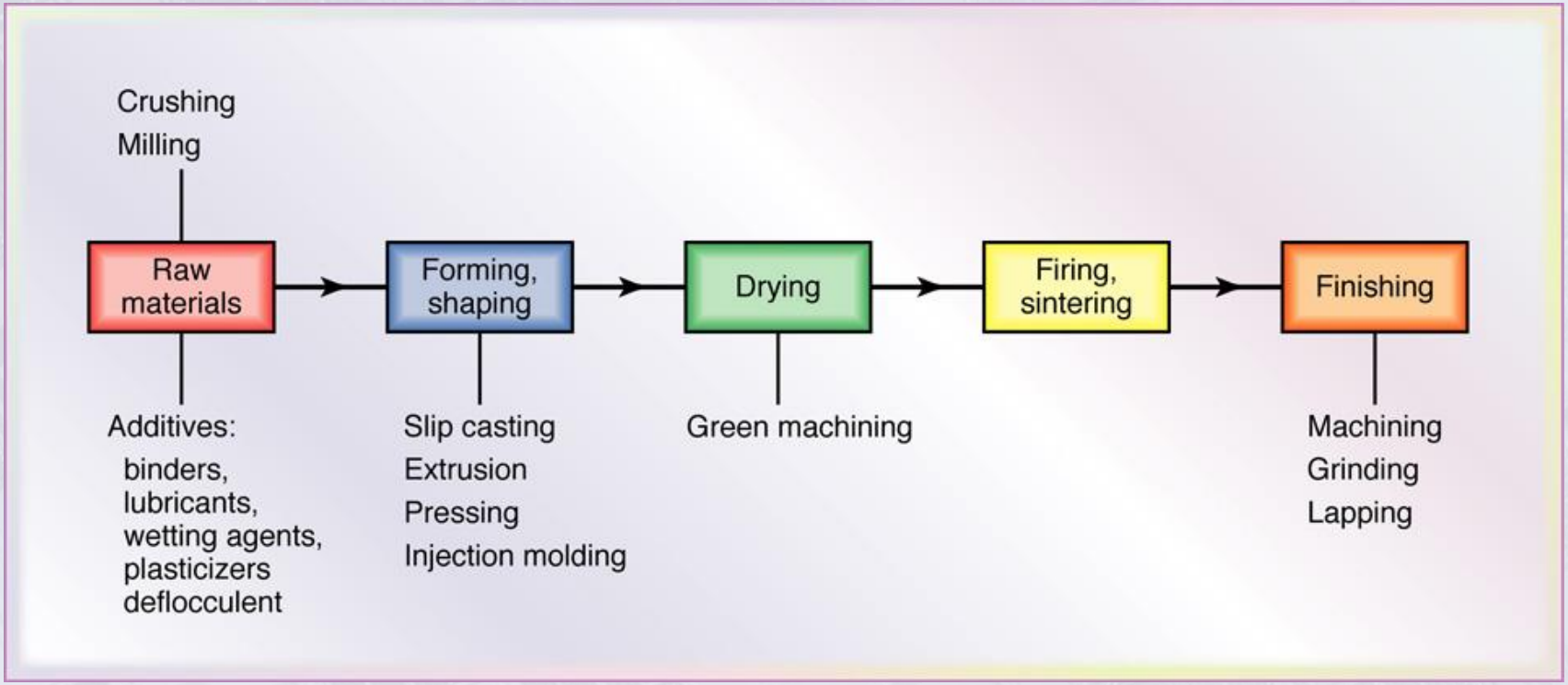


Figure 18.2 Processing steps involved in making ceramic parts.

Slip-casting a Ceramic Part

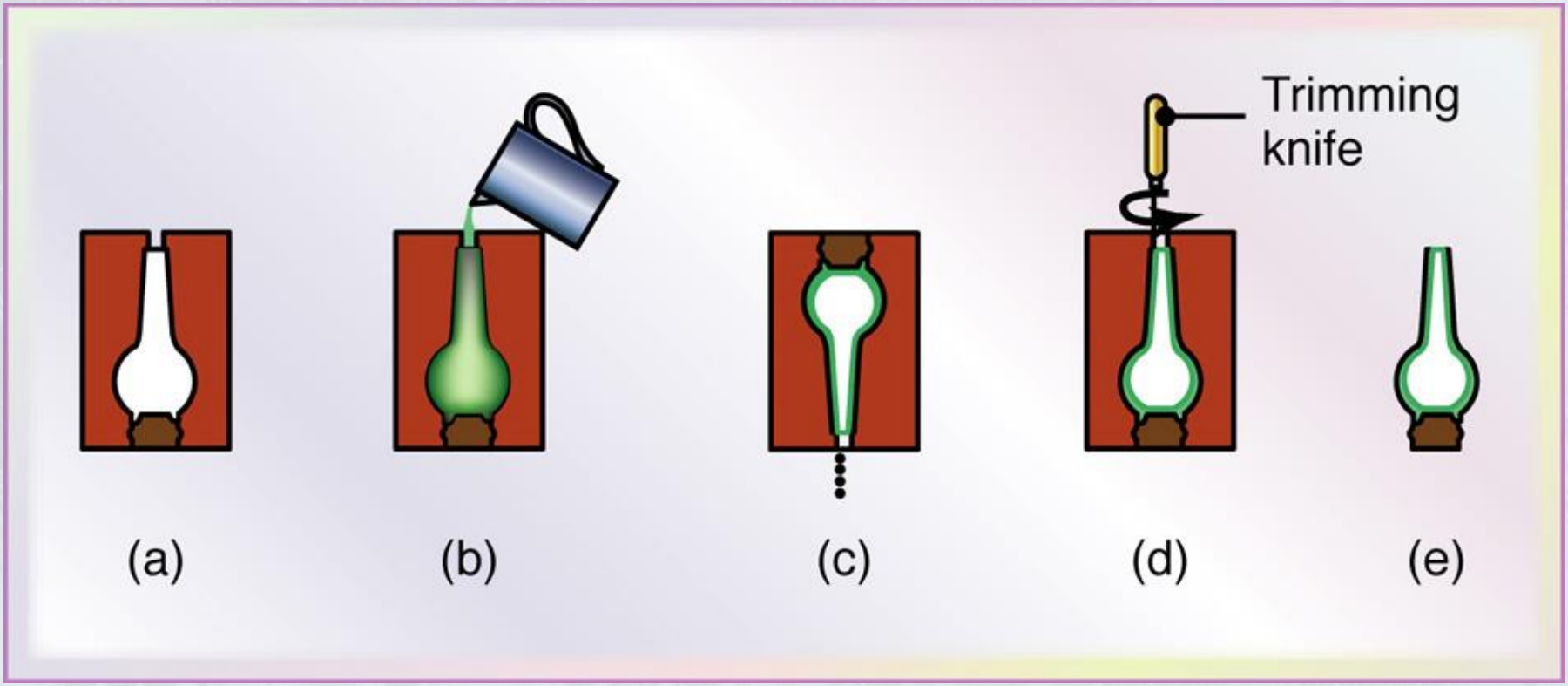


Figure 18.3 Sequence of operations in slip-casting a ceramic part. After the slip has been poured, the part is dried and fired in an oven to give it strength and hardness. *Source*: After F. H. Norton

Doctor-Blade Process

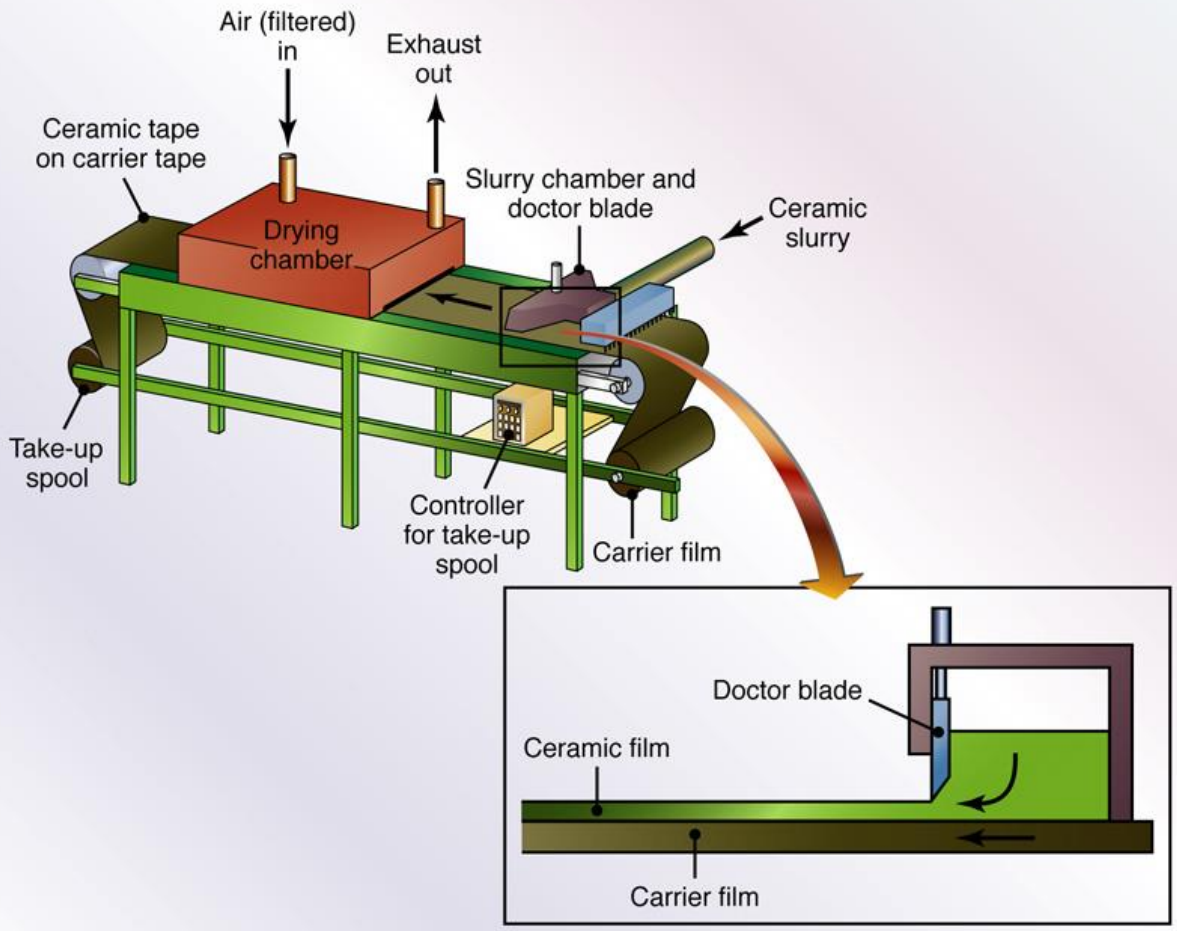


Figure 18.4 Production of ceramic sheets through the doctor-blade process

Extruding and Jiggering

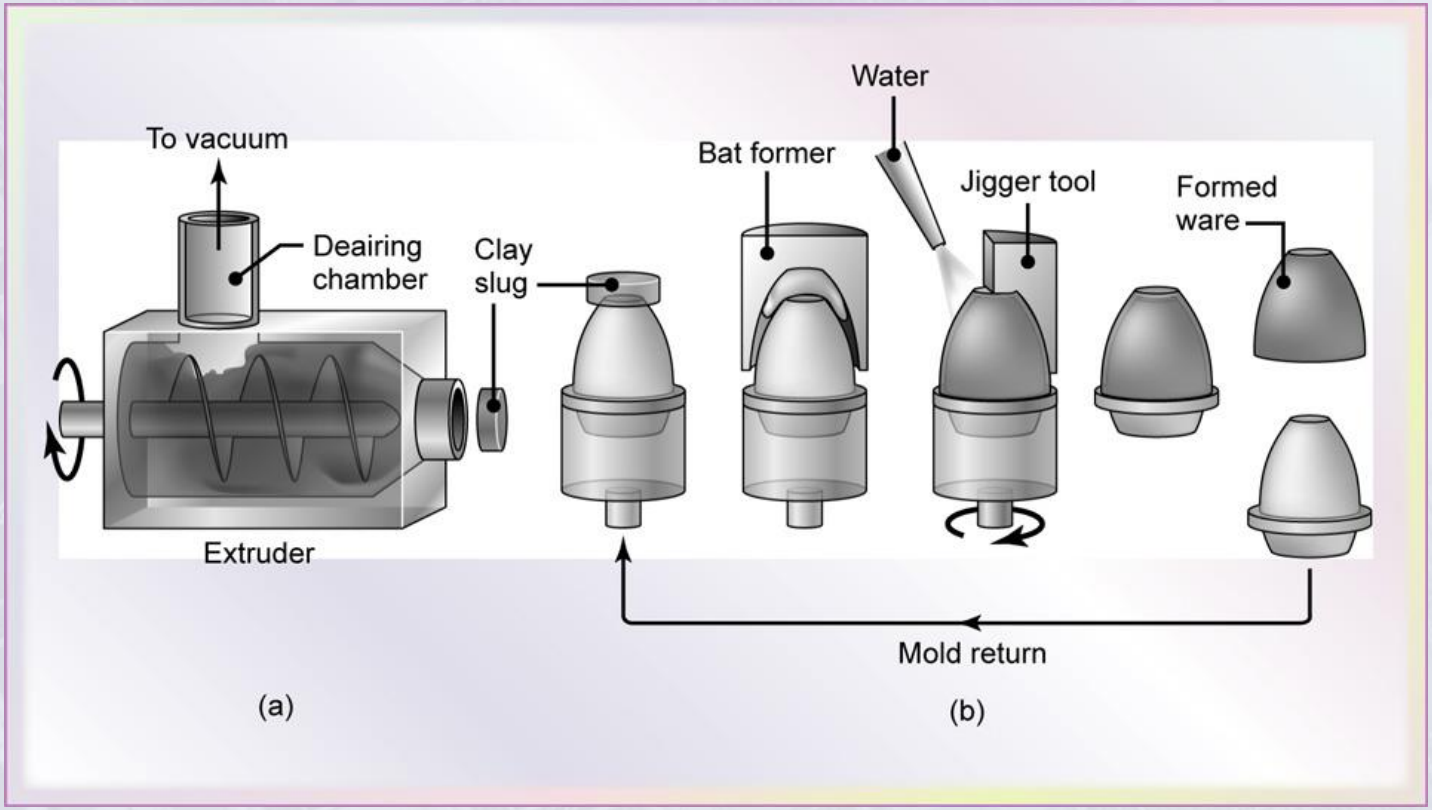


Figure 18.5 (a) Extruding and (b) jiggering operations.
Source: After R. F. Stoops

Shrinkage of Wet Clay

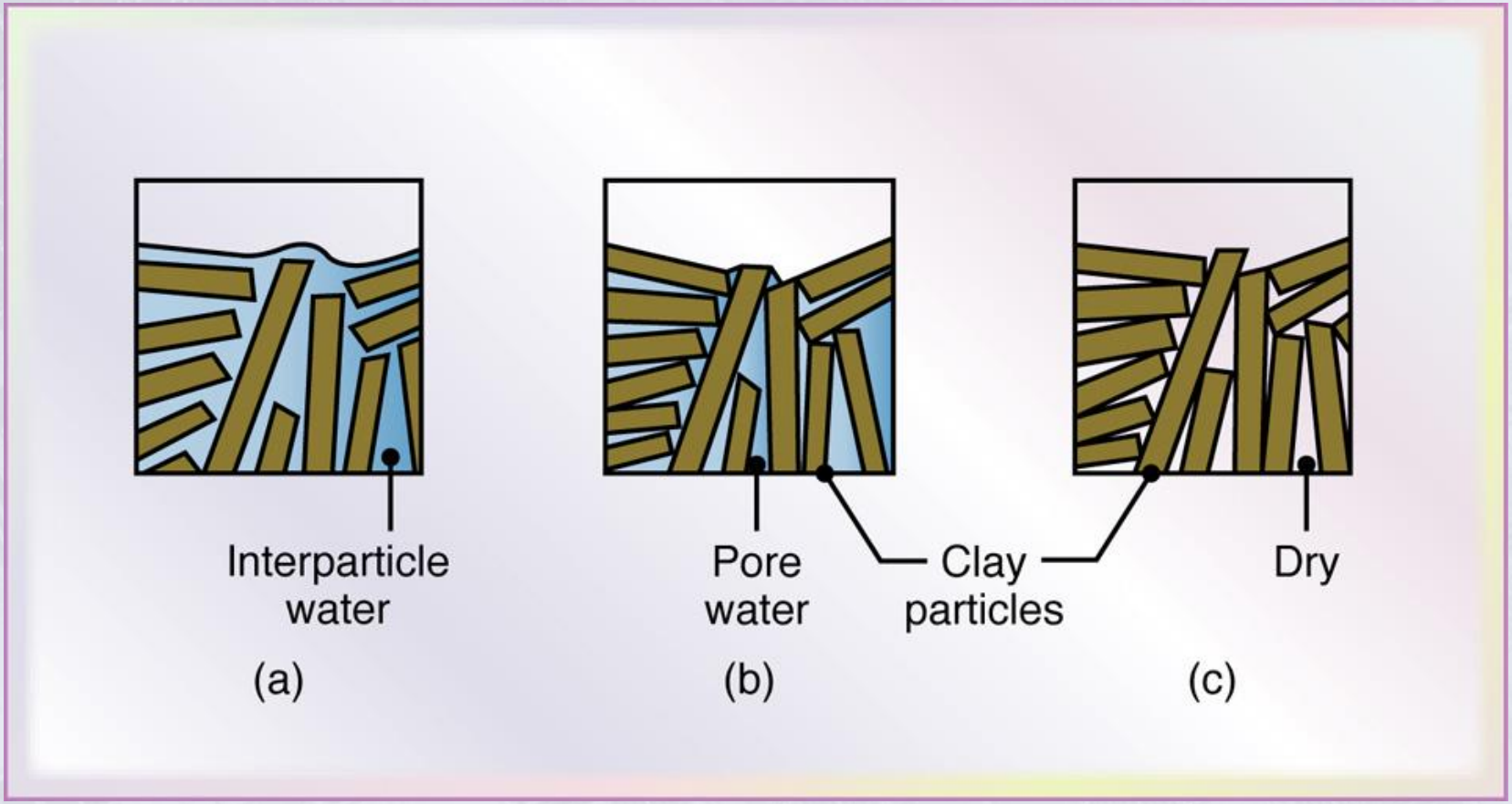


Figure 18.6 Shrinkage of wet clay caused by the removal of water during drying. Shrinkage may be as much as 20% by volume. *Source:* After F. H. Norton.

Float Method

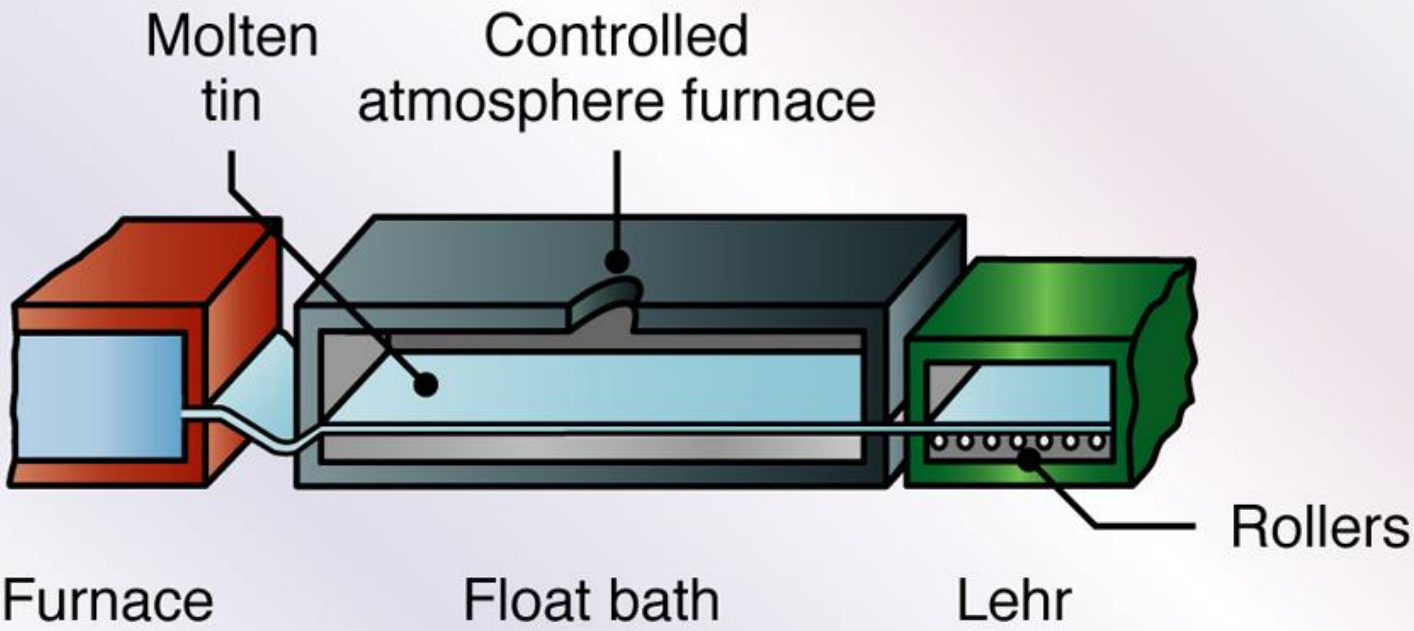


Figure 18.7 The float method of forming sheet glass.
Source: Courtesy of Corning Glass Works.

Drawing Process and Rolling Process

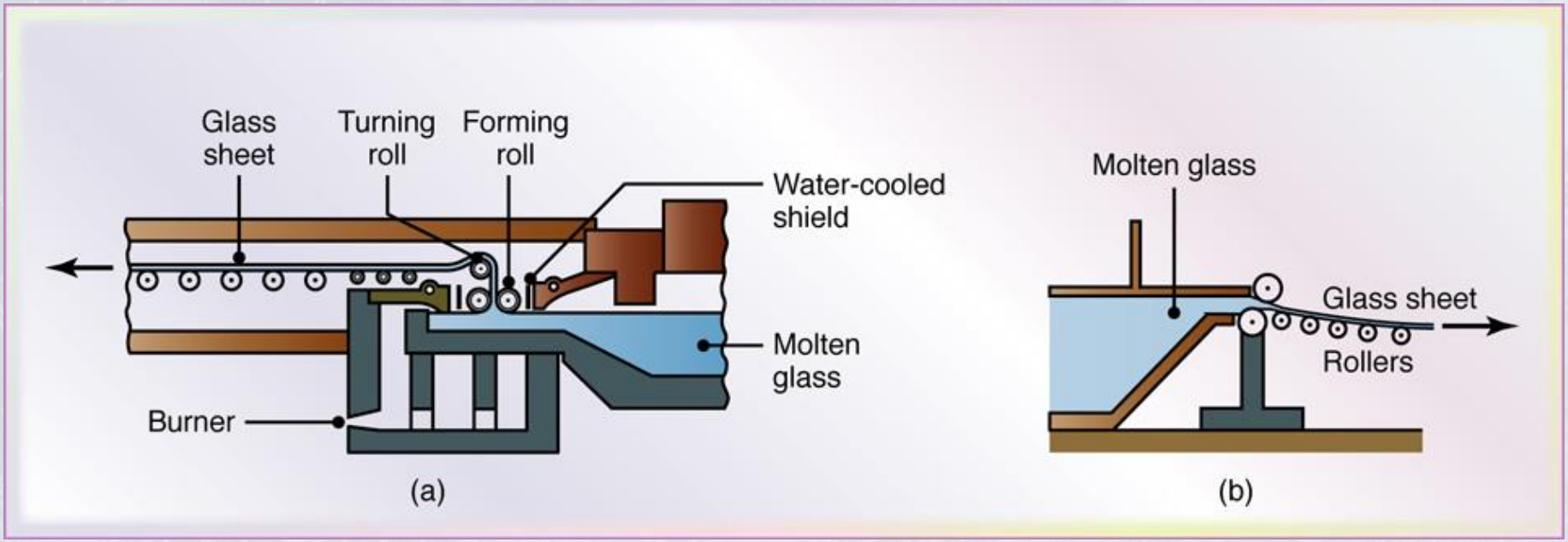


Figure 18.8 (a) Drawing process for drawing sheet glass from a molten bath. (b) Rolling process. *Source*: After W. D. Kingery.

Glass Tubing Manufacturing

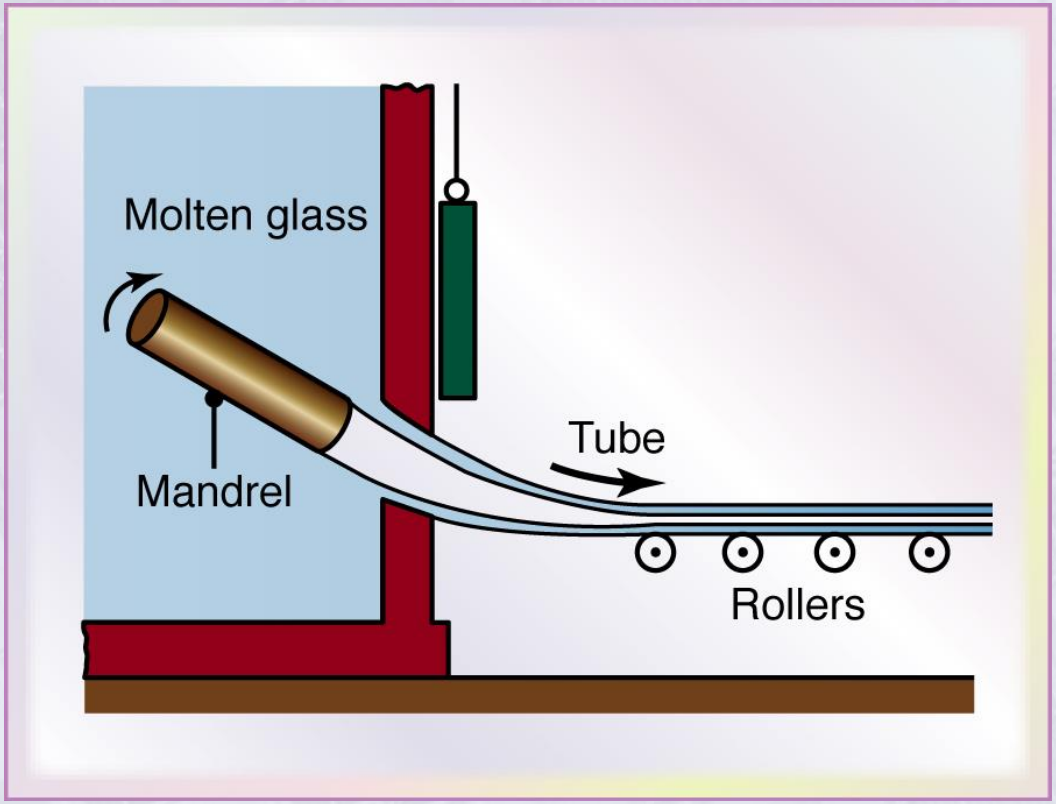


Figure 18.9 Manufacturing process for glass tubing. Air is blown through the mandrel to keep the tube from collapsing. Glass tubes for fluorescent light bulbs are made by this method.

Steps in Manufacturing Glass Bottles

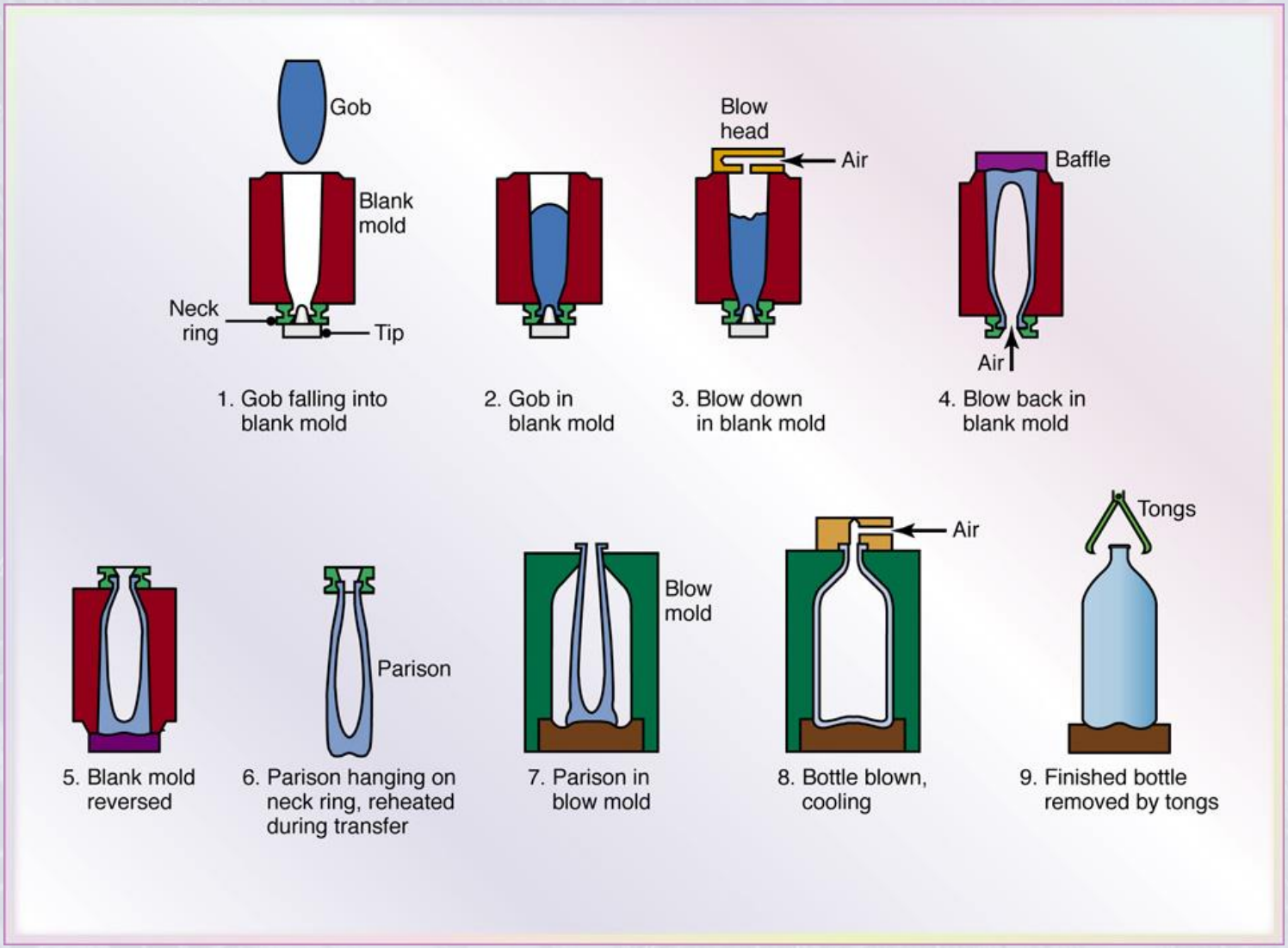


Figure 18.10 Stages in manufacturing an ordinary glass bottle. *Source:* After F. H. Norton.

Manufacturing Glass by Pressing into Mold

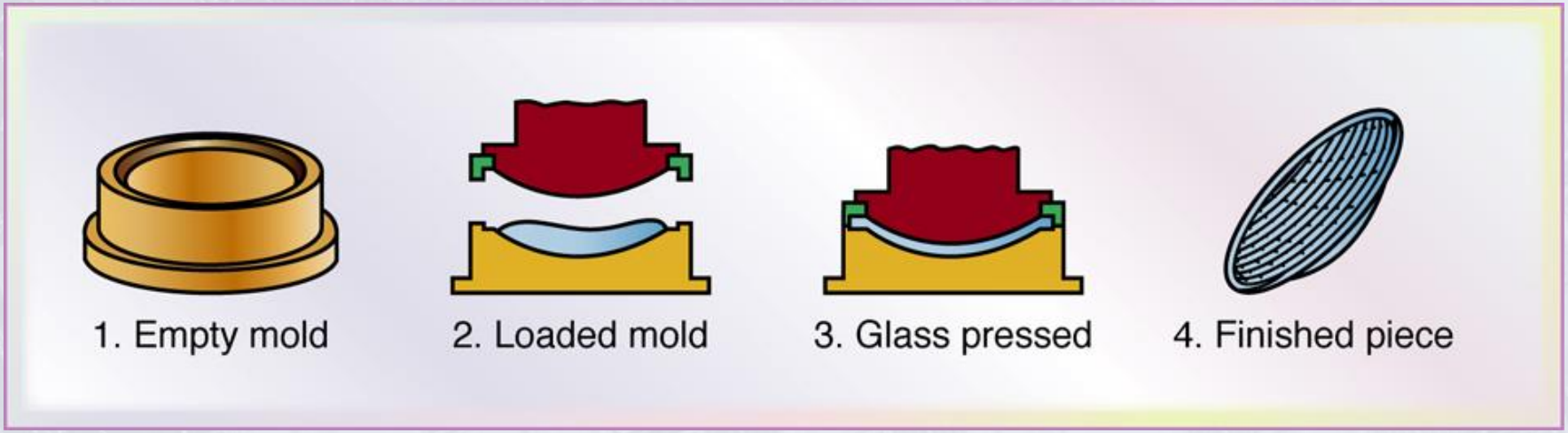


Figure 18.11 Manufacturing a glass item by pressing glass into a mold. *Source*: Courtesy of Corning Glass Works.

Pressing Glass into a Split Mold

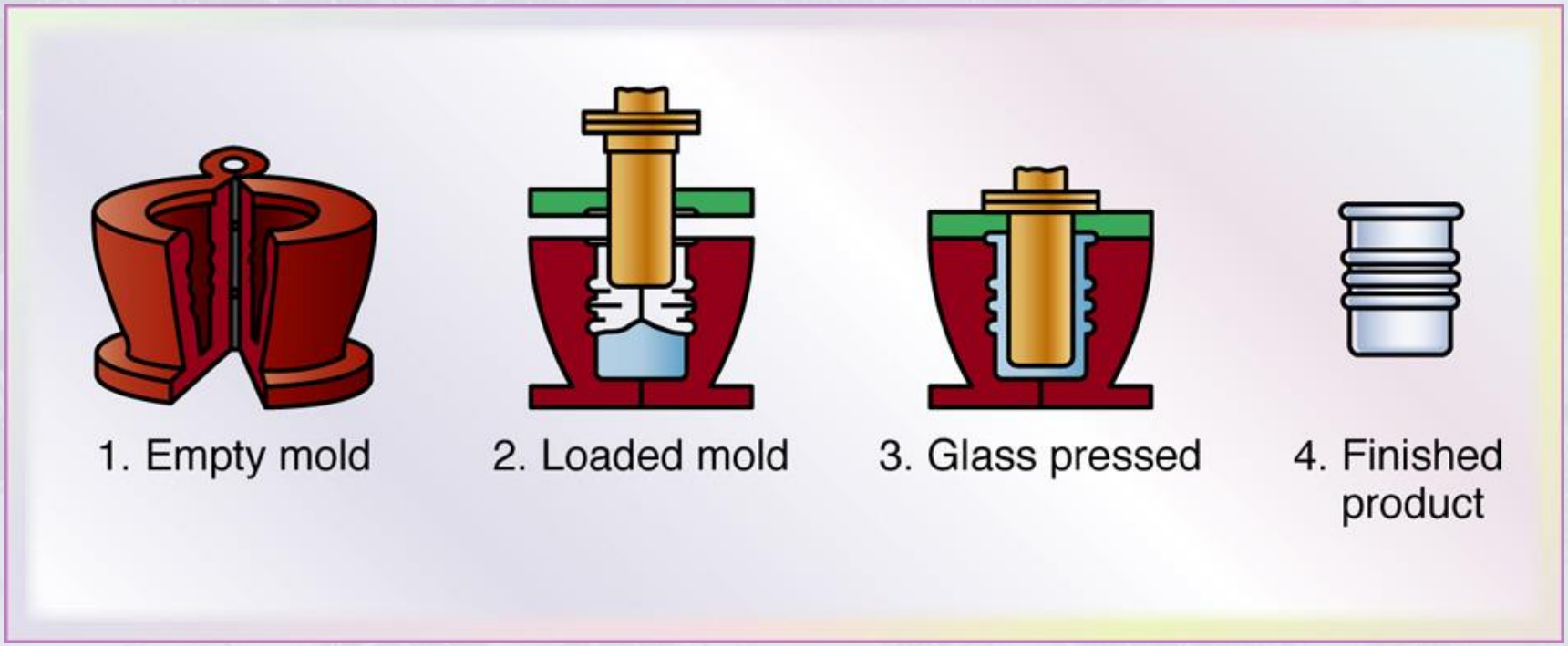


Figure 18.12 Pressing glass into a split mold. *Source*: After E. B. Shand.

Centrifugal Casting of Glass

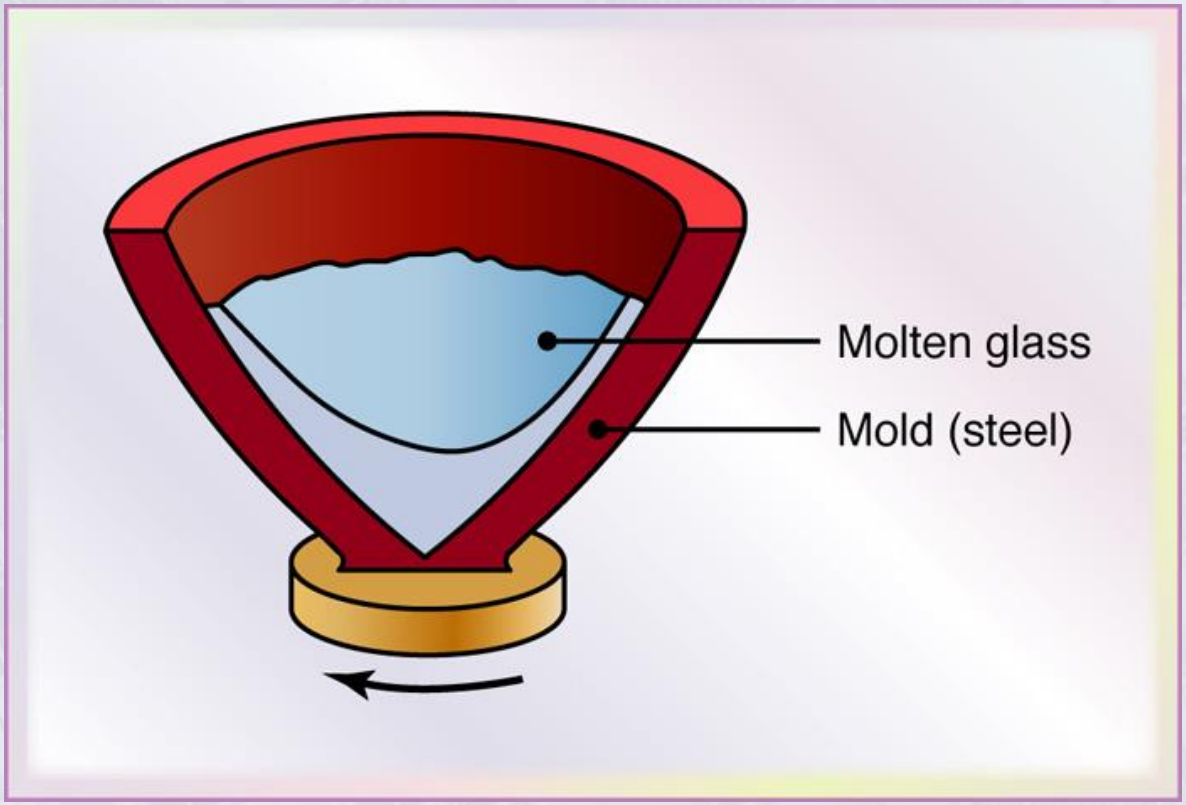


Figure 18.13 Centrifugal casting of glass. Large telescope lenses and television-tube funnels are made by this process. *Source*: Courtesy of Corning Glass Works.

Residual Stresses in Tempered-Glass Plate

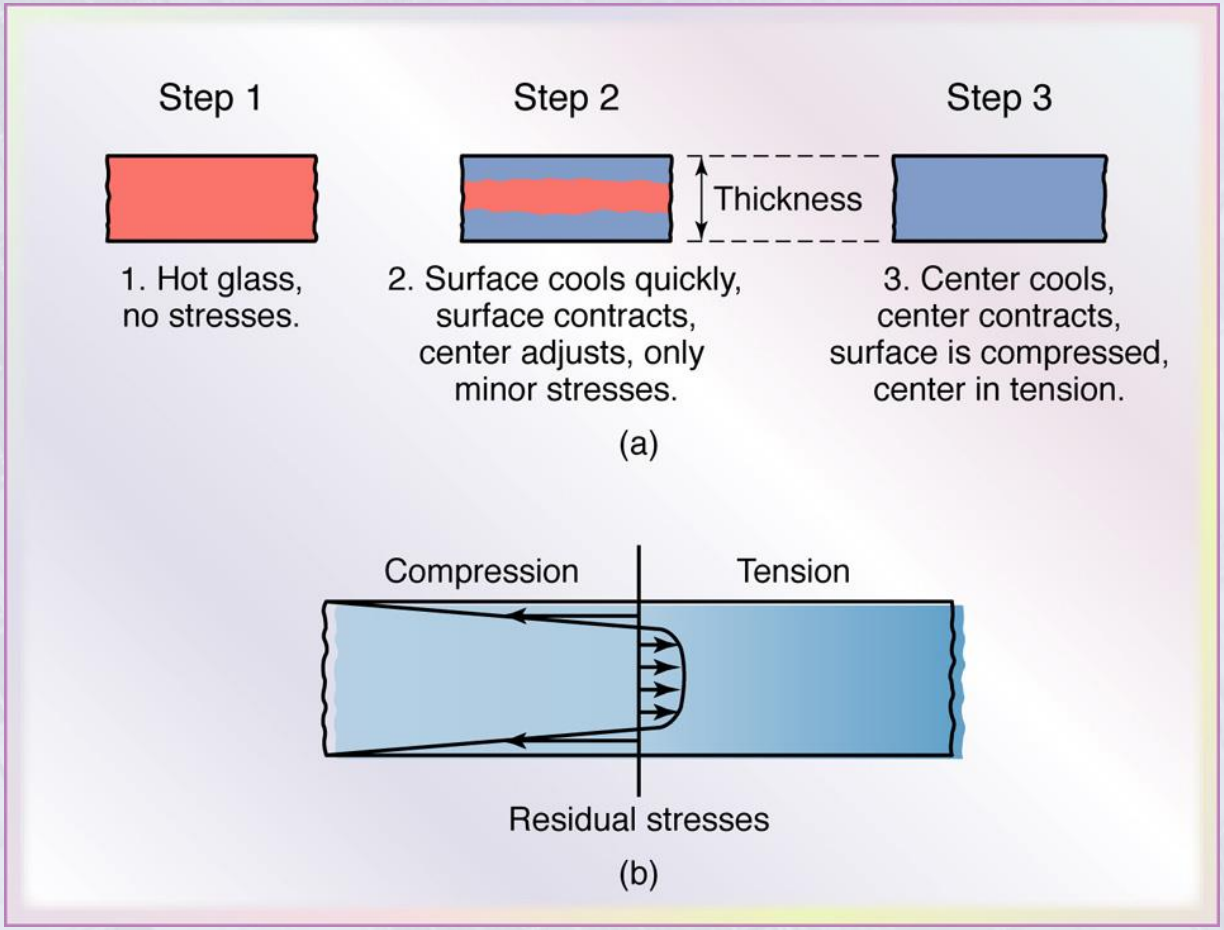


Figure 18.14 Residual stresses in tempered-glass plate, and the stages involved in inducing compressive surface residual stresses for improved strength.

Powder-In-Tube Process

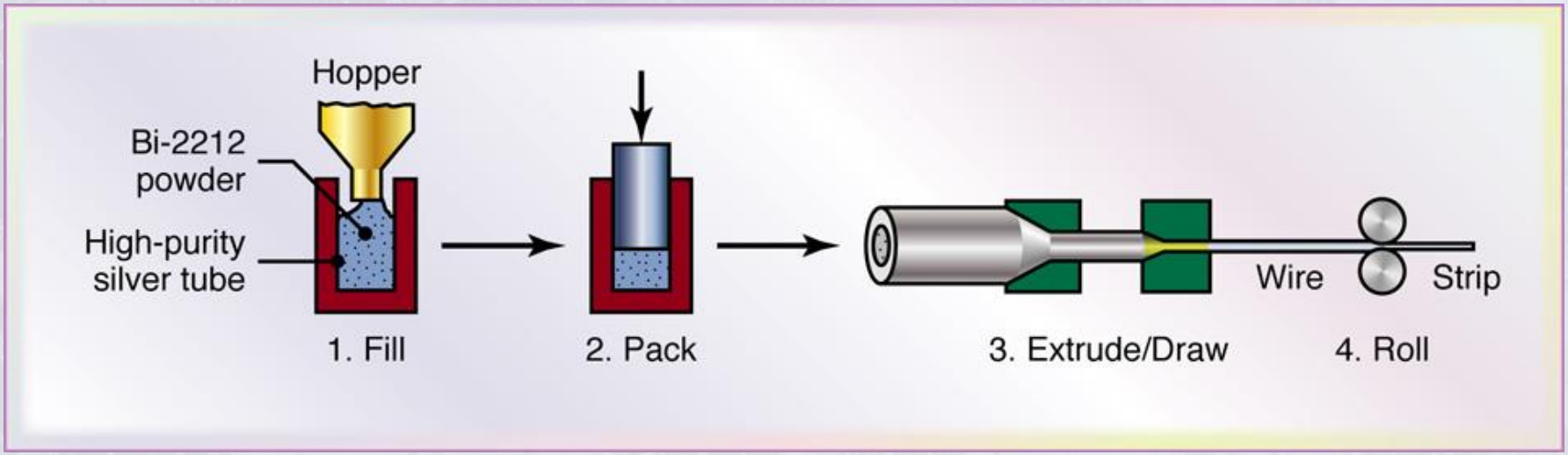


Figure 18.15 Schematic illustration of the powder-in-tube process.