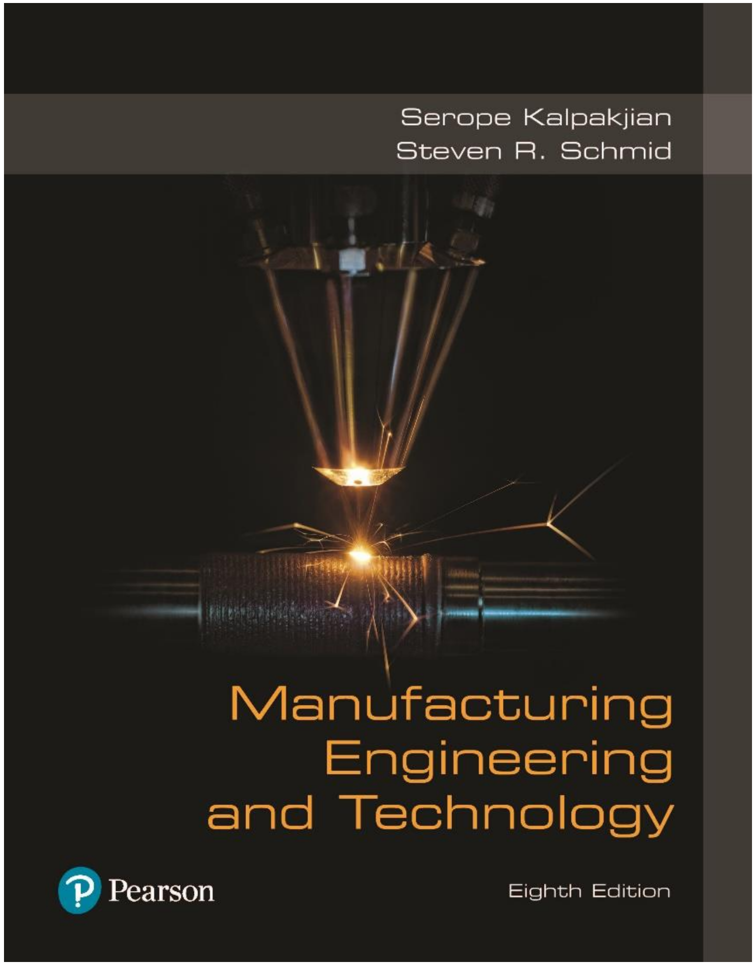
Manufacturing Engineering and Technology

Eighth Edition



Chapter 33-34

Figure VII.1

Components in a typical automobile that are related to the topics described in Part VII.

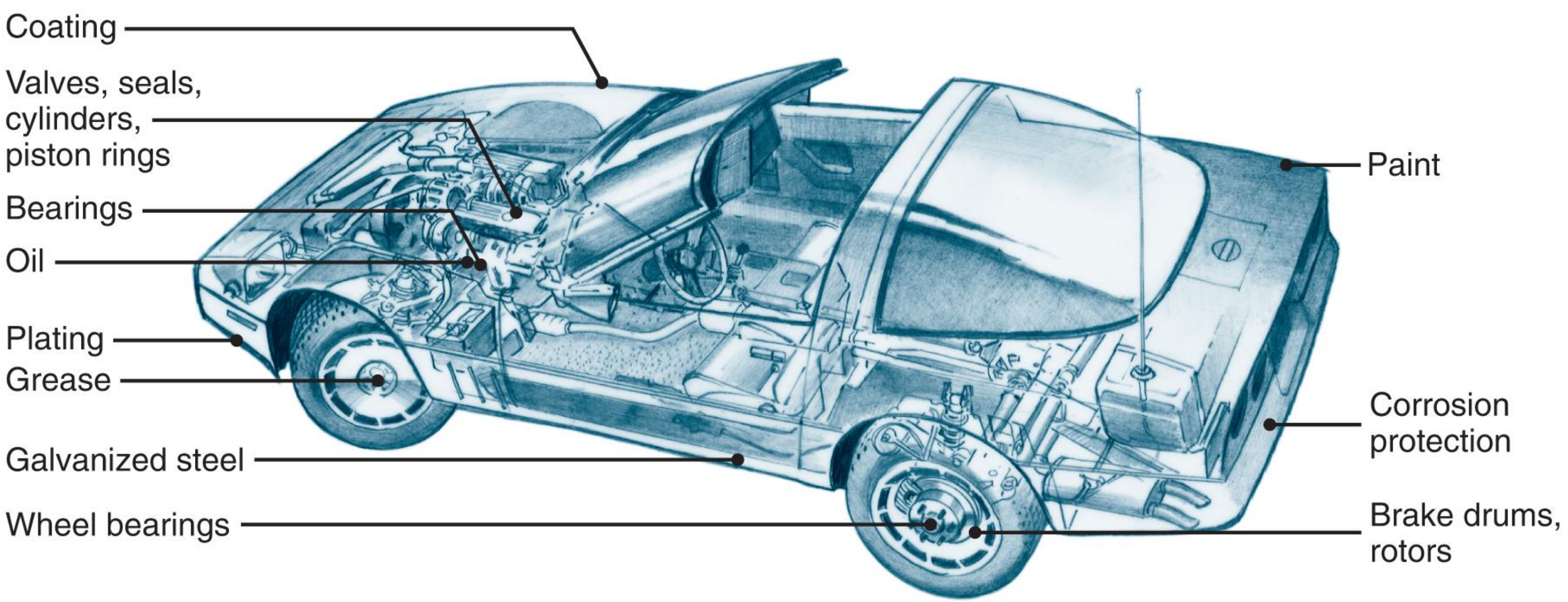


Figure VII.2

An outline of topics covered in Part VII.

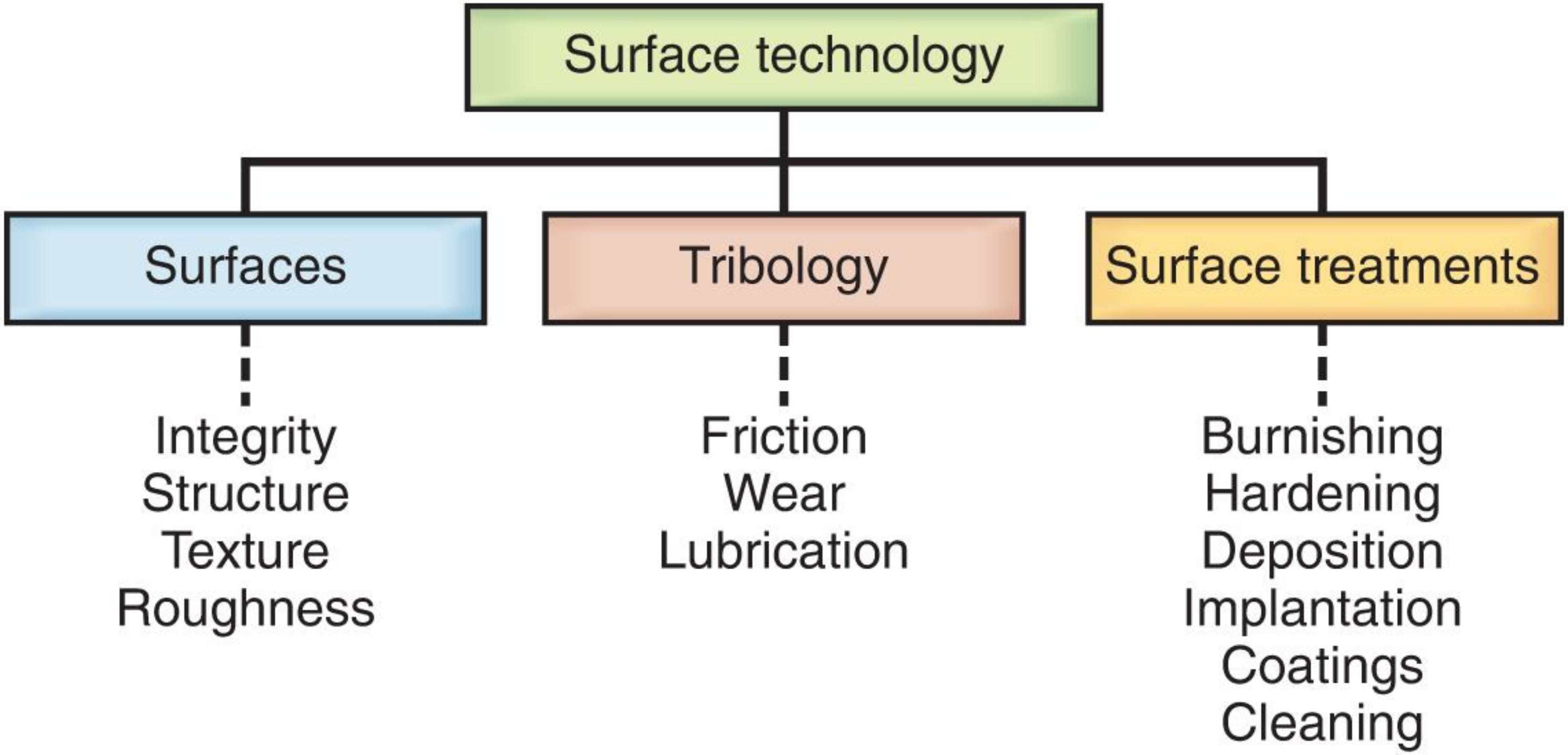
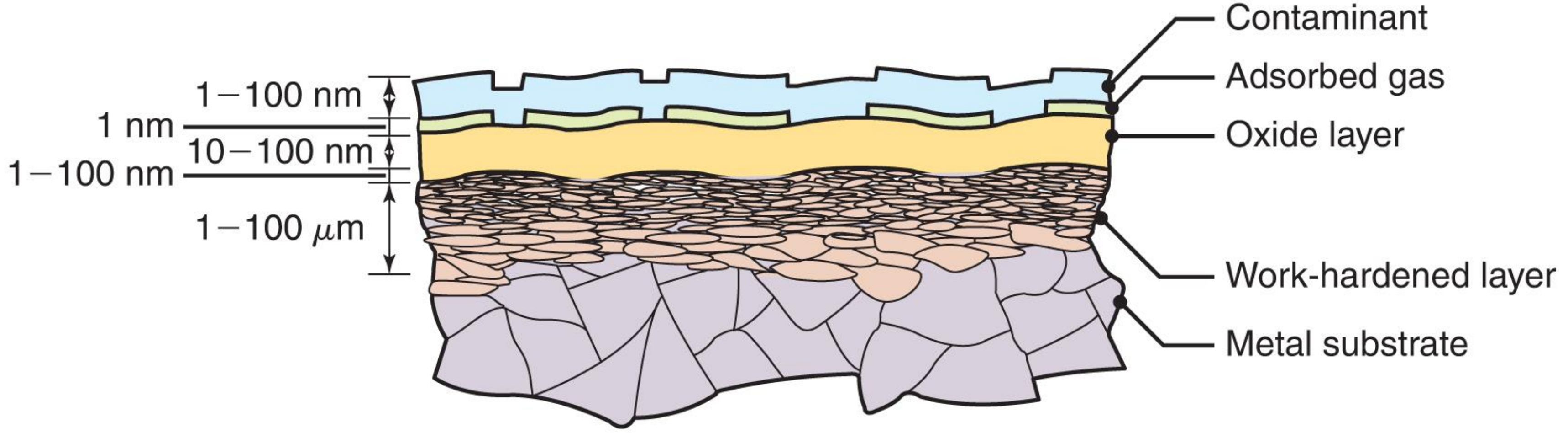


Figure 33.1

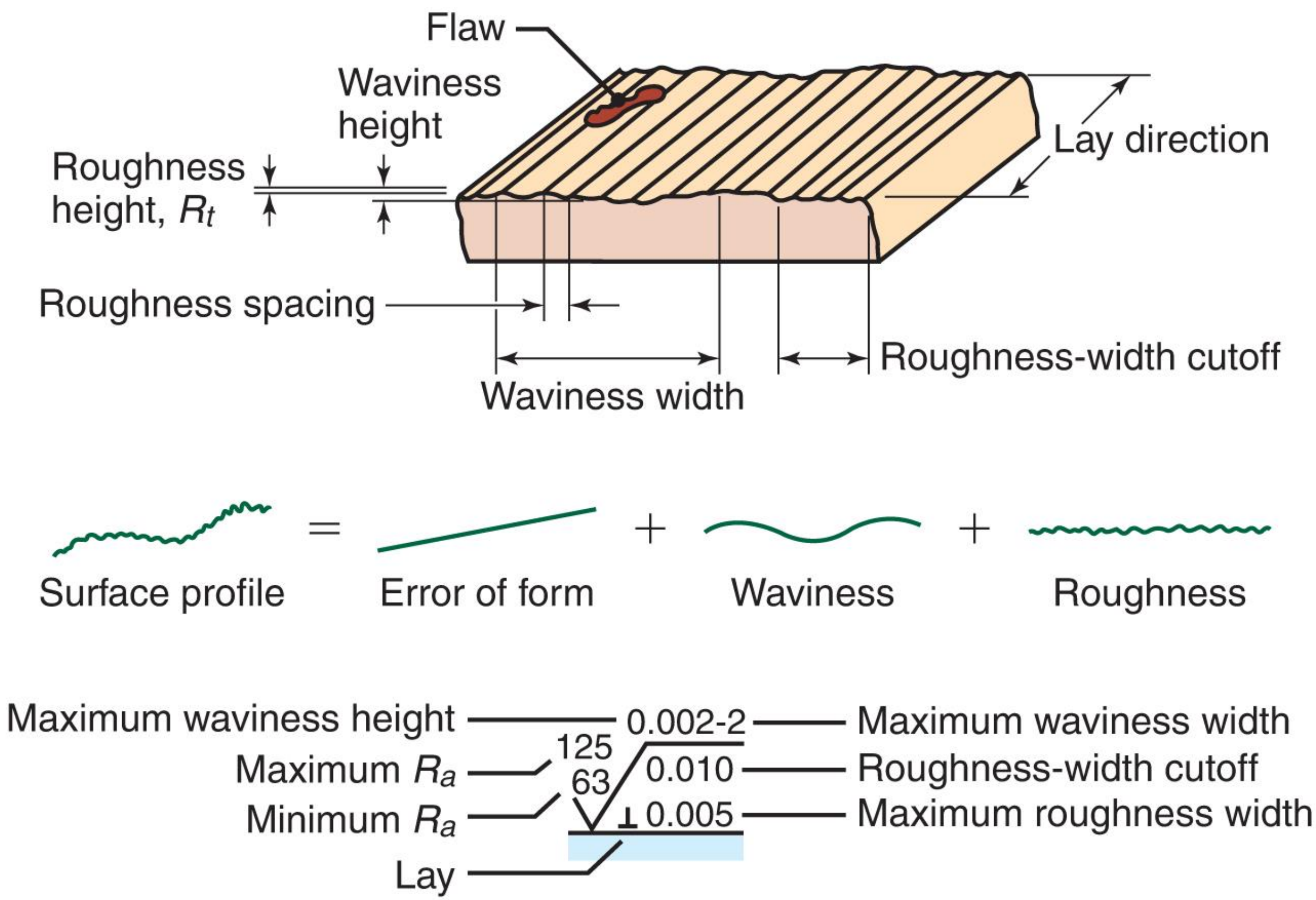
Schematic illustration of a cross-section of the surface structure of a metal. The thickness of the individual layers depends on both processing conditions and the processing environment.



Source: After E. Rabinowicz and B. Bhushan.

Figure 33.2 (1 of 2)

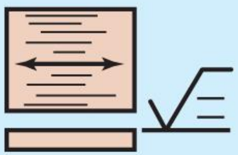
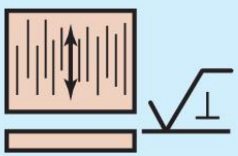
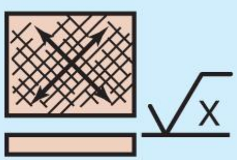
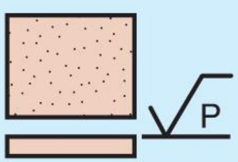
(a) Standard terminology and symbols to describe surface finish. The quantities are given in microinches.



(a)

Figure 33.2 (2 of 2)

(b) Common surface lay symbols.

Lay symbol	Interpretation	Examples
$=$	Lay parallel to the line representing the surface to which the symbol is applied	
$\perp$	Lay perpendicular to the line representing the surface to which the symbol is applied	
X	Lay angular in both directions to line representing the surface to which symbol is applied	
P	Pitted, protuberant, porous, or particulate nondirectional lay	

(b)

Figure 33.3

Coordinates used for surface-roughness measurement defined by Eqs. (33.1) and (33.2).

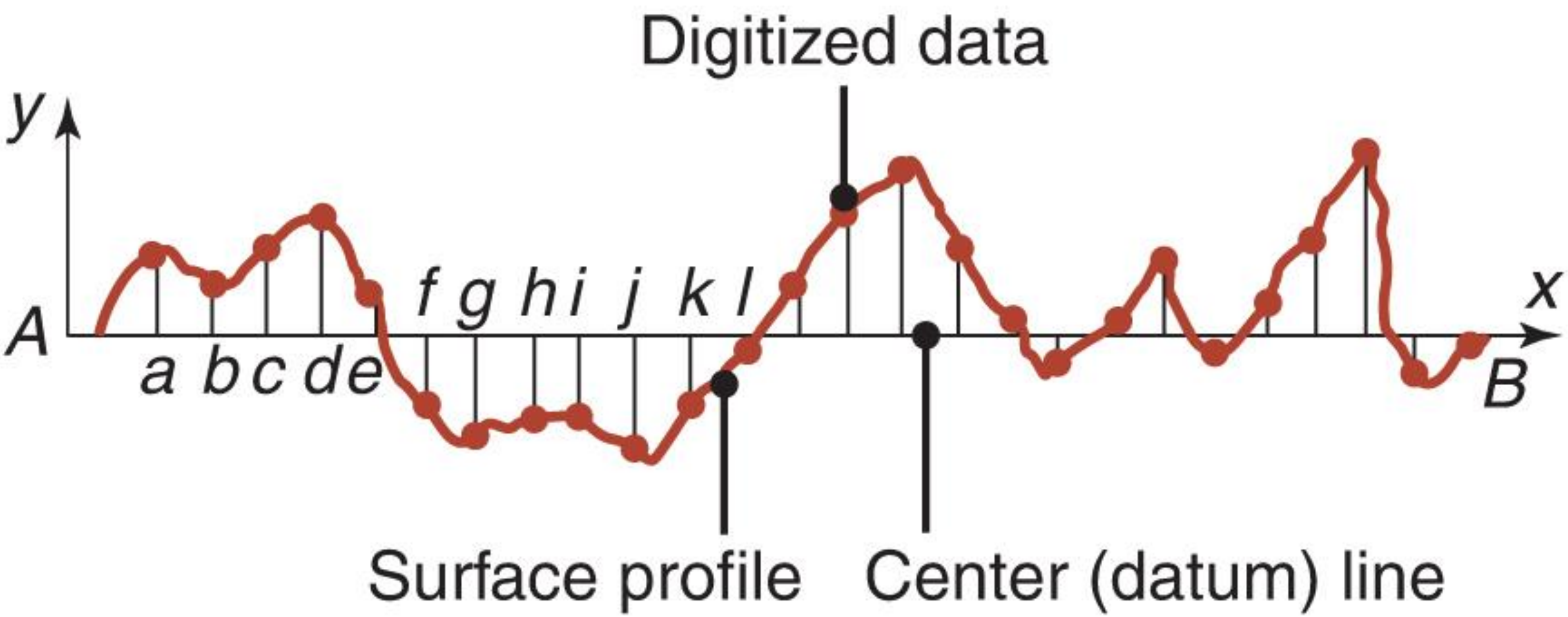
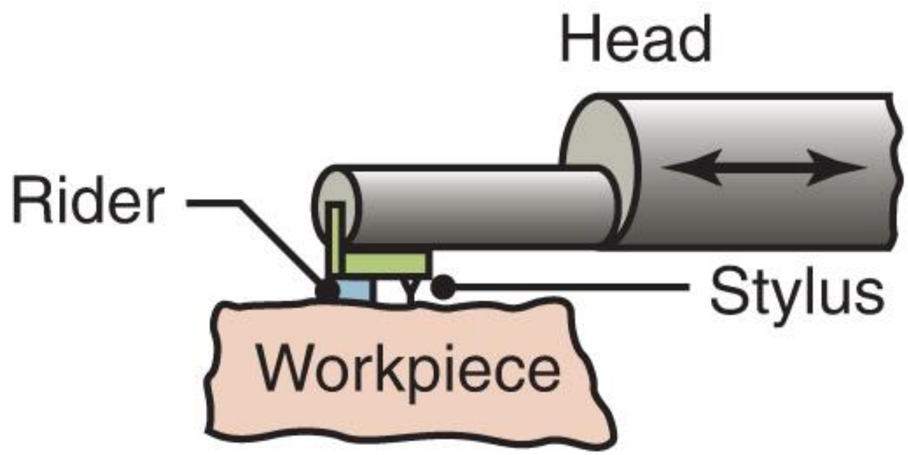


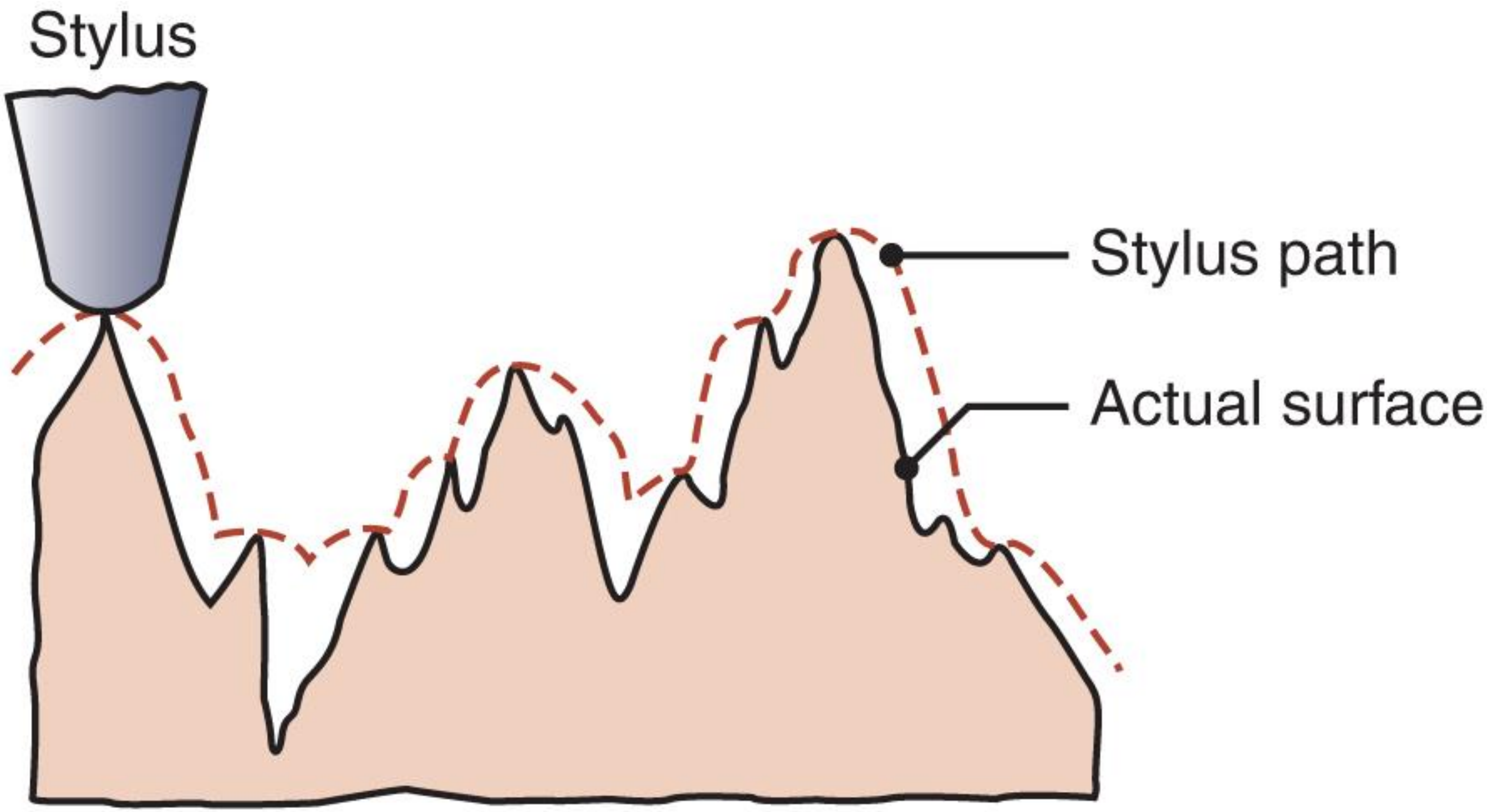
Figure 33.4 (1 of 6)

(a) Measuring surface roughness with a stylus. The rider supports the stylus and guards against damage. (b) Path of the stylus in surface-roughness measurements (broken line), compared with the actual roughness profile. Note that the profile of the stylus path is smoother than that of the actual surface. (c) through (f) Typical surface profiles produced by various machining and surface-finishing processes. Note the difference between the vertical and horizontal scales.



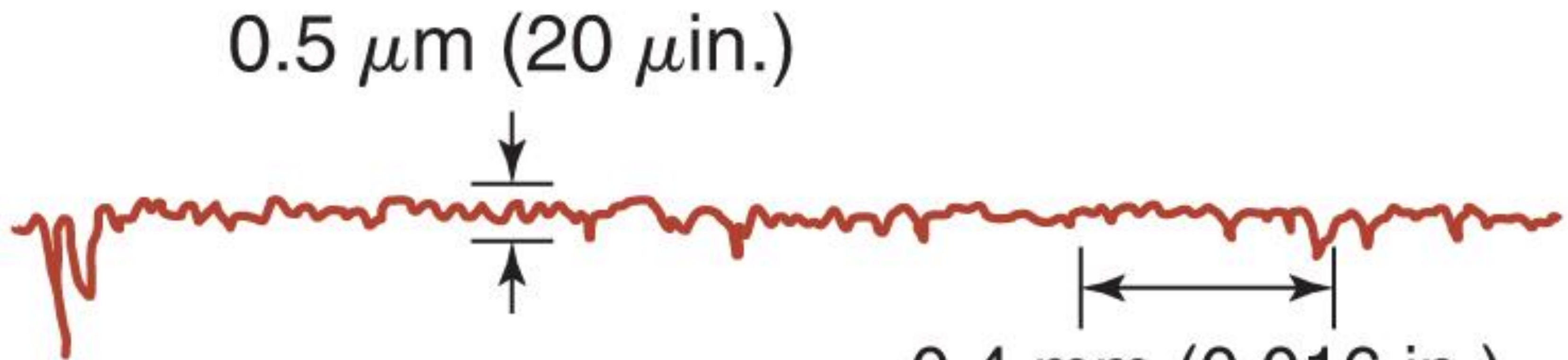
(a)

Figure 33.4 (2 of 6)



(b)

Figure 33.4 (3 of 6)

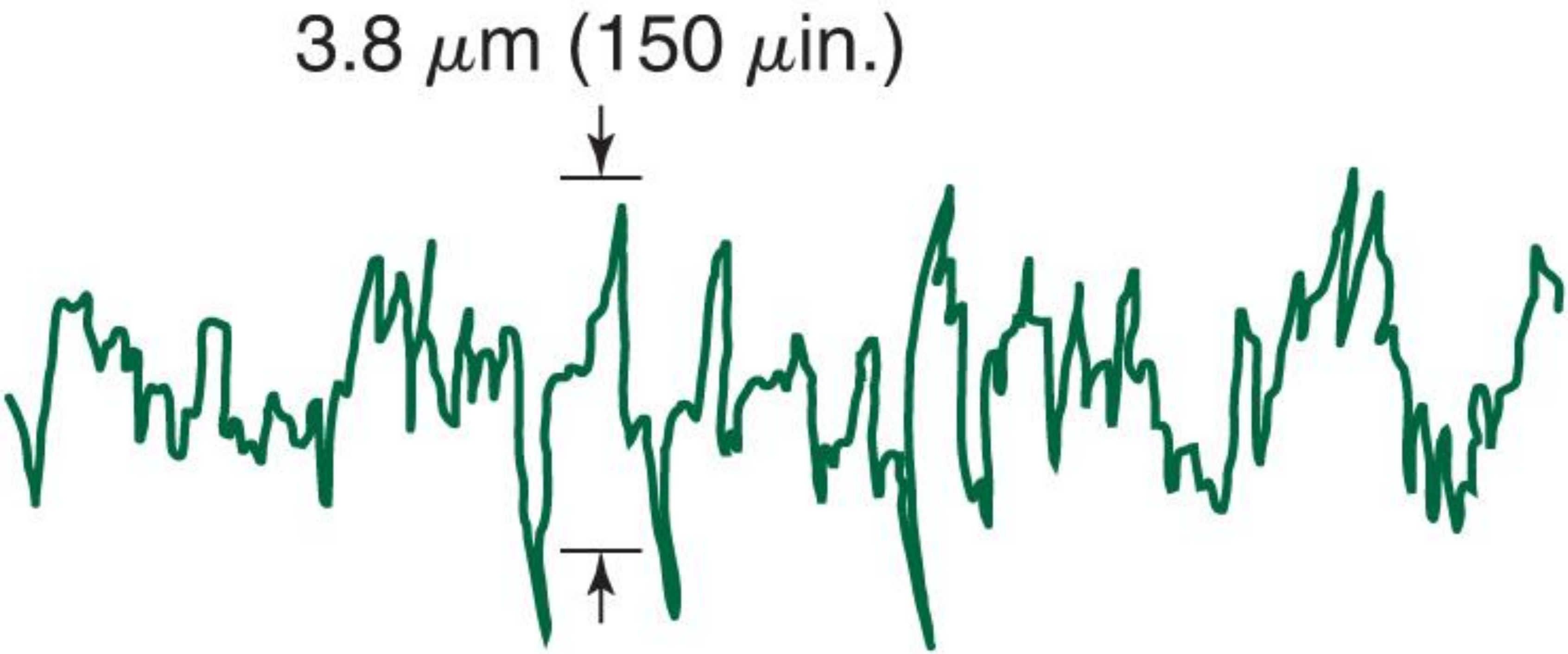


(c) Lapping

Figure 33.4 (4 of 6)

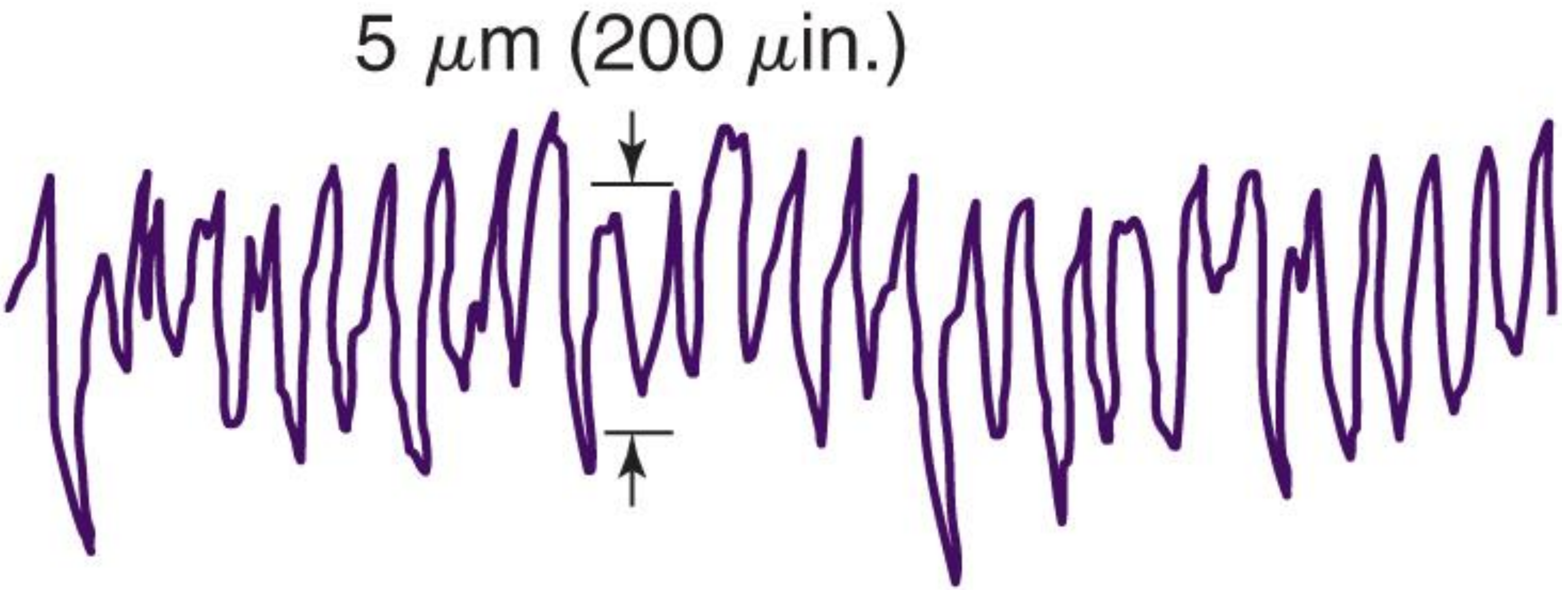
(d) Finish grinding

Figure 33.4 (5 of 6)



(e) Rough grinding

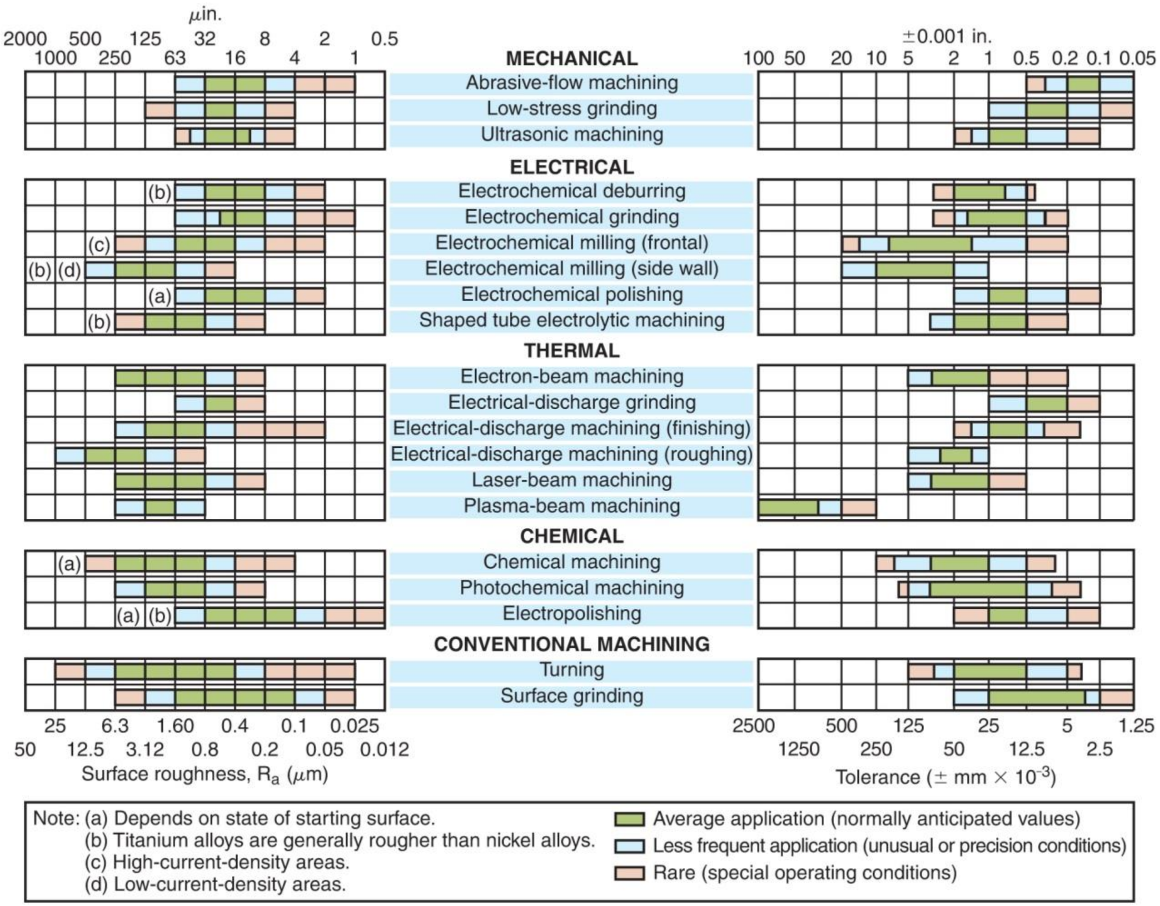
Figure 33.4 (6 of 6)



(f) Turning

Figure 33.5

Surface roughness and tolerances obtained in various machining processes; note the wide range within each process (see also Fig. 23.14).



Source: Machining Data Handbook, 3rd ed. Copyright 1980. Used by permission of Metcut Research Associates, Inc.

Figure 33.6

Schematic illustration of the interface of two bodies in contact showing real areas of contact at the asperities. In engineering surfaces, the ratio of the apparent-to-real areas of contact can be as high as 4 to 5 orders of magnitude.

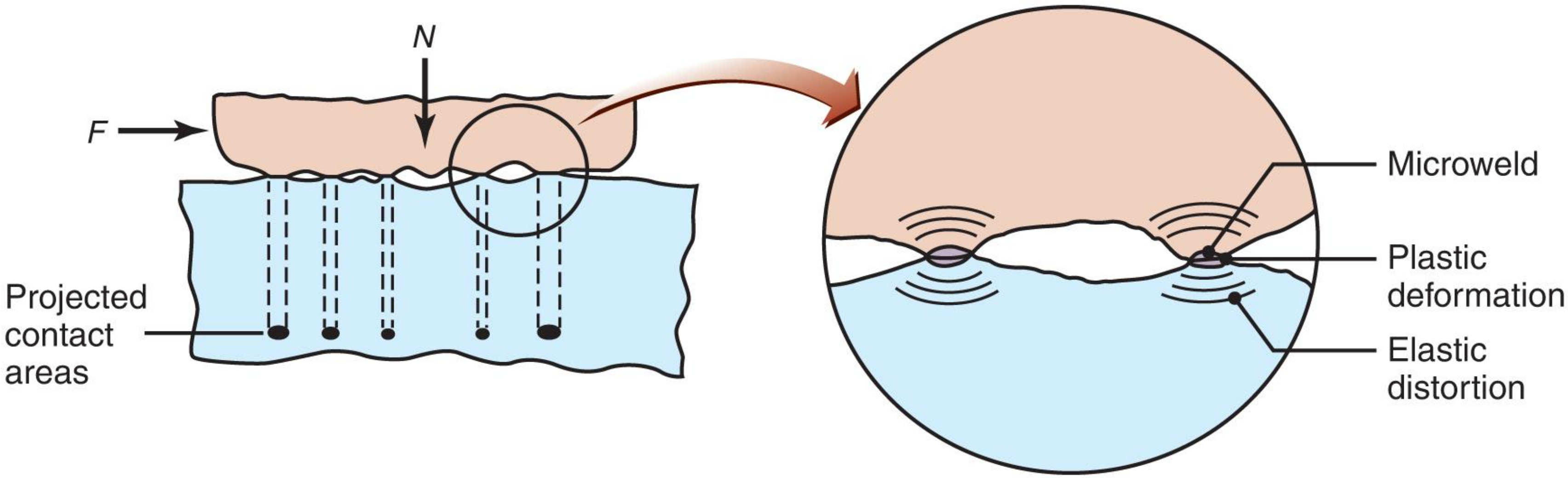


Figure 33.7 (1 of 2)

Ring-compression test between flat dies. (a) Effect of lubrication on type of ring-specimen barreling.

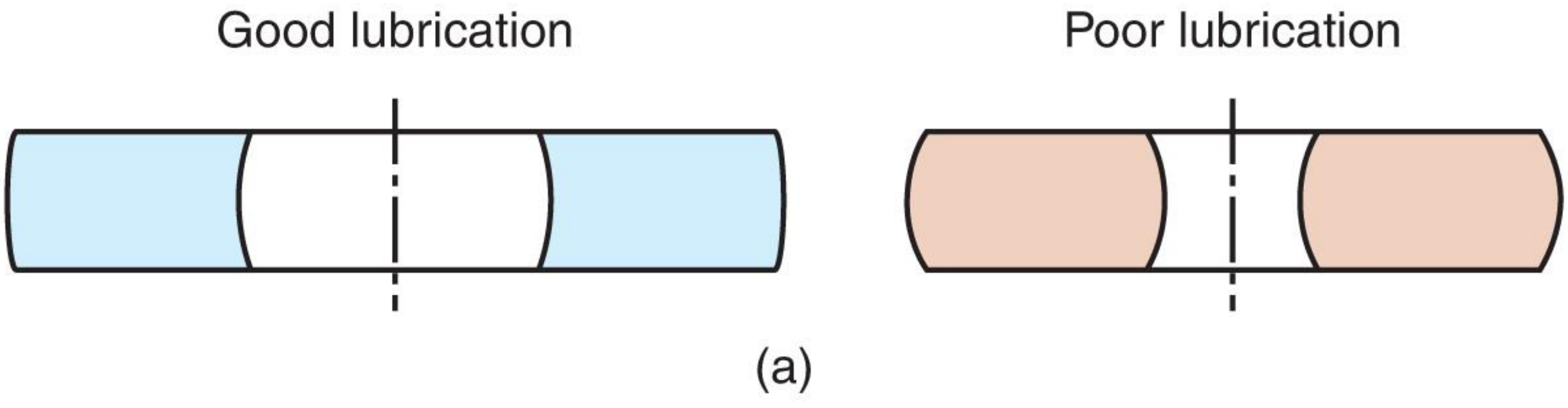
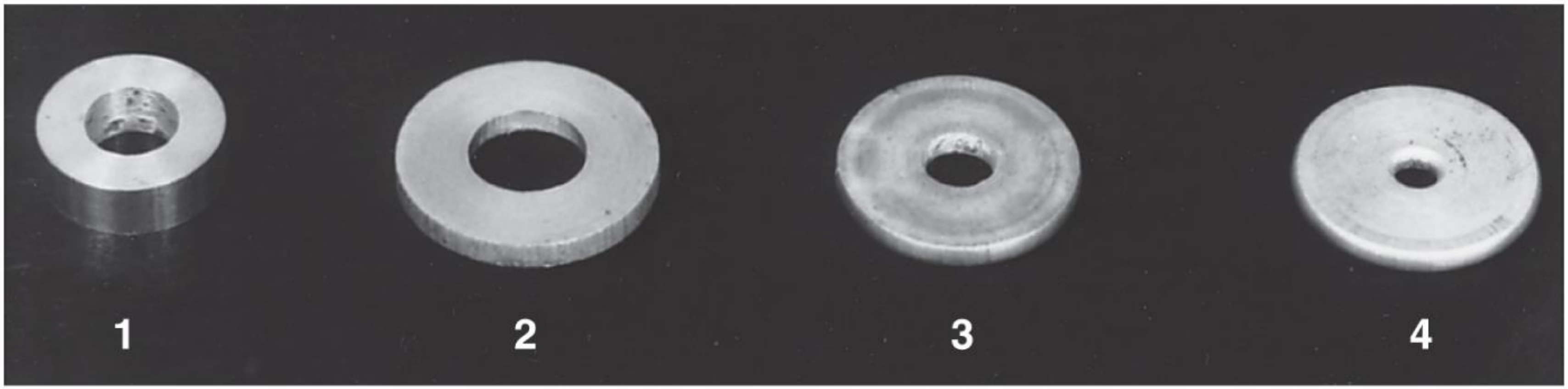


Figure 33.7 (2 of 2)

Ring-compression test between flat dies. (b) Test results: (1) original specimen and (2) to (4) increasing friction.



(b)

Source: After A.T.Male and M.G. Cockcroft.

Figure 33.8 (1 of 2)

Chart to determine friction coefficient from a ring-compression test. Reduction in height and change in internal diameter of the ring are measured; then μ is read directly from this chart. For example, if the ring specimen is reduced in height by 40% and its internal diameter decreases by 10%, the coefficient of friction is 0.10.

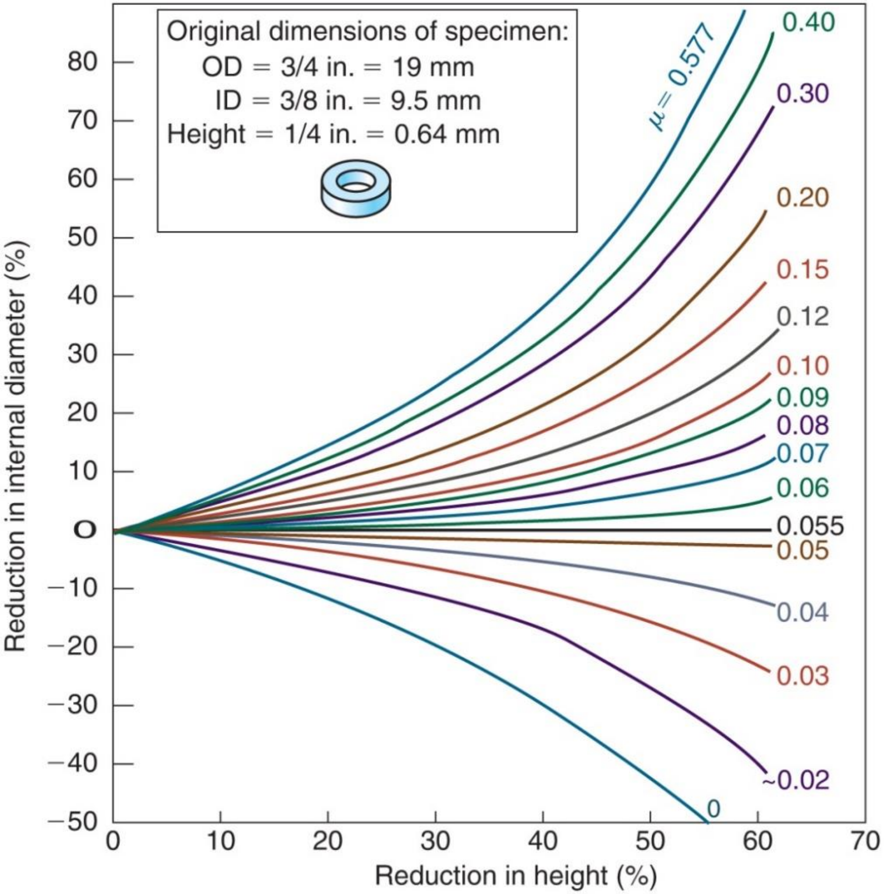


Figure 33.9 (1 of 2)

Changes in original (a) wire-brushed.

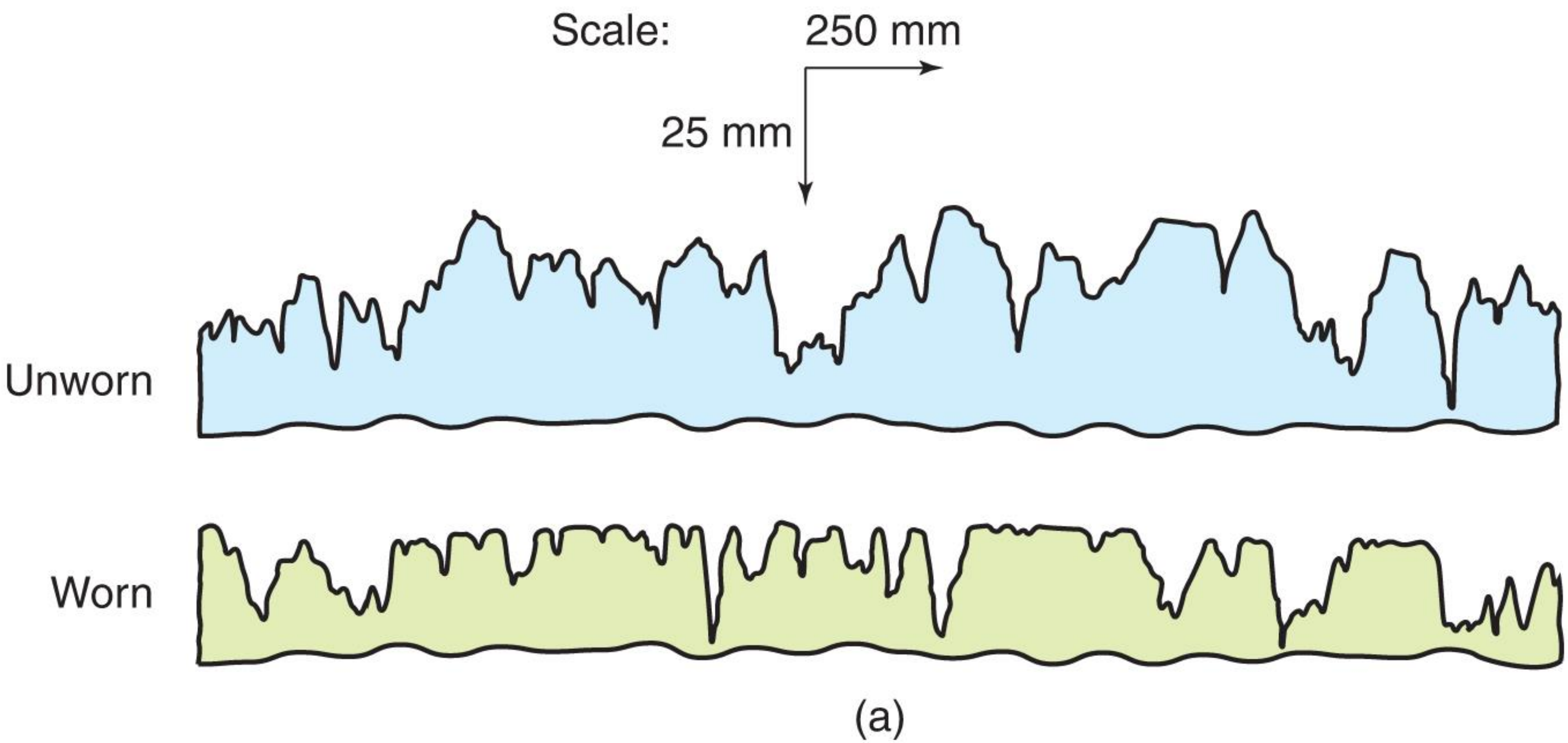
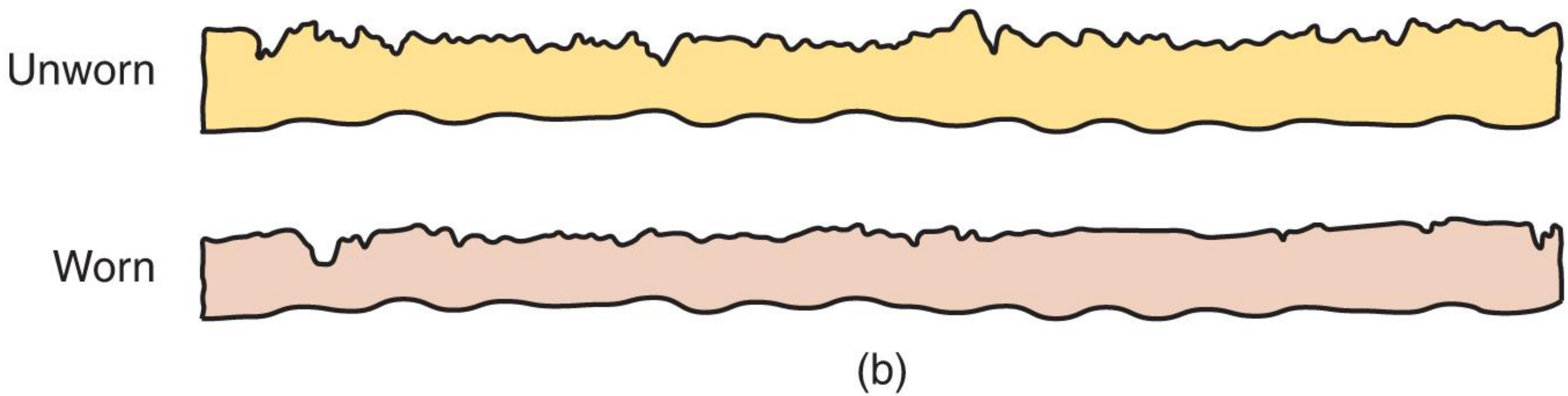


Figure 33.9 (2 of 2)

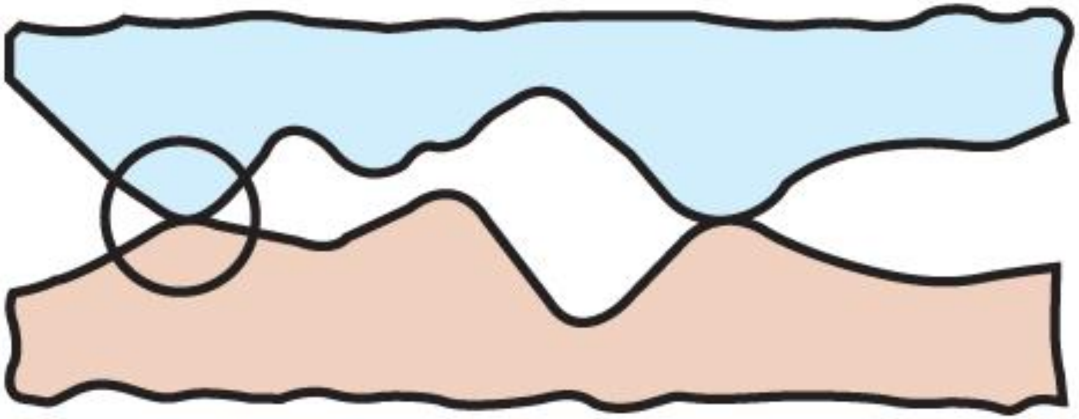
Changes in original (b) ground-surface profiles after wear. Note the difference in the vertical and horizontal scales.



Source: After E. Wild and K.J. Mack.

Figure 33.10 (1 of 3)

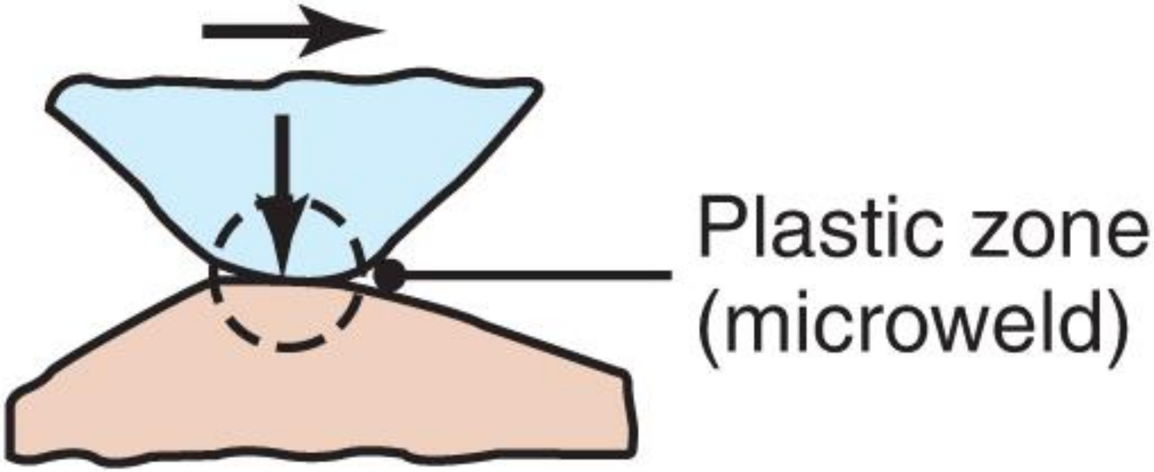
Schematic illustration of (a) two contacting asperities.



(a)

Figure 33.10 (2 of 3)

Schematic illustration of (b) adhesion between two asperities.



(b)

Figure 33.10 (3 of 3)

Schematic illustration of (c) the formation of a wear particle.

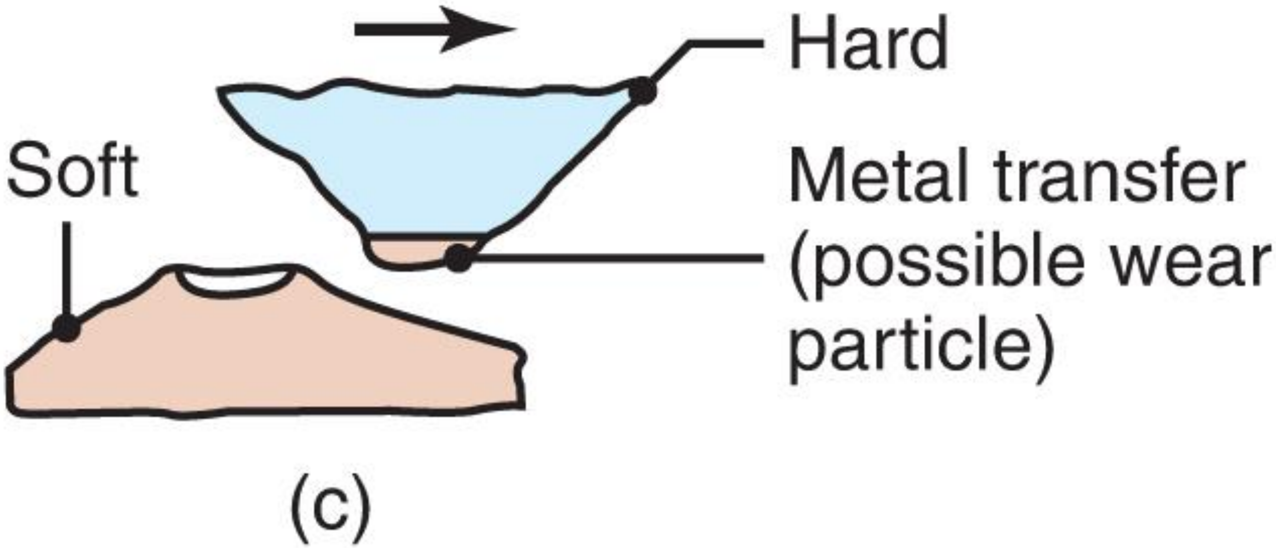


Figure 33.11

Schematic illustration of abrasive wear in sliding. Longitudinal scratches on a surface usually indicate abrasive wear.

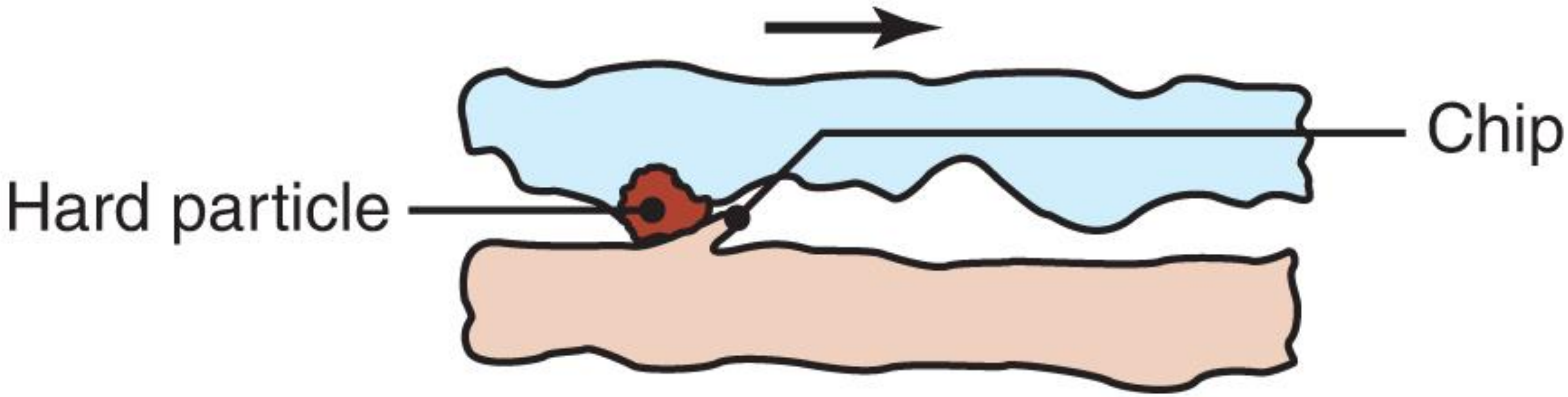
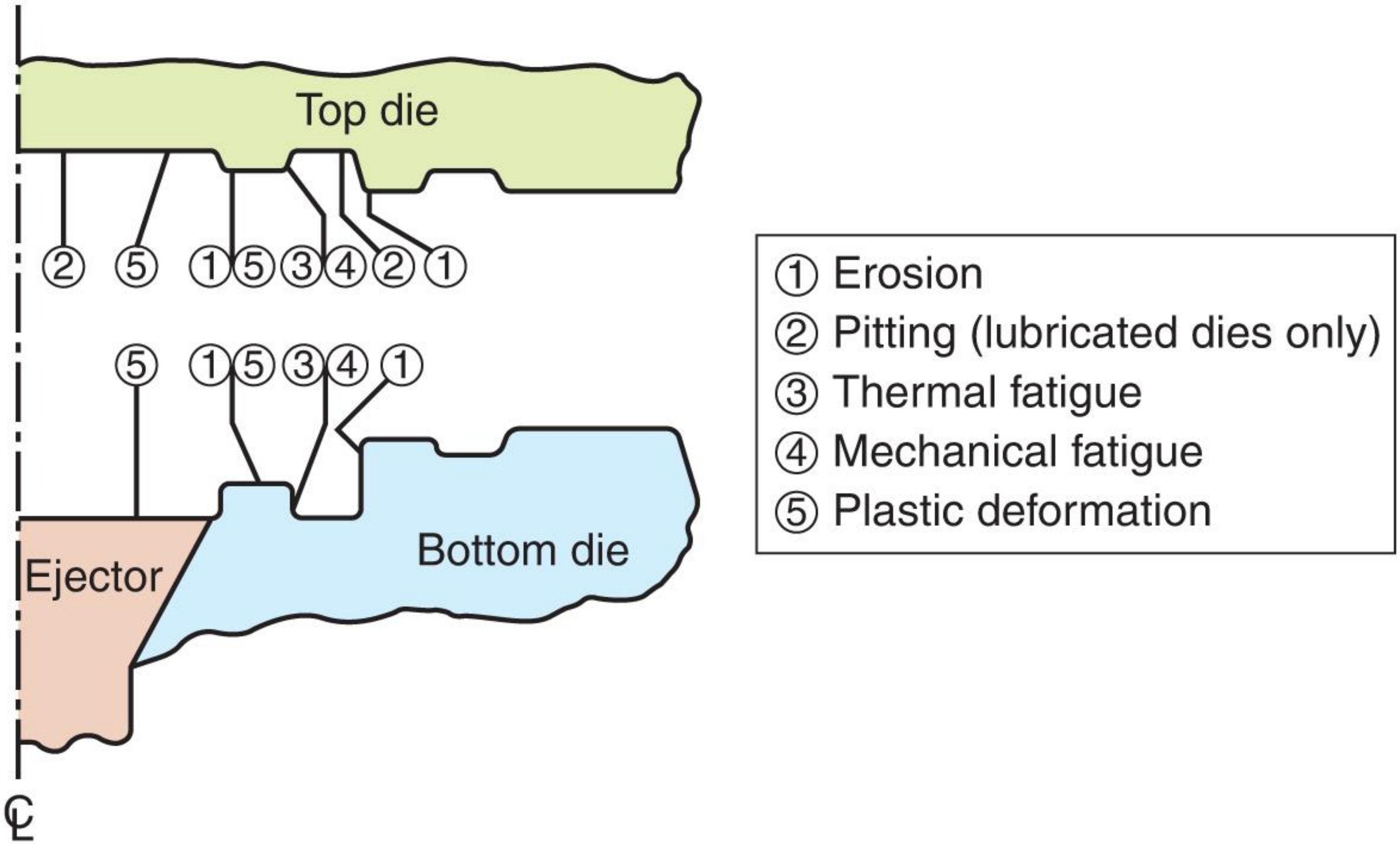


Figure 33.12

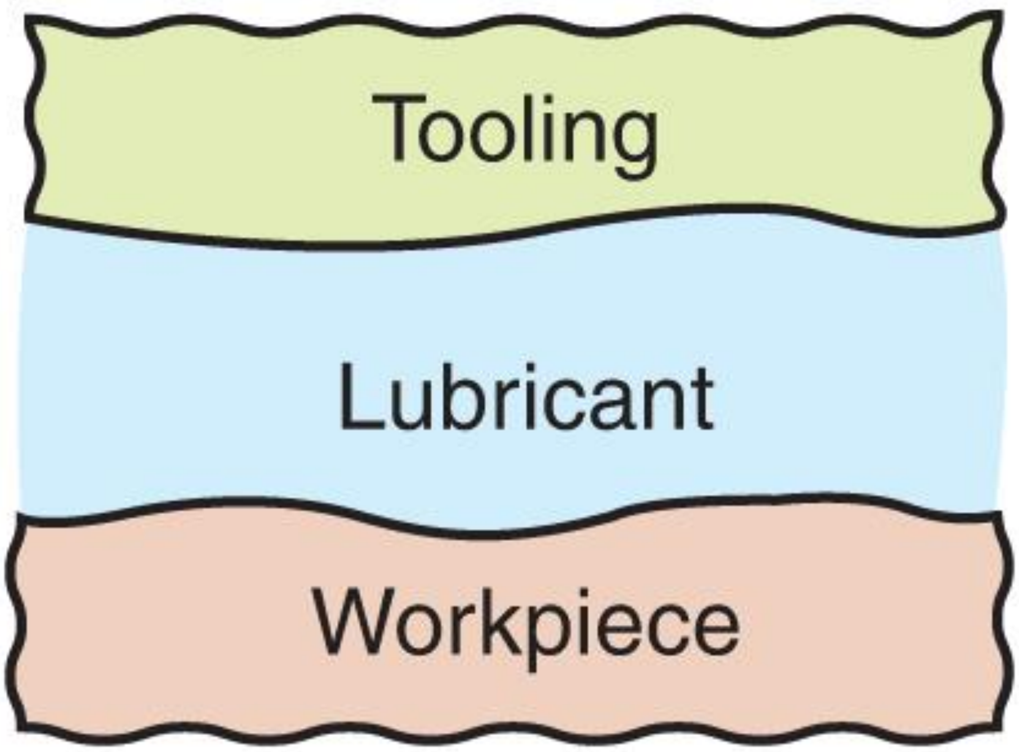
Types of wear observed in the cavity of a single pair of dies used for hot forging.



Source: After T.A. Dean.

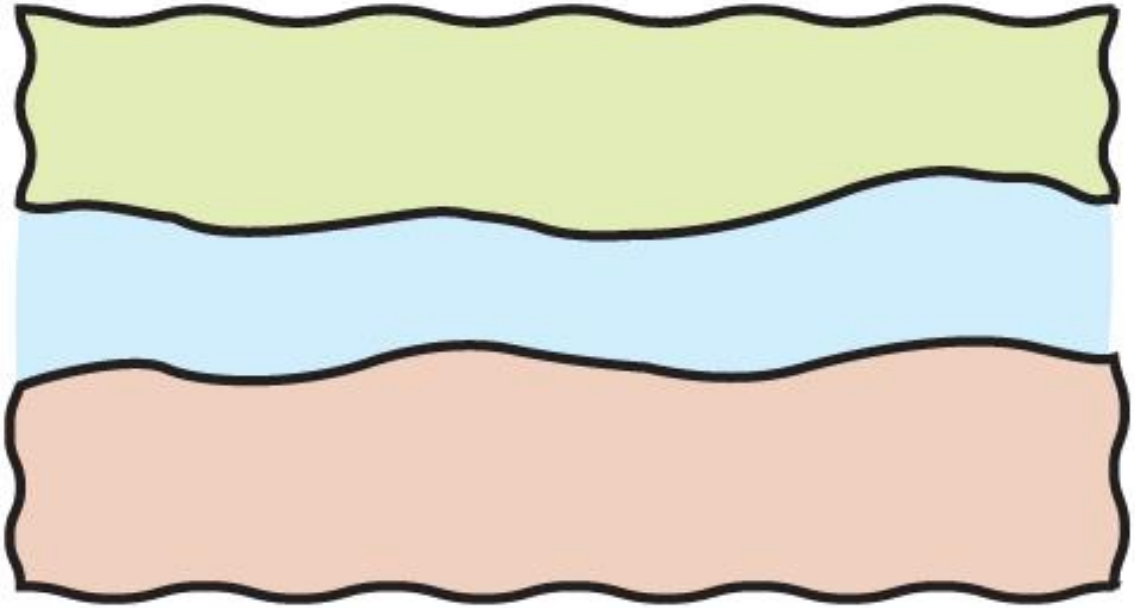
Figure 33.13 (1 of 4)

Regimes of lubrication generally occurring in metalworking operations.



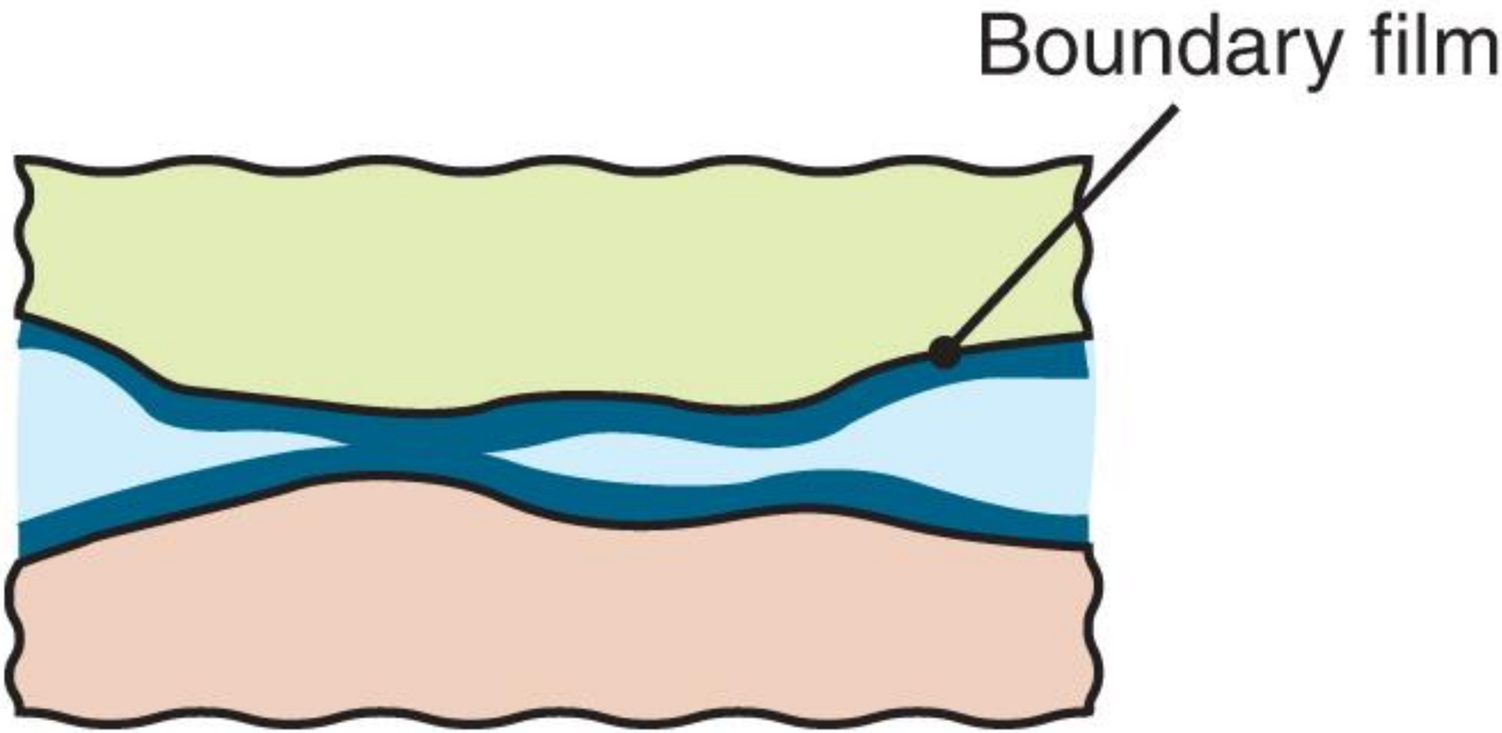
(a) Thick film

Figure 33.13 (2 of 4)



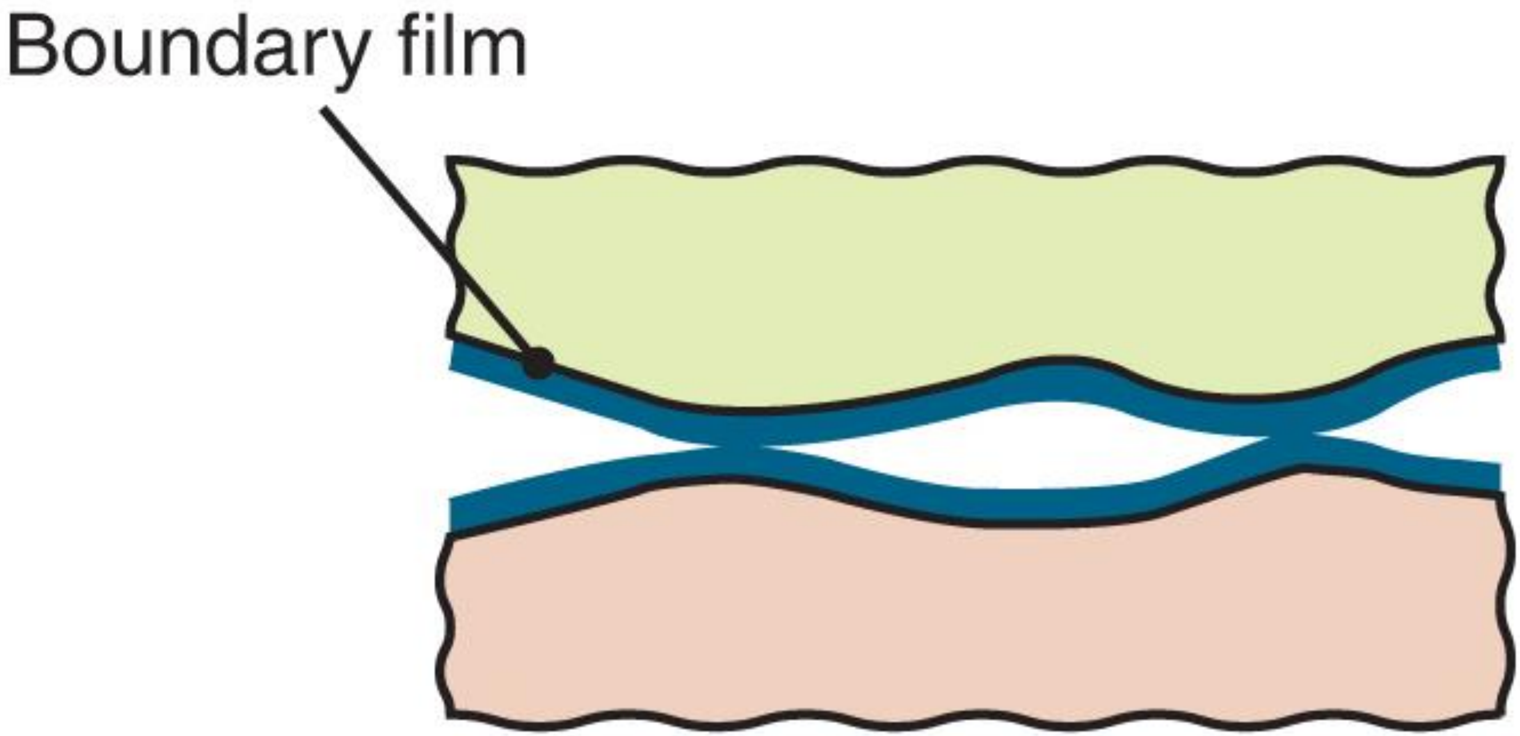
(b) Thin film

Figure 33.13 (3 of 4)



(c) Mixed

Figure 33.13 (4 of 4)

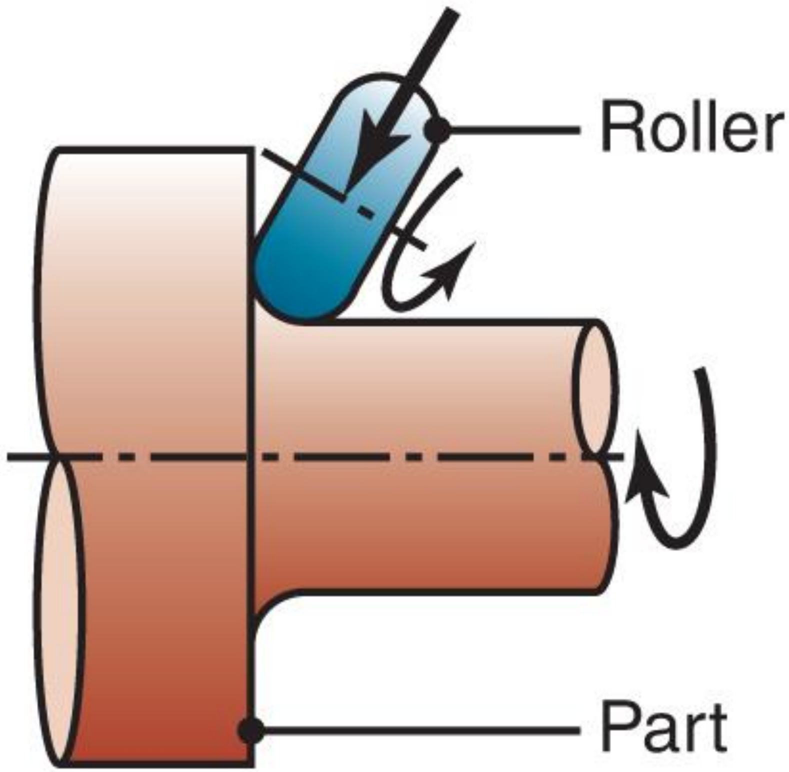


(d) Boundary

Source: After W.R.D.Wilson.

Figure 34.1 (1 of 3)

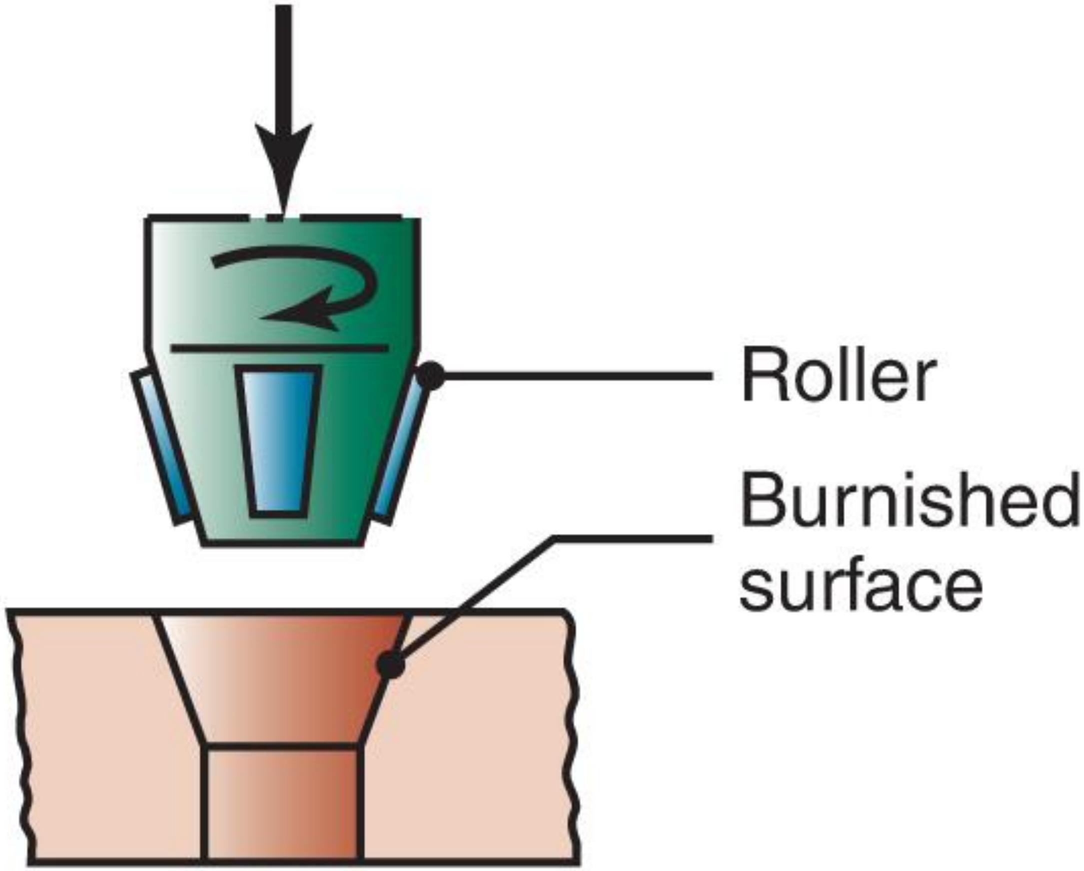
Burnishing tools and roller burnishing of (a) the fillet of a stepped shaft to induce compressive surface residual stresses for improved fatigue life;



(a)

Figure 34.1 (2 of 3)

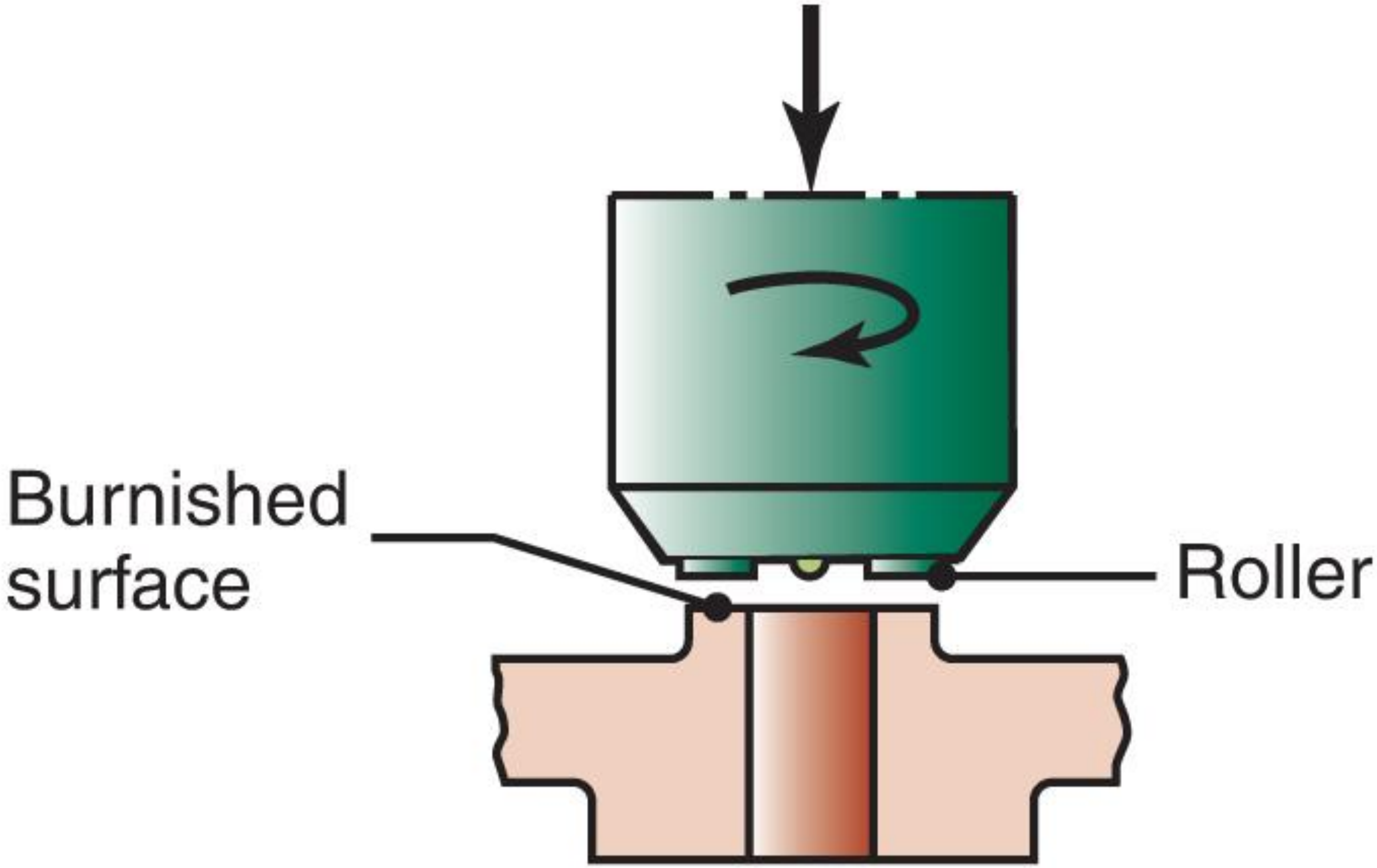
Burnishing tools and roller burnishing of (b) a conical surface.



(b)

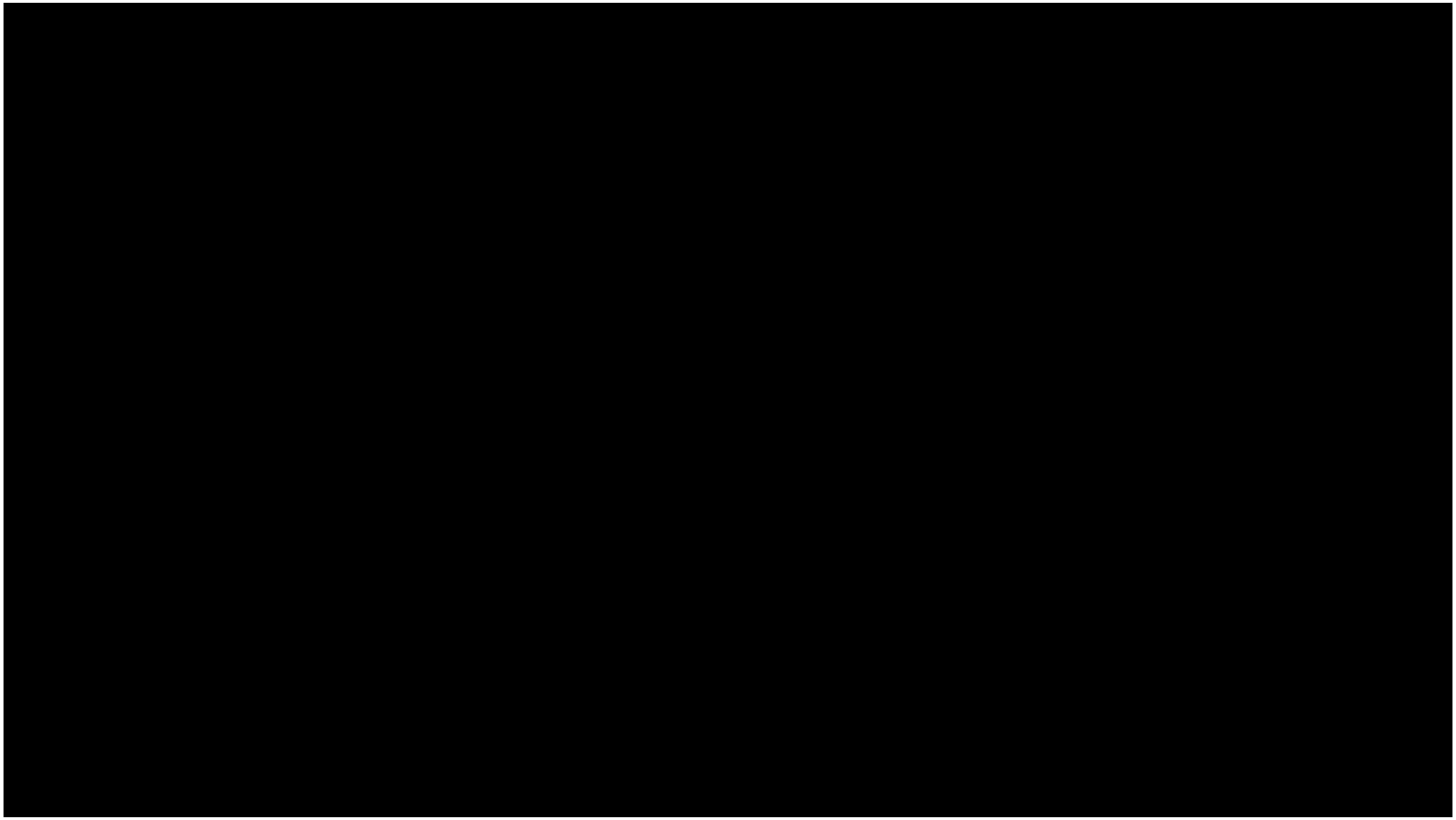
Figure 34.1 (3 of 3)

Burnishing tools and roller burnishing of (c) a flat surface.



(c)

Roller Burnishing



https://youtu.be/E0gO1jtNCm4

Figure 34.2 (1 of 3)

Schematic illustrations of thermal-spray operations: (a) thermal wire spray.

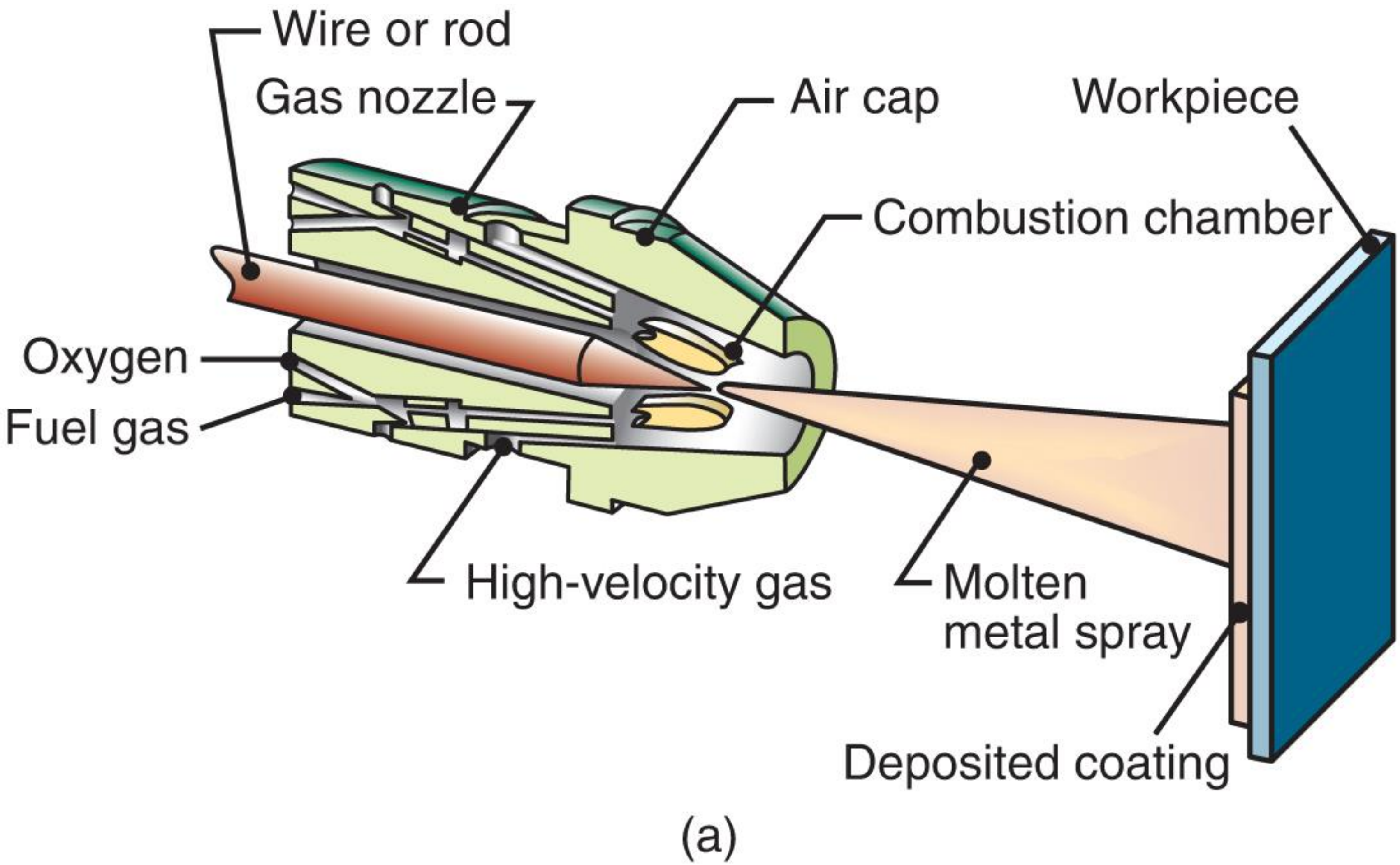
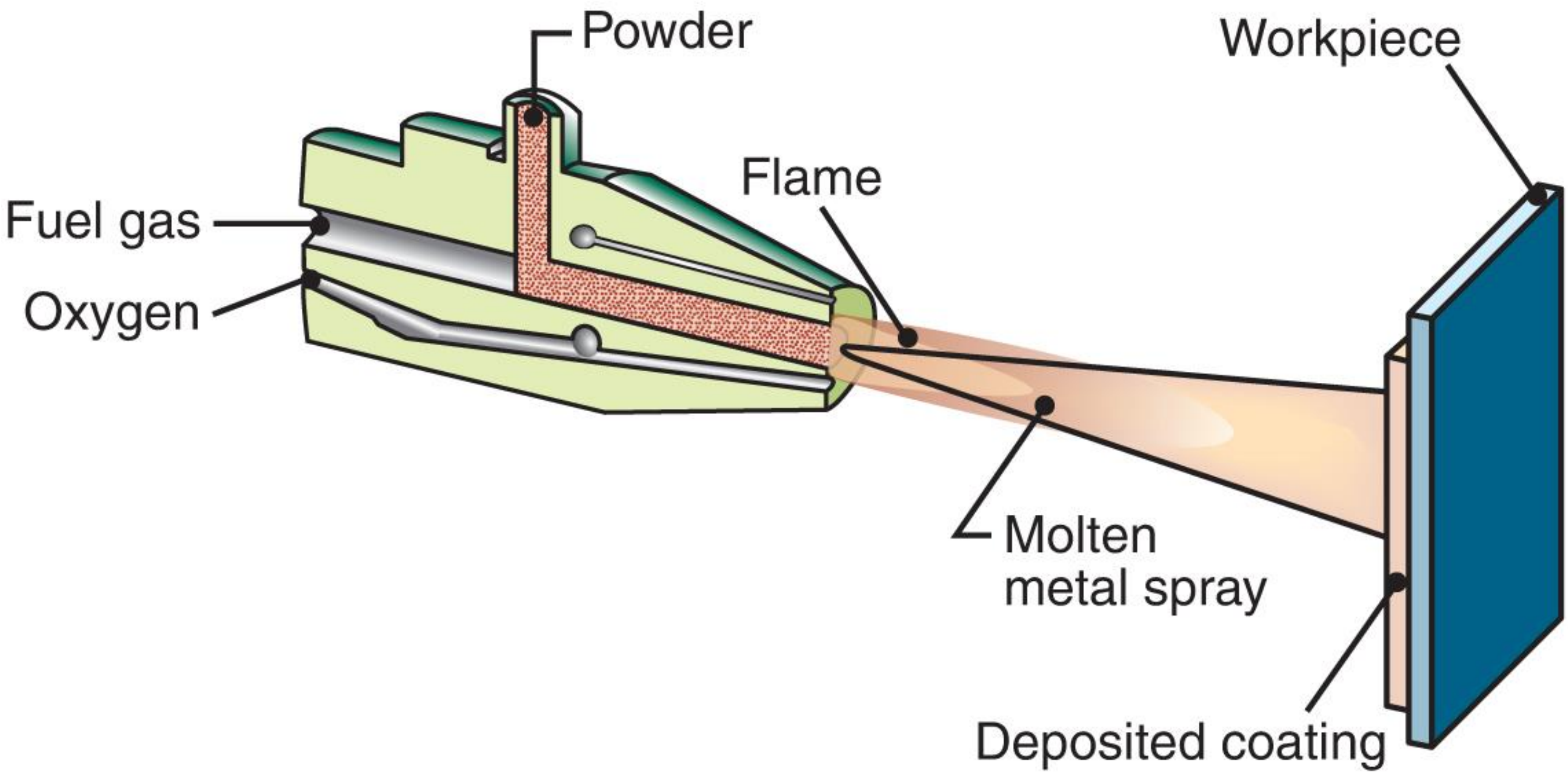


Figure 34.2 (2 of 3)

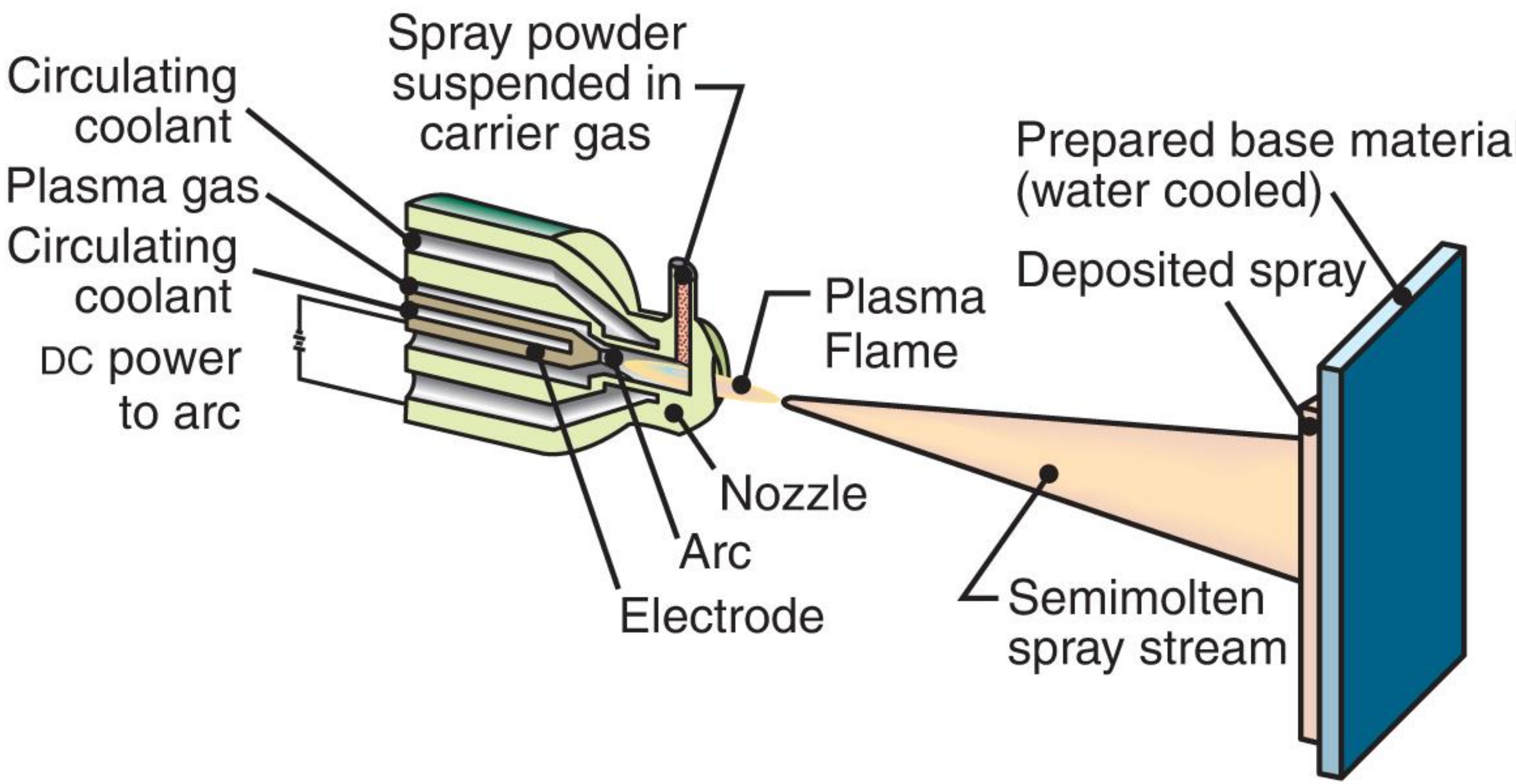
Schematic illustrations of thermal-spray operations: (b) thermal metalpowder spray.



(b)

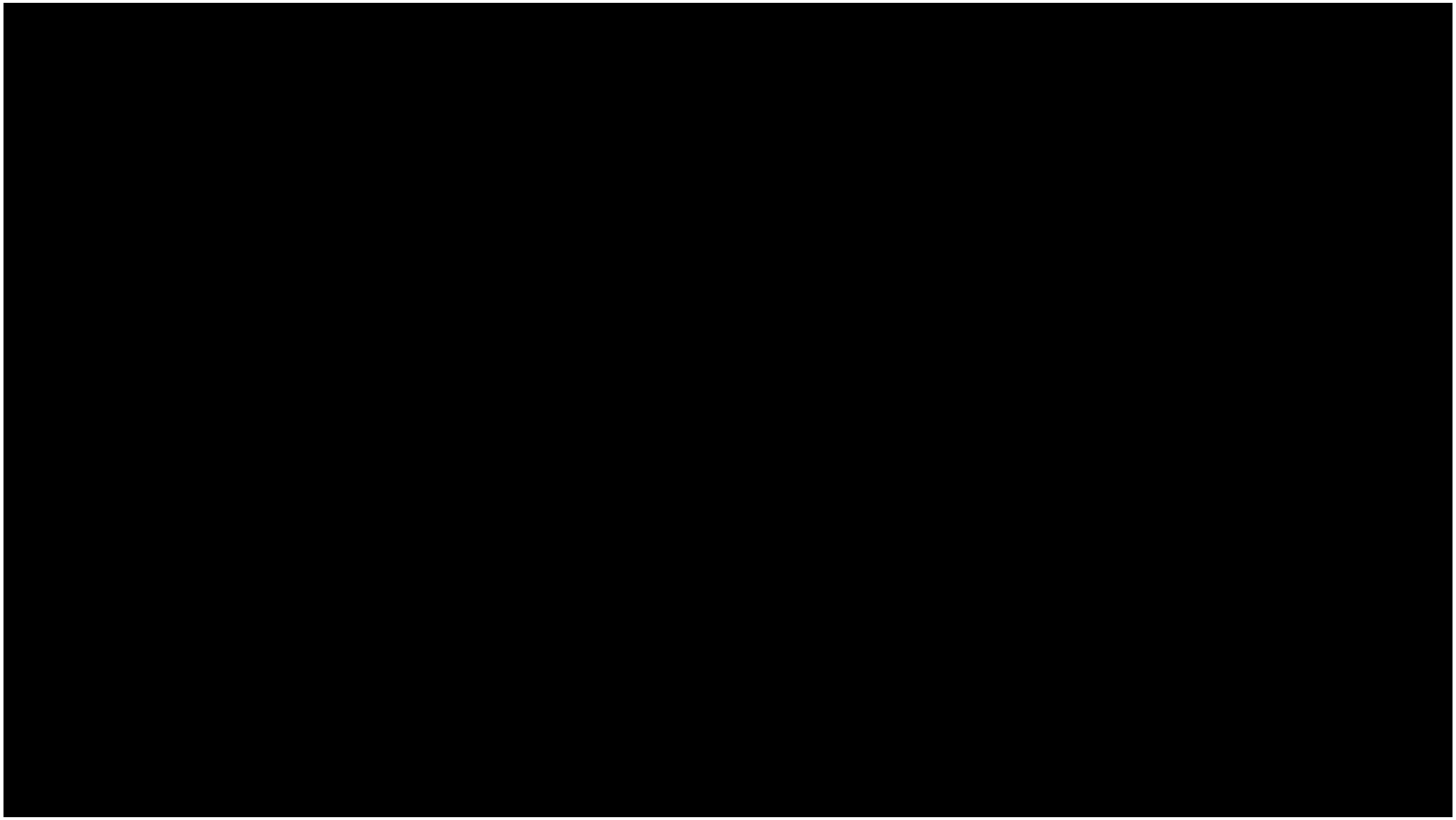
Figure 34.2 (3 of 3)

Schematic illustrations of thermal-spray operations: (c) plasma spray.



(c)

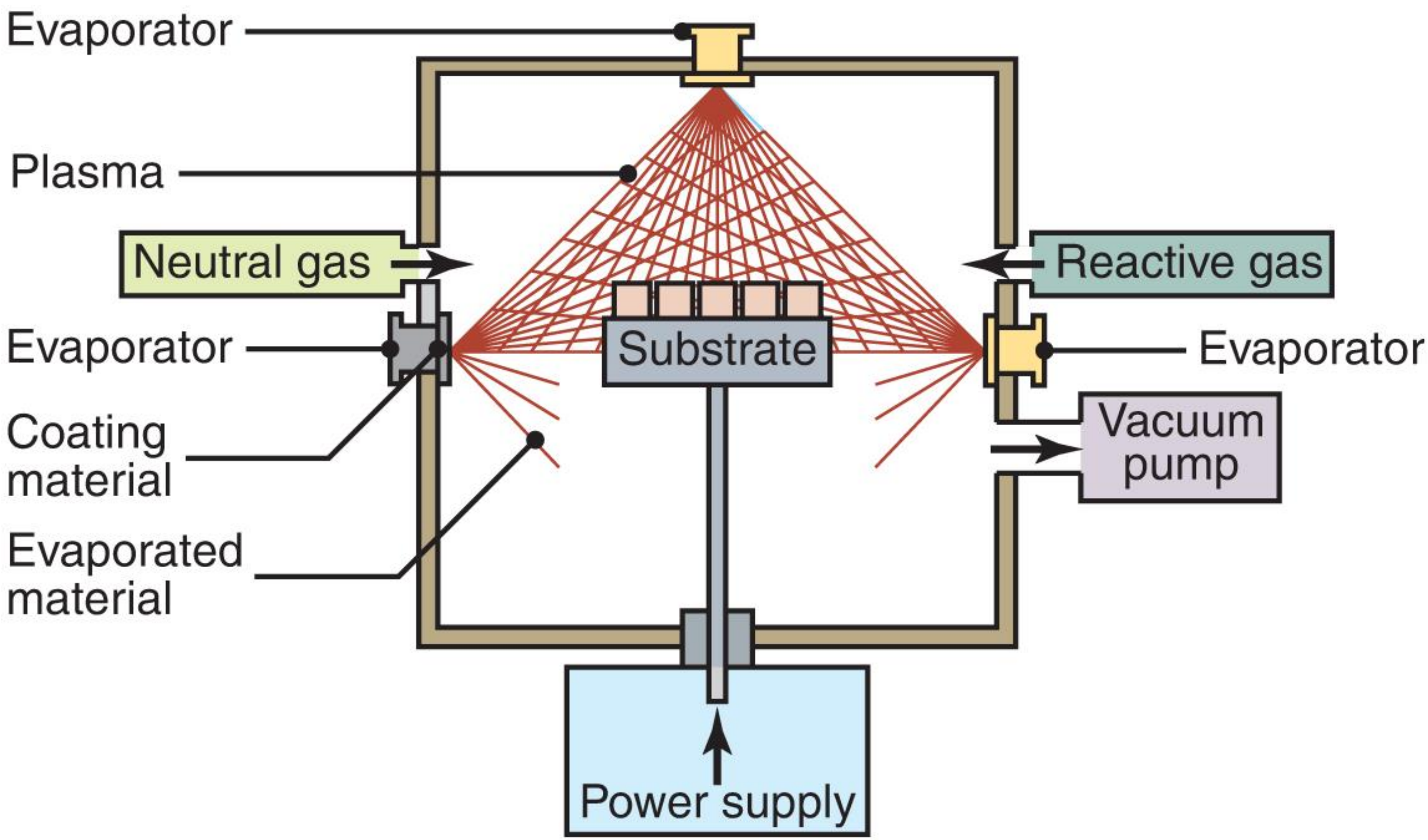
Thermal Spray



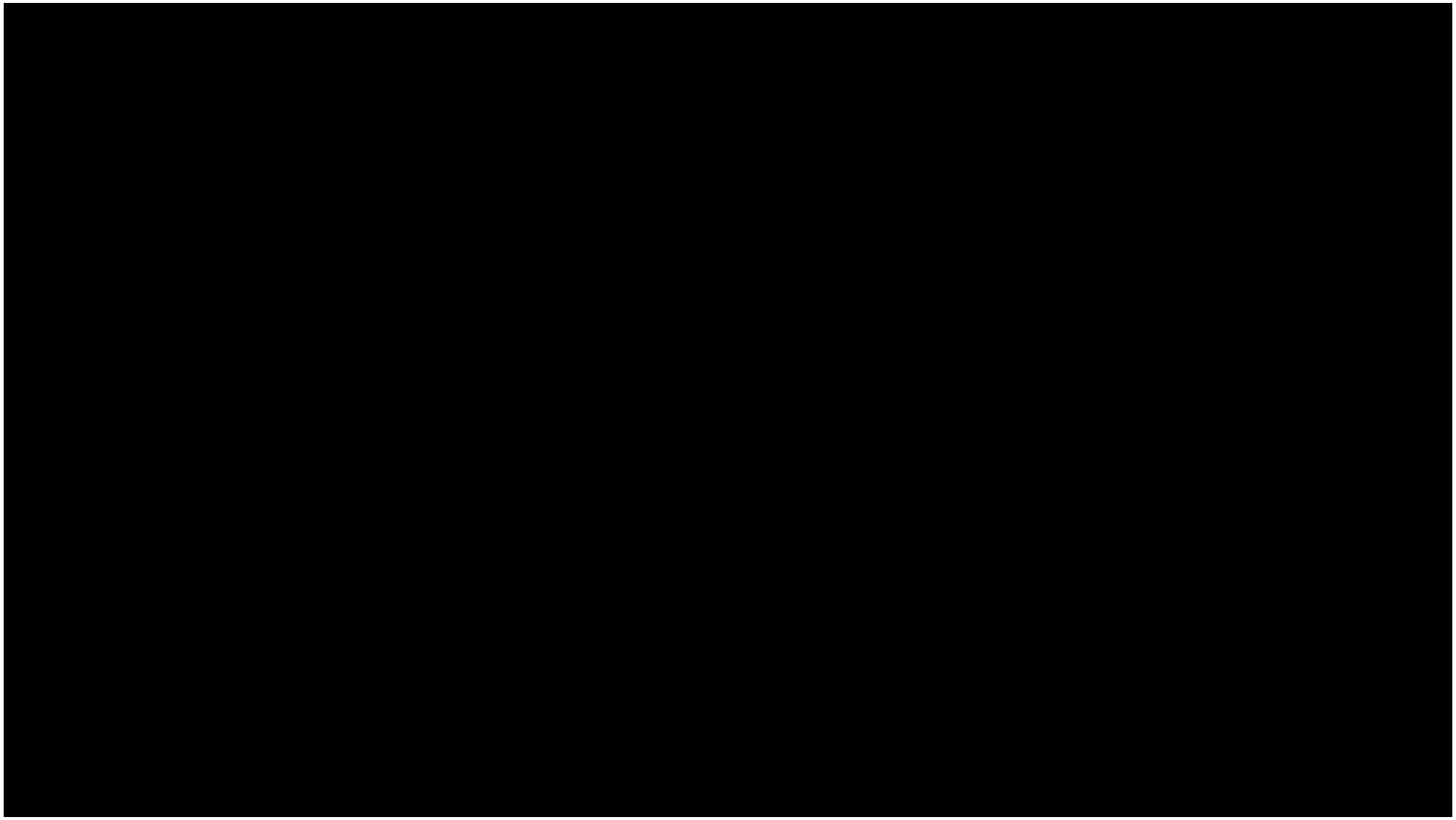
https://youtu.be/IIlErxrjlRg

Figure 34.3

Schematic illustration of the physical-vapor-deposition process. Note that there are three arc evaporators and the parts to be coated are placed on a tray inside the chamber.



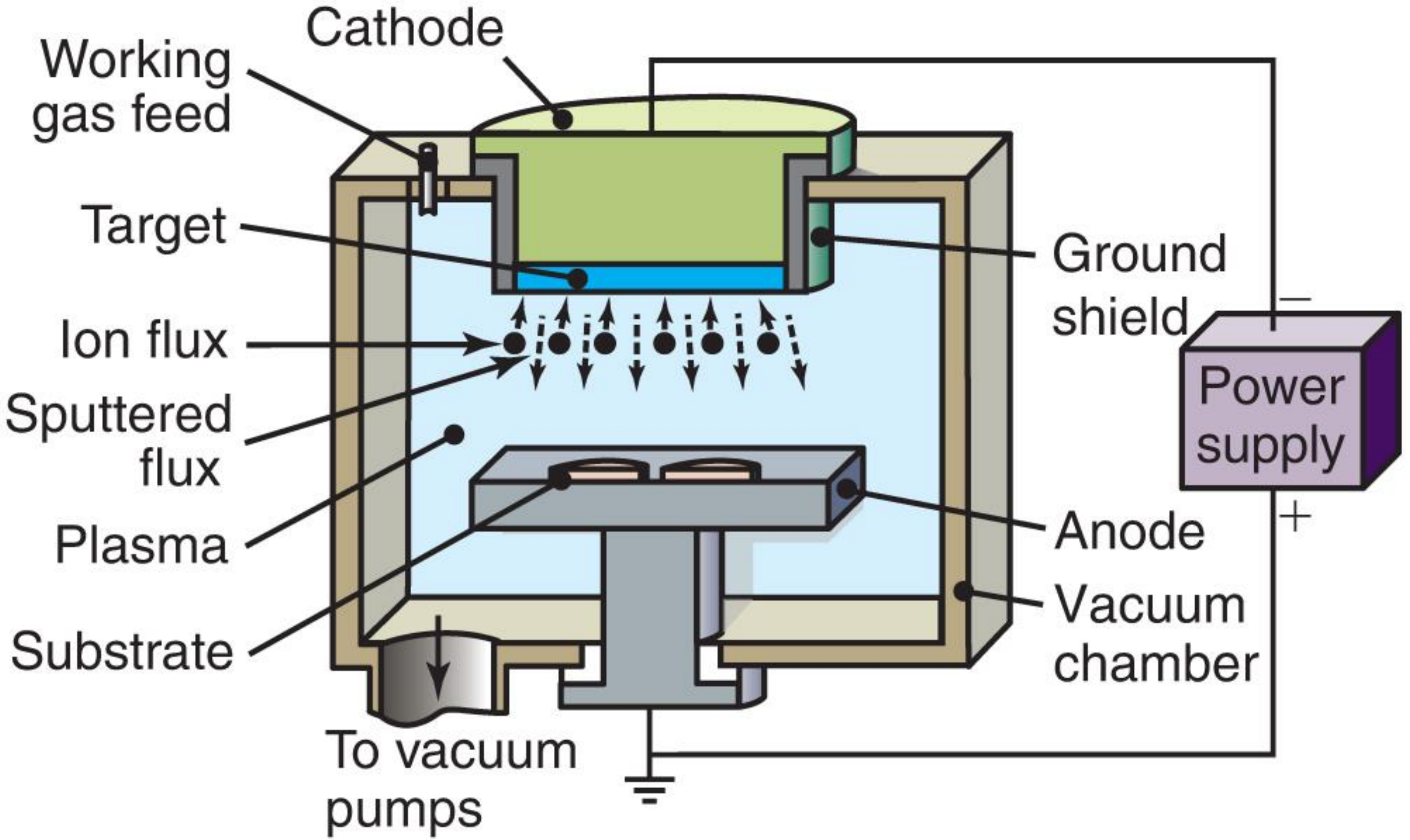
PVD Process



https://youtu.be/csCrDaY-JJI

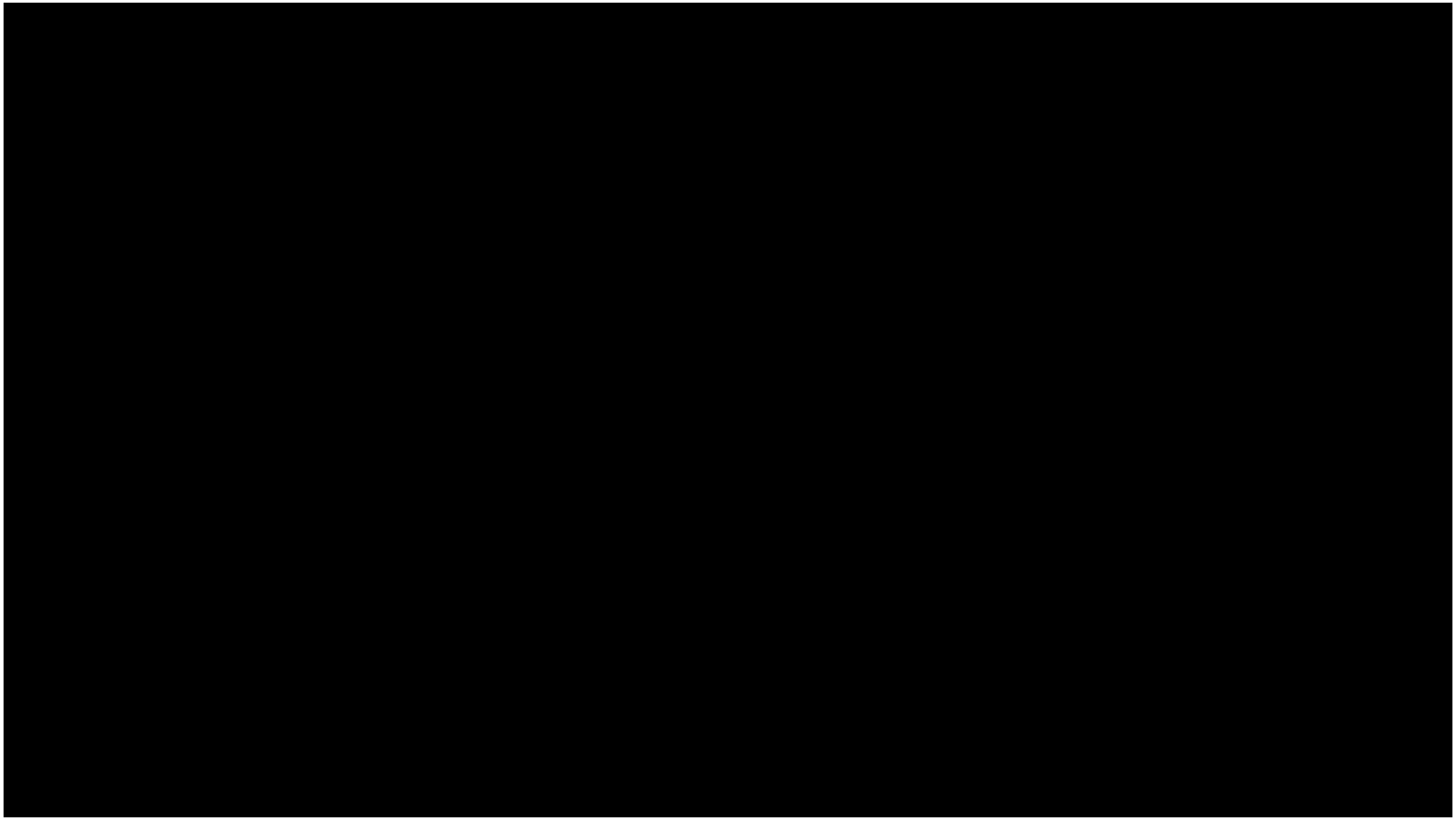
Figure 34.4

Schematic illustration of the sputtering process.



Pearson

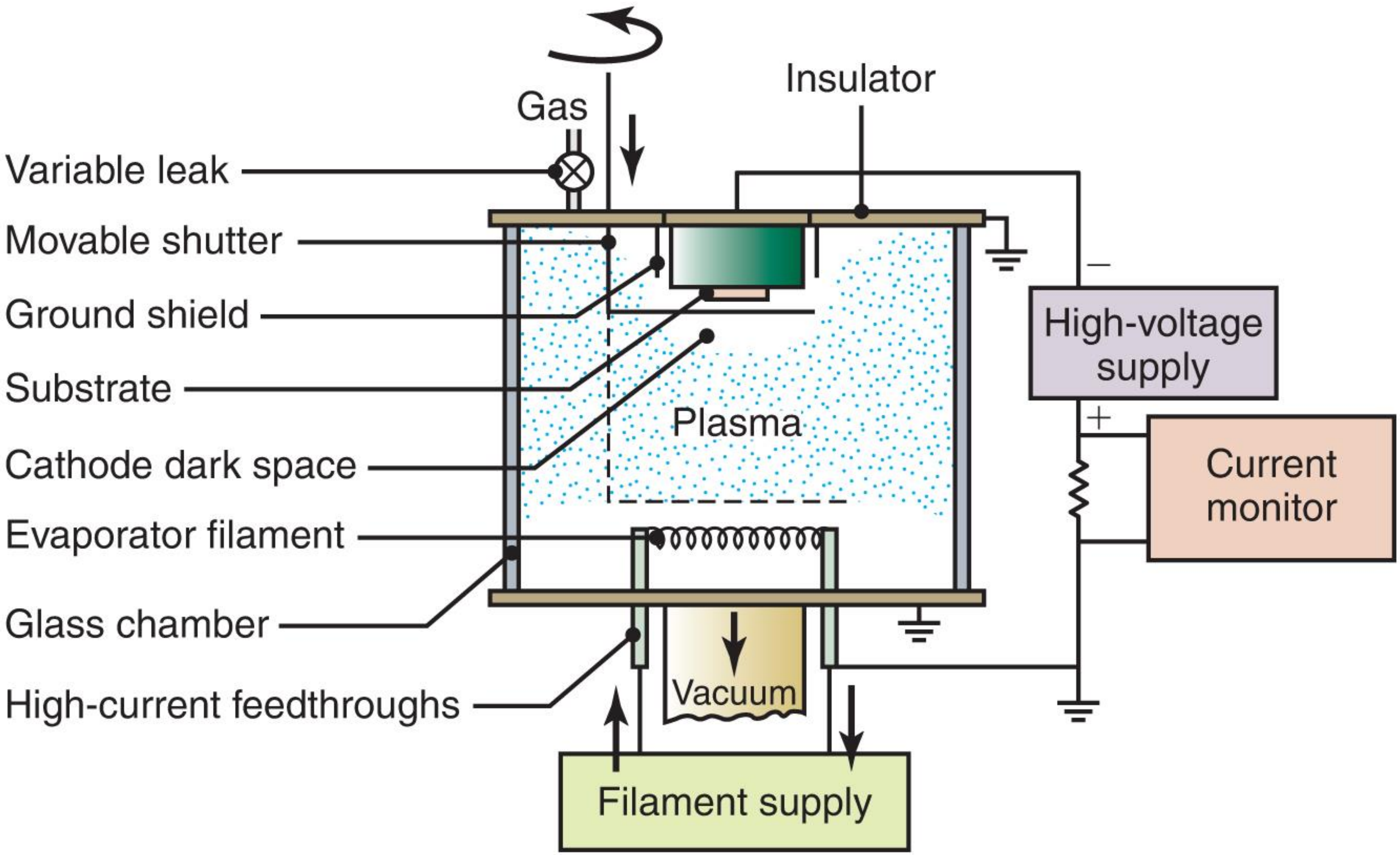
Sputtering



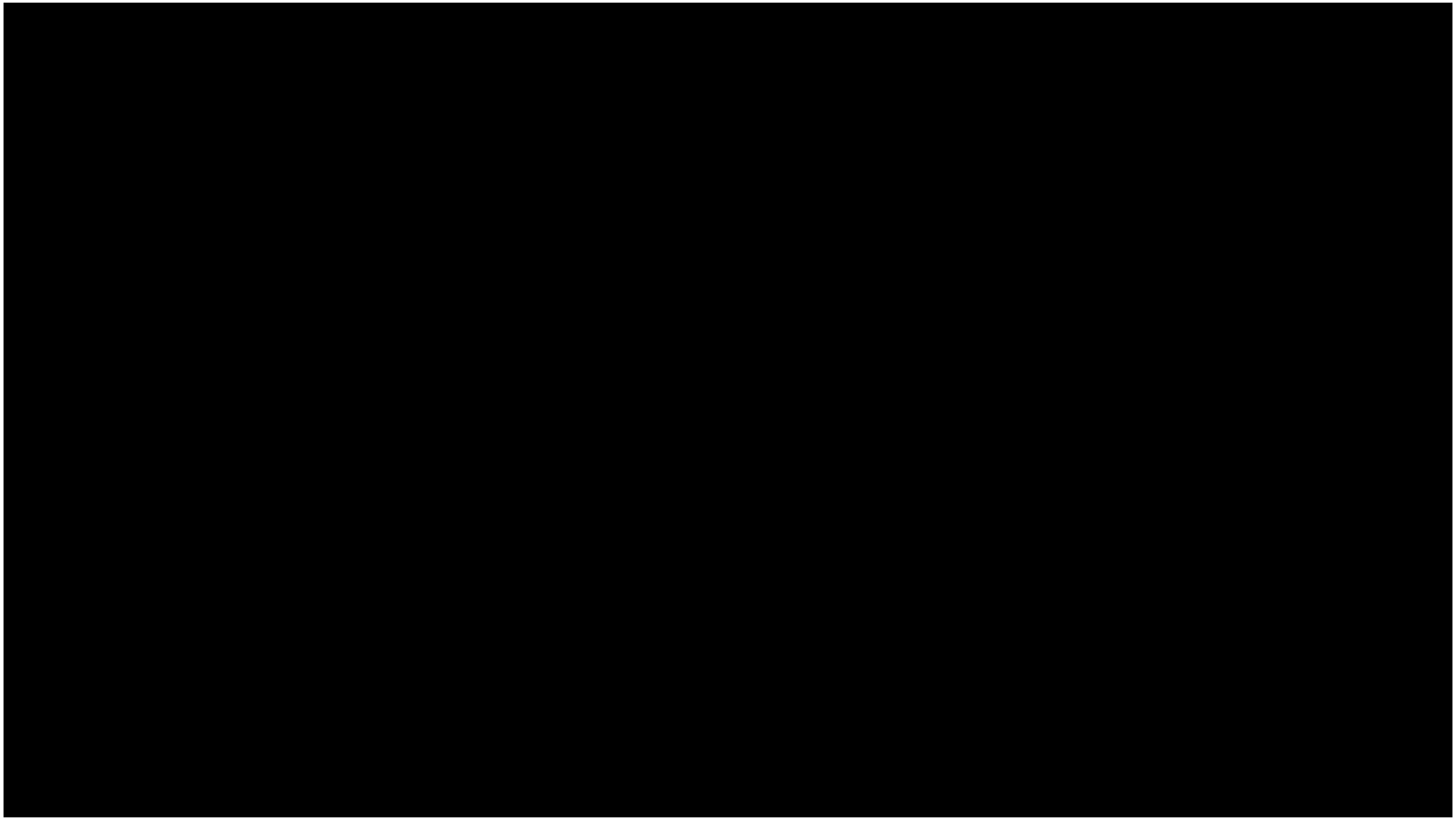
https://youtu.be/L6ZIkmIVm6c

Figure 34.5

Schematic illustration of an ion-plating apparatus.



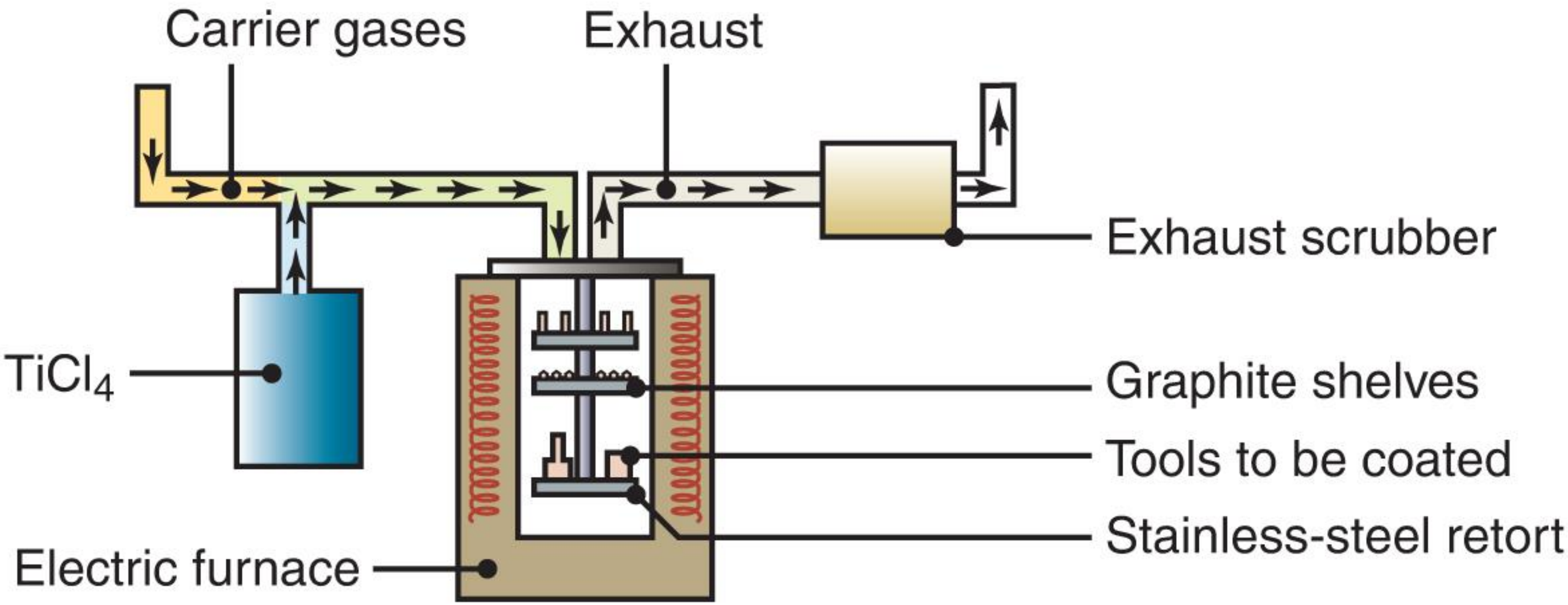
Ion Plating



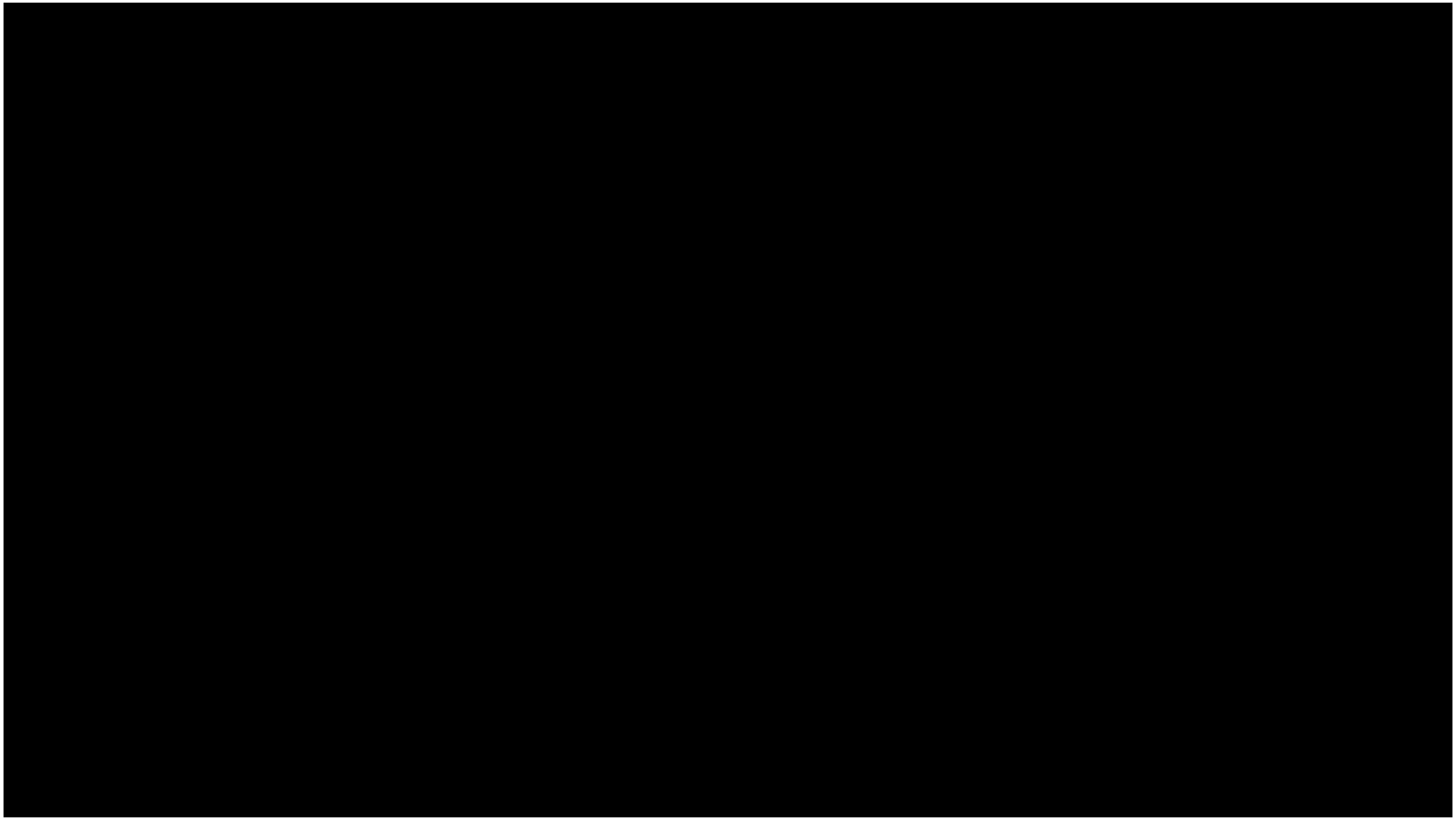
https://youtu.be/C0GINDPG8Ns

Figure 34.6

Schematic illustration of the chemical-vapor-deposition process; note that parts and tools to be coated are placed on trays inside the chamber.



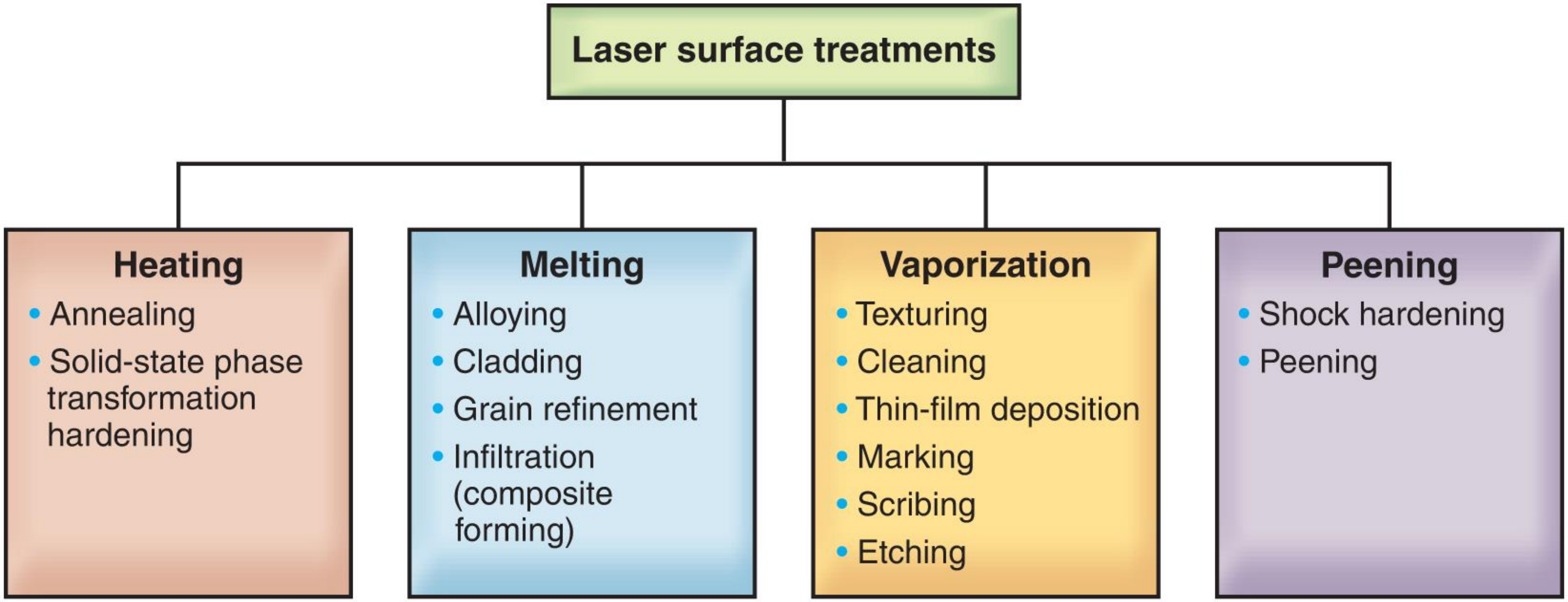
CVD process



https://youtu.be/j80jsWFm8Lc

Figure 34.7

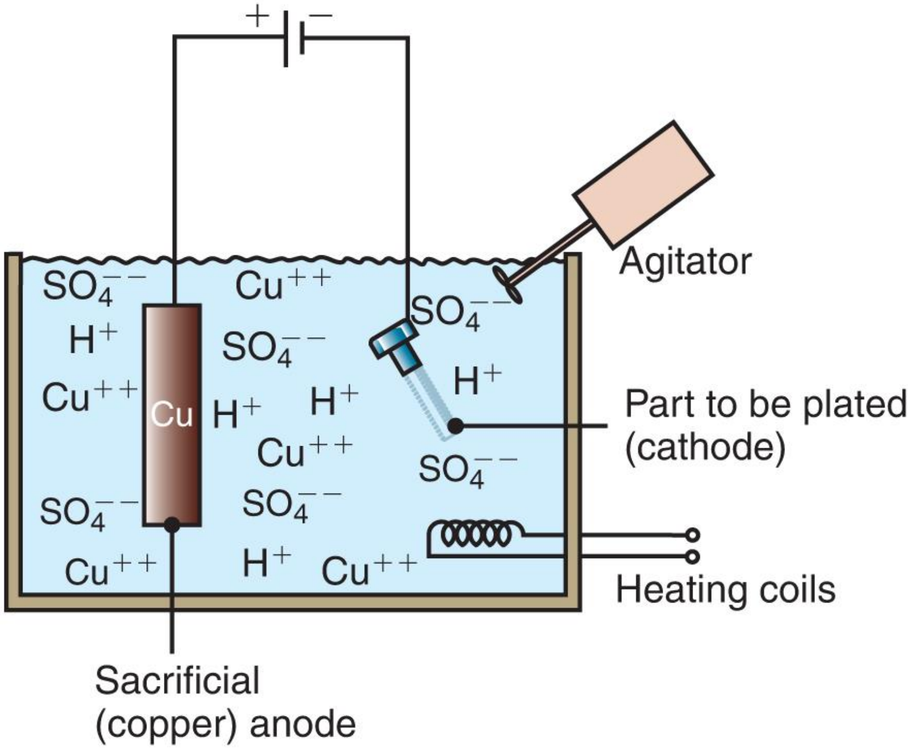
An outline of laser surface-engineering processes.



Source: After N.B. Dahotre.

Figure 34.8 (1 of 2)

(a) Schematic illustration of the electroplating process.



(a)

Figure 34.8 (2 of 2)

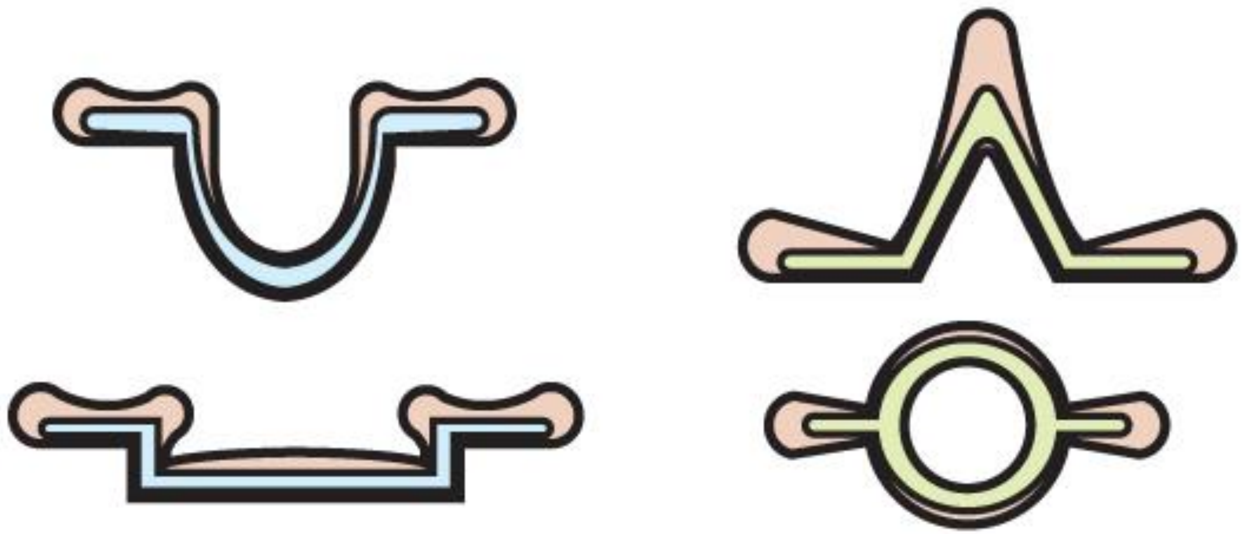
(b) Examples of electroplated parts.

(b)

Source: Courtesy of Shutterstock/Jarous.

Figure 34.9 (1 of 2)

(a) Schematic illustration of nonuniform coatings (exaggerated) in electroplated parts.



(a)

Figure 34.9 (2 of 2)

(b) Design guidelines for electroplating. Note that sharp external and internal corners should be avoided for uniform plating thickness.

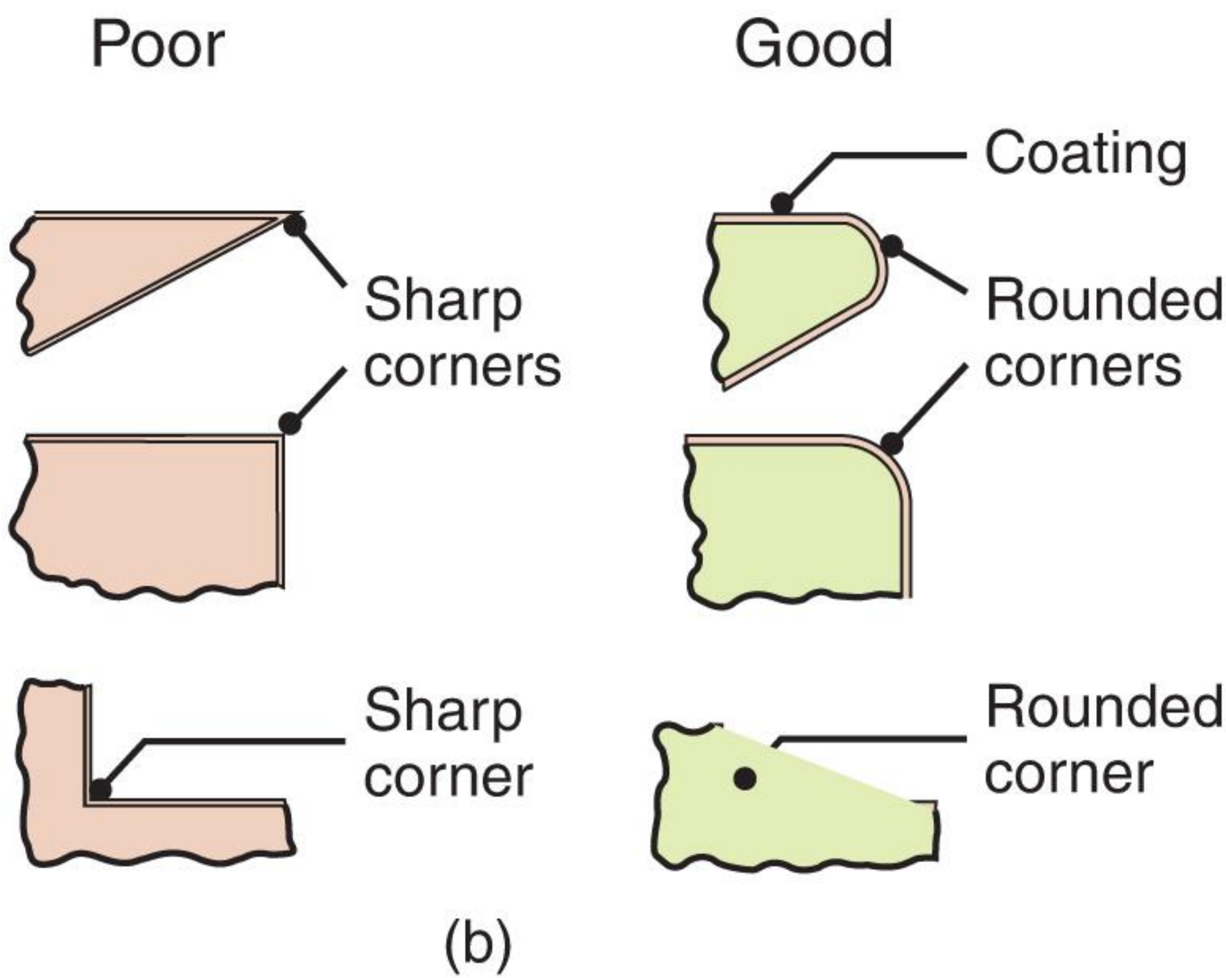
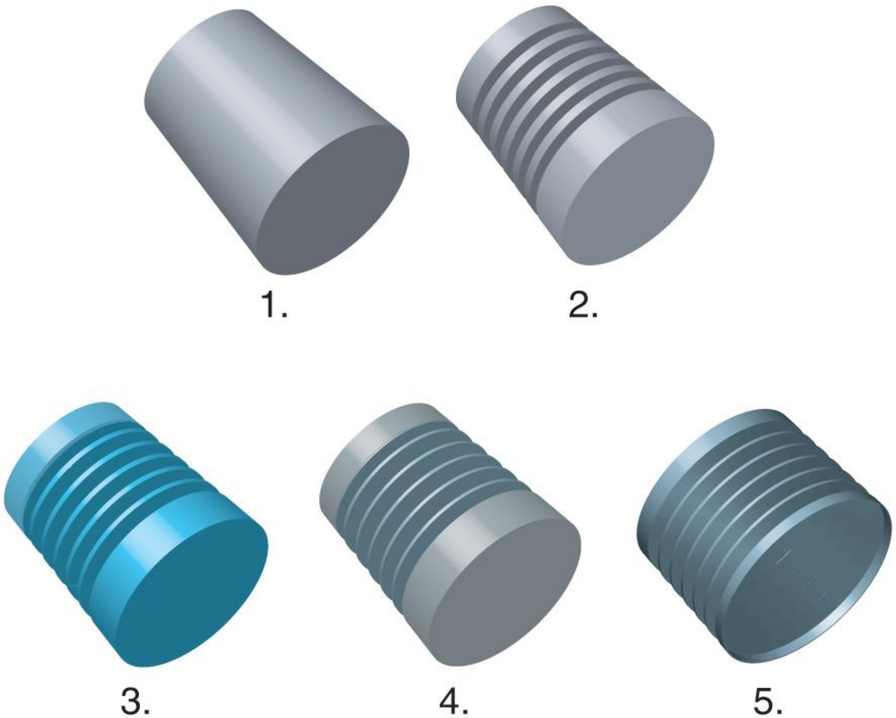


Figure 34.10 (1 of 2)

(a) Typical sequence in electroforming. (1) A mandrel is selected with the correct nominal size. (2) The desired geometry (in this case, that of a bellows) is machined into the mandrel. (3) The desired metal is electroplated onto the mandrel. (4) The plated material is trimmed if necessary. (5) The mandrel is dissolved through chemical machining.



(a)

Figure 34.10 (2 of 2)

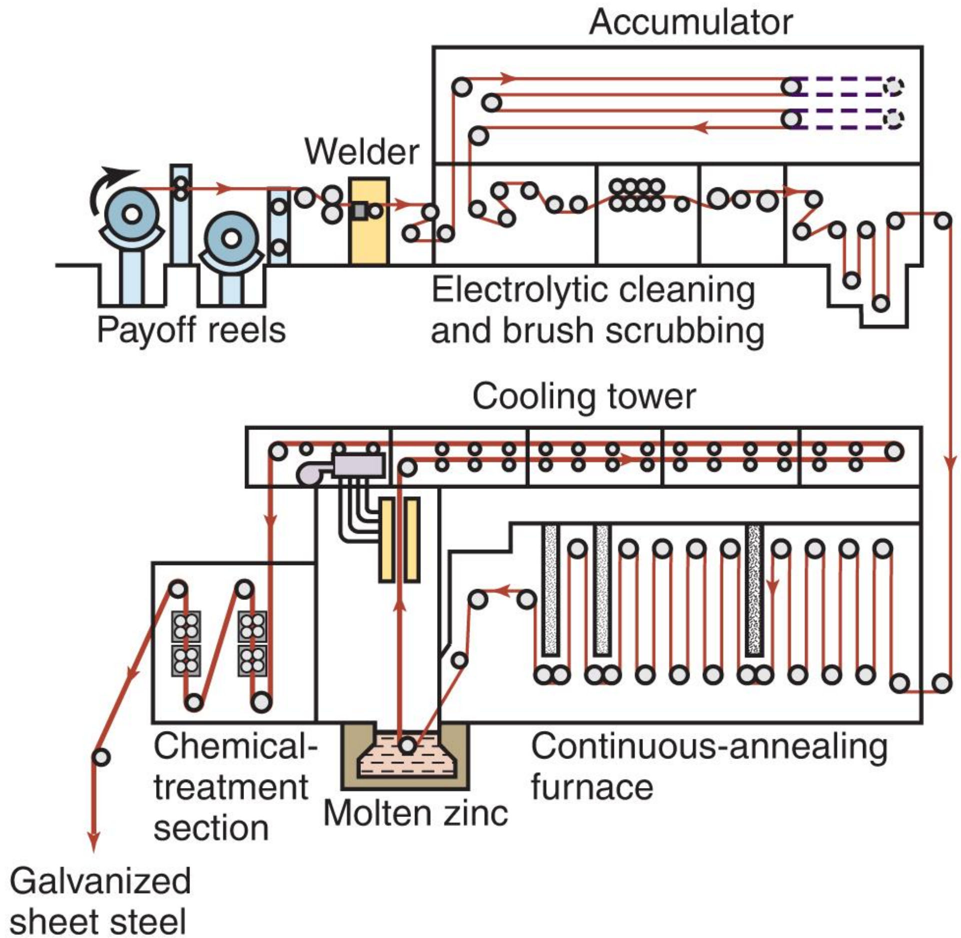
(b) A collection of electroformed parts.

(b)

Source: Courtesy of Servometer®, Cedar Grove, NJ.

Figure 34.11

Flow line for the continuous hot-dipped galvanizing of sheet steel. The welder (upper left) is used to weld the ends of coils to maintain continuous material flow.



Source: Courtesy of the American Iron and Steel Institute.

Table 34.1

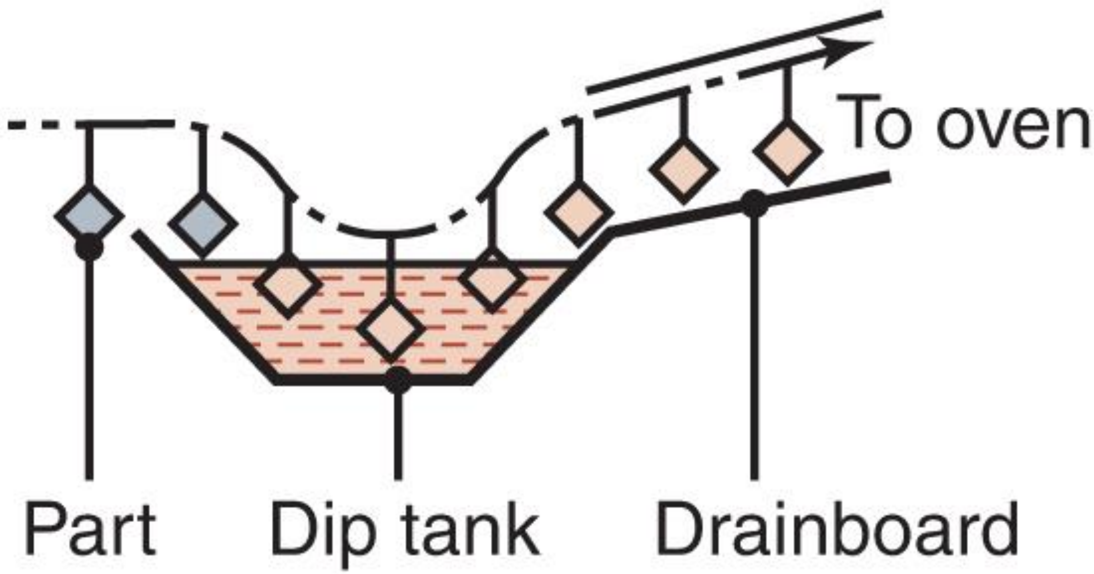
Ceramic Coatings Used for High-temperature Applications.

Property	Type of ceramic	Applications
Wear resistance	Chromium oxide, aluminum oxide, aluminum titania	Pumps, turbine shafts, seals, and compressor rods for the petroleum industry; plastics extruder barrels; extrusion dies
Thermal insulation	Zirconium oxide (yttria stabilized), zirconium oxide (calcia stabilized), magnesium zirconate	Fan blades, compressor blades, and seals for gas turbines; valves, pistons, and combustion heads for automotive engines
Electrical insulation	Magnesium aluminate, aluminum oxide	Induction coils, brazing fixtures, general electrical applications

Pearson

Figure 34.12 (1 of 3)

Methods of paint application: (a) dip coating.



(a)

Figure 34.12 (2 of 3)

Methods of paint application: (b) flow coating.

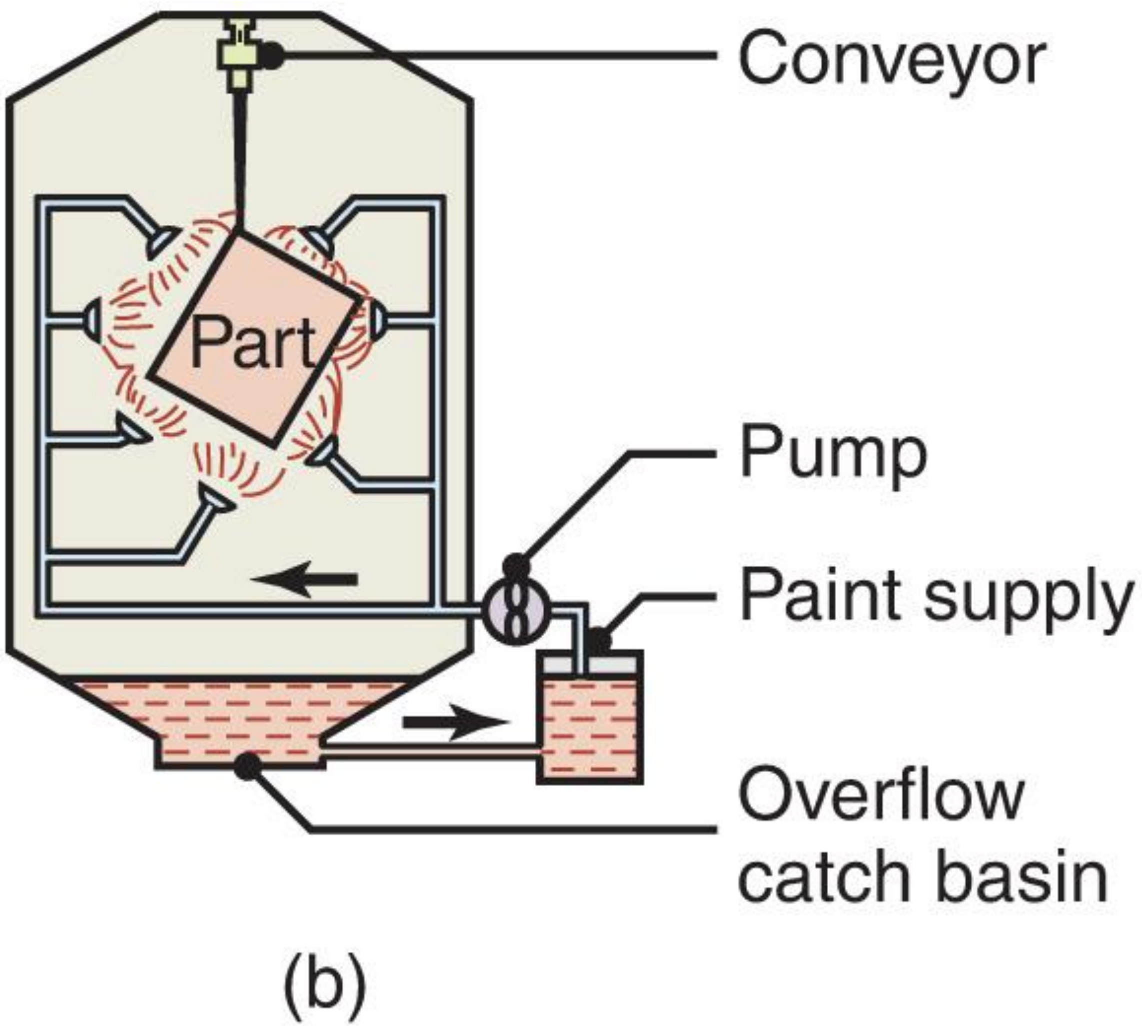
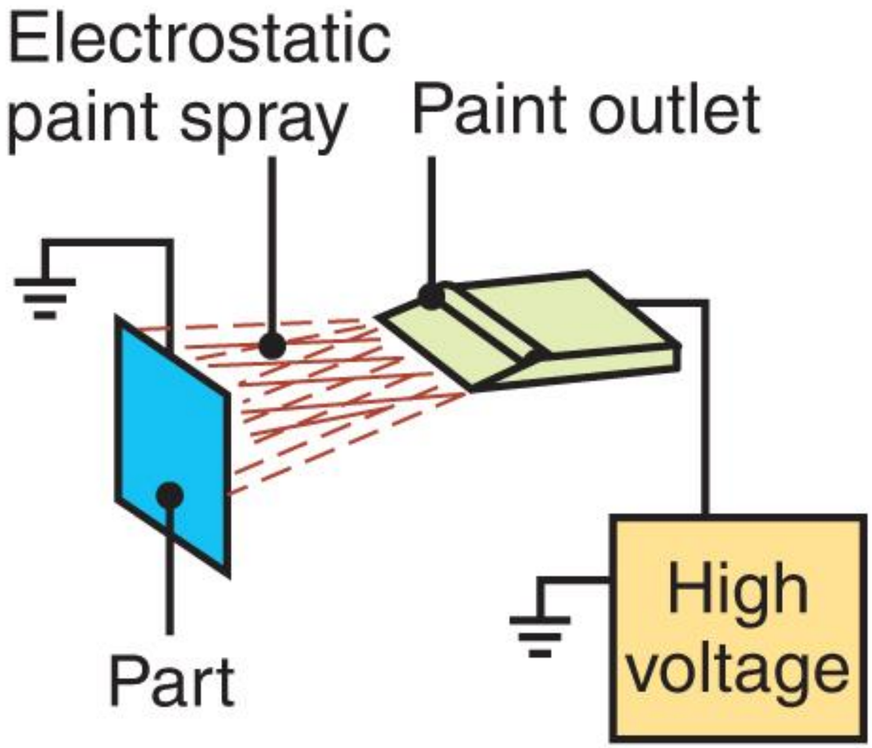


Figure 34.12 (3 of 3)

Methods of paint application: (c) electrostatic spraying (used particularly for automotive bodies).



(c)