

Other Machining Operations

Chapter 27

27.1 Introduction

- This chapter covers:
 - Shaping
 - Planing
 - Broaching
 - Sawing
 - Filing

27.2 Introduction to Shaping and Planing

- Shaping and Planing among the oldest techniques
 - Shaping is where the workpiece is fed at right angles to the cutting motion between successive strokes of the tool.
 - Planing the workpiece is reciprocated and the tool is fed at right angles to the cutting motion.
- These process require skilled operators and for the most part have been replaced by other processes

Basics of Shaping

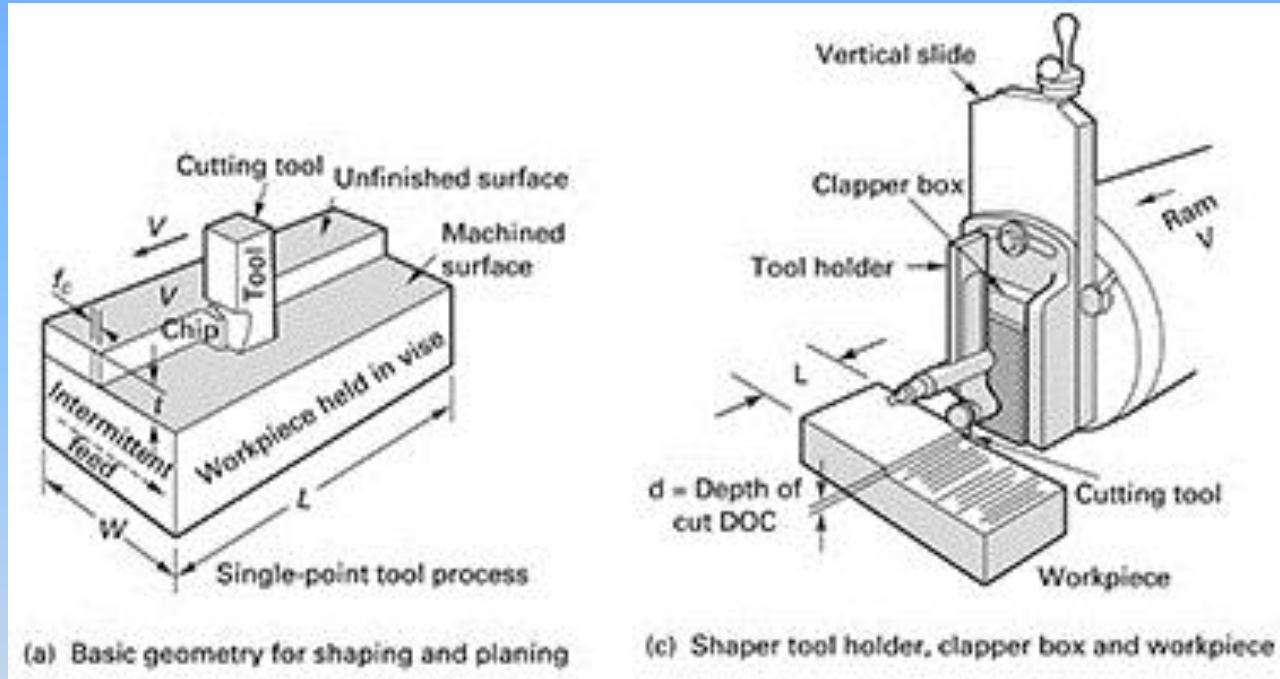
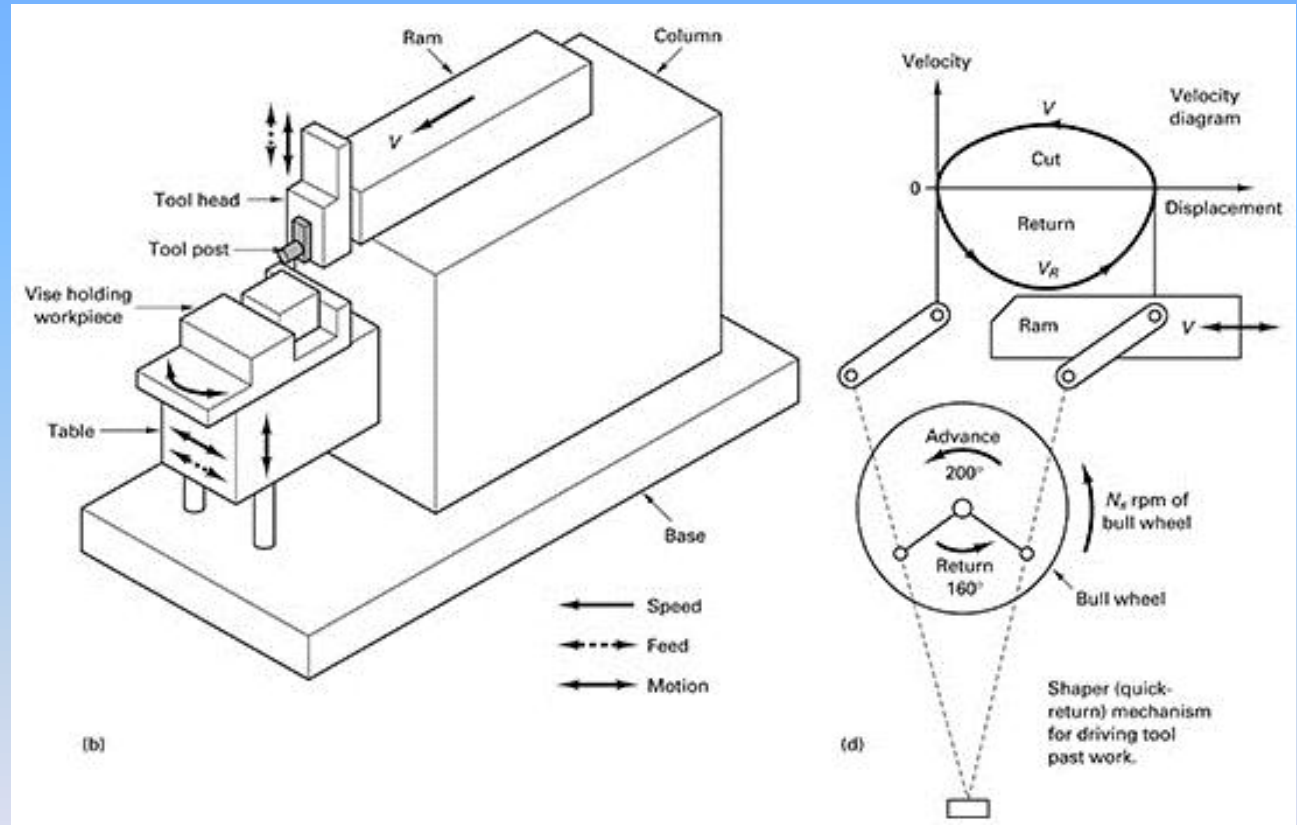


FIGURE 27-1 Basics of shaping and planing. (a) The cutting speed, V , and feed per stroke f_c . (c) The cutting tool is held in a clapper box so the tool does not damage the workpiece on the return stroke.

Basics of Shaping

FIGURE 27-1 Basics of shaping and planing. (b) Block diagram of the machine tool. (d) The ram of the shaper carries the cutting tool at cutting velocity V and reciprocates at velocity VR by the rotation of a bull wheel turning at rpm ns .



Common Shaping and Planing Geometry

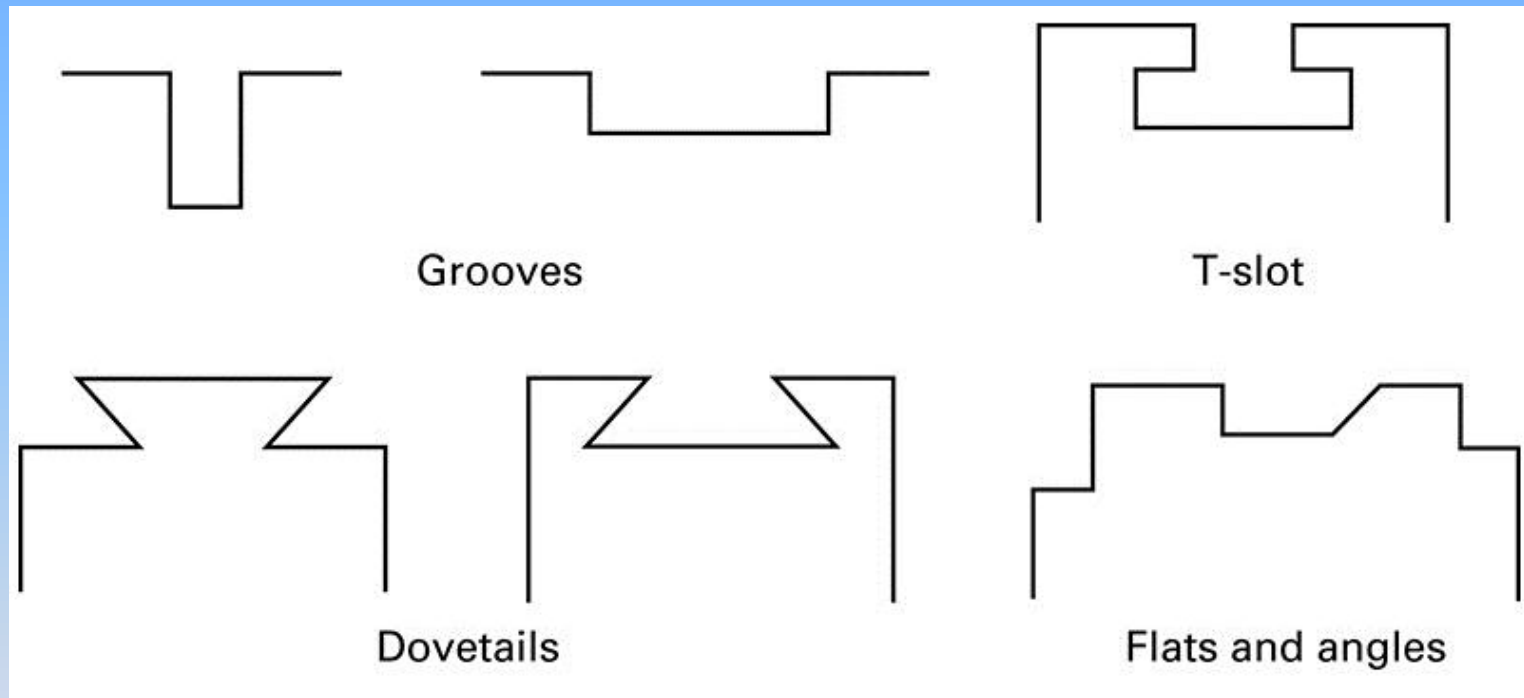


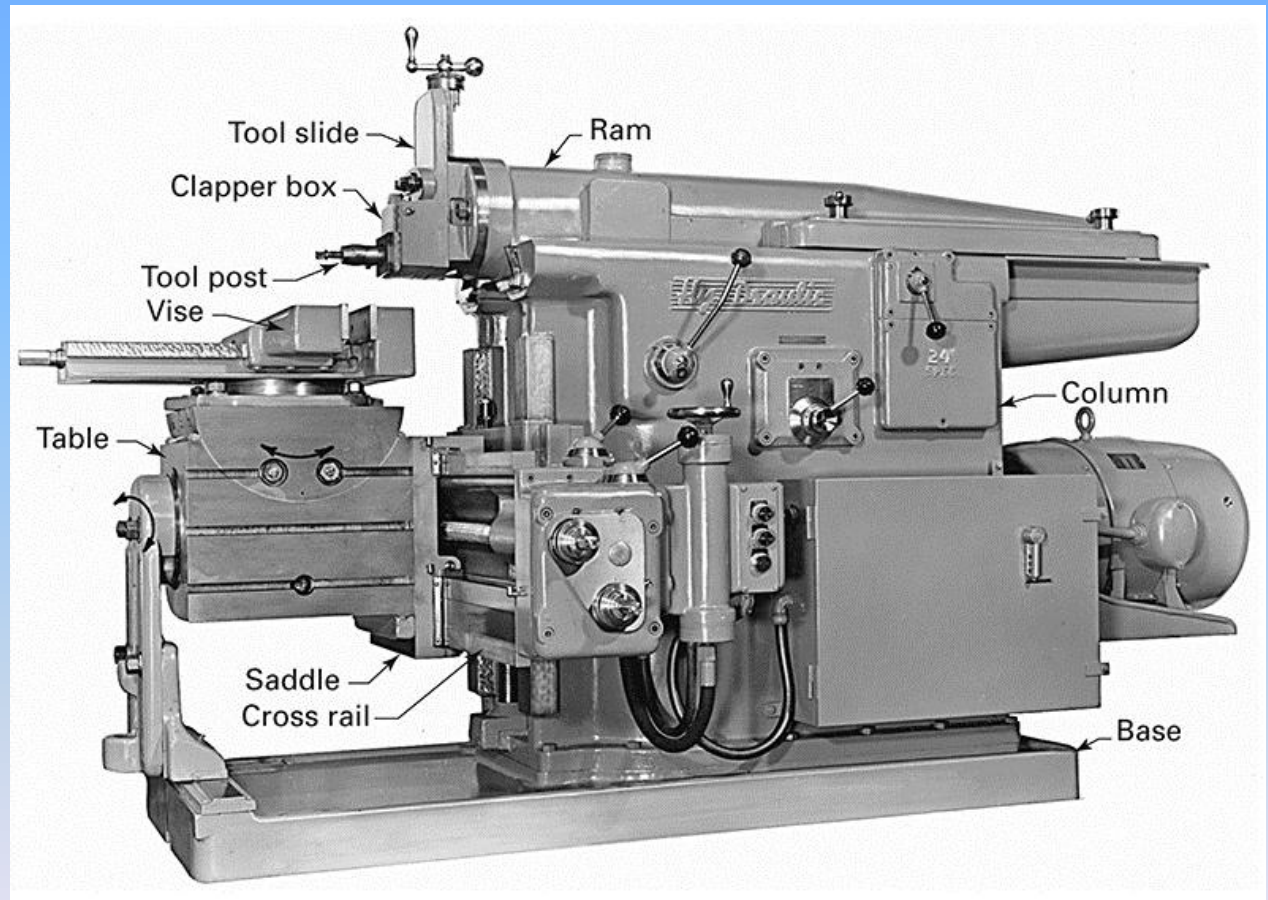
FIGURE 27-2 Types of surfaces commonly machined by shaping and planing.

Machine Tools for Shaping

- Shapers, as machine tools, are usually classified according to their general design features as follows:
 - **1. Horizontal**
 - **a. Push-cut**
 - **b. Pull-cut or draw-cut shaper**
 - **2. Vertical**
 - **a. Regular or slotters**
 - **b. Keyseaters**
 - **3. Special**
- They are also classified by their drive mechanisms:
Mechanical and Hydraulic

Shaper

FIGURE 27-3 The most widely used shaper is the horizontal push-cut machine tool, shown here with no tool in the tool post.



Planing Machines

- Planing is used for large workpieces too big for shapers
- Planing machines have largely been replaced by planing mills
- In planing, large workpieces and their support tables are slowly moved against the tool head.

Schematic of a Planer

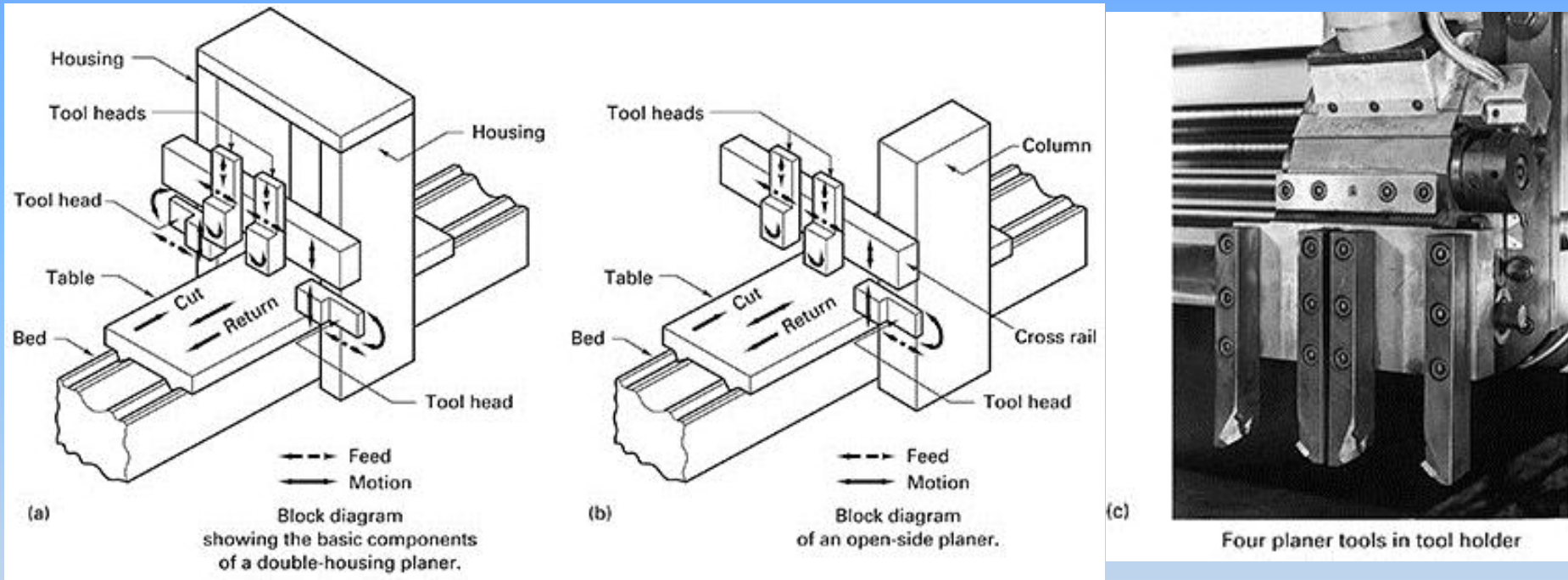


FIGURE 27-4 Schematic of planers. (a) Double-housing planer with multiple tool heads (4) and a large reciprocating table; (b) single-housing or open-sided planer; (c) interchangeable multiple tool holder for use in planers. (Photograph courtesy Gebr Boehringer GmbH.)

27.3 Introduction to Broaching

- Broaching is where a tool, with successively increasing tooth size, is moved through the workpiece, creating the desired shape with a single pass.
- Broaching is similar to sawing, with the exception that a saw requires multiple passes, and the teeth are not increased in size along the length of the tool.
- Broaching can be used for holes of various geometry, grooves, and flat surface features.

Basic Geometry of a Broach

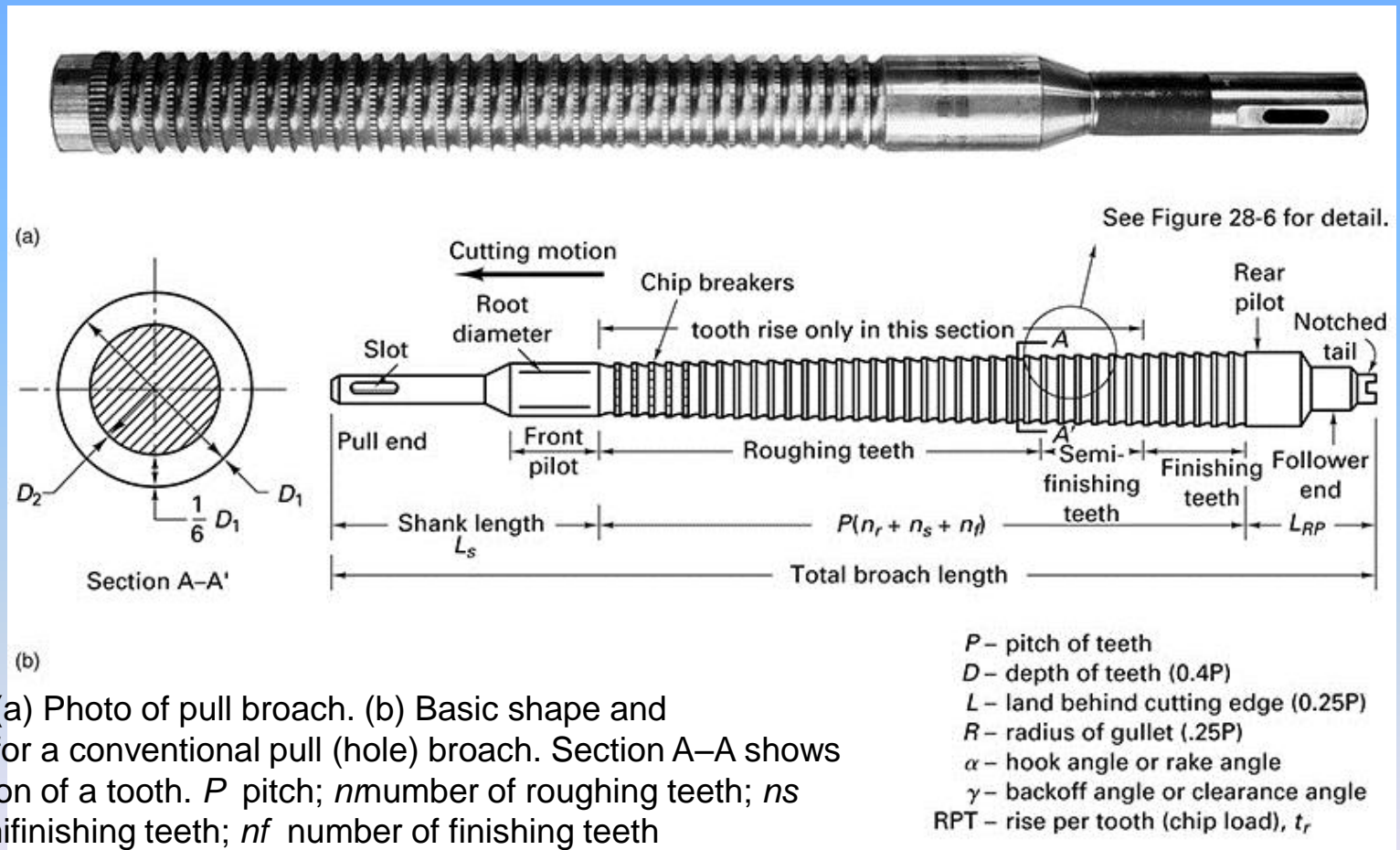


FIGURE 27-5 (a) Photo of pull broach. (b) Basic shape and nomenclature for a conventional pull (hole) broach. Section A–A shows the cross section of a tooth. P pitch; n_r number of roughing teeth; n_s number of semifinishing teeth; n_f number of finishing teeth

Cutting Geometry of a Broach

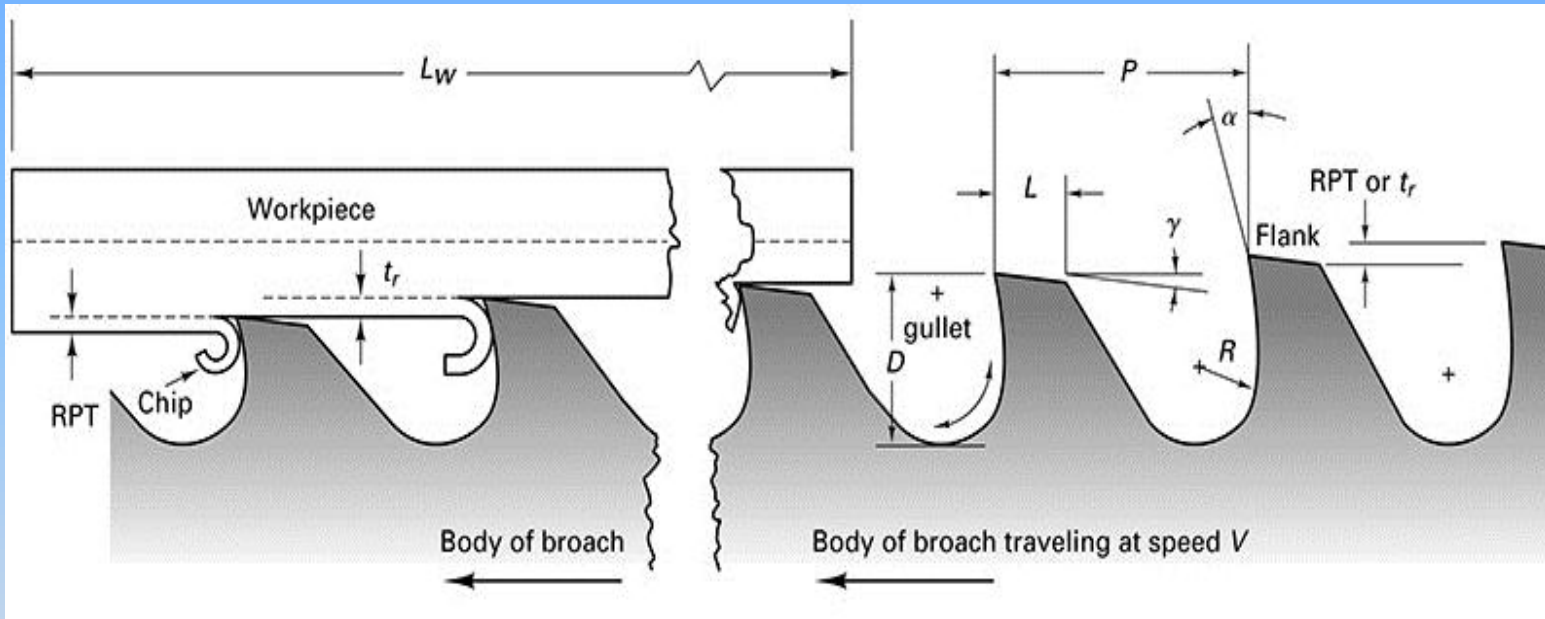


FIGURE 27-6 The feed in broaching depends on the rise per tooth t_r (RPT). The sum of the RPT gives the depth of cut, DOC. P pitch of teeth; D depth of teeth ($0.4P$); L land behind cutting edge ($0.25P$); R radius of gullet ($0.25P$); hook angle or rake angle; backoff angle or clearance angle.

27.4 Fundamentals of Broaching

- In broaching, the tool (or work) is translated past the work (or tool) with a single stroke of velocity V .
- The feed is provided by a gradual increase in height of successive teeth.
- The rise per tooth varies depending on whether the tooth is for roughing (tr), semifinishing (ts), or final sizing or finishing (tf).

Advantages and Disadvantages

- Broaching is a rapid method of producing a finished feature.
- Complex geometries are possible using broaching
- Custom tools must be produced for each feature at \$15K to \$30K per tool
- Standard keyways can be used off the shelf tooling

Advantages and Disadvantages

- Broaching requires that the geometry be two dimensional with a straight profile.
- Broaching requires that the tool be able to pass fully through the part.
- Broach designs require that the tool be stiff enough for the work required, small geometries are a challenge.

Broach Design

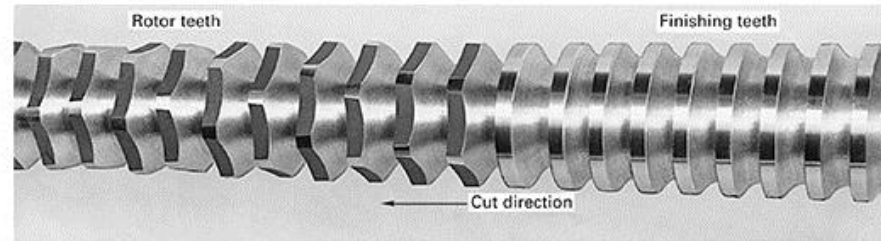
BROACH DESIGN (THE CUTTING TOOL)

Broaches commonly are classified by the following design features:

Purpose	Motion	Construction	Function
Single	Push	Solid	Roughing
Combination	Pull	Built-up	Sizing
	Stationary		Burnishing

Principle Components of a Broach

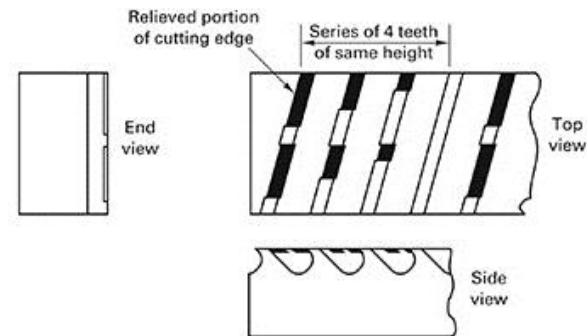
FIGURE 27-7 Methods to decrease force or break up chip rings in broaches. (a) Rotor or jump tooth; (b) notched tooth, round; (c) notched tooth, flat design (overlapping teeth permit large RPTs without increasing chip load); (d) progressive tooth design for flat broach.



(a) Rotor- or jump-tooth broach design.



(b) Round, push-type broach with chip-breaking notches on alternate teeth except at the finishing end.



(c) Notched tooth, flat broach



(d) Progressive surface broach. (Courtesy of Detroit Broach & Machine Company)

Broach Examples

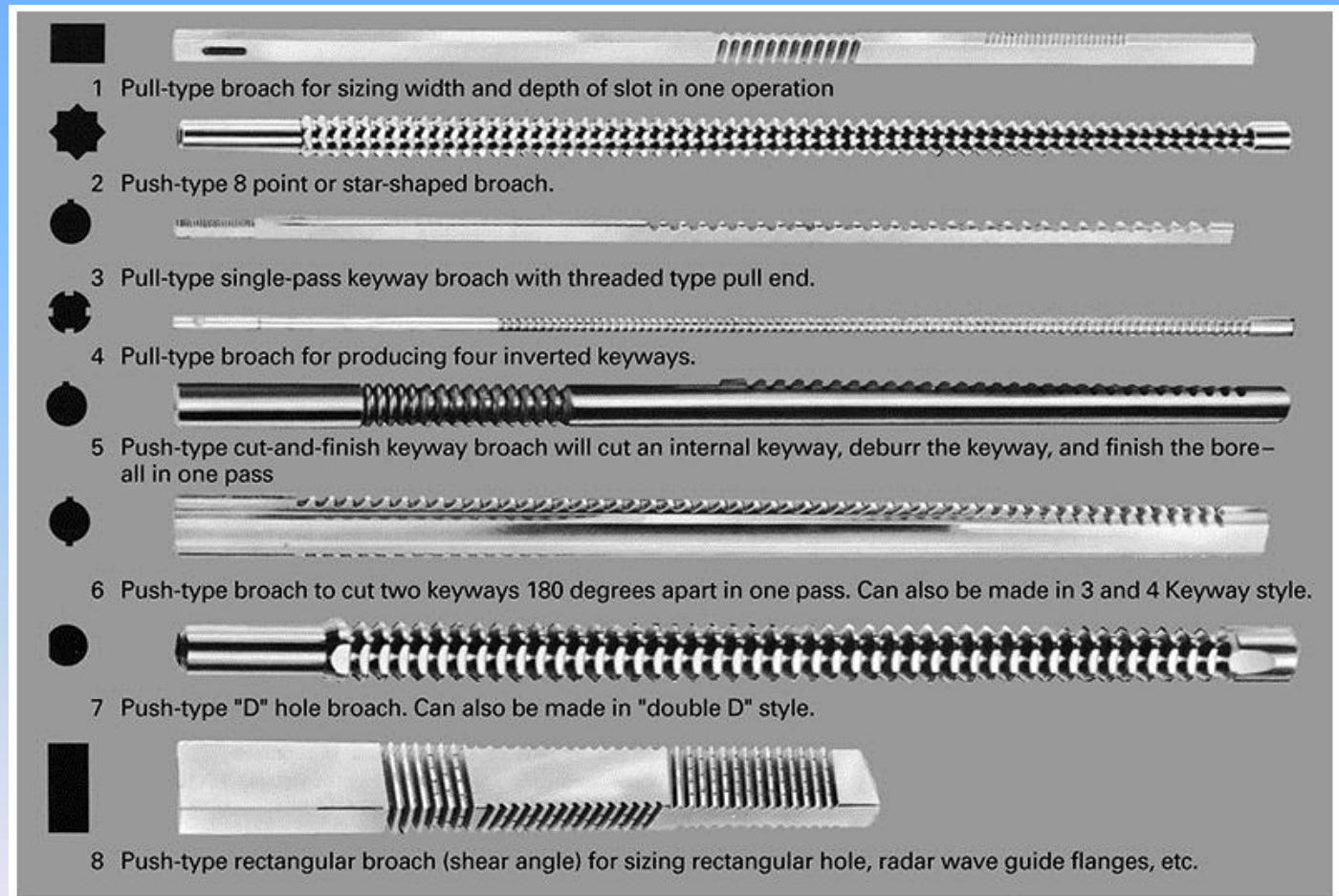


FIGURE 27-8
Examples of push- or pull-type broaches.
(Courtesy of DuMont Corporation.)

Replaceable Broach Shells

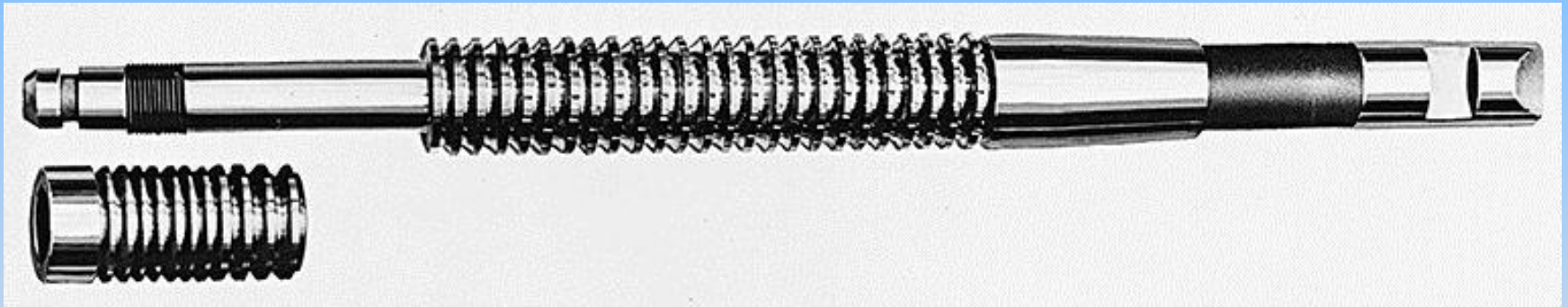


FIGURE 27-9 Shell construction for a pull broach.

27.5 Broaching Machines

TABLE 27-1 Broaching Machines

Vertical

Push-broaching	Arbor press with guided ram 5- to 50-ton capacity Internal broaching
Pull-down	Double-ram design most common Long changeover times
Pull-up	Ram above table pulling broach up Machines with multiple rams common
Surface	No handling of broach Multiple slides

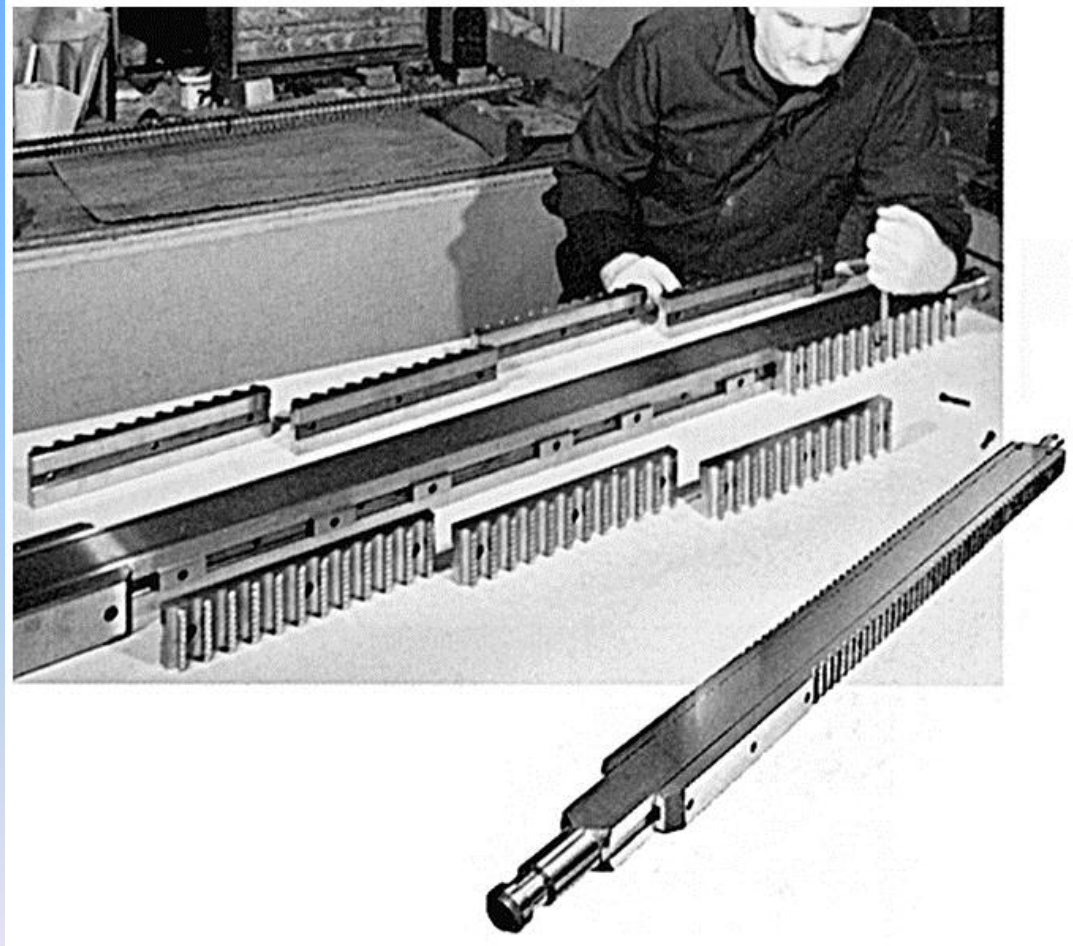
Horizontal

Short Cycle Times

Pull	Longer strokes and broaches Basically vertical machines laid on side
Surface	Broaches stationary, work moves on conveyor Work held in fixtures
Continuous	Conveyor chain holds fixtures
Rotary	Rotary broach stationary, work translates beneath tool Work held in fixtures

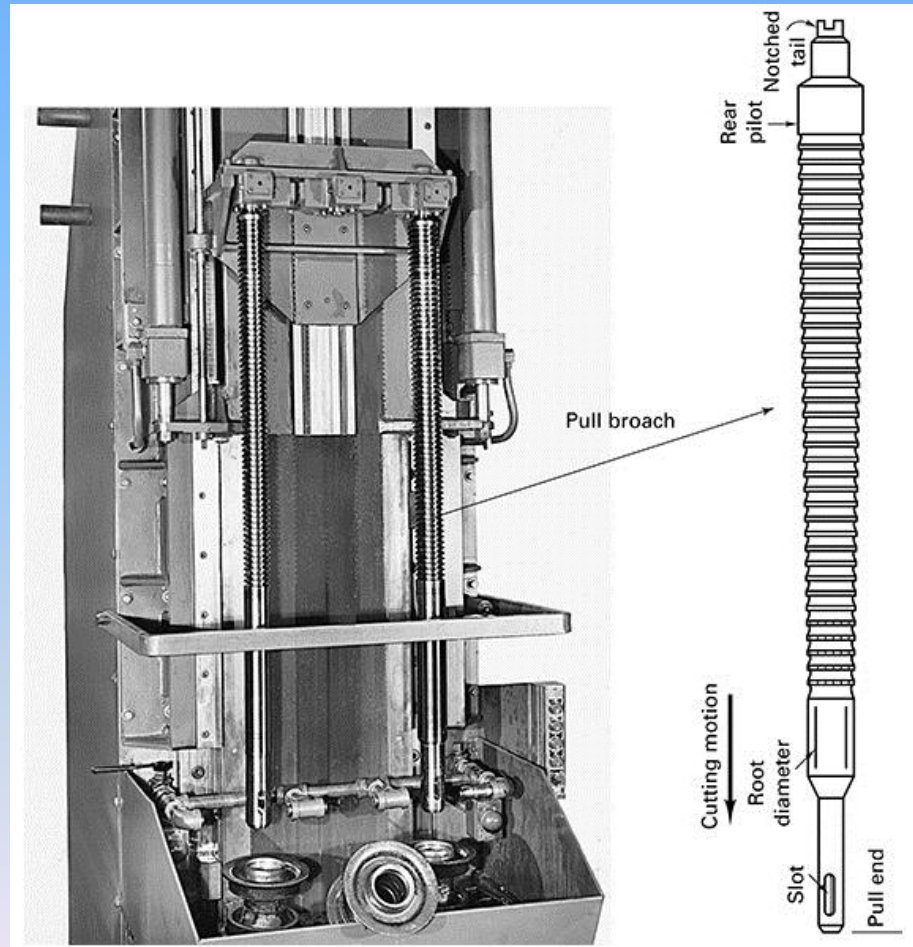
Modular Broaching Machine

FIGURE 27-10 A modularly constructed broach is cheaper to build and can be sharpened in sections



Vertical Pulldown Broach

FIGURE 27-11 Vertical pulldown broaching machine shown with parts in position ready for the two broaches to be inserted. An extra part is shown lying at the front of the machine.



27.6 Introduction to Sawing

- Sawing is the process by which successive teeth, arranged in a narrow line, remove a small amount of material.
- Each tooth forms a chip as it passes through the material, with chips contained between the teeth
- Parts of considerable size can be severed from the workpiece with only little material removed, making this a very economical process.

Principles of a Saw Blade

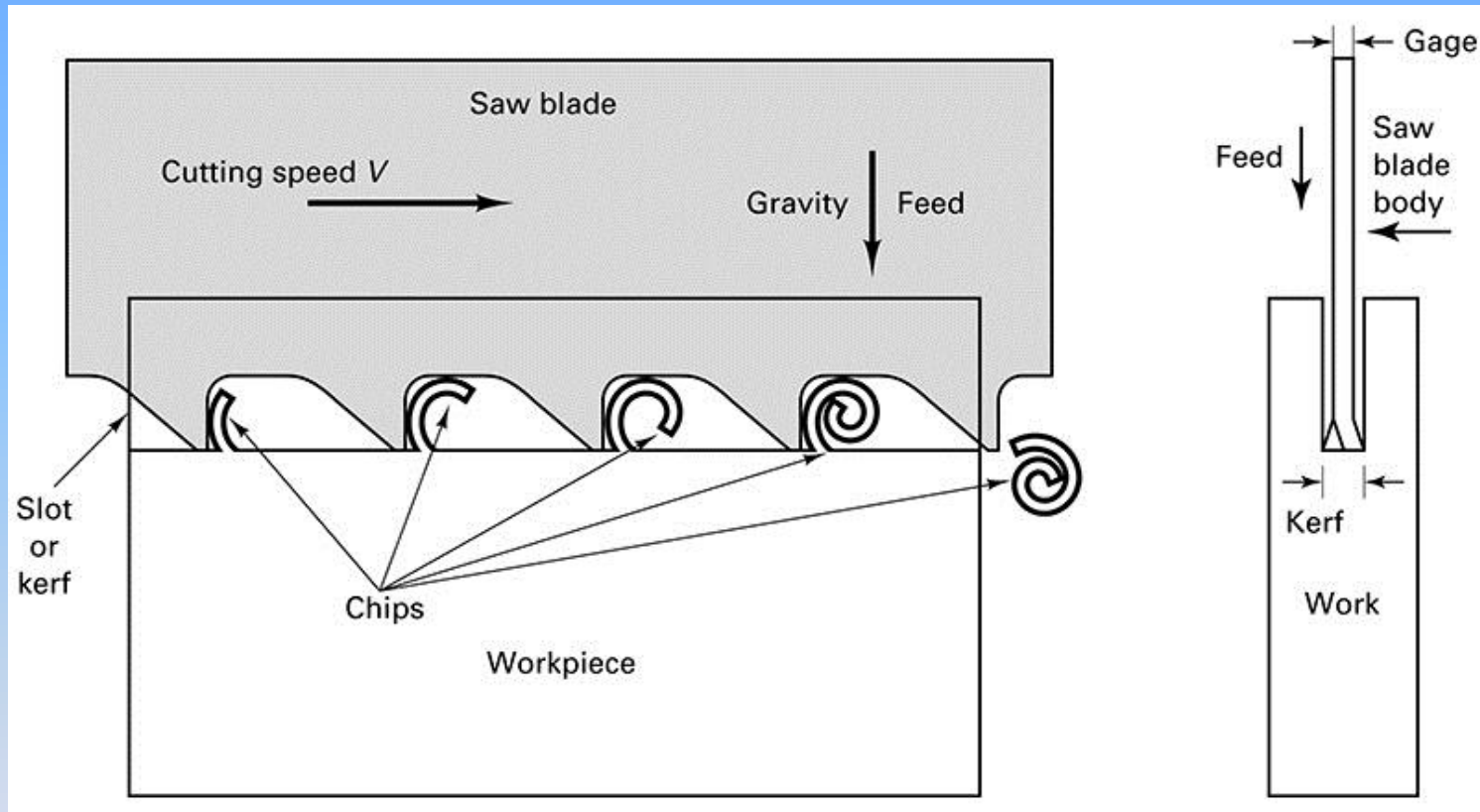


FIGURE 27-12 Formation of chips in sawing.

Types of Blades

- There are three basic types of saws
 - Hacksaws
 - A rigid straight blade with limited teeth
 - Bandsaws
 - A flexible long blade that is formed into a continuous band
 - Circular Saws
 - A rigid disk with teeth on the circumference

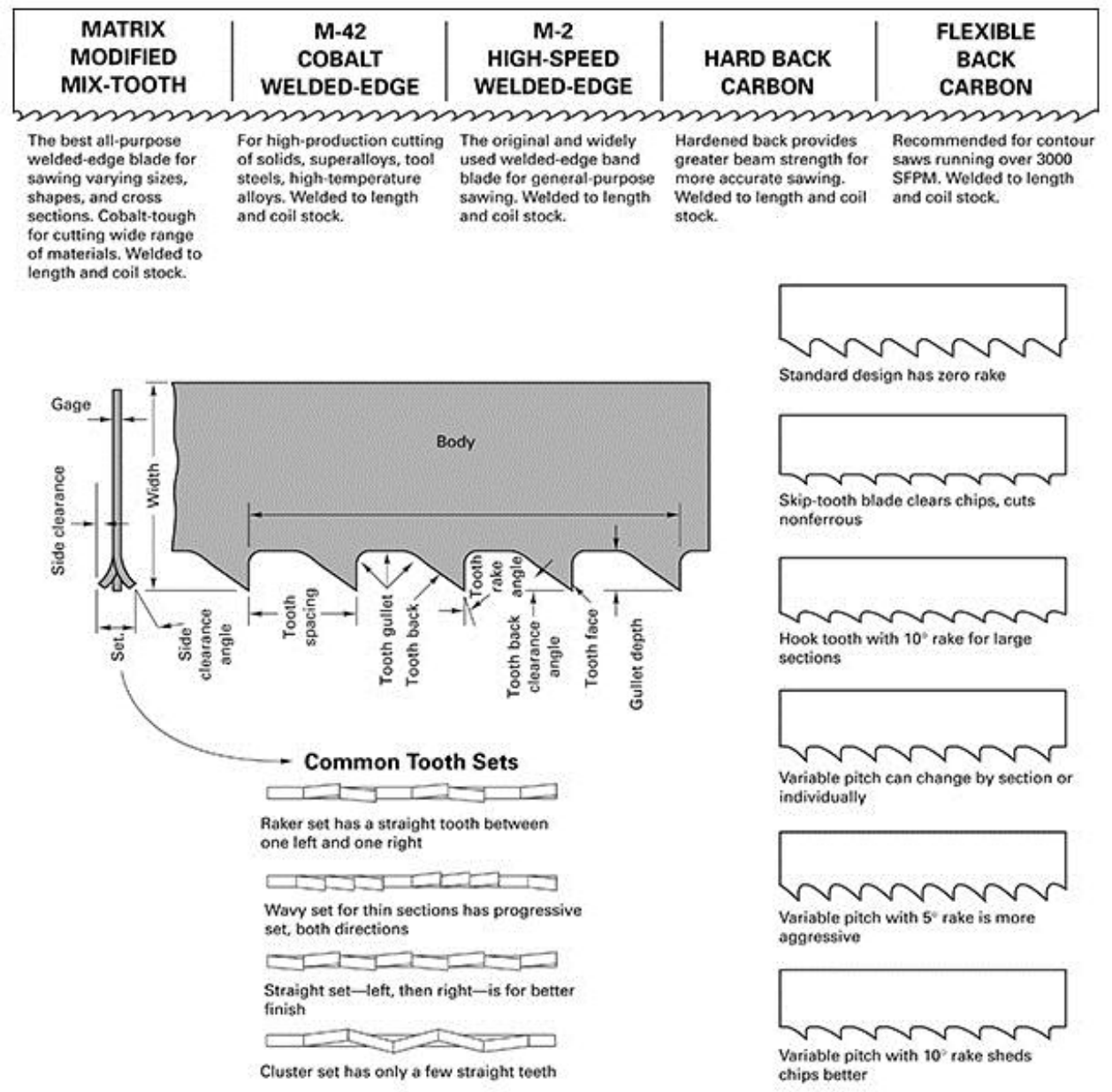


FIGURE 27-13 Bandsaw blade designs and nomenclature (above). Tooth set patterns (left) and tooth designs (right).

Types of Sawing Machines

- Metal-sawing machines may be classified as follows:
 - **1. Reciprocating saw**
 - **a. Manual hacksaw**
 - **b. Power hacksaw (Figure 27-15)**
 - **c. Abrasive disc**
 - **2. Bandsaw**
 - **a. Vertical cutoff (Figure 27-16)**
 - **b. Horizontal cutoff (Figure 27-17)**
 - **c. Combination cutoff and contour (Figure 27-18)**
 - **d. Friction**
 - **3. Circular saw (Figure 27-14)**
 - **a. Cold saw**
 - **b. Steel friction disk**

Circular Saw

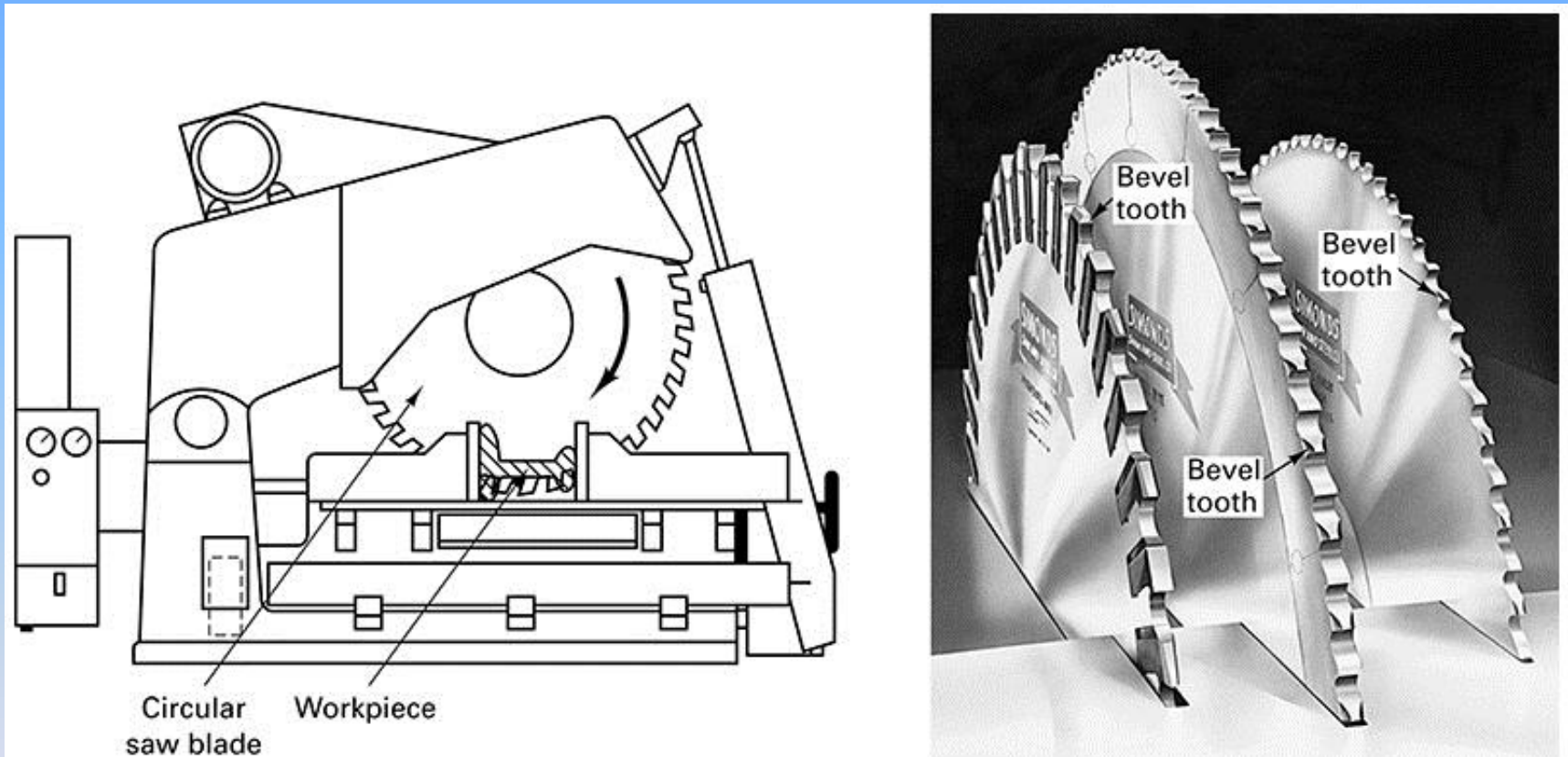


FIGURE 27-14 Circular sawing a structural shape, using (*left to right*) an insert tooth, a segmental tooth, and an integral-tooth circular saw blade.

Hacksaw

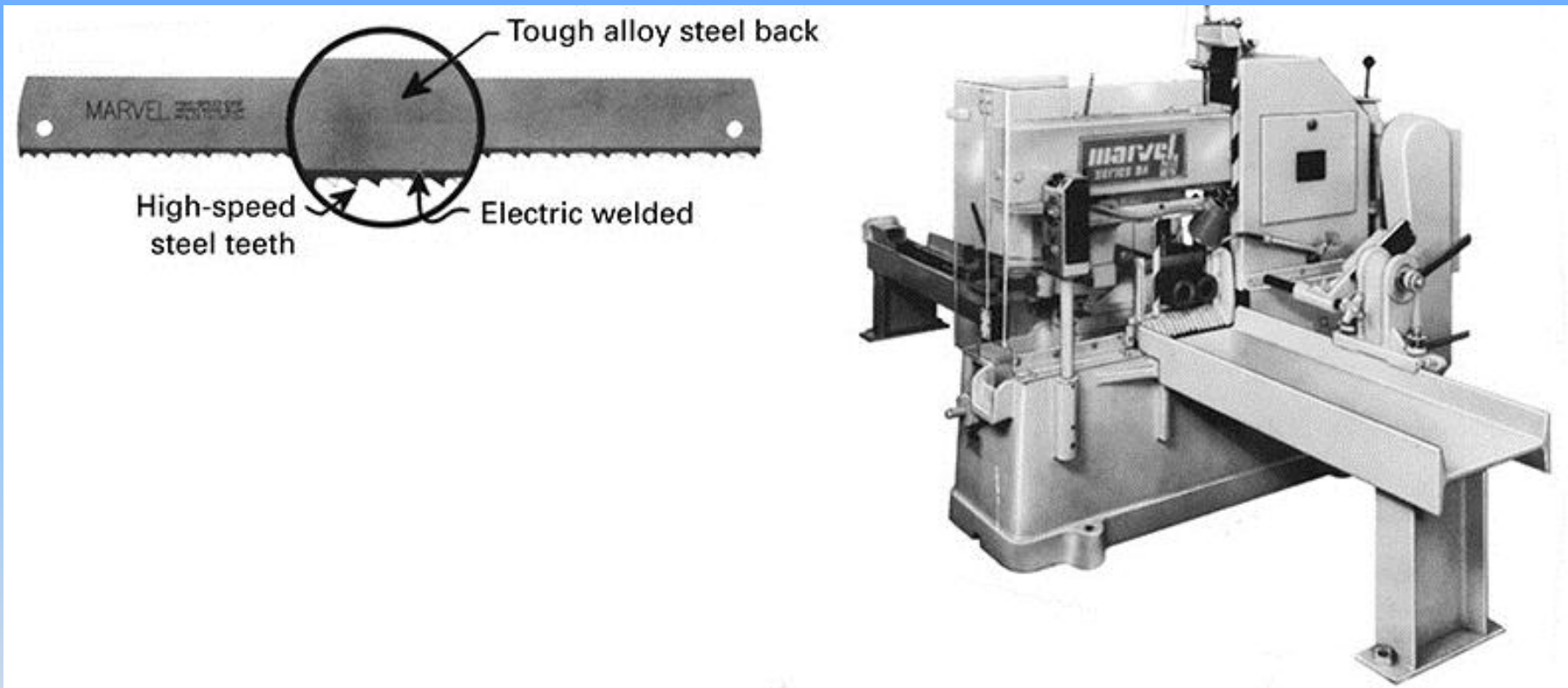
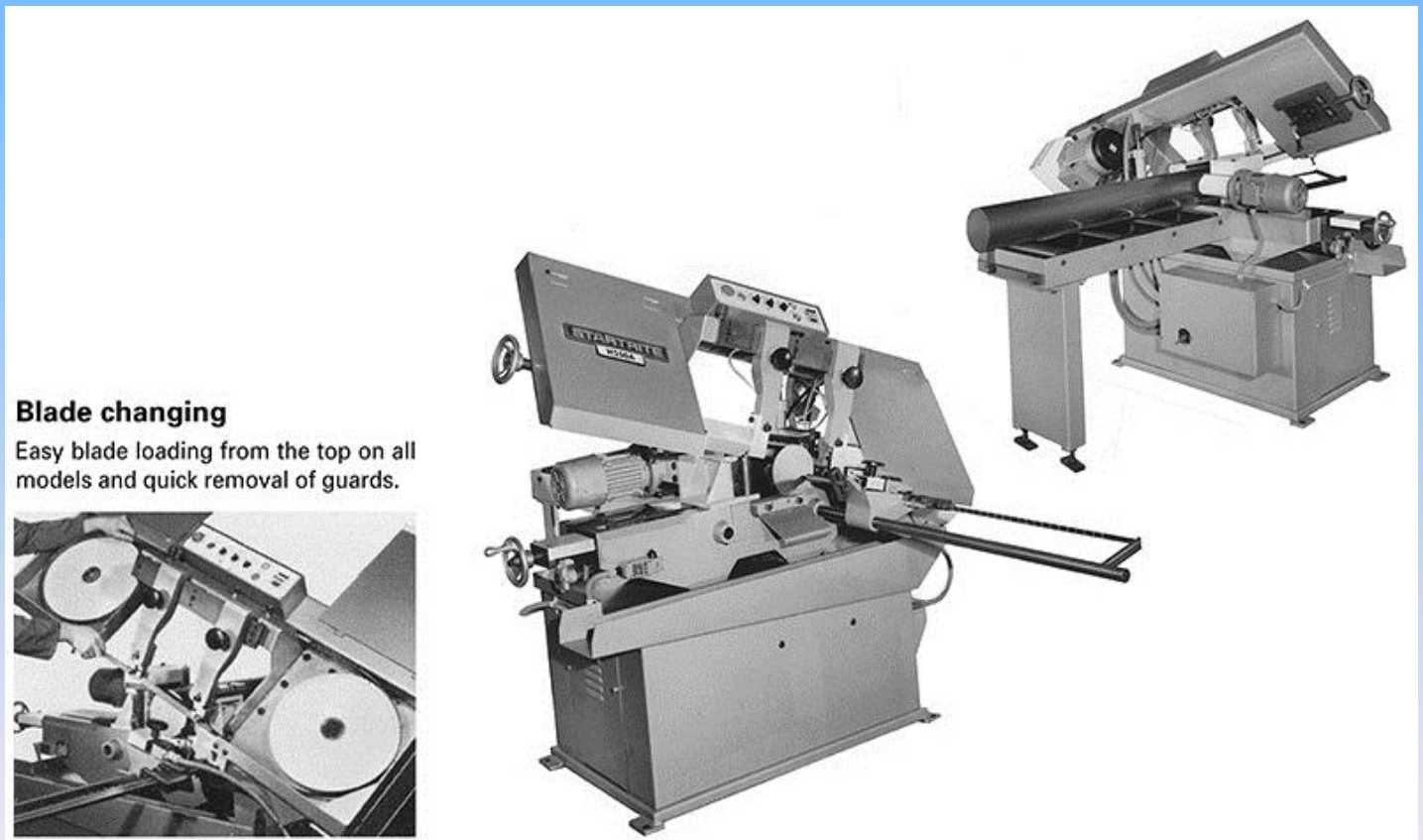


FIGURE 27-15 Power hacksaw blade (above) and hacksaw with automatic bar feeding (right) cutting two pieces of round stock.

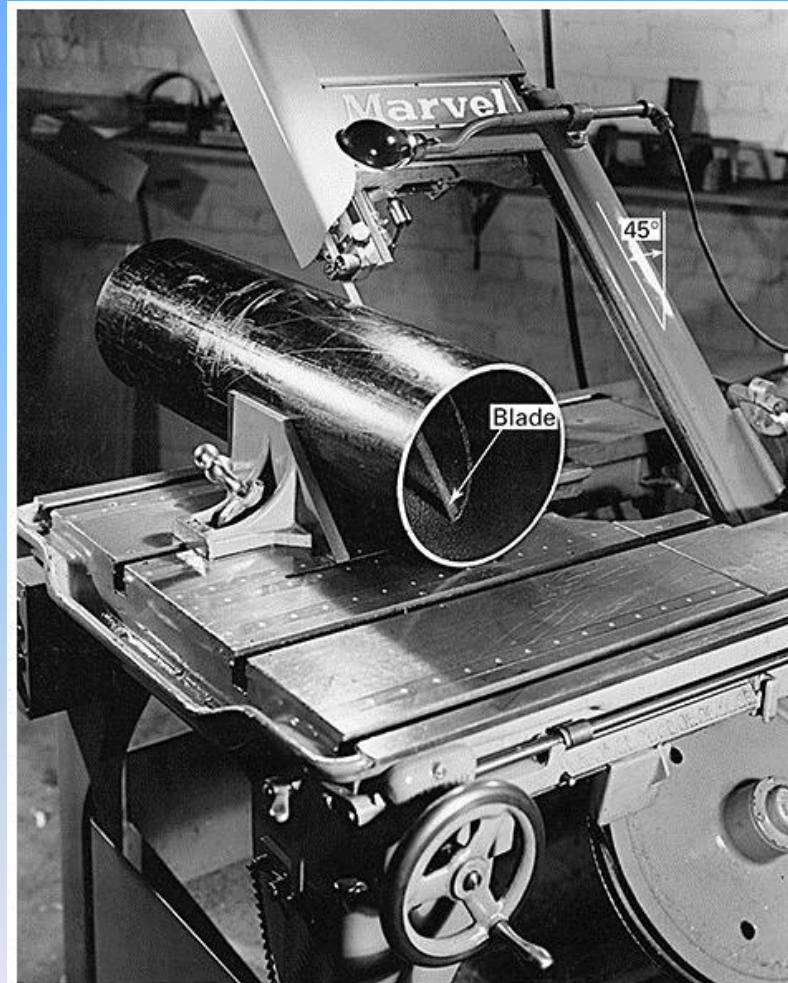
Horizontal Band Saw

FIGURE 27-16 Front view and rear view of a horizontal bandsawing machine sawing a cylinder of steel. Inset shows blade-changing operation.



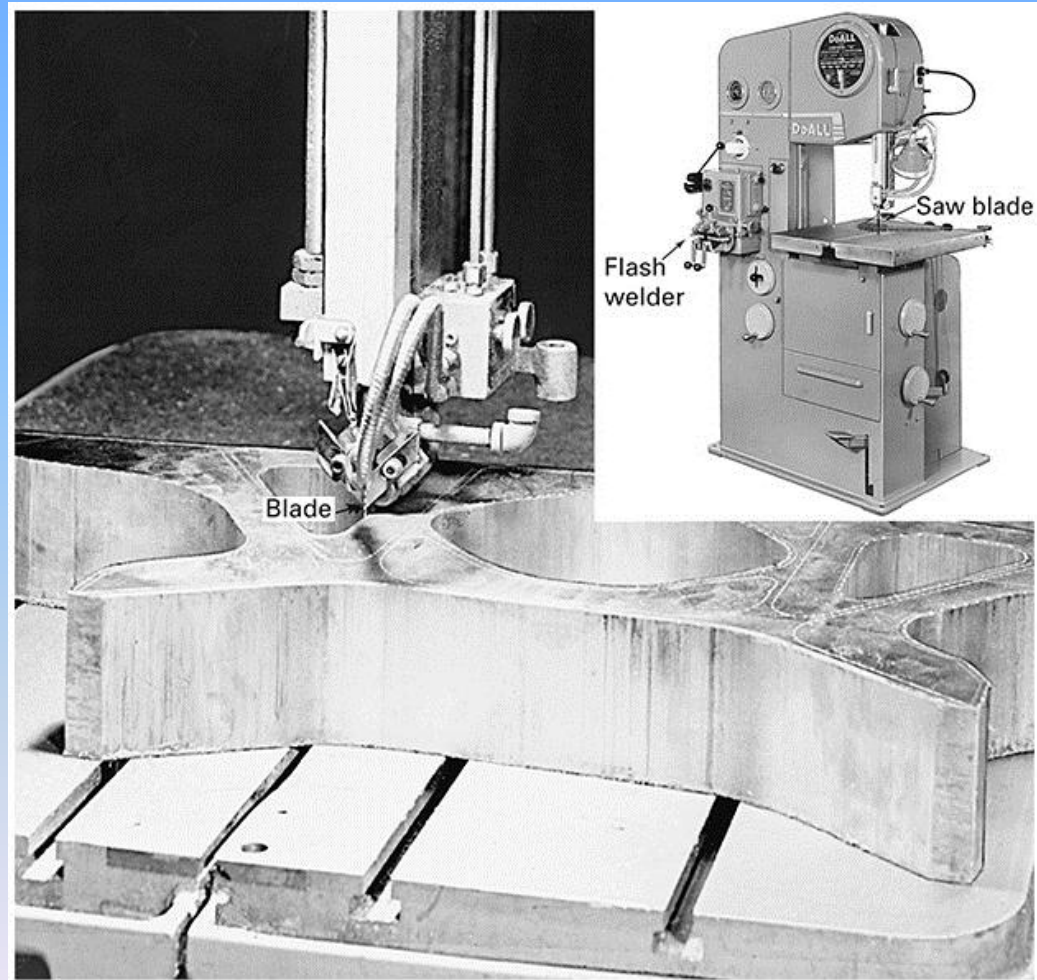
Vertical Bandsaw

FIGURE 27-17 Vertical bandsaw cutting a piece of pipe, showing head tilted 45°.



Contour Sawing

FIGURE 27-18 Contour bandsawing on vertical bandsawing machine, shown in inset.



27.7 Introduction to Filing

- The metal-removing action in filing is the same as in sawing, in that chips are removed by cutting teeth that are arranged in succession along the same plane on the surface of a tool, called a *file*.
- Files are classified according to the following:
 - 1. The type, or *cut*, of the teeth
 - 2. The degree of coarseness of the teeth
 - 3. Construction
 - a. Single solid units for hand use or in die-filing machines
 - b. Band segments, for use in band-filing machines
 - c. Disks, for use in disk-filing machines

File Types

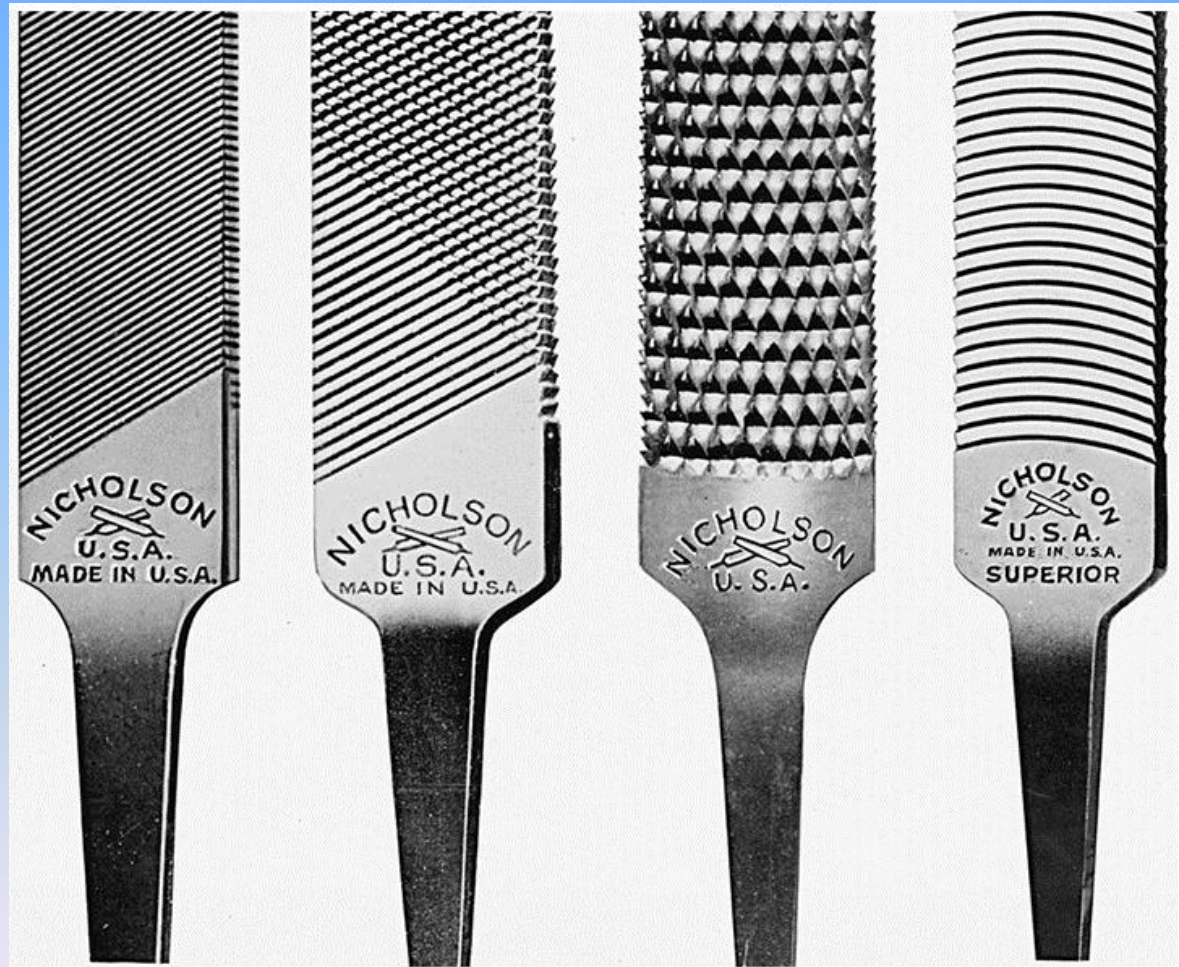
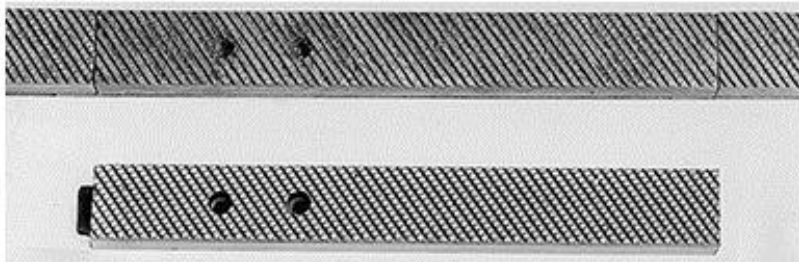


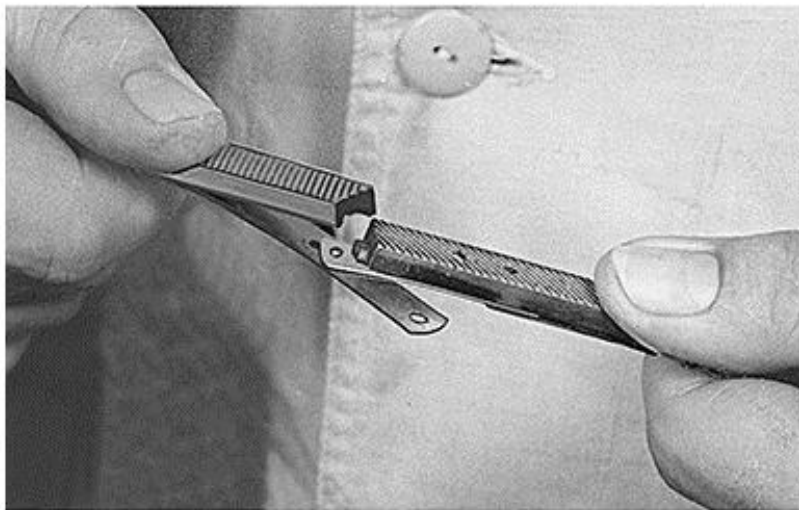
FIGURE 27-19 Four types of teeth (cuts) used in files. Left to right: Single, double, rasp, and curved (vixen). (Courtesy of Nicholson File Company.)

Band File Machines

FIGURE 27-20 Band file segments (a) are joined together to form a continuous band (b) which runs on a band-filing machine (c). (Courtesy of DoALL Co.)



(a)



(b)



(c)

Disk File Machine

FIGURE 27-21 Disk-type filing machine and some of the available types of disk files.
(Courtesy of Jersey Manufacturing Company.)

