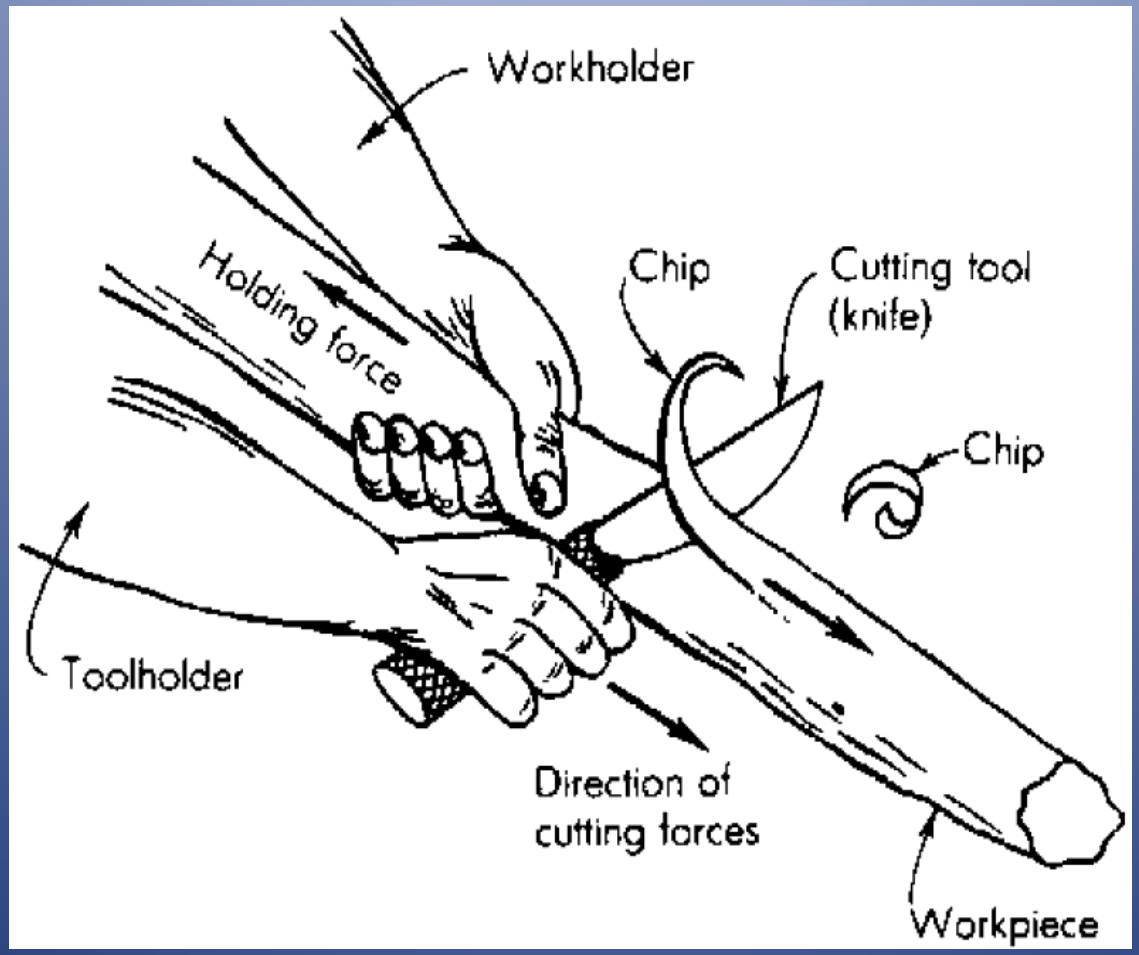
Work Holding Principles
ITCD – 301 - 001

Rajeev Madhavan Nair

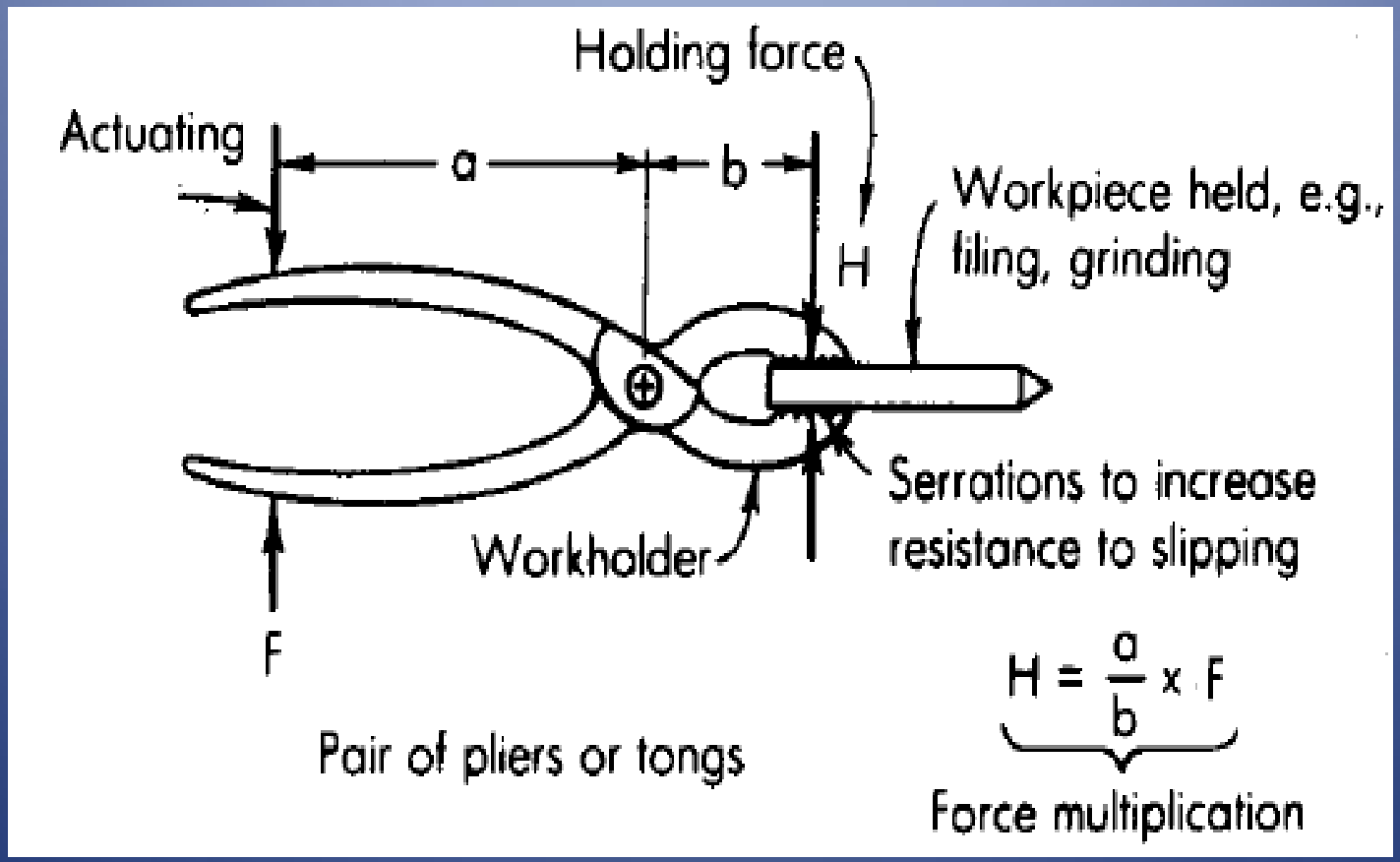
Work Holding

- One of the most important elements of the machining process
- Work holder includes all devices that hold, grip or chuck a work piece to perform a manufacturing operation
- Applied mechanically, electrically, hydraulically or pneumatically

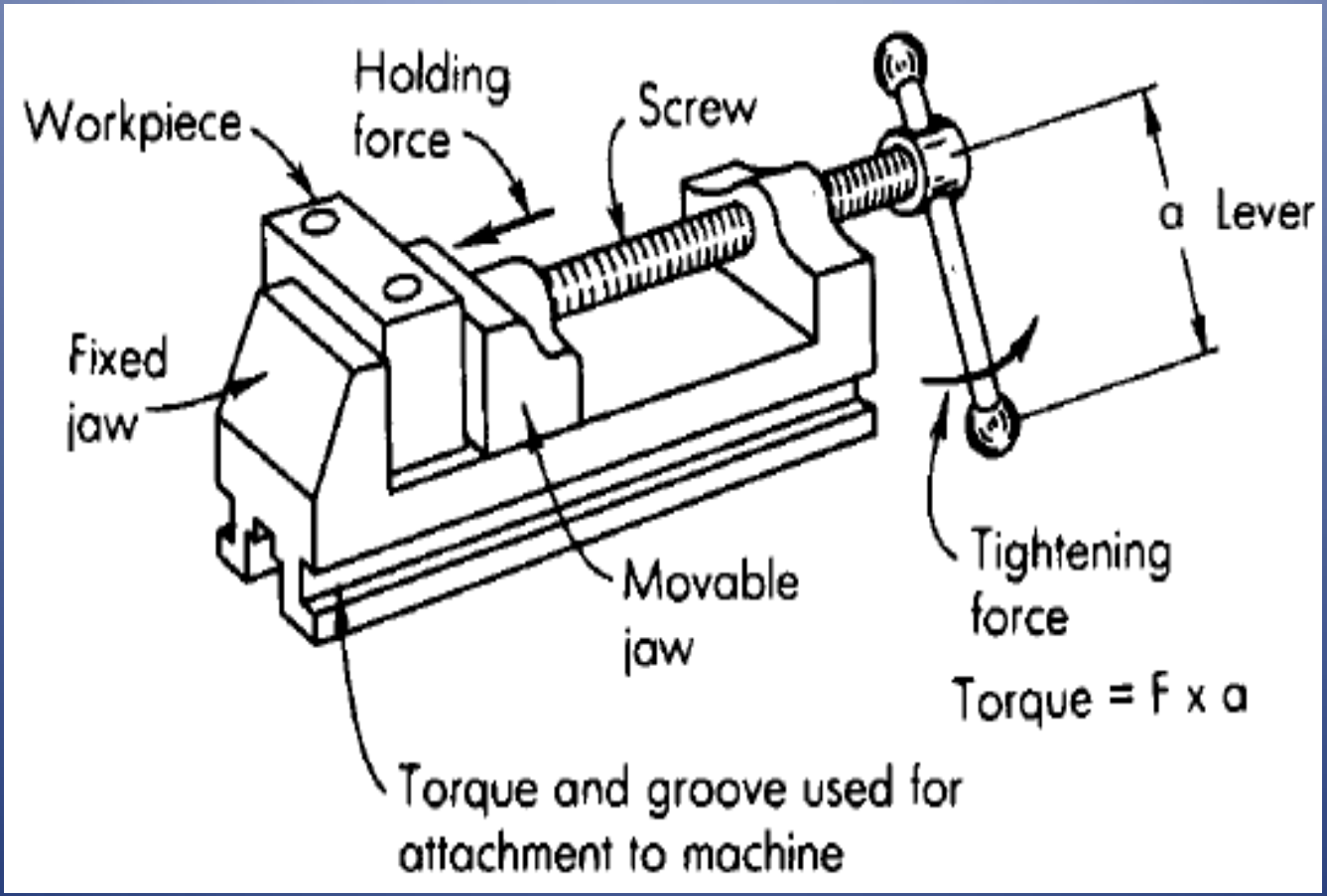
Principles


Workholder
Holding force
Chip
Cutting tool
(knife)
Chip
Toolholder
Direction of
cutting forces
Workpiece

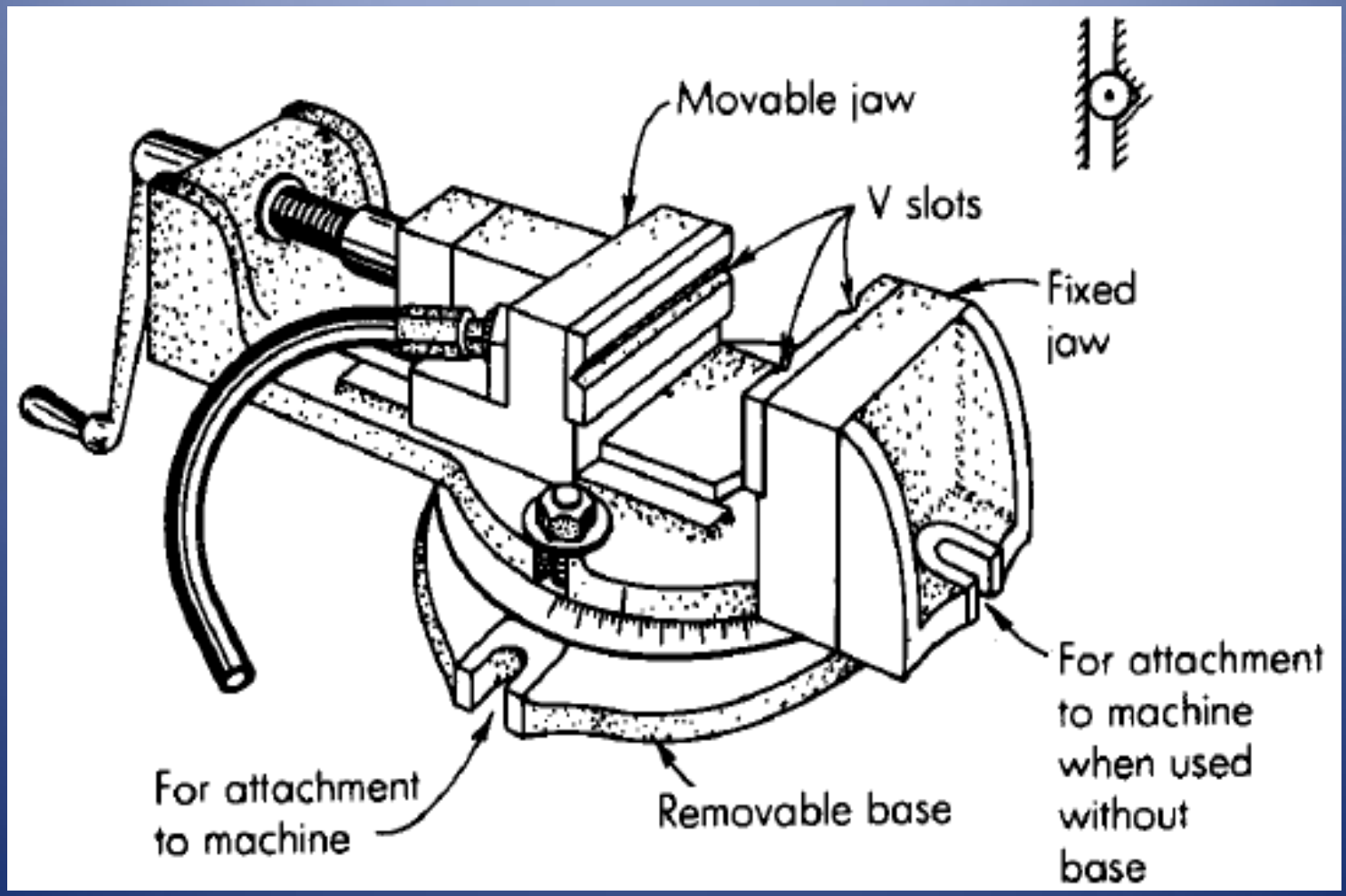
Multiplication of holding force



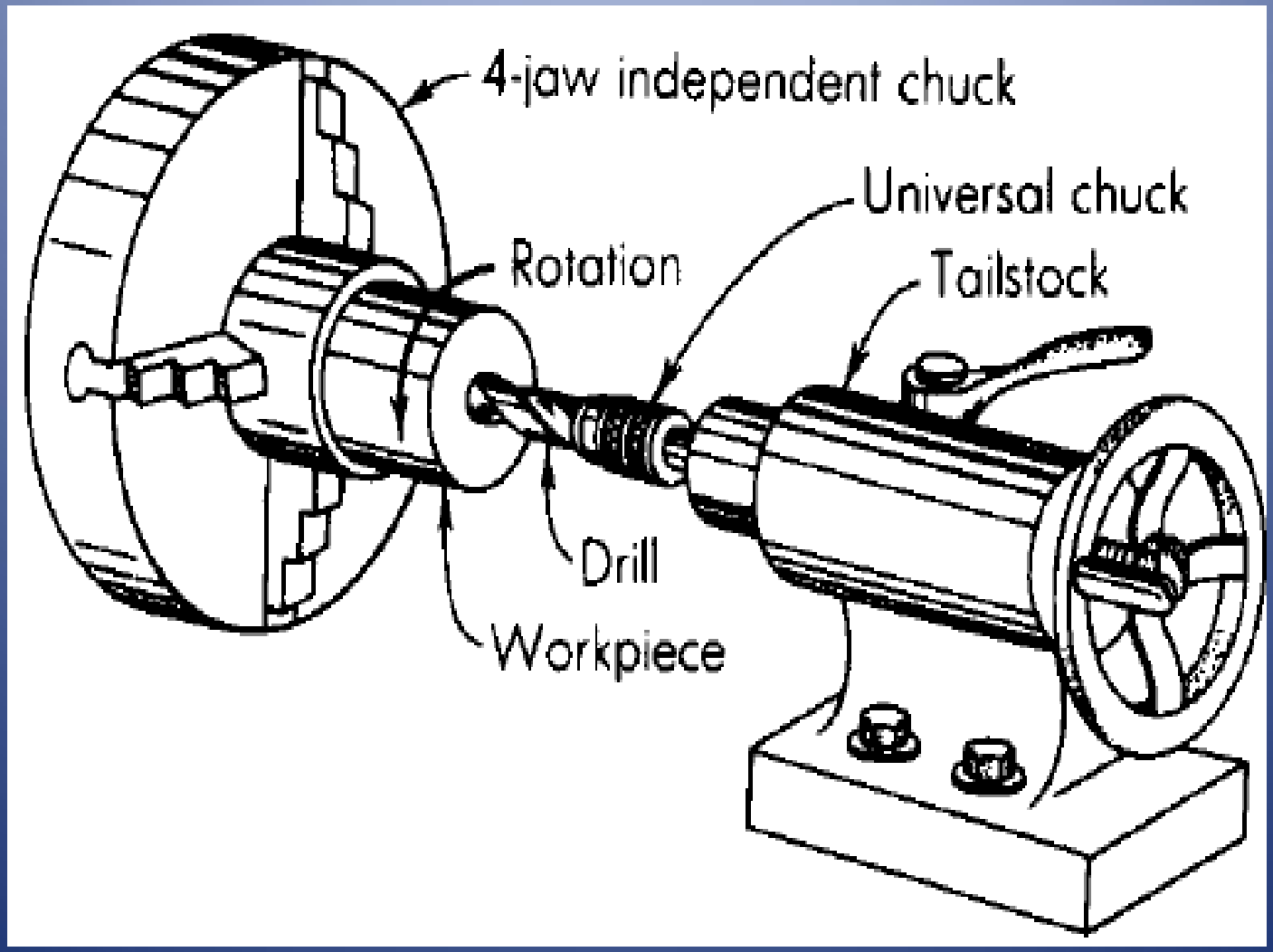
Elementary work holder (vise)



Hydraulic clamping vise



Holding a round workpiece



Purpose and function

- Location
- Clamping
- Support
- Precision
- Withstand cutting forces
- Apply holding forces
- Safety

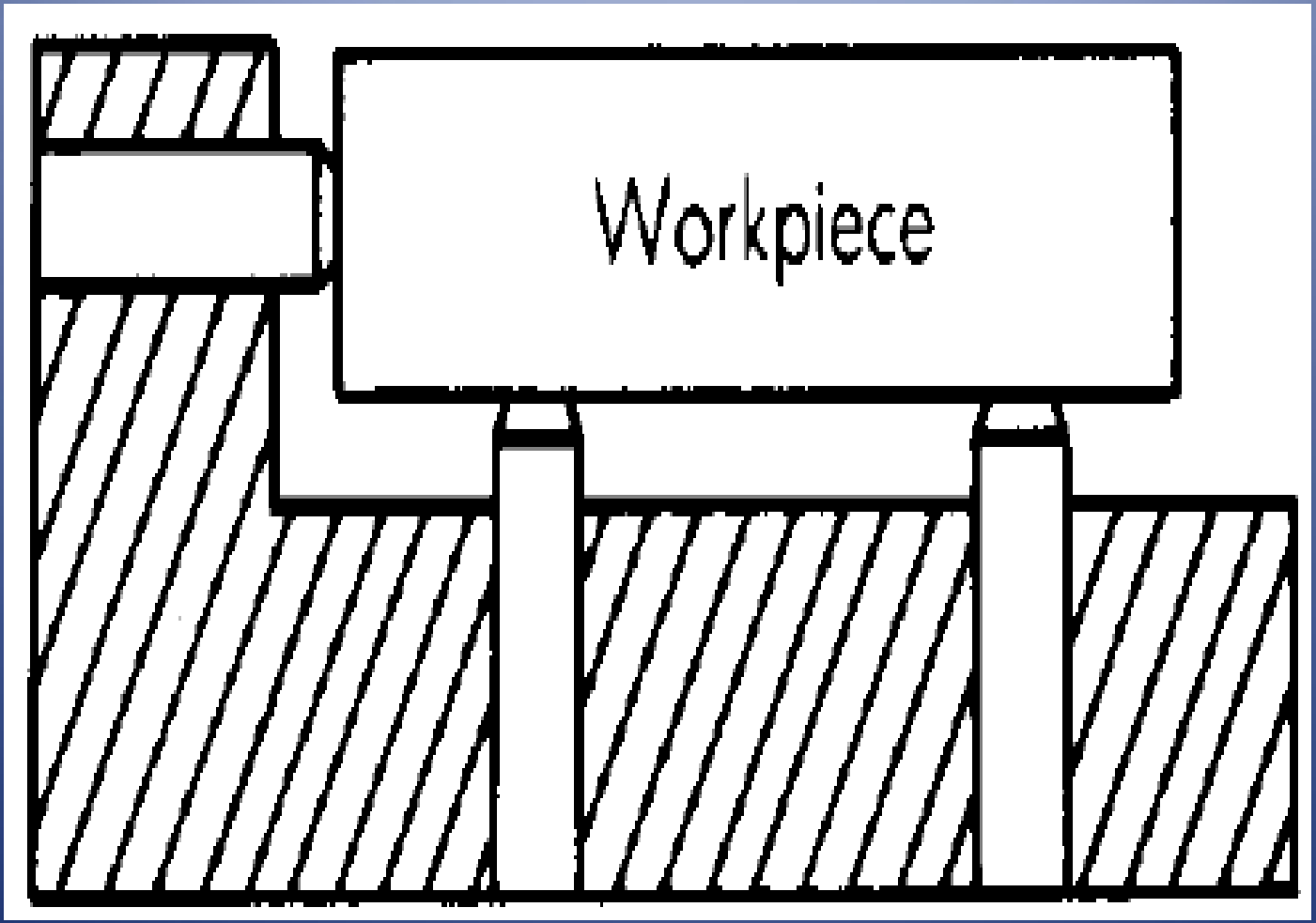
General Considerations

- Physical characteristics of the workpiece
  - Degree of precision
  - Strength and stiffness of workpiece
  - Production requirements
  - Safety requirements
- Use standard work holders

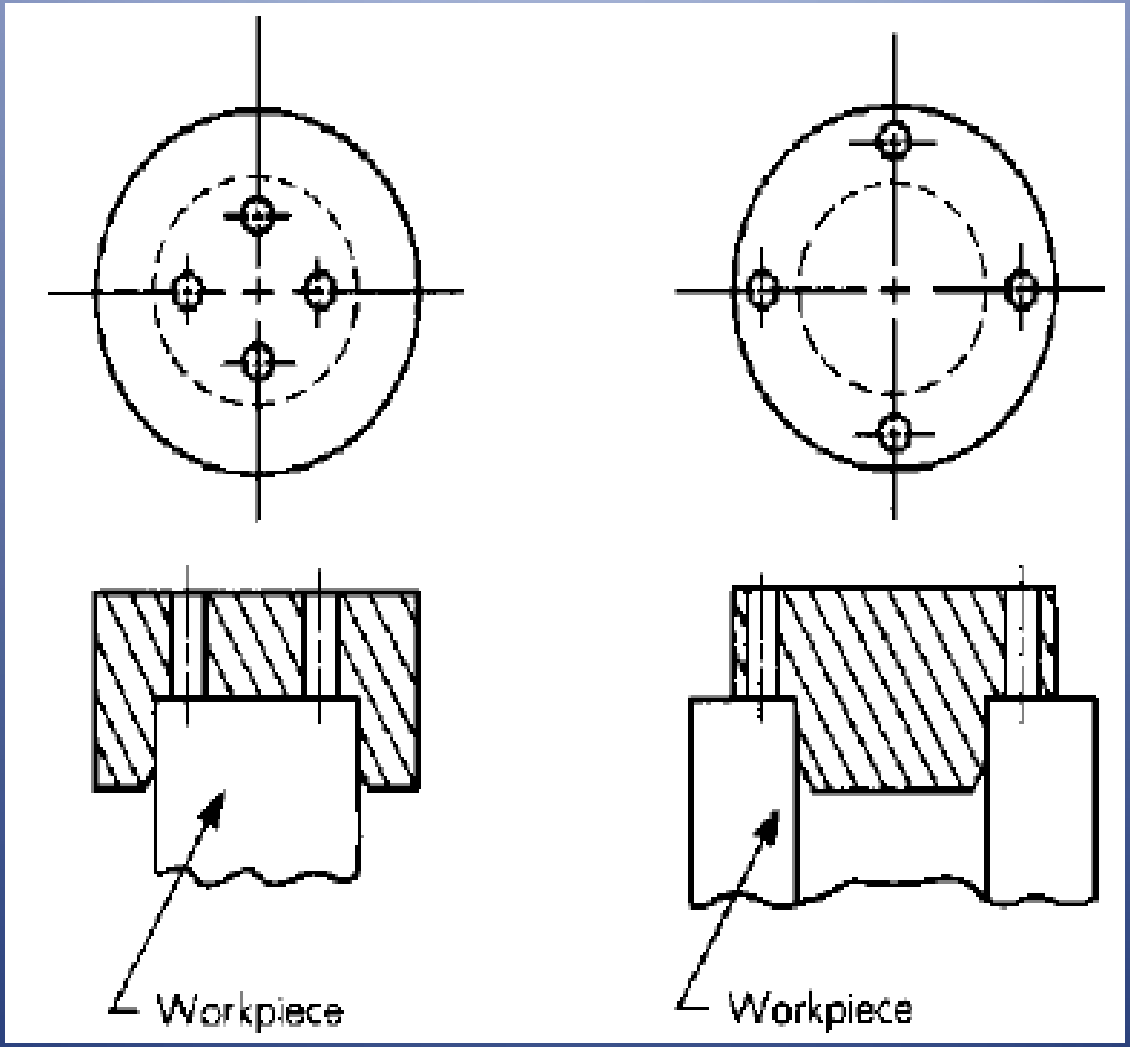
Locating Principles

- Work piece surfaces
  - Flat surfaces
  - Cylindrical surfaces
  - Irregular surfaces
- Types of Location
  - Plane
  - Concentric
  - Combined
  - Radial

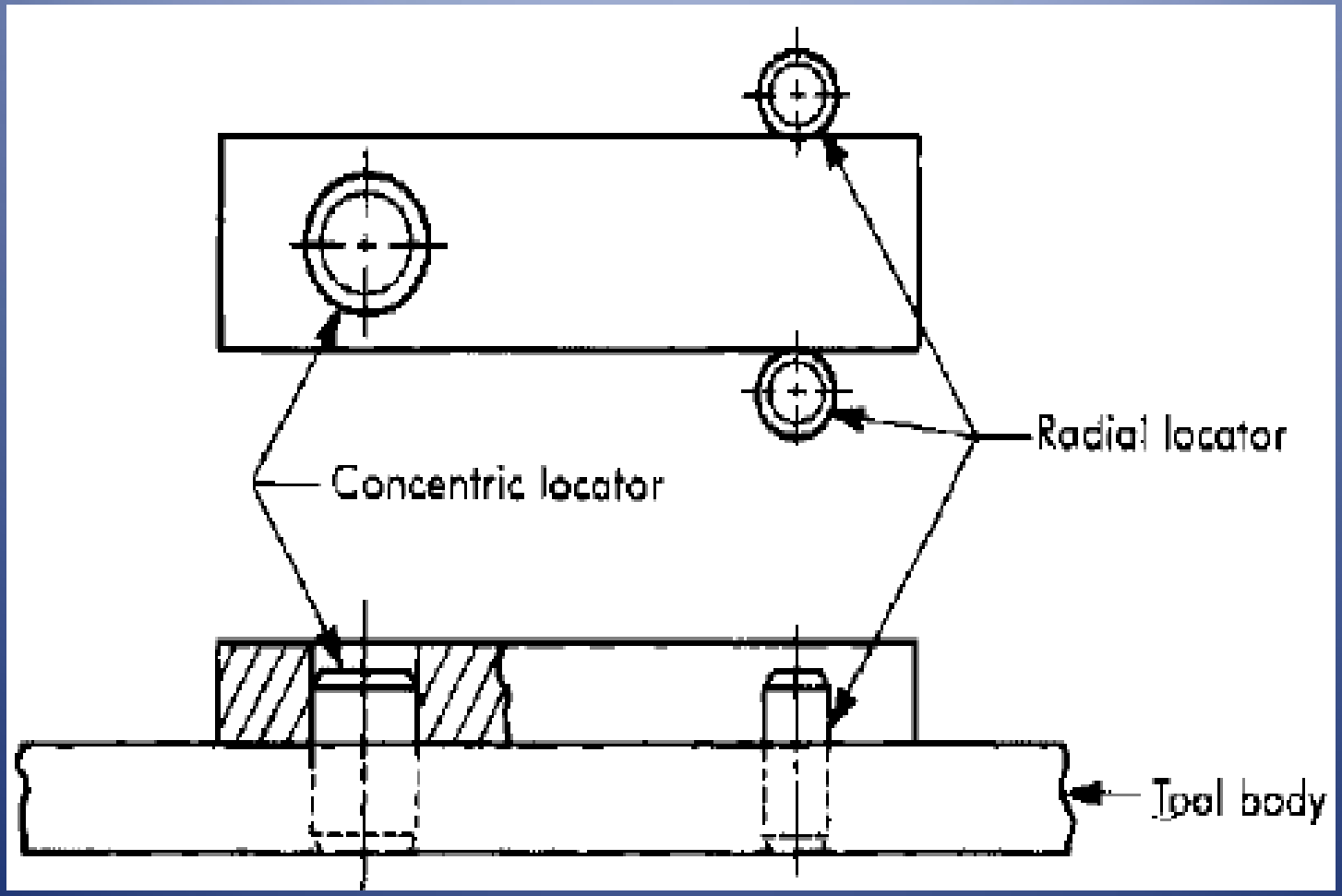
Plane Location



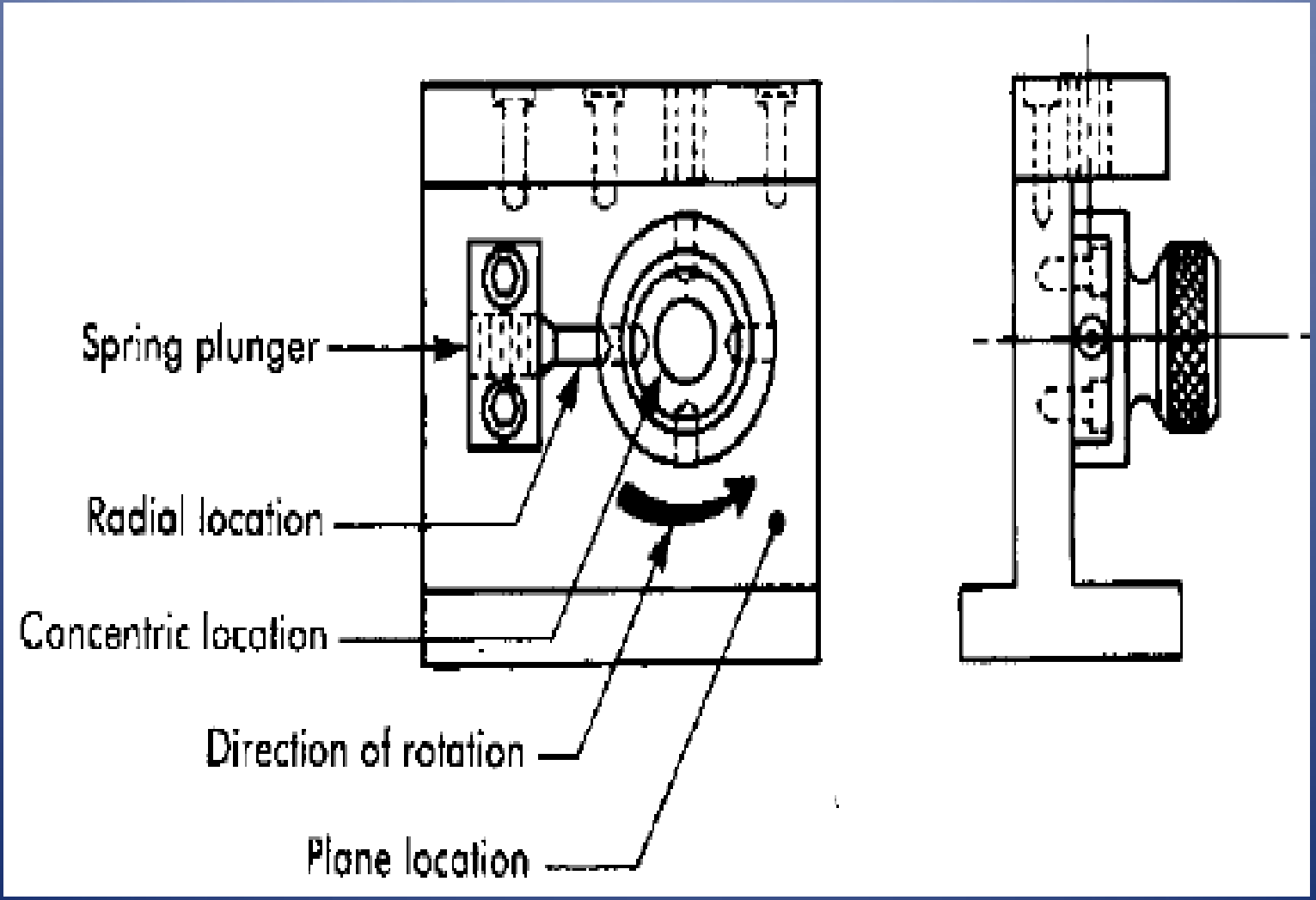
Concentric location



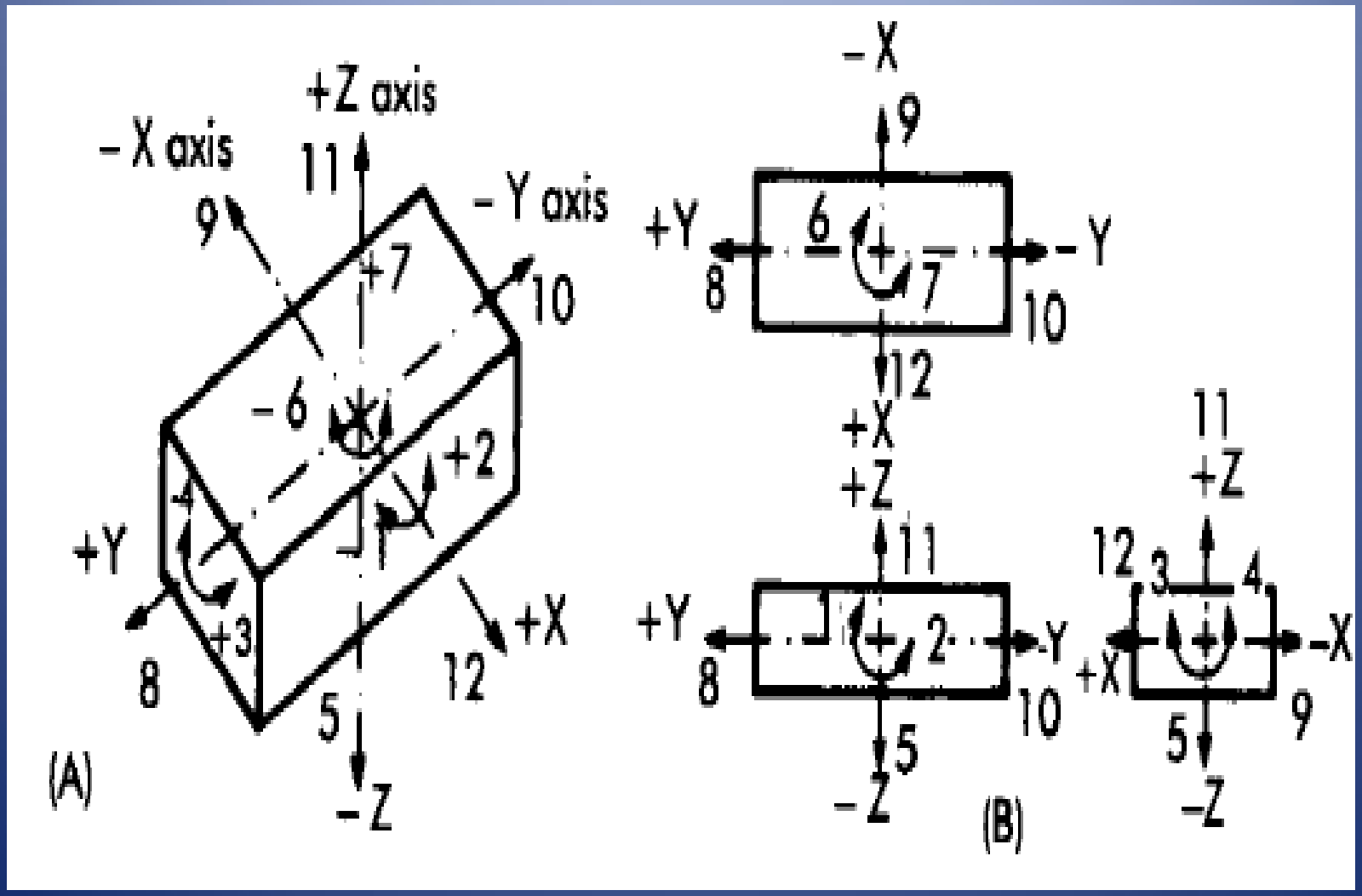
Radial location



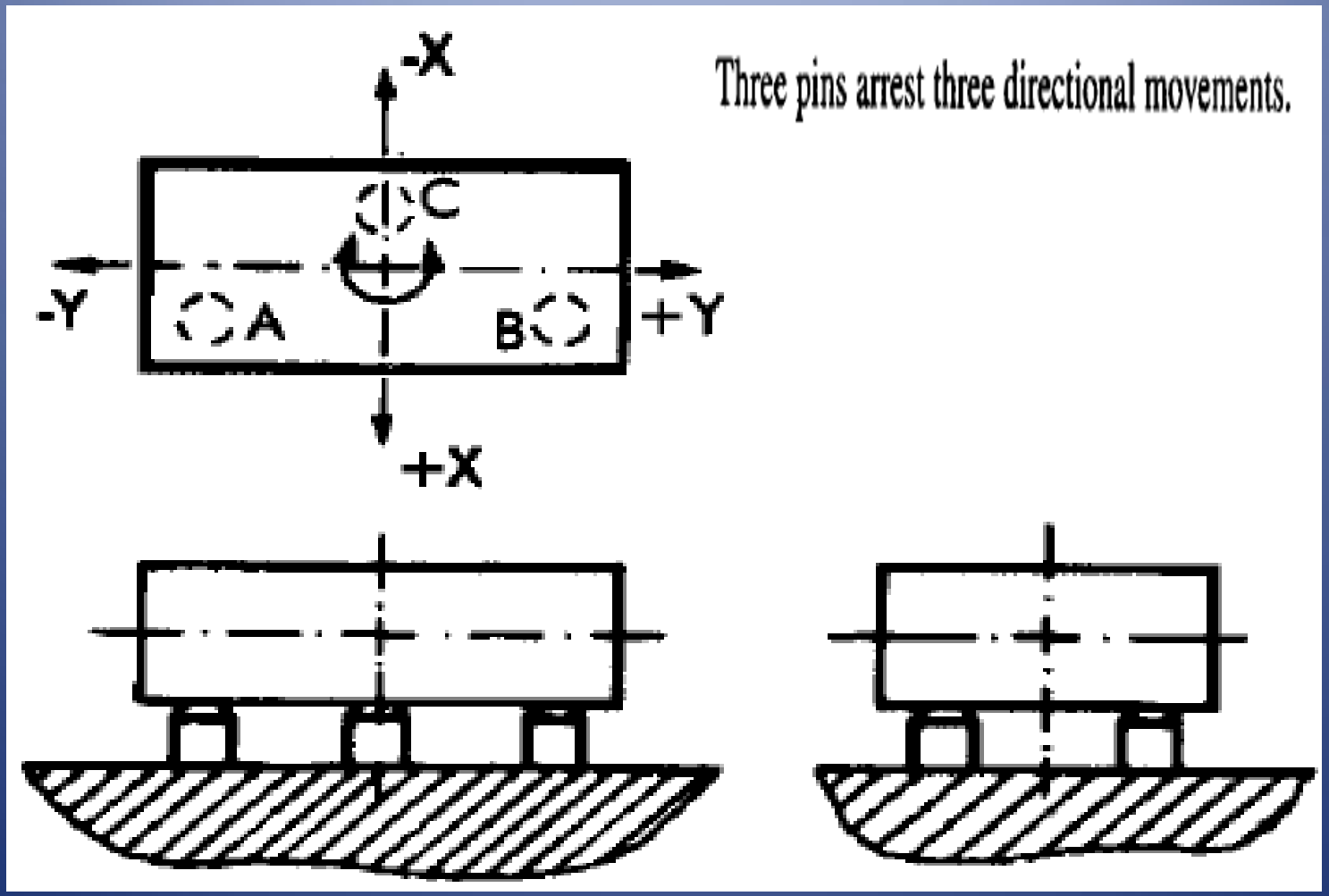
Combined location



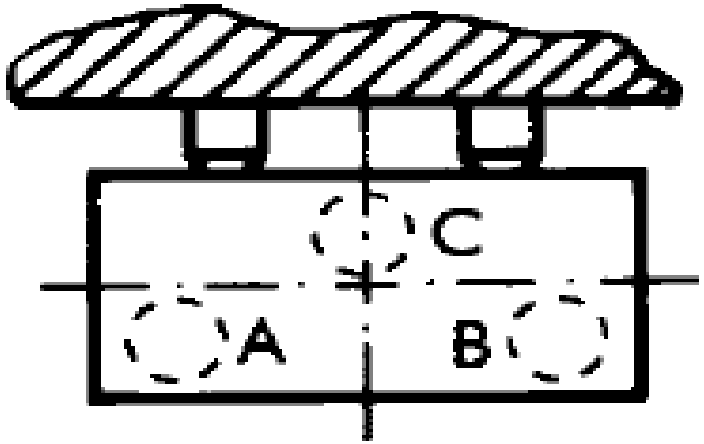
Degrees of freedom



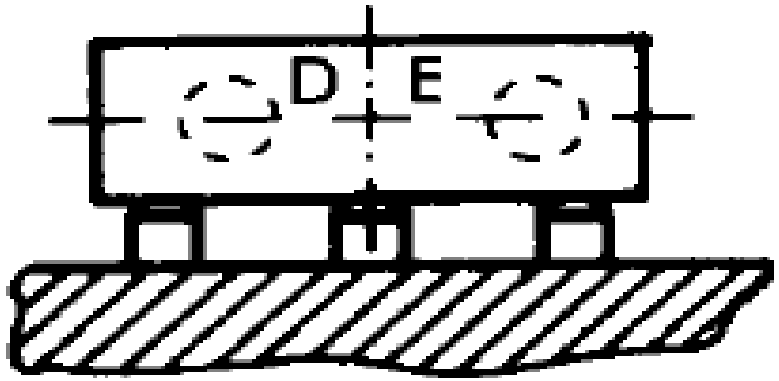
Method of location

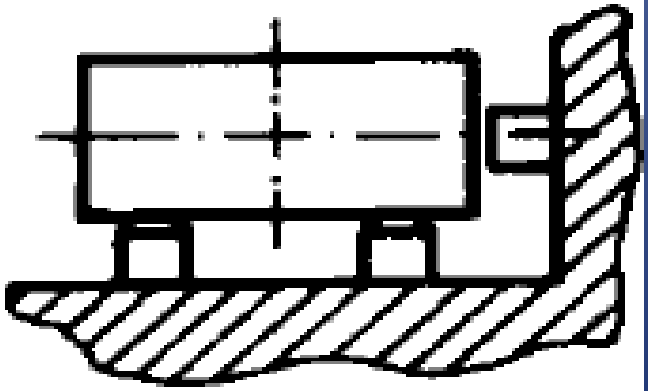


Method of location (contd.)

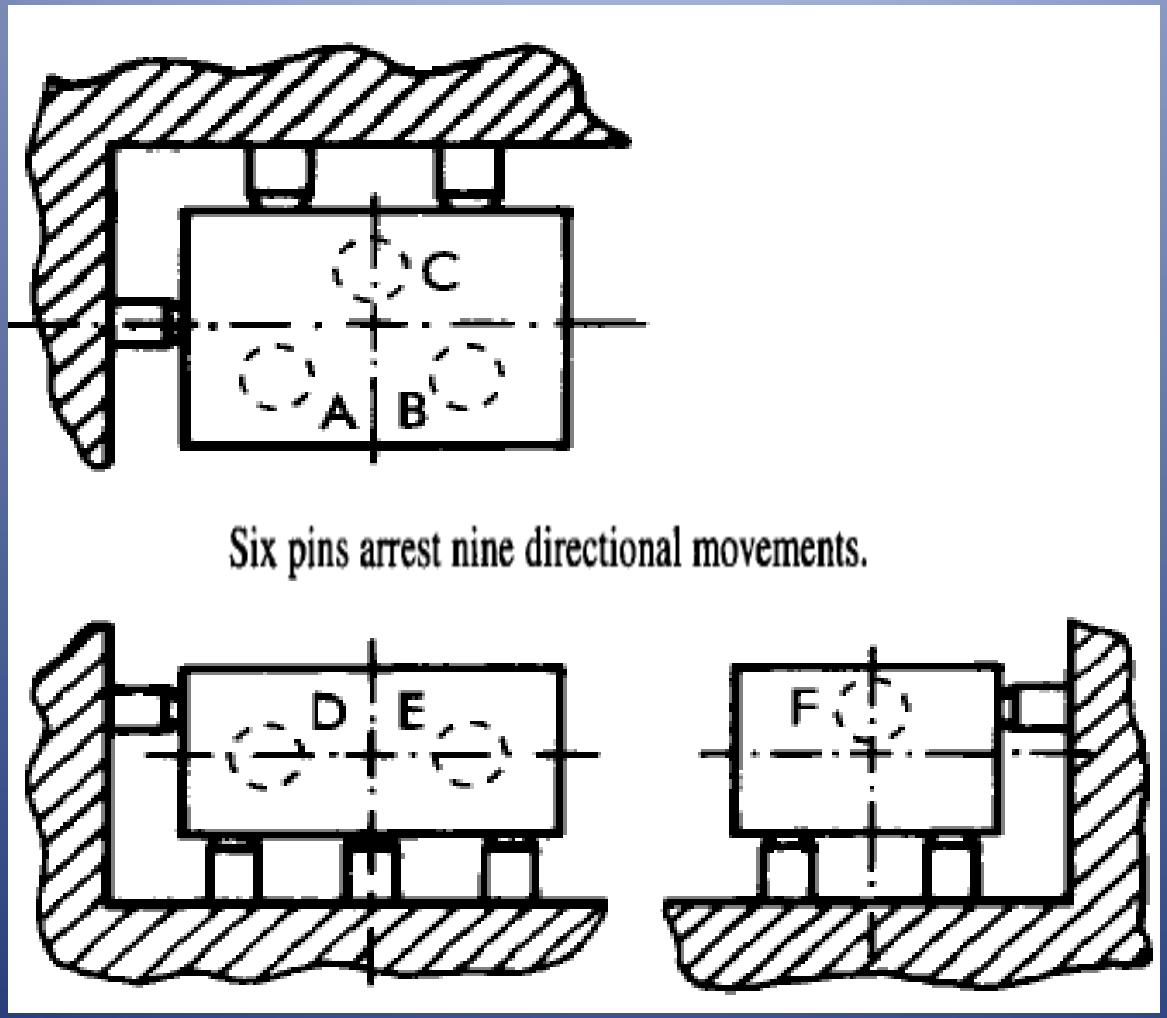


Five pins arrest eight directional movements.



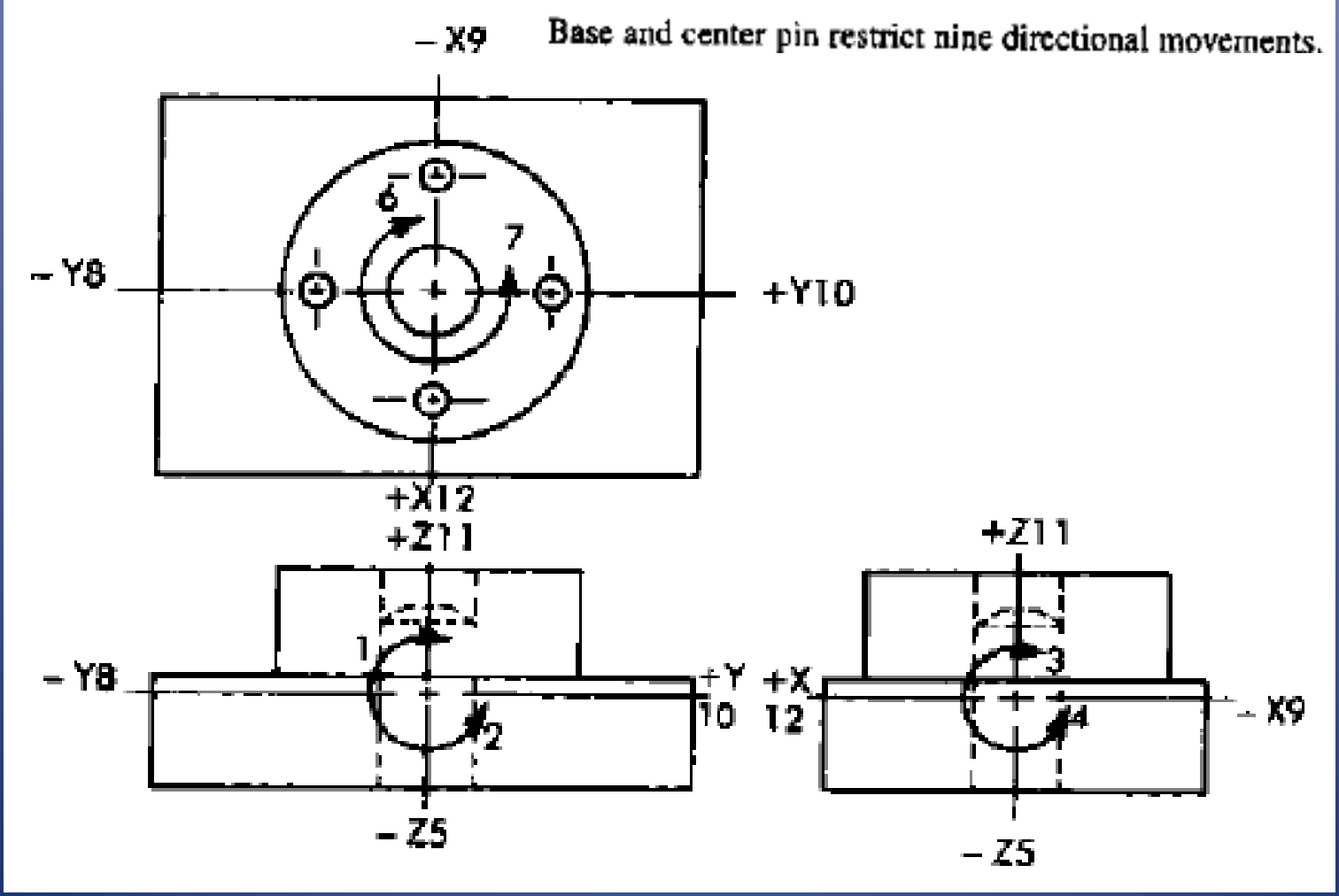


Method of location (contd.)

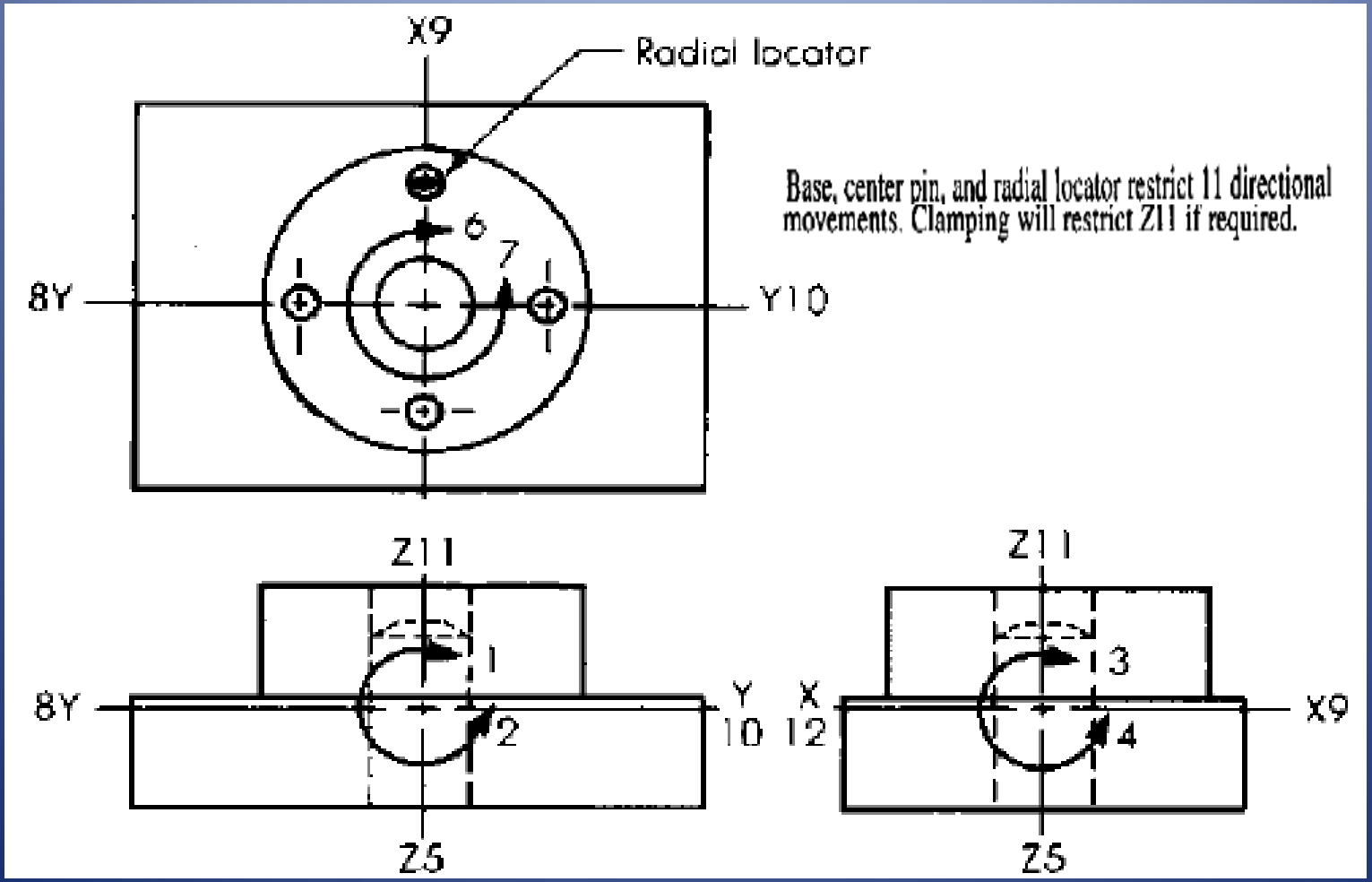


Six pins arrest nine directional movements.

Concentric location



Radial location



Basic locating rules

- Position and number of locators
- Redundant locators
- Locational tolerances
- Fool proofing

Placement rules

- When more than one locator is placed on a surface, they should be distributed as far as possible on the surface

- This would help in placing the work piece on locators without much skill

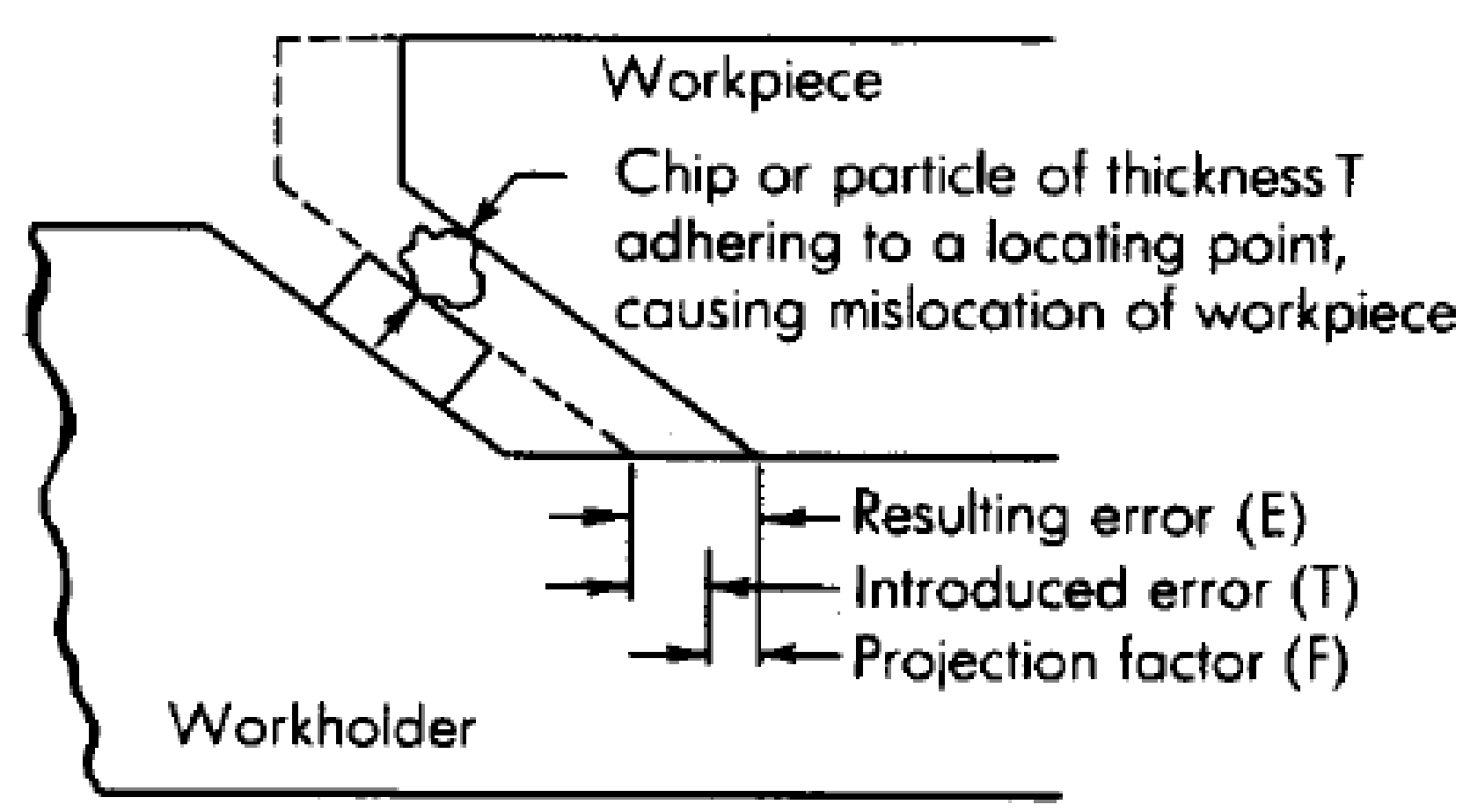
- Also the clamping force would not be able to shift the work piece from such locators

- A blank with irregular surface (such as sand casting) would be better located on such distributed locators

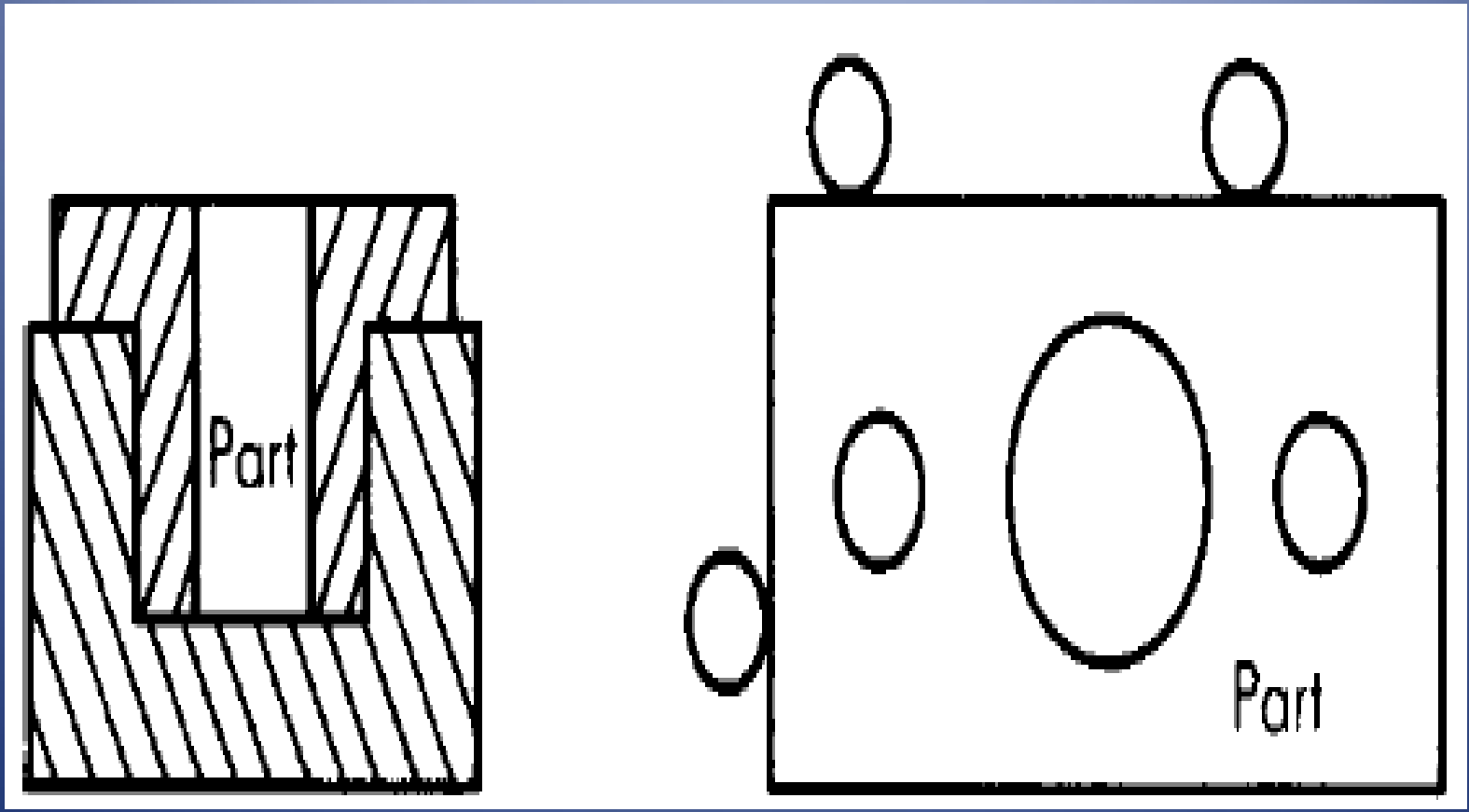
Placement rules (contd.)

- Machining forces would not be able to disturb the equilibrium of the work piece in the fixture with properly distributed locators
- Wear of any locator contributes less to the inaccuracy of location if the locators are placed far apart
- While selecting the surface for the largest locators, consideration should be given to the largest area of the work piece
- The two locators should be placed on the surface with the next largest area and the single locator on the surface with the least surface area

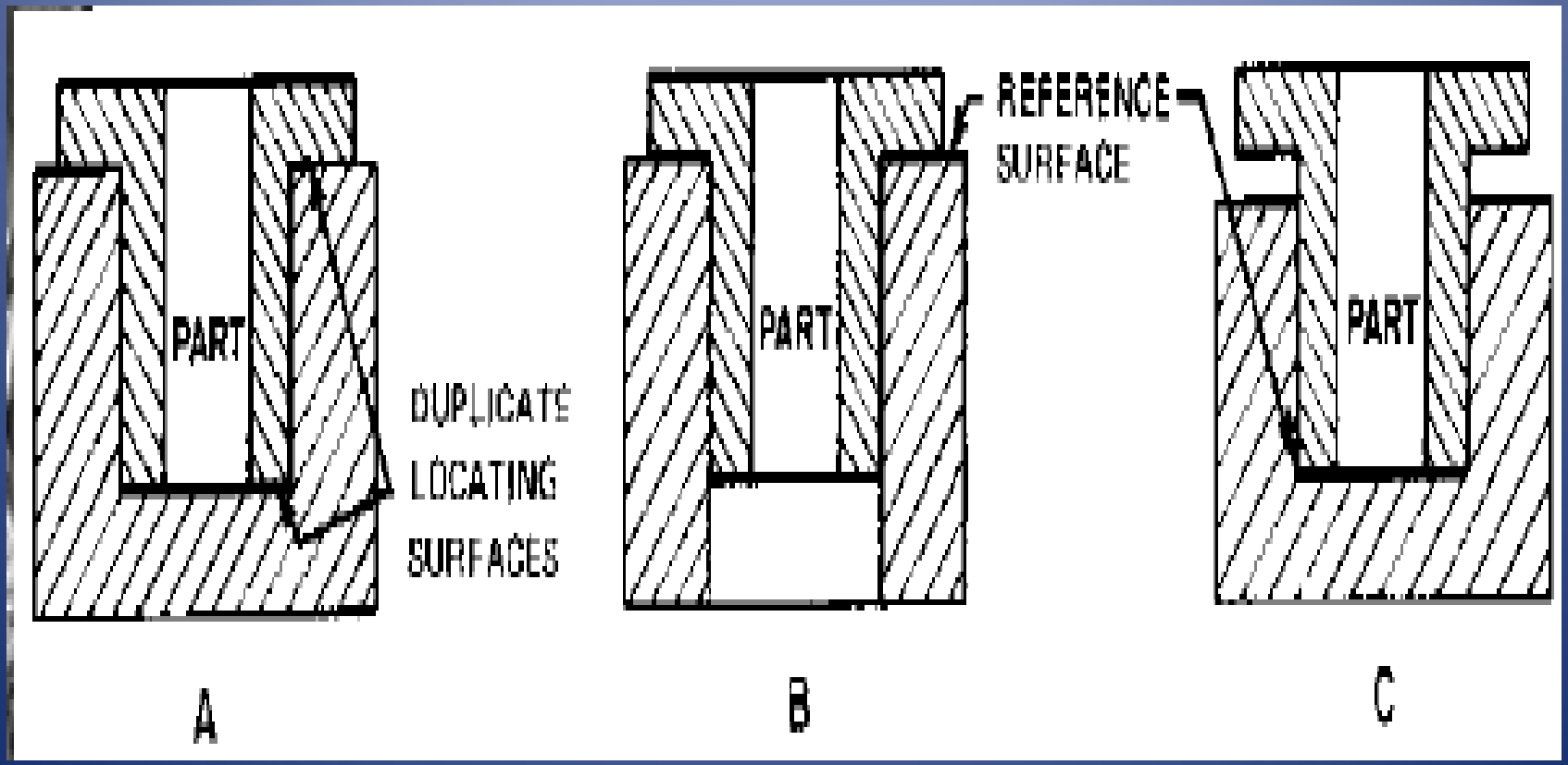
Magnification and projection of error



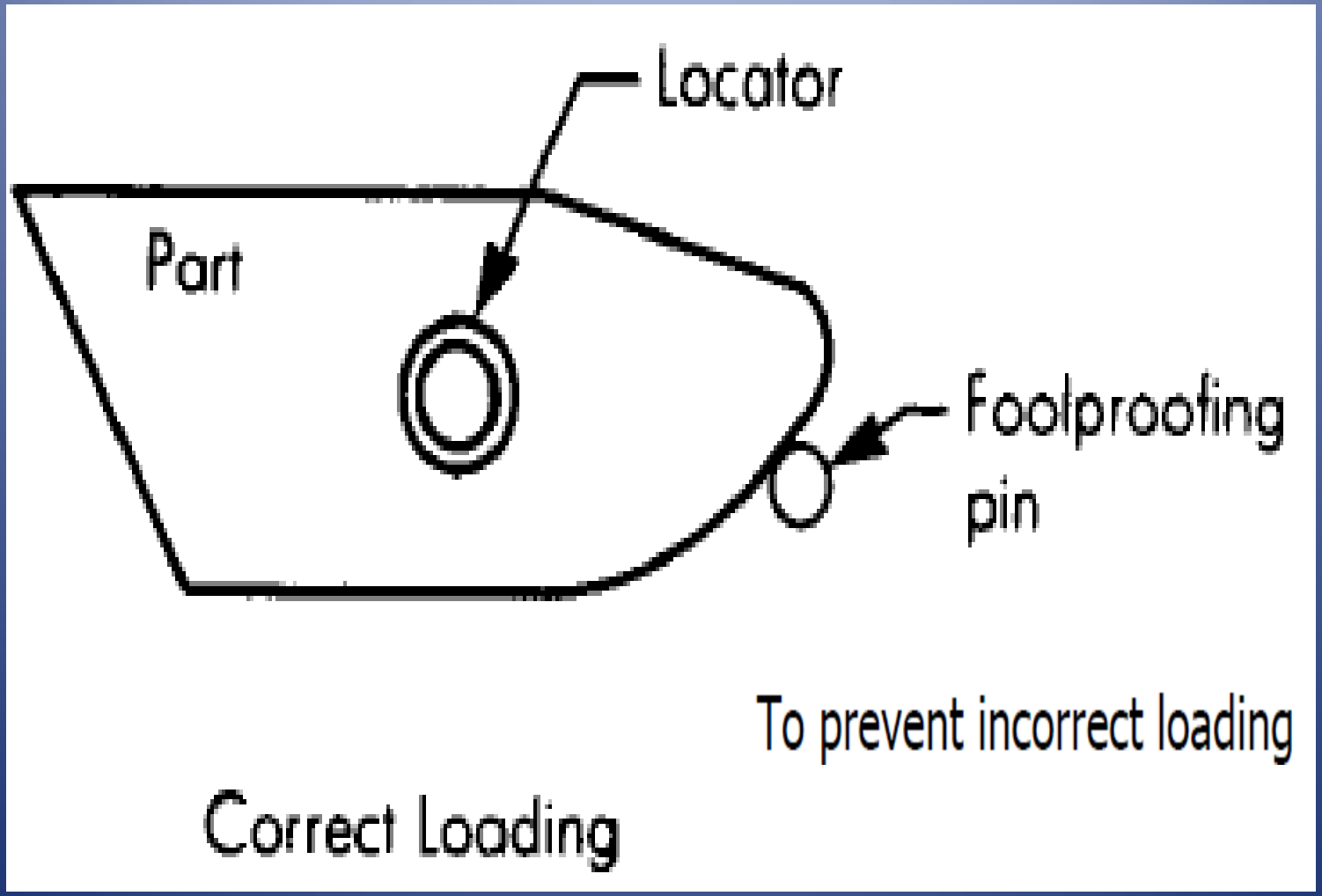
Redundant locators



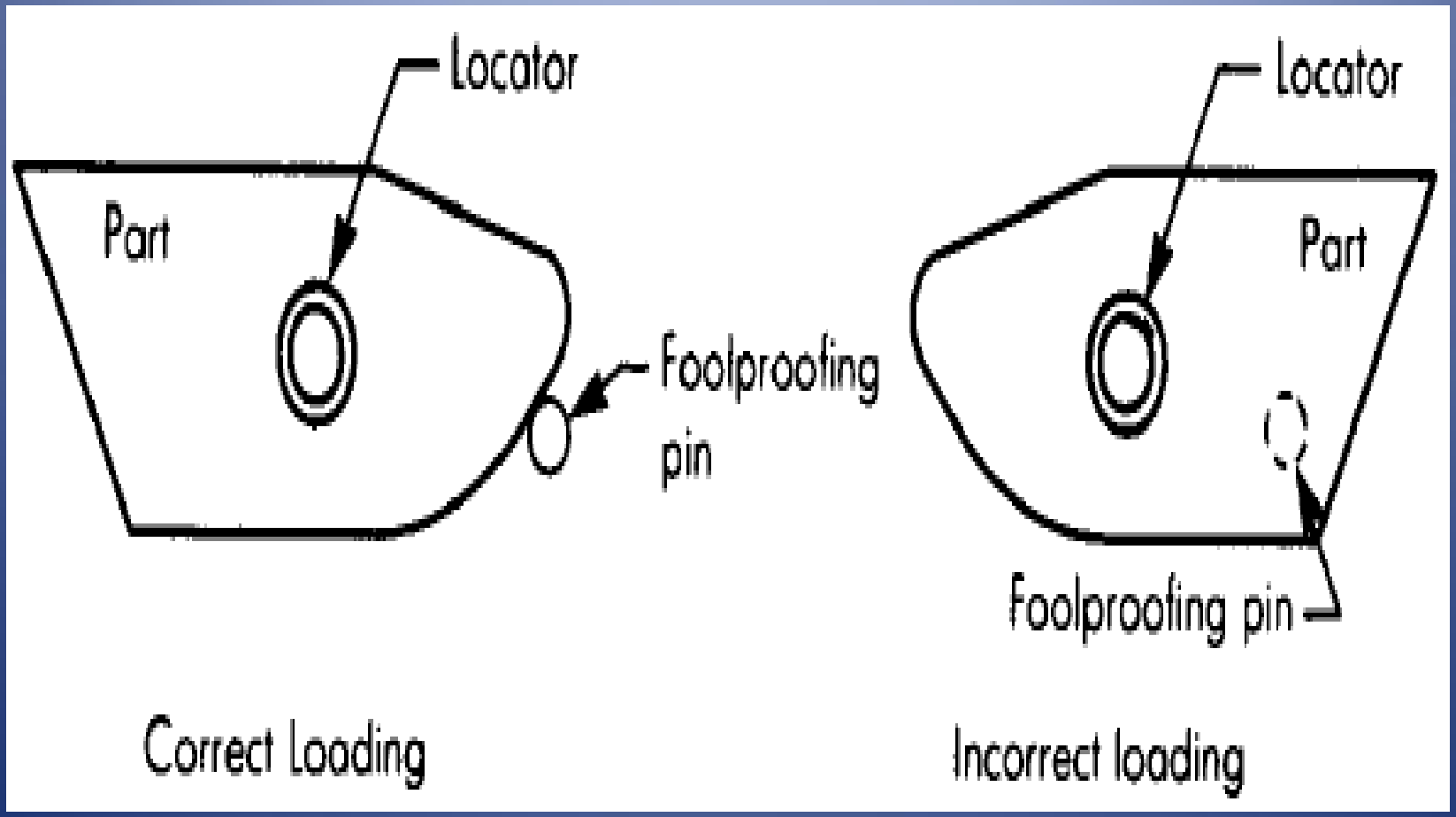
Redundant locators (contd.)



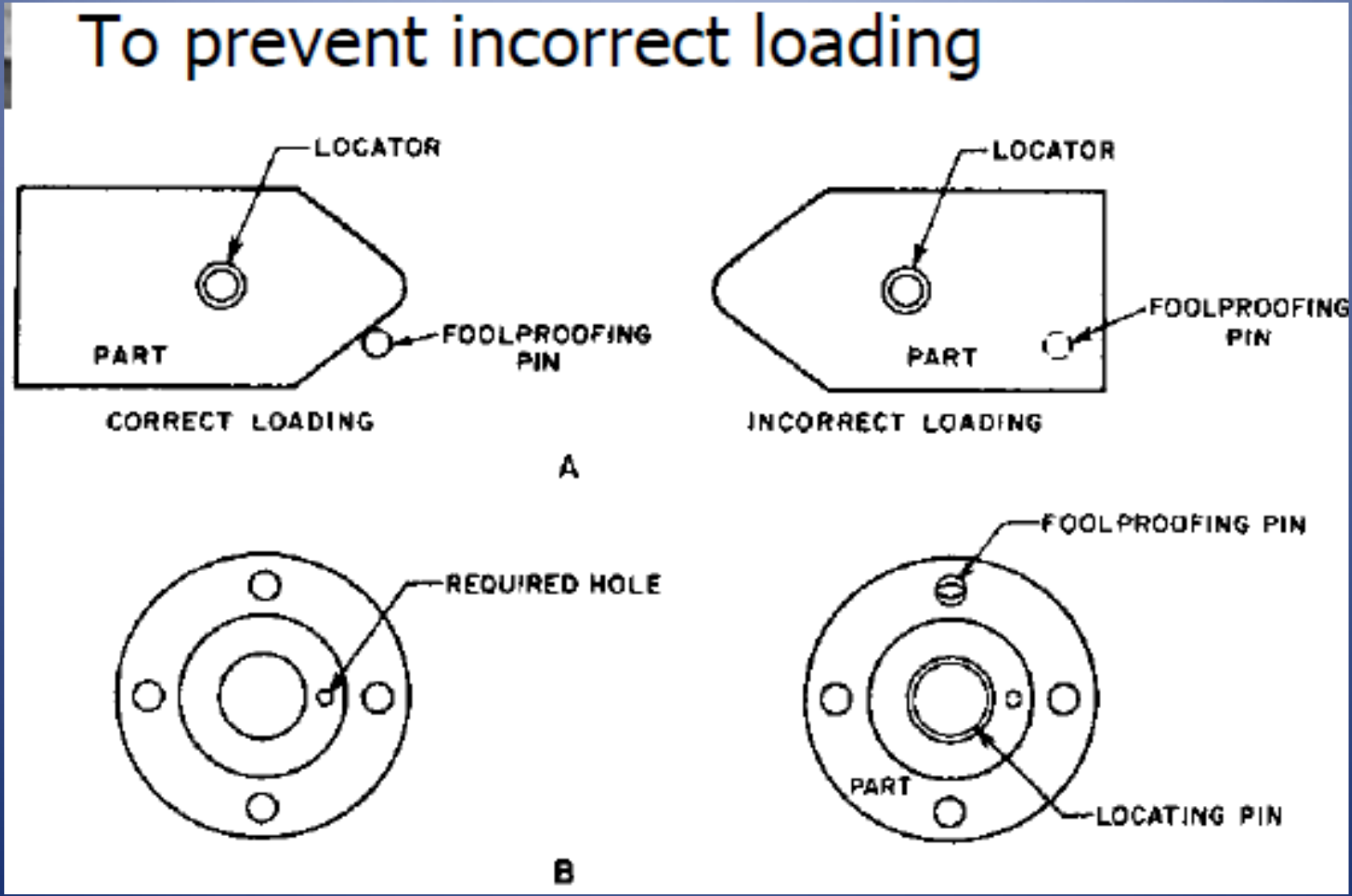
Fool Proofing



Fool proofing (contd.)



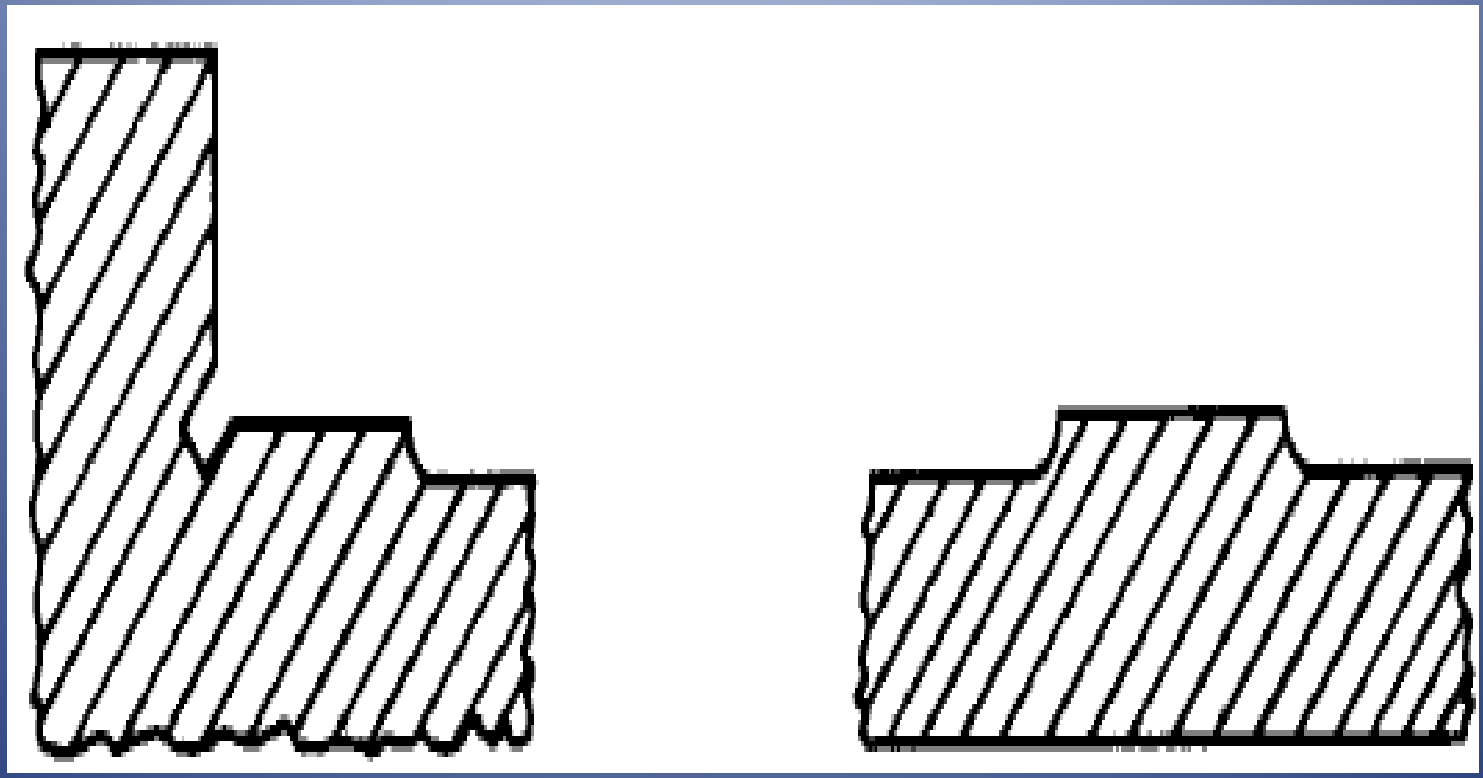
Fool proofing (contd.)



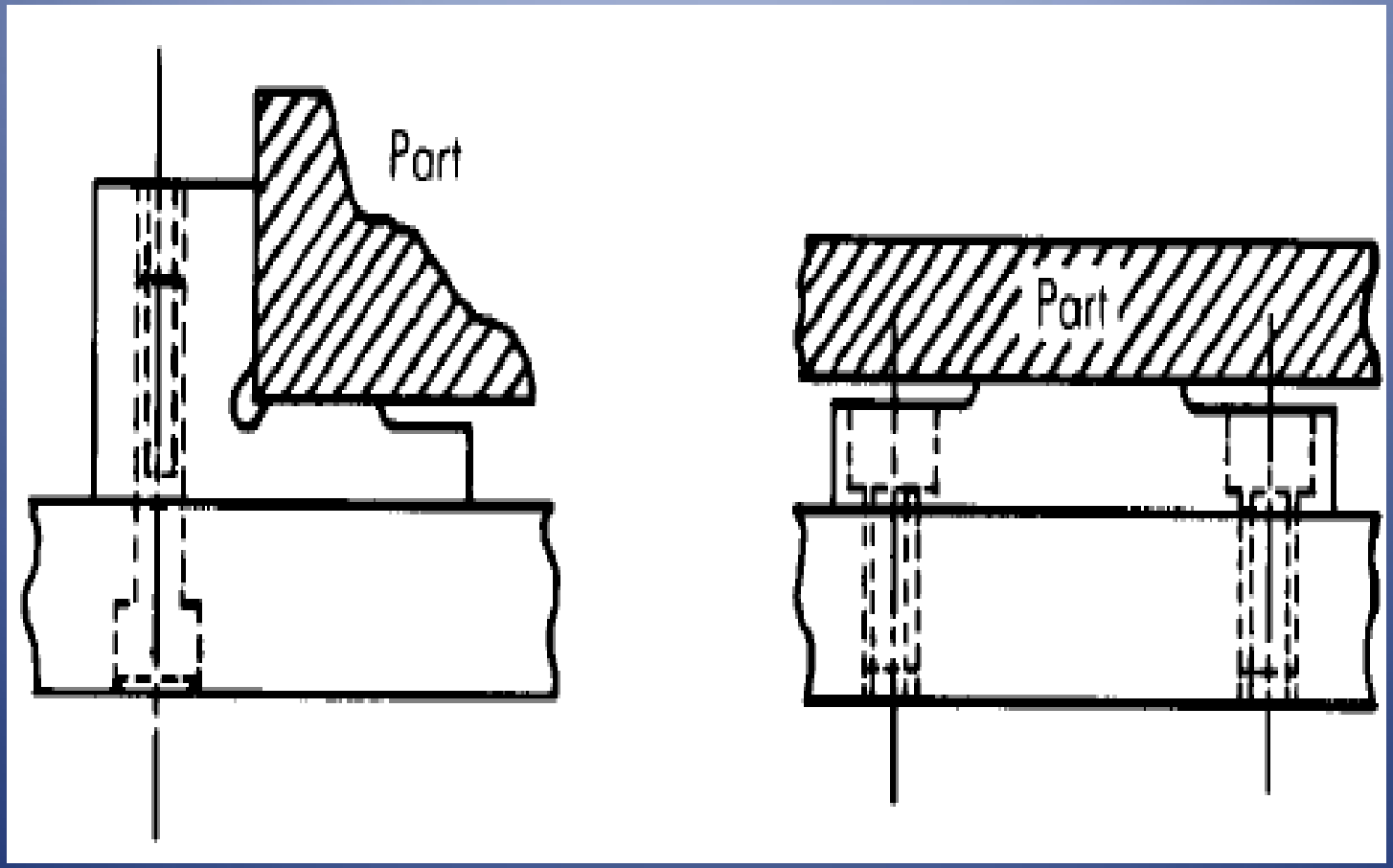
Basic types of locators

- External locators
- Fixed
- Adjustable
  - Threaded locators
  - Spring pressure locators
  - Equalizing locators
- Integral locators
- Assembled locators

Integral locators



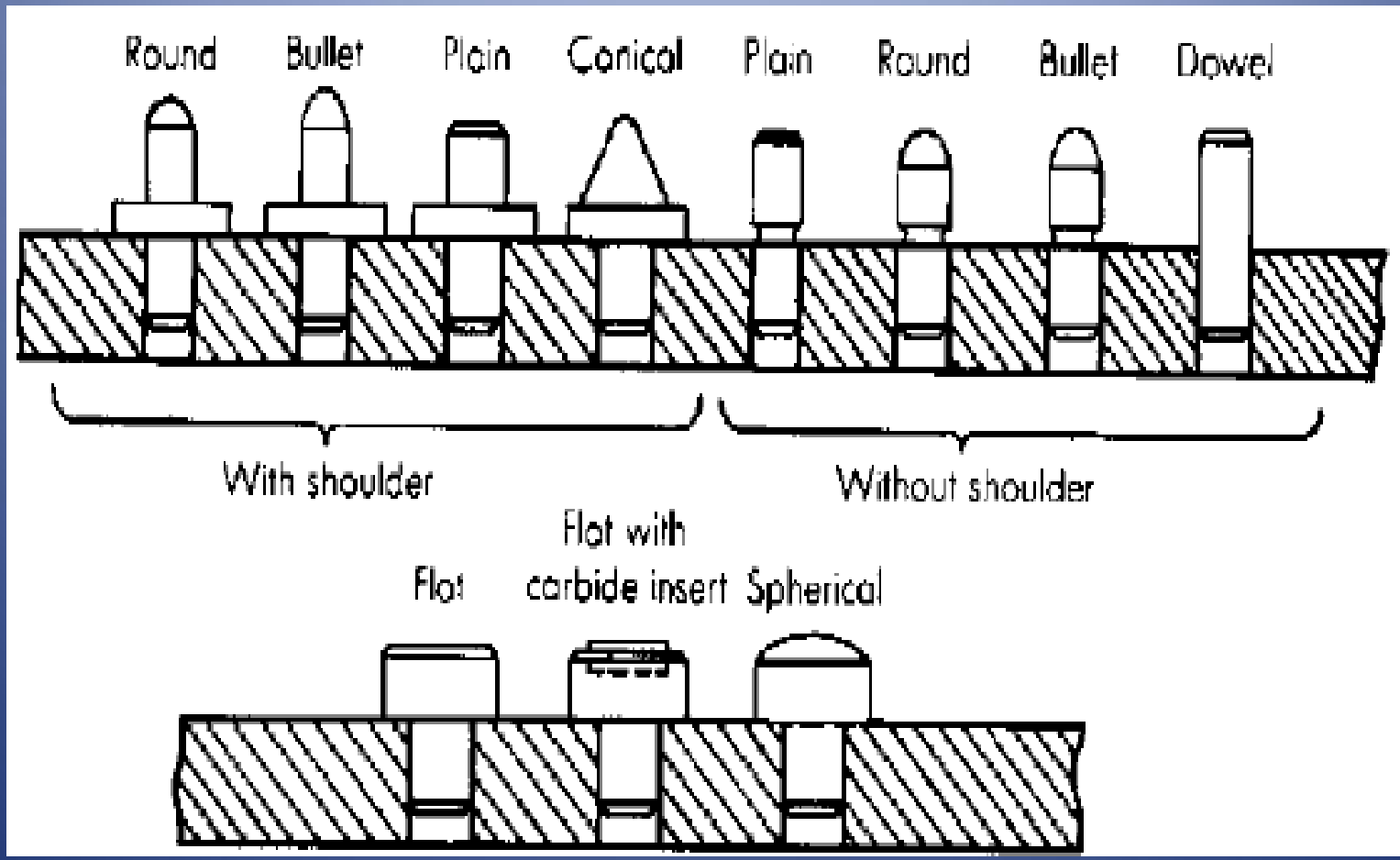
Assembled locators



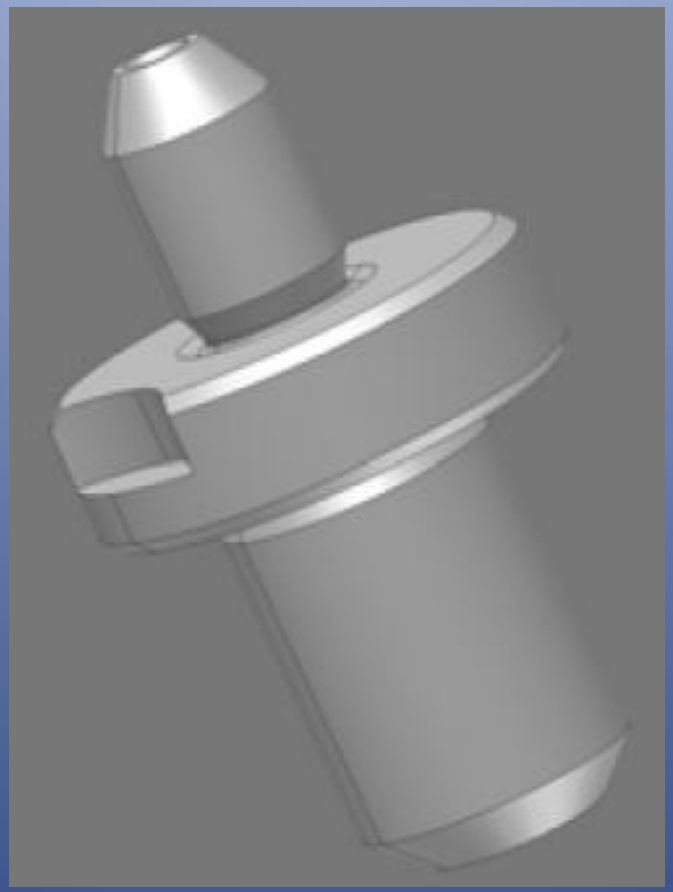
Basic types of locators

- Locating pins
- V-locators
- Locating nests
- Adjustable locators

Locating pins

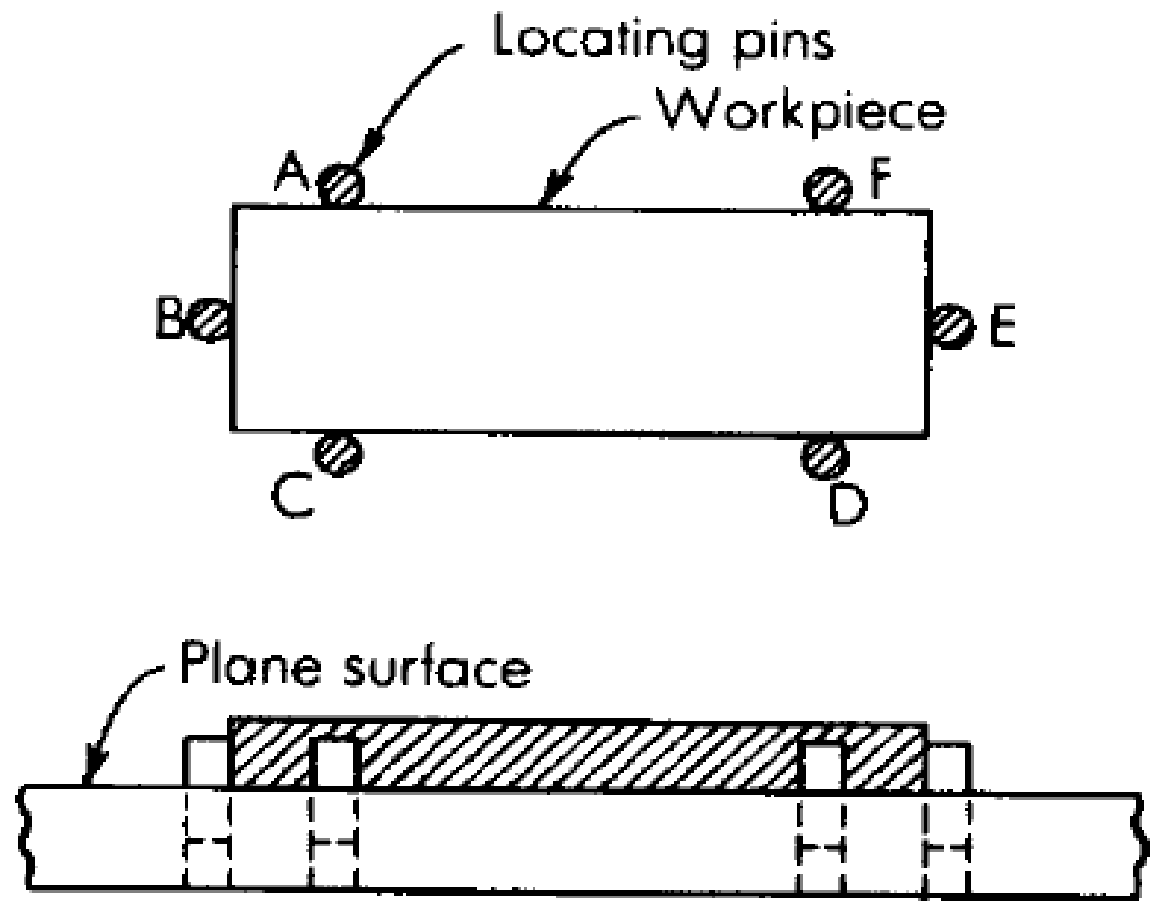


Locator (0.5 in) - Jergens

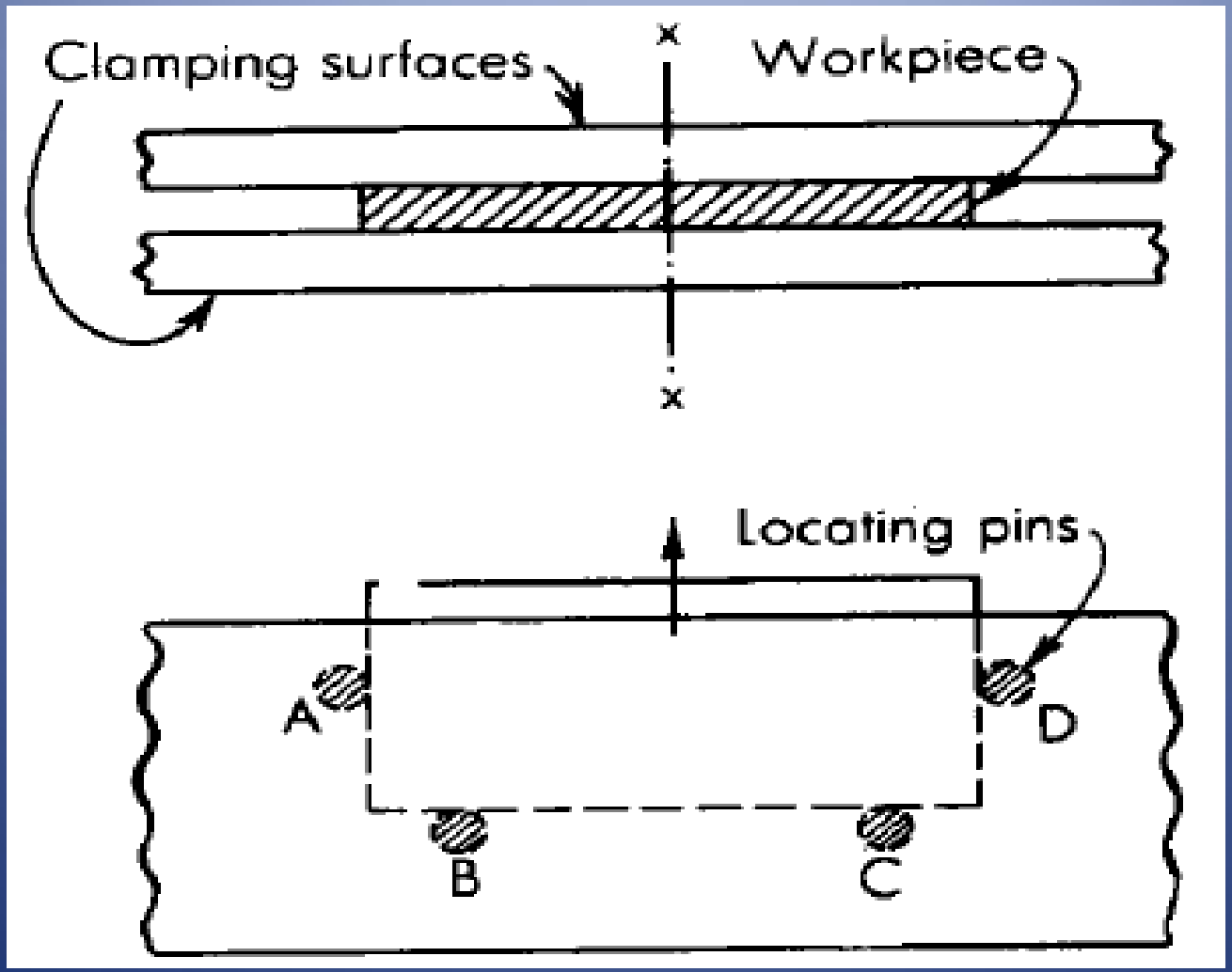


Rajeev Madhavan Nair

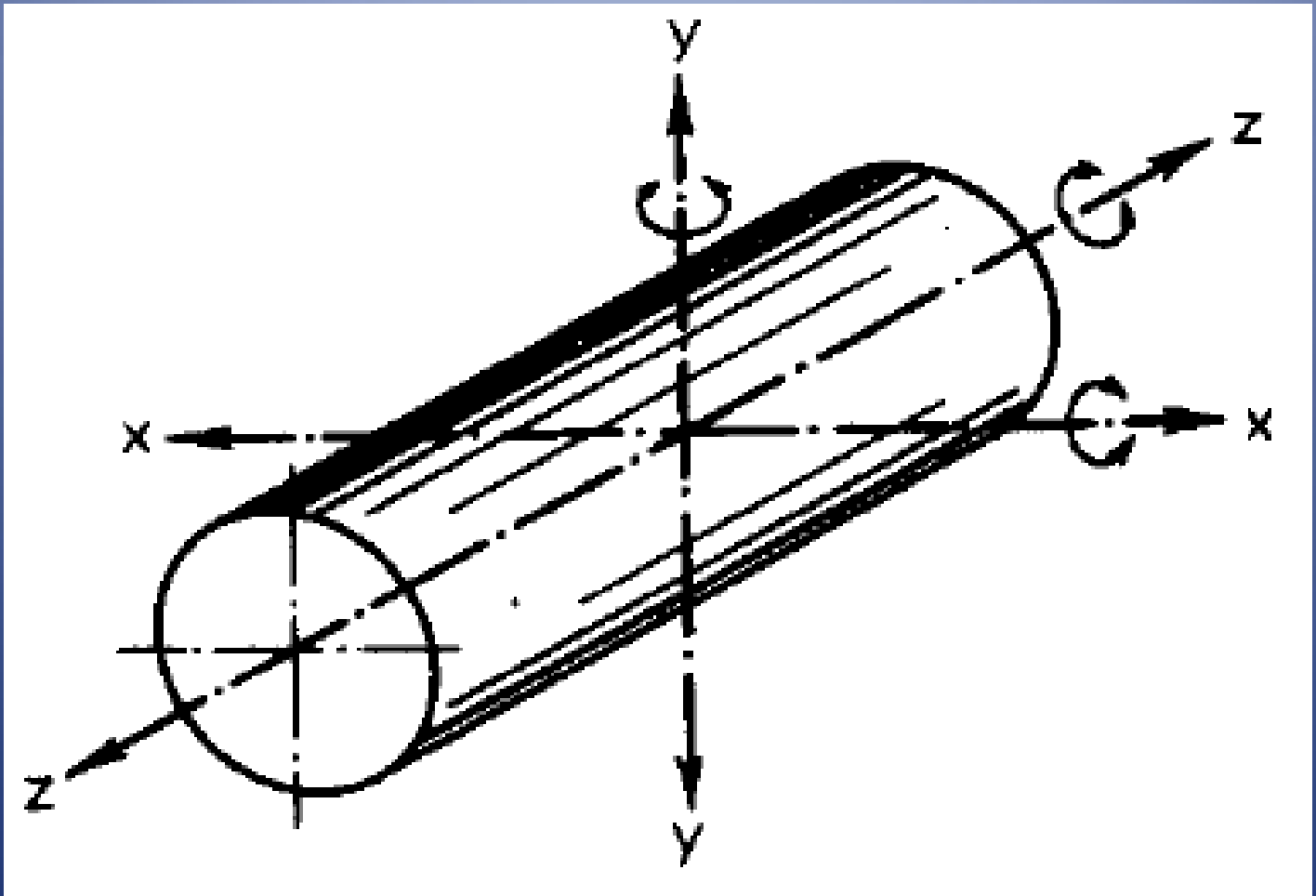
Simple work holder



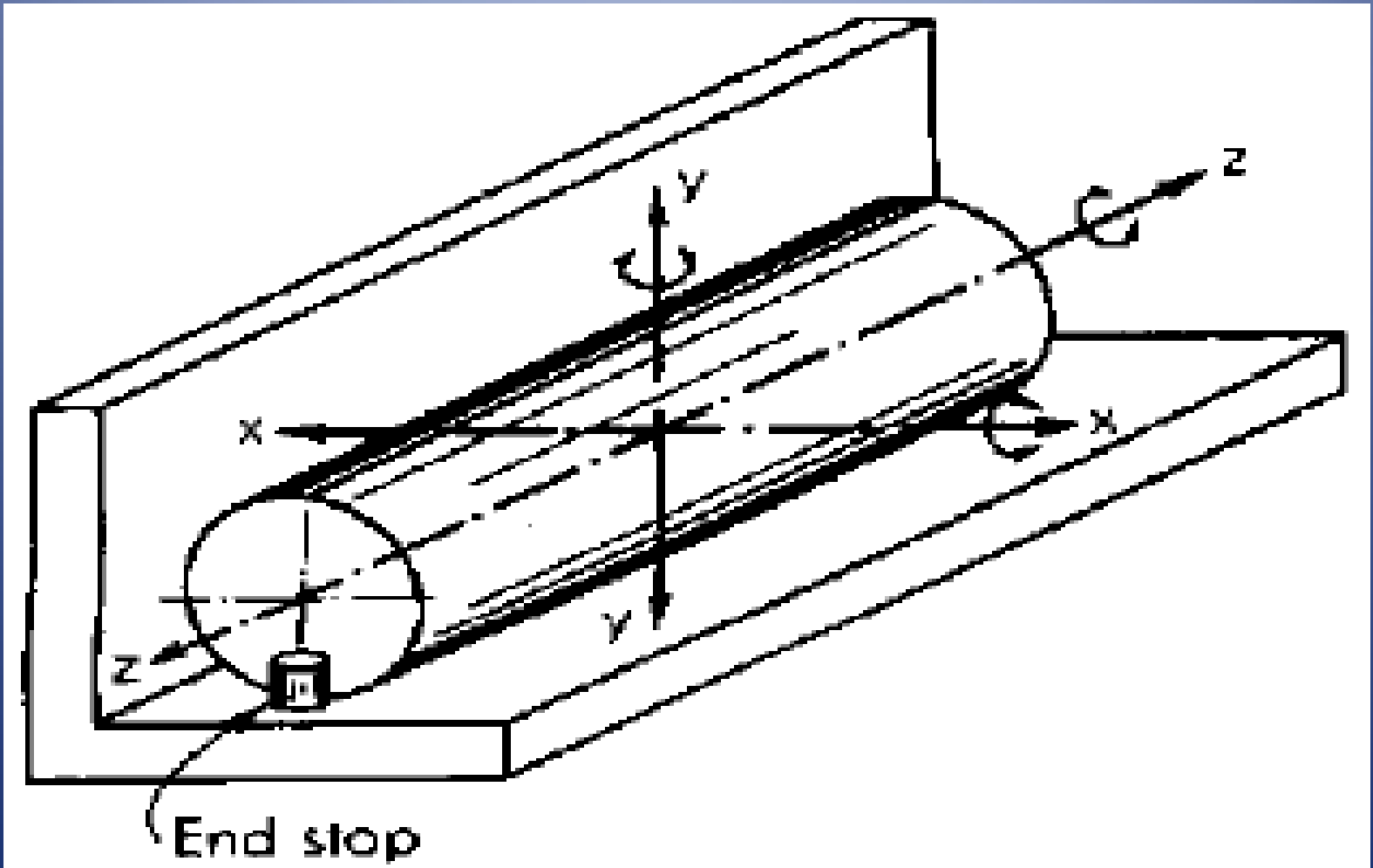
Vertical locating



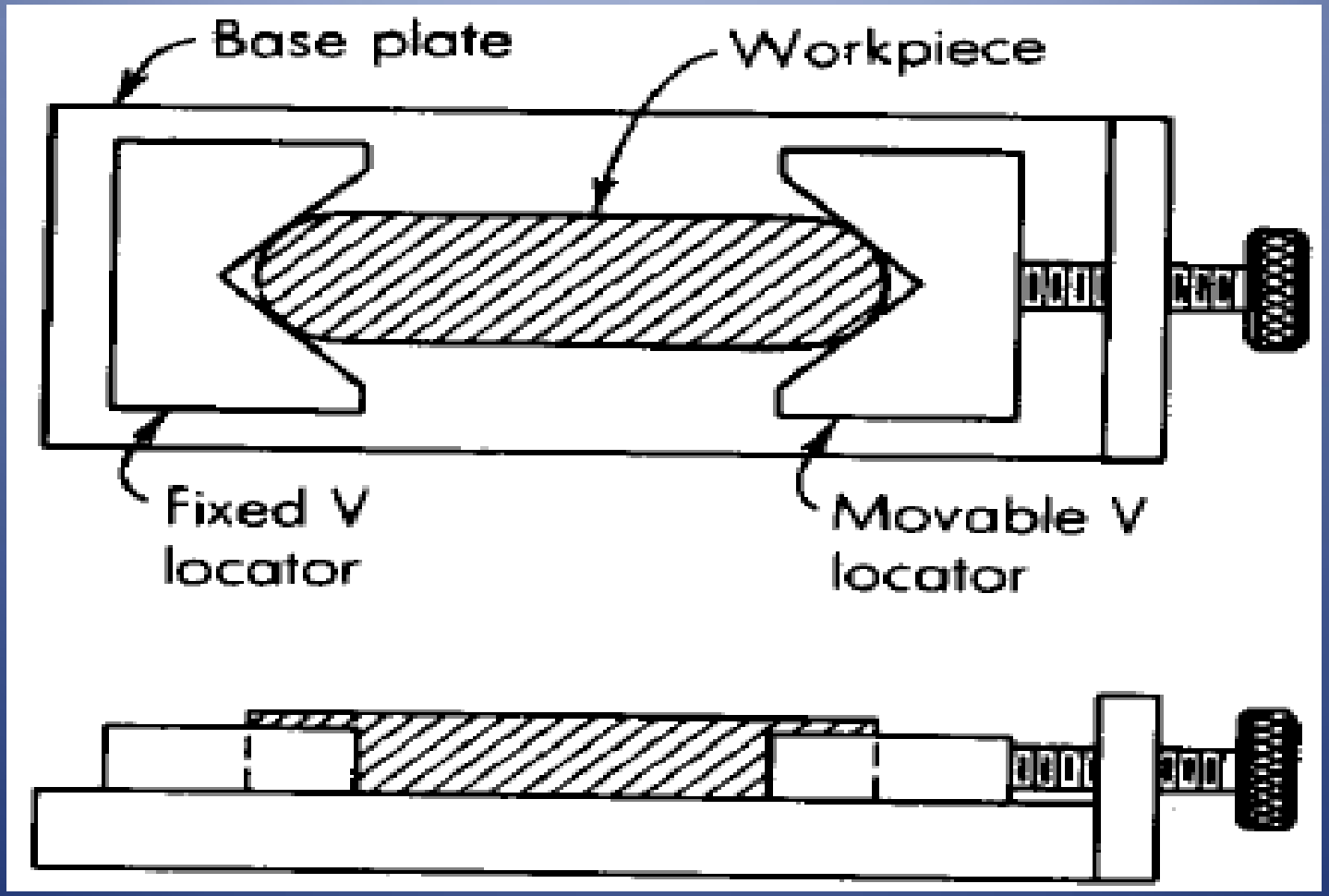
Degrees of freedom of a cylindrical work piece



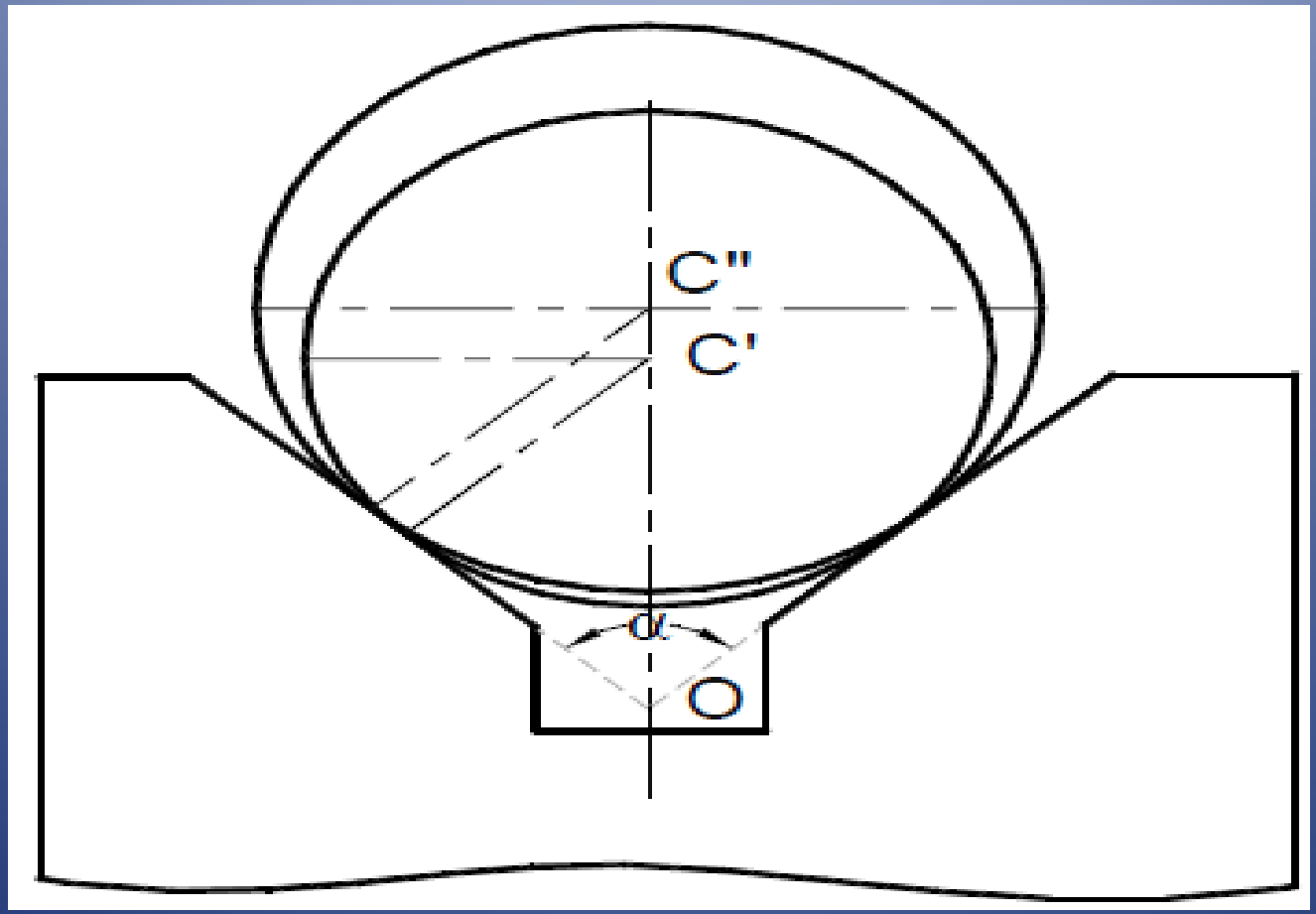
V-locator with stop pin



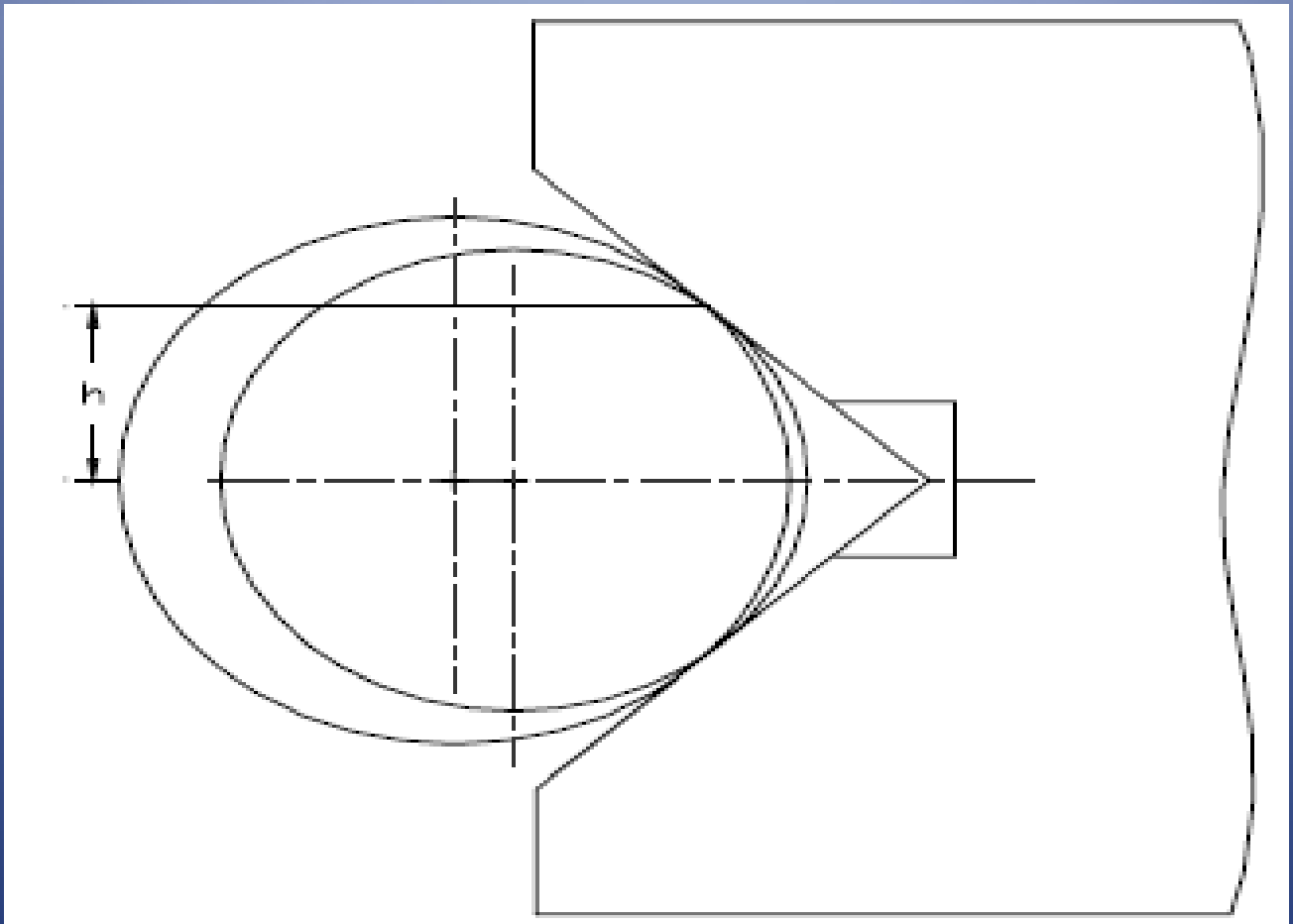
Workholder with multiple V-locators



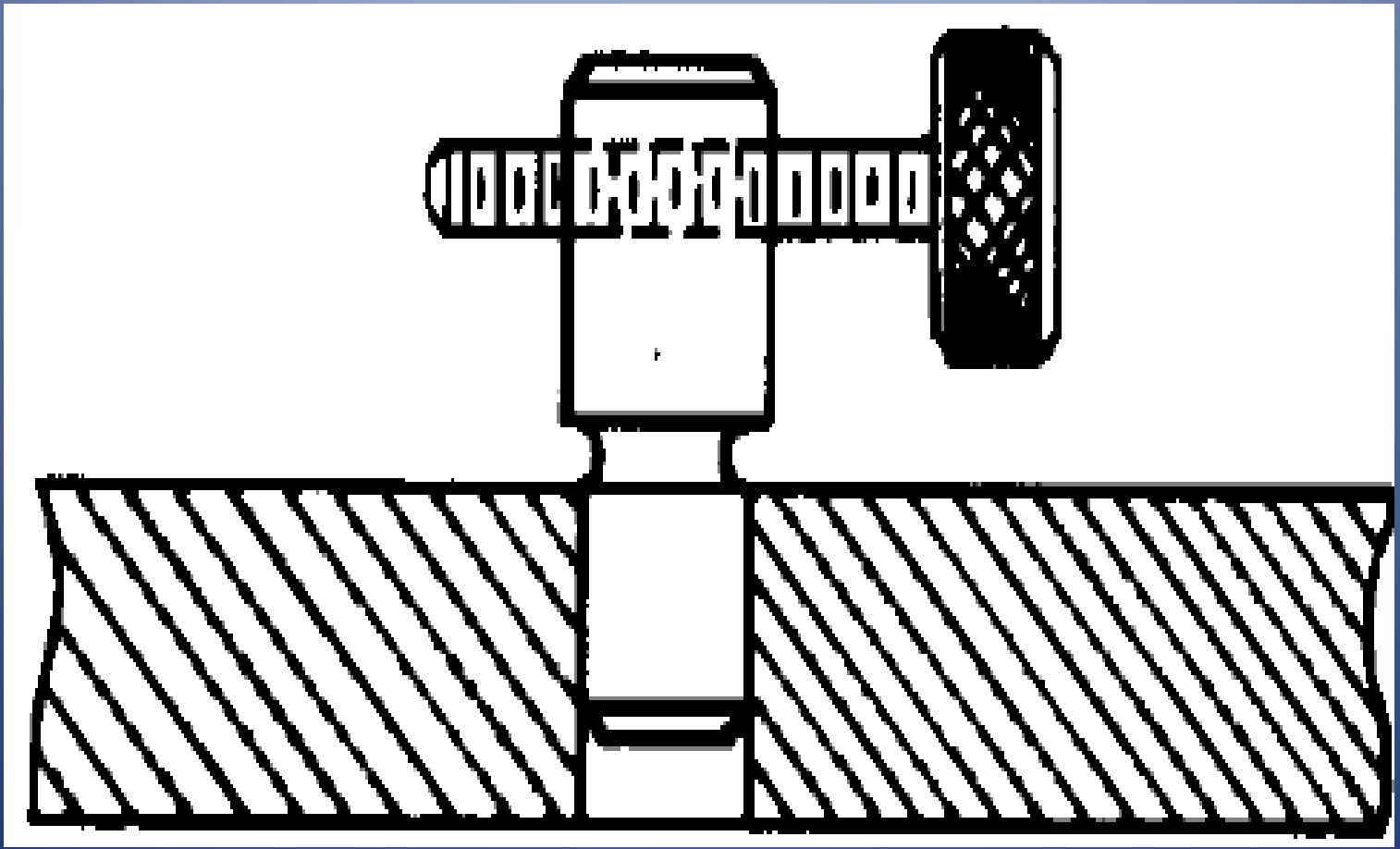
V-locator error



V-locator error



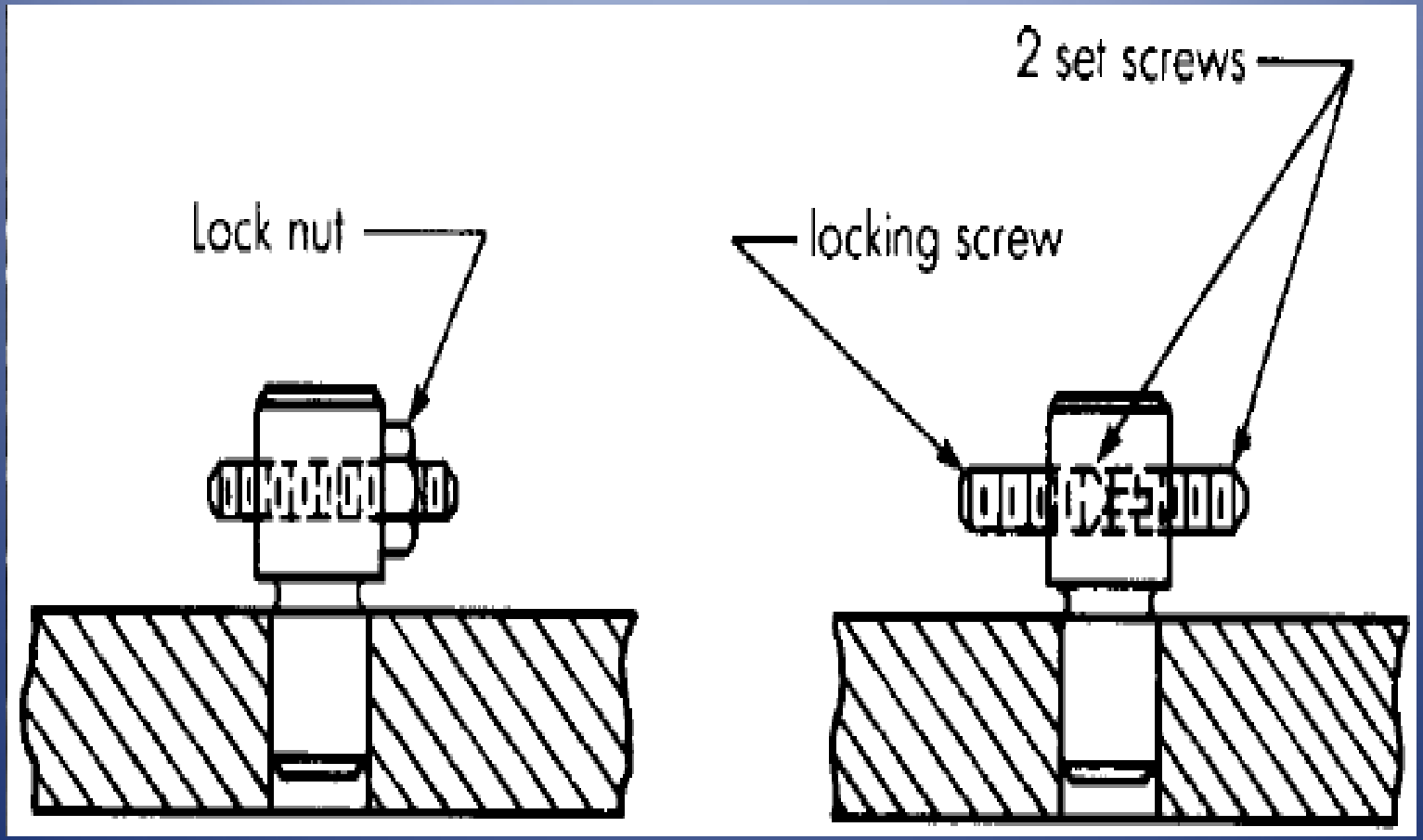
Threaded adjustable locator



Support surfaces

- Select a surface where there is maximum likelihood for the part to deflect under the action of clamping and cutting forces
- Support areas selected should not disturb the location of the work piece in any manner nor displace the locators while providing the support
- Support areas selected should not interfere with the loading and unloading of the component into the work holding fixture

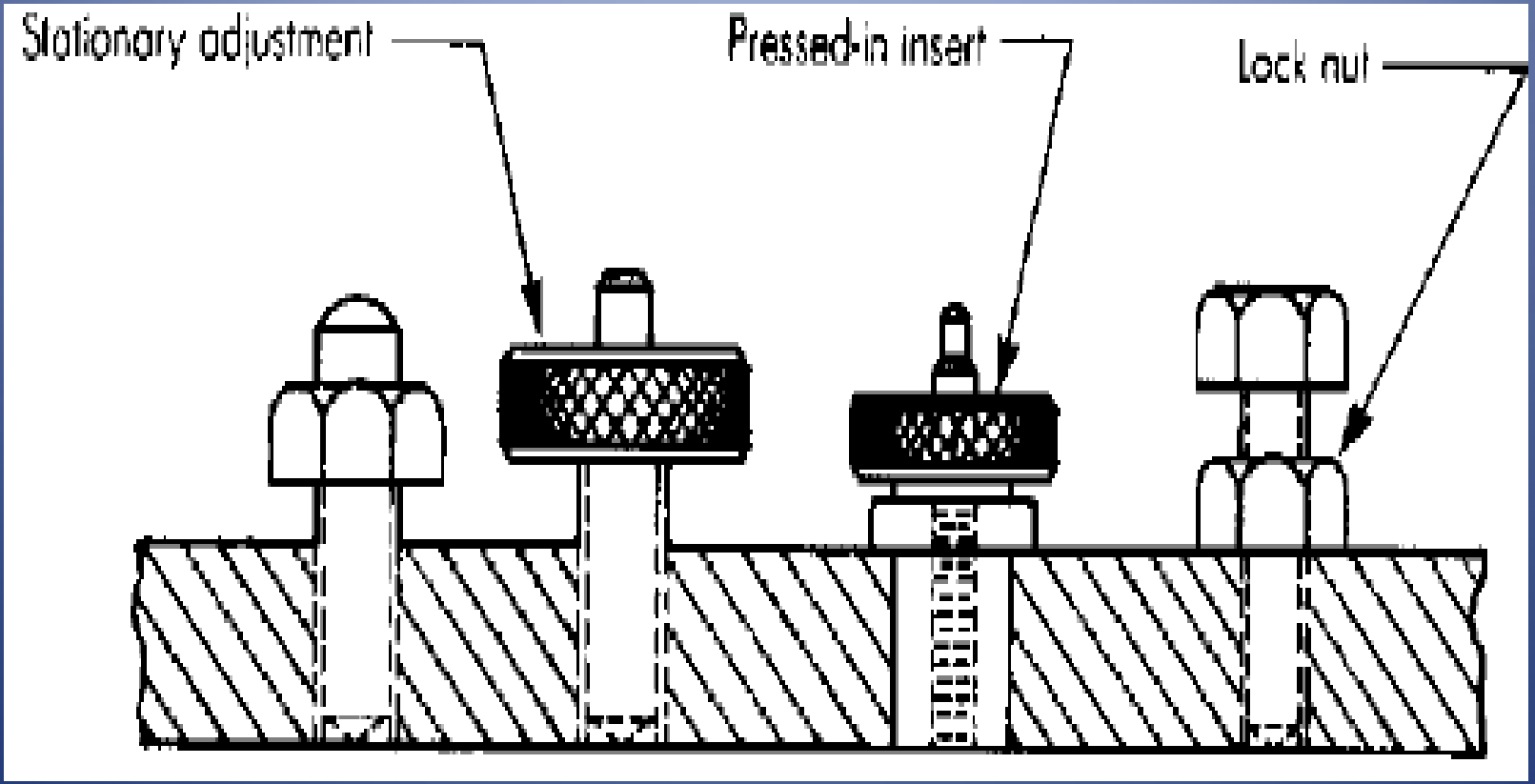
Adjustable locators with locknut or screw



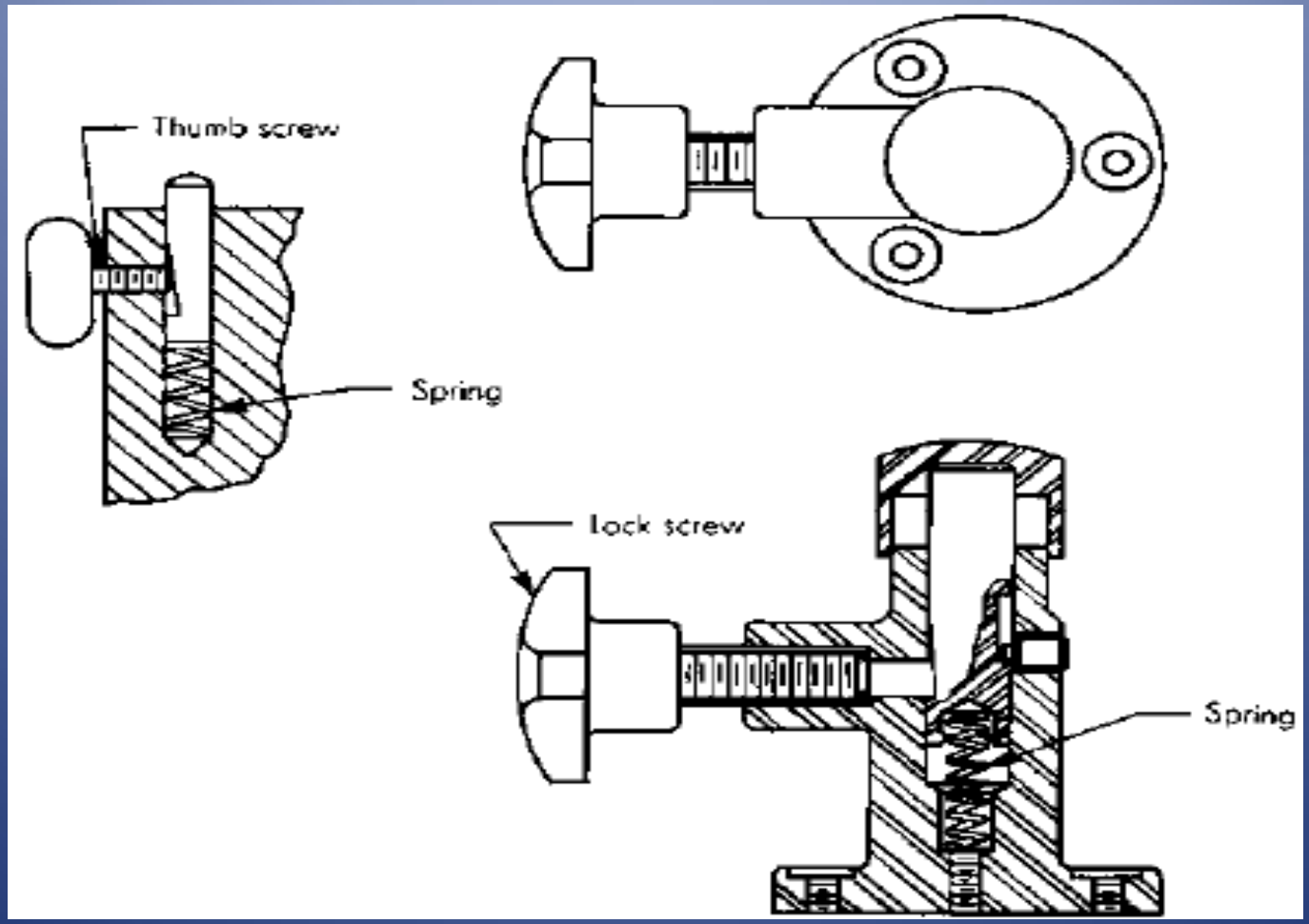
Adjustable supports

- Adjustable locators positioned below the work piece
- Threaded
- Spring
- Equalizers

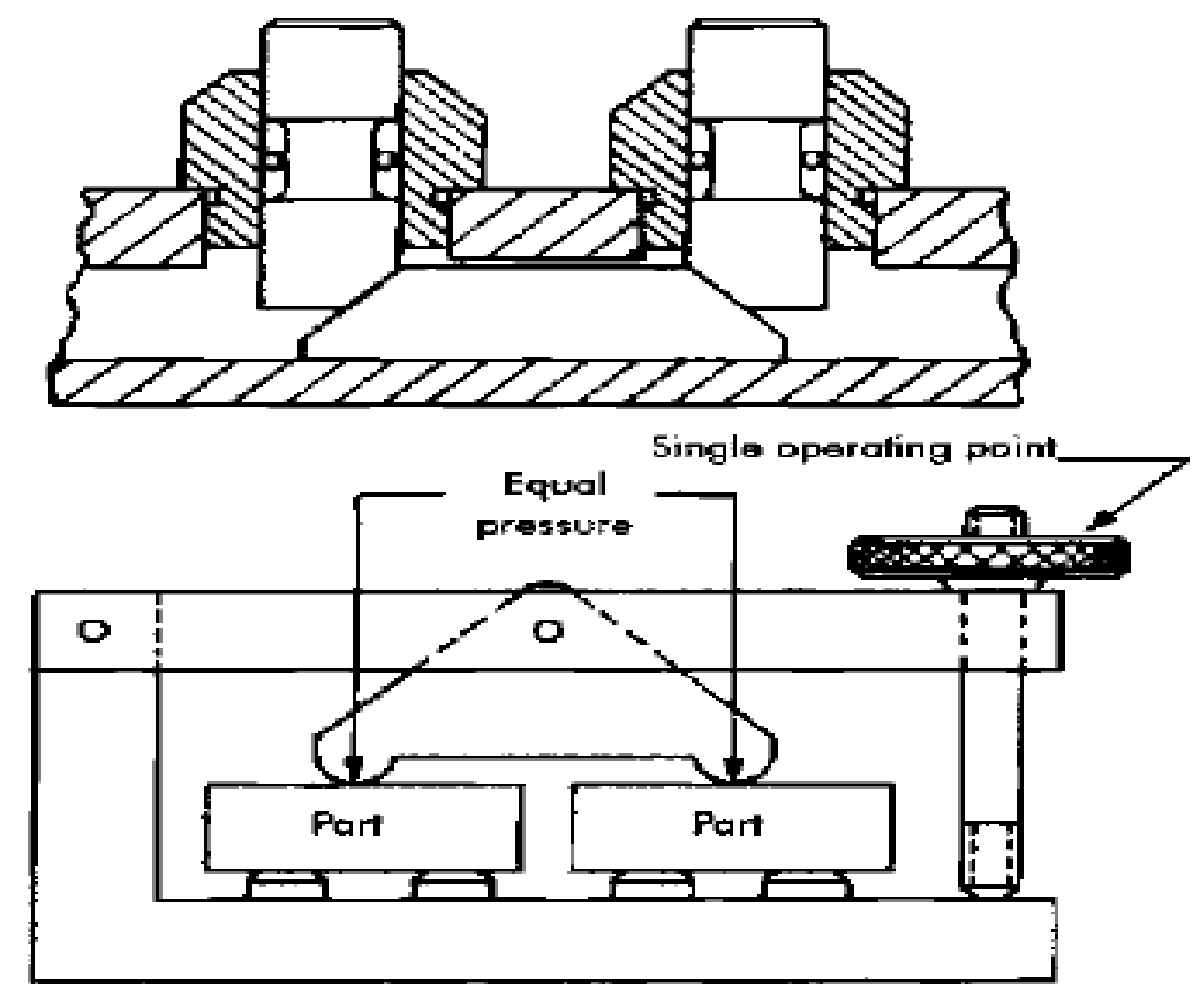
Threaded type adjustable supports



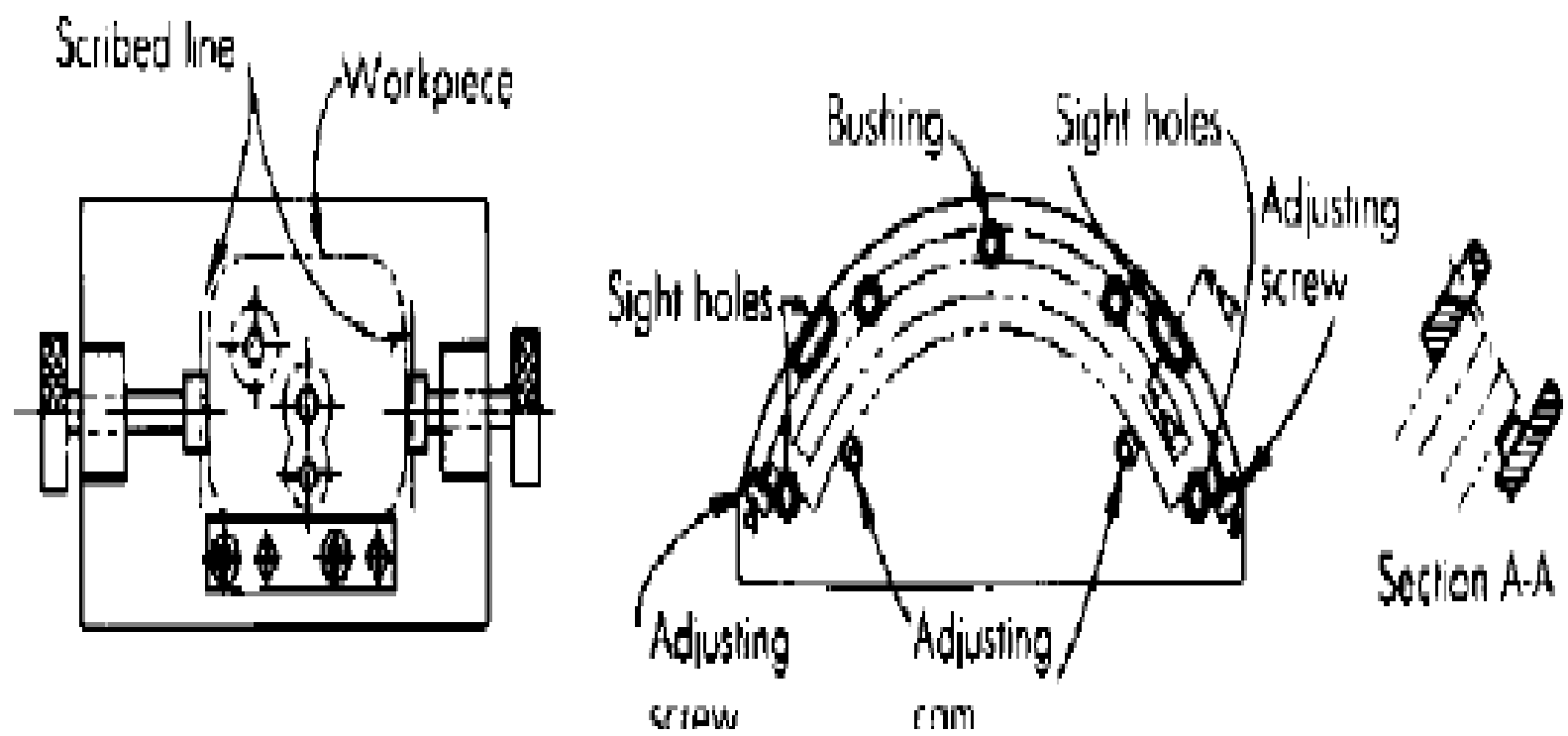
Spring type adjustable supports



Equalizing type adjustable supports



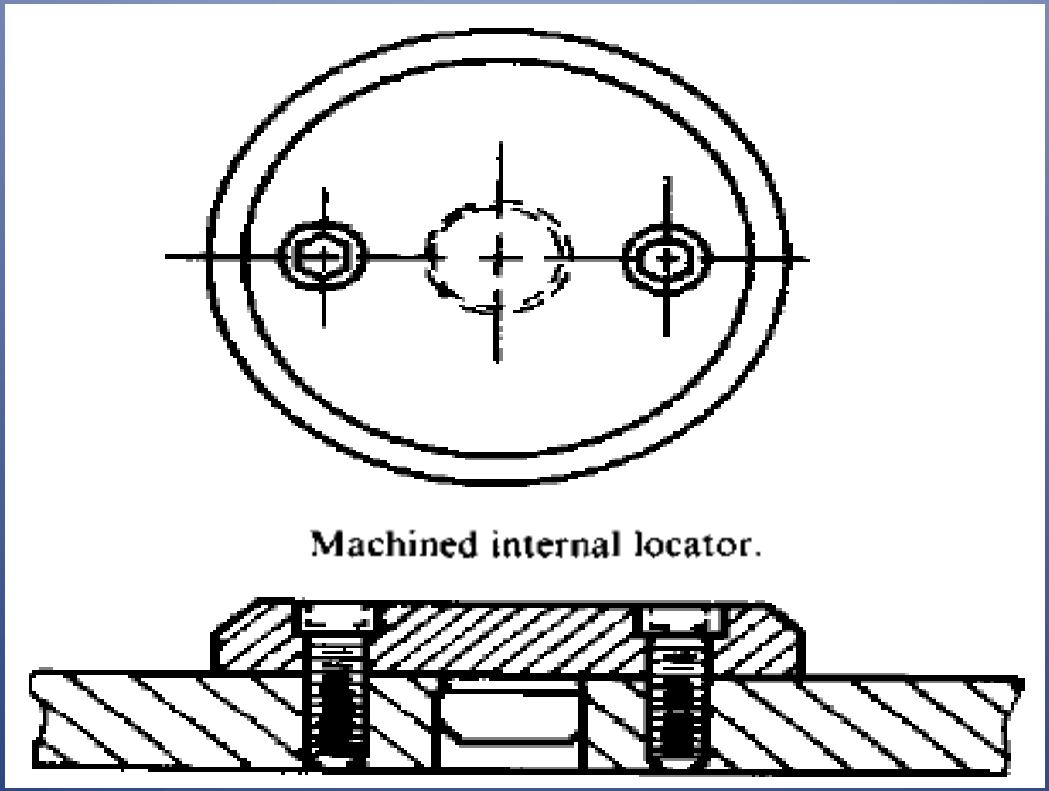
Sight locators



(A) Sight locators: (*a*) by scribed lines; and (*b*) by sighting holes. (B)

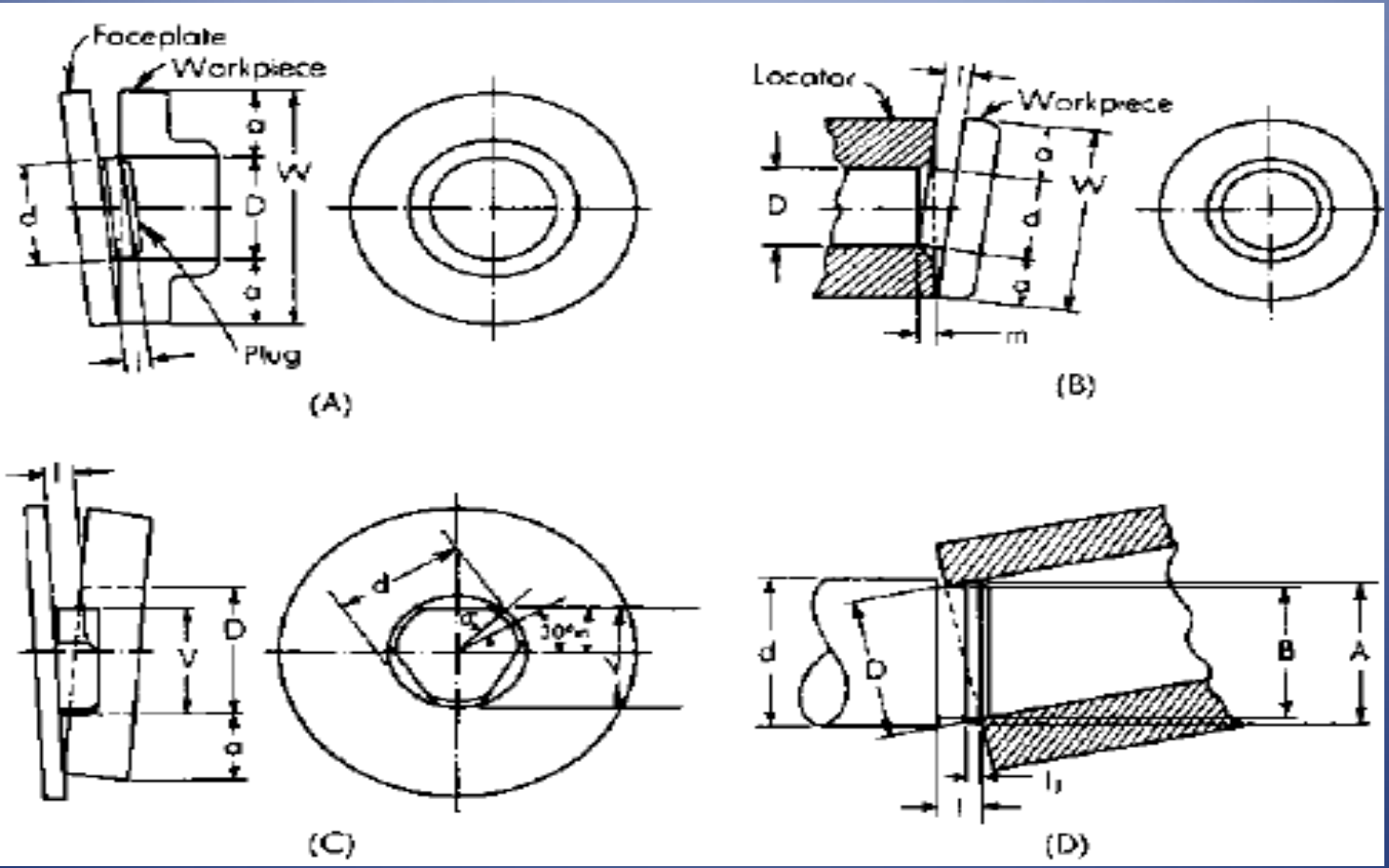
Internal locators

- Use holes or bored diameters



Machined internal locator.

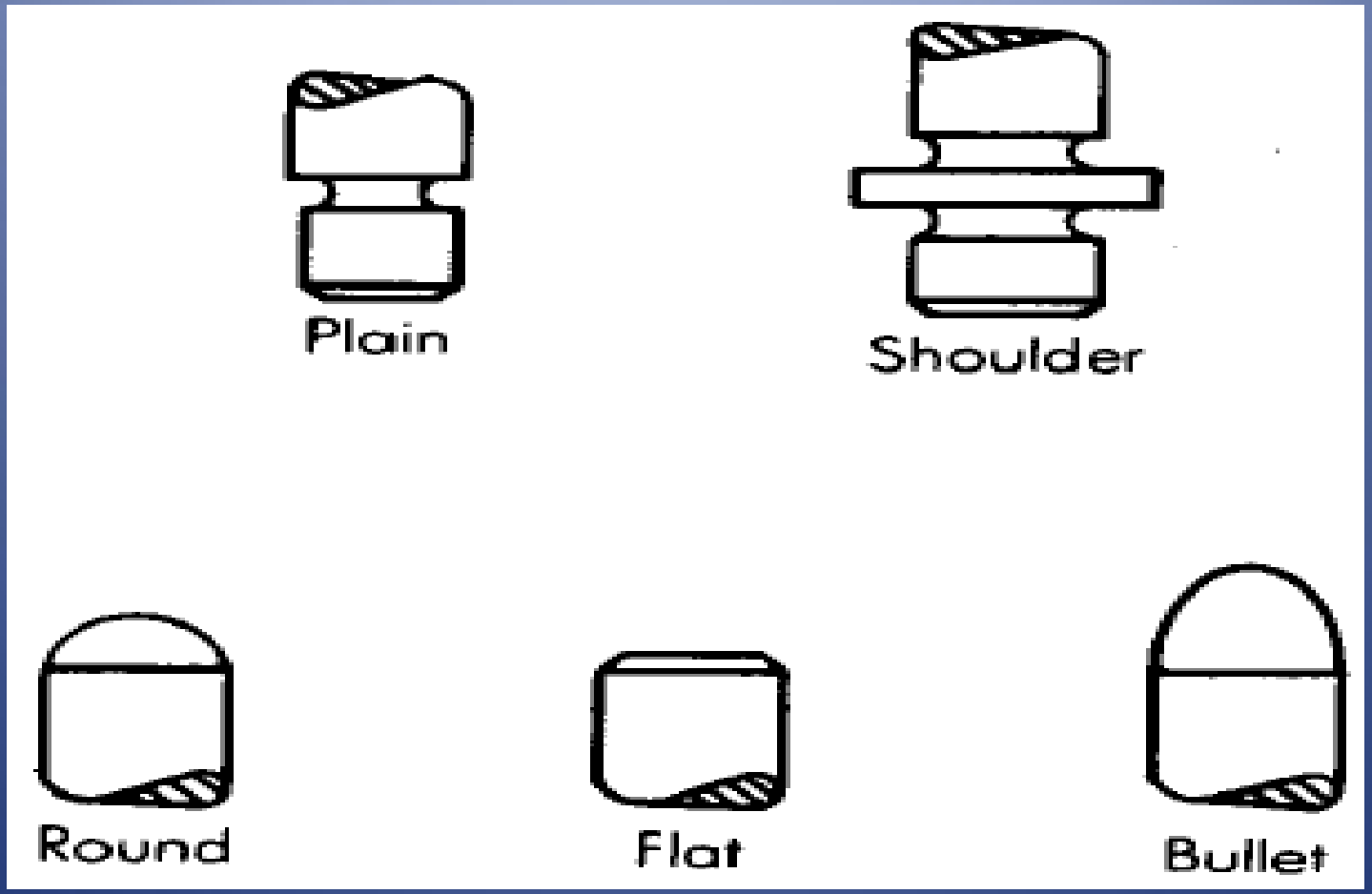
Nonsticking locator design



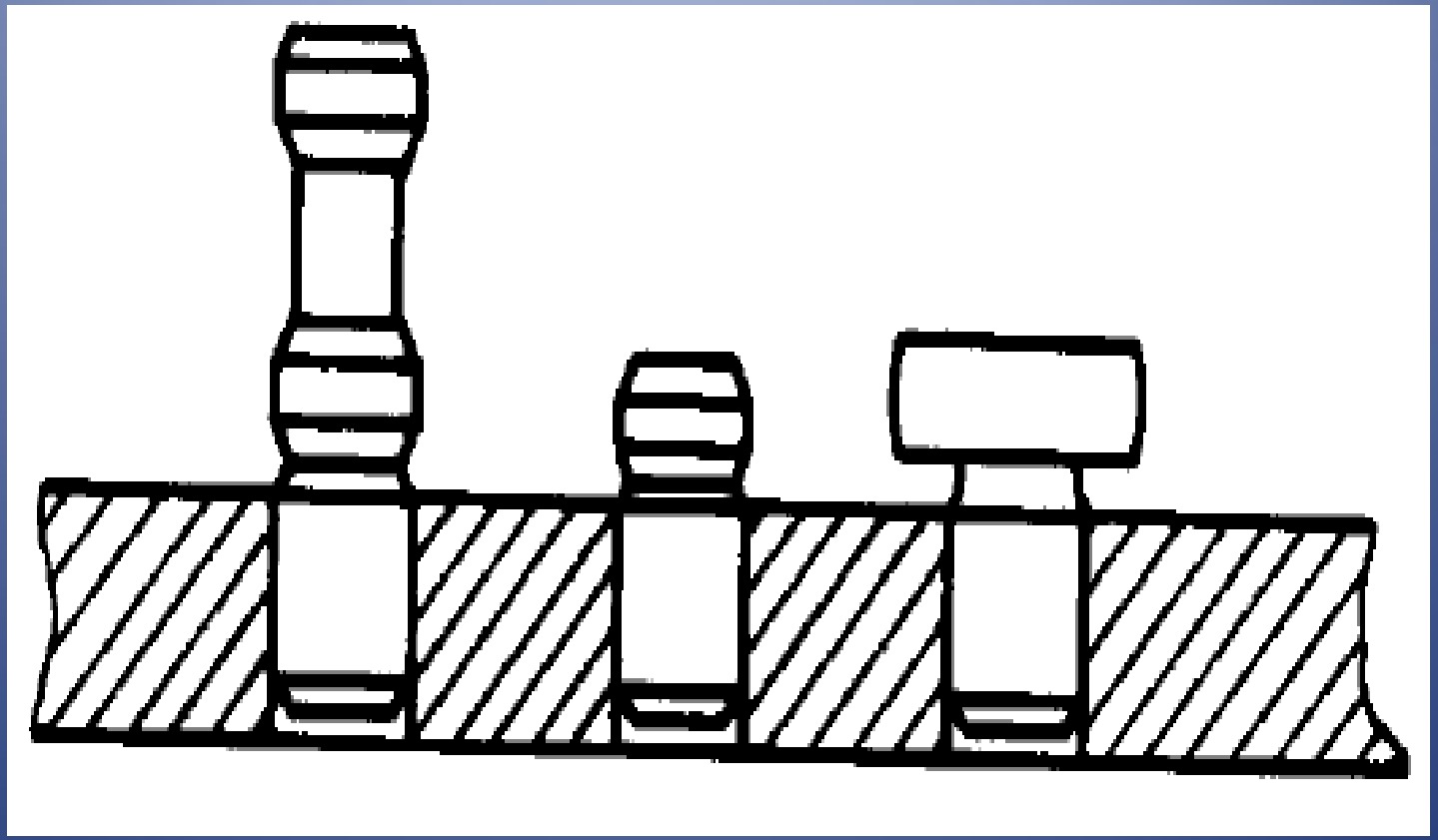
Pin locators

- Plain
- Shouldered
- Undersized (0.0005 to 0.002”)
- Prevent jamming

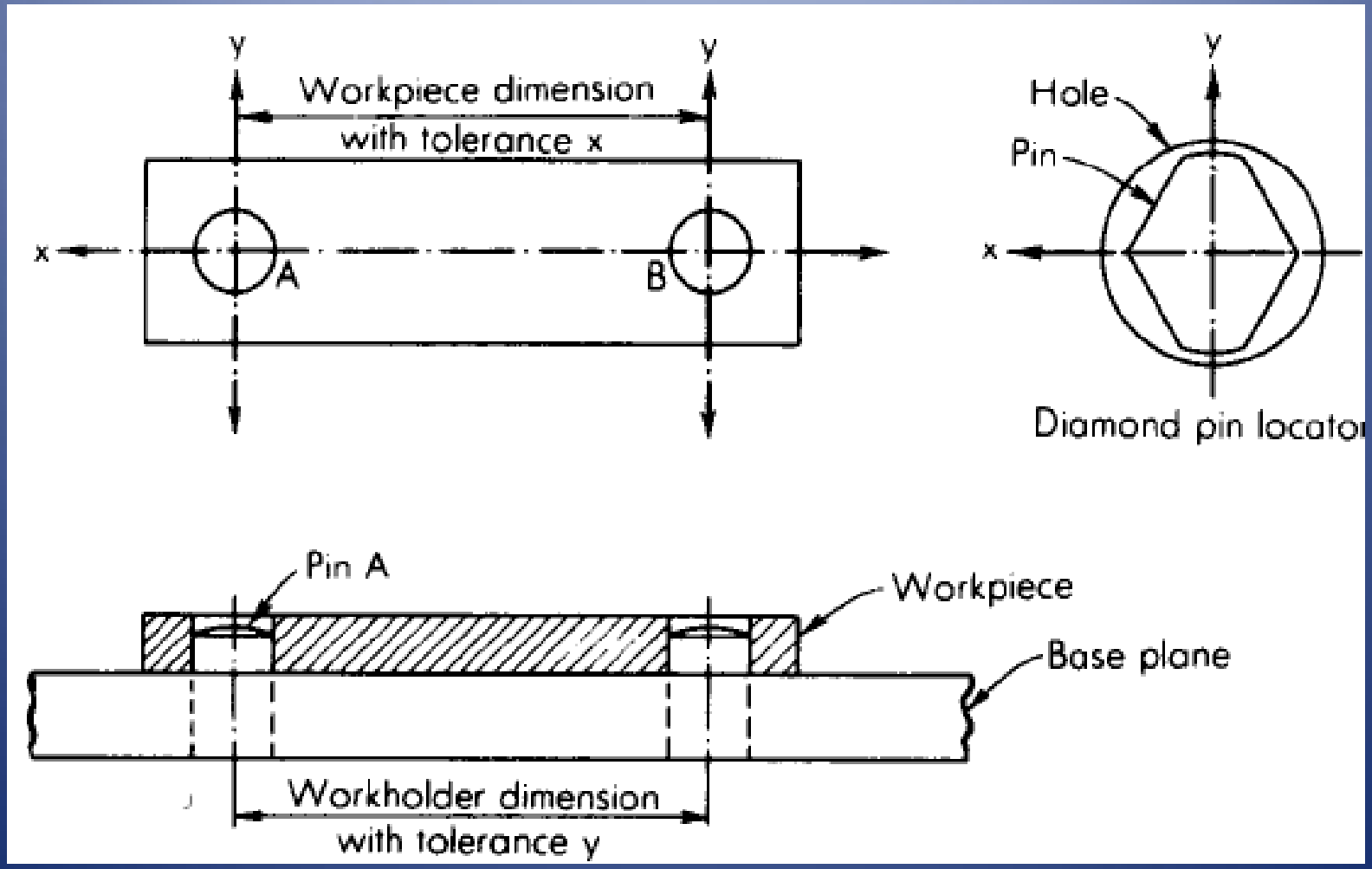
Commercial pin locators



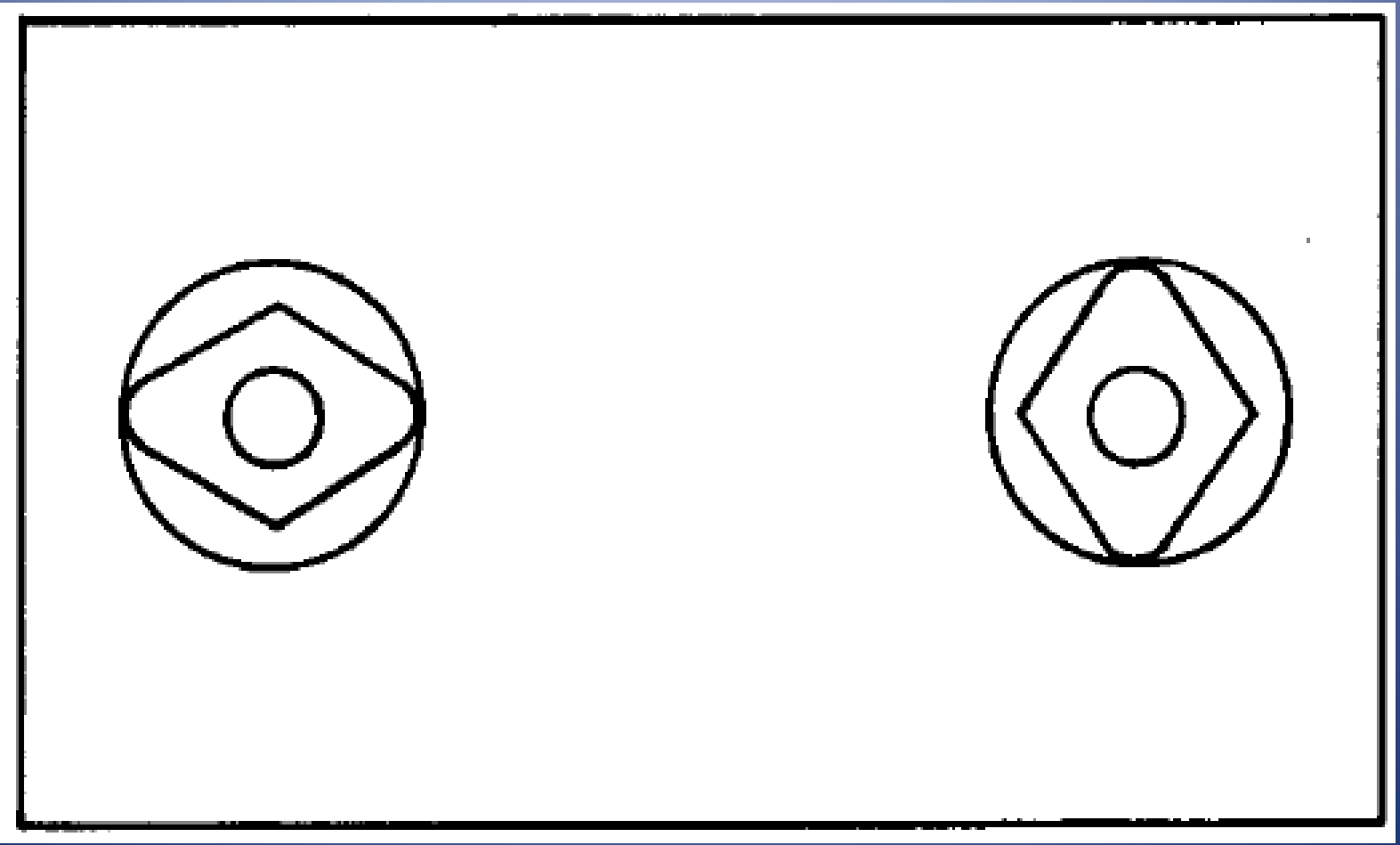
Relieved locators



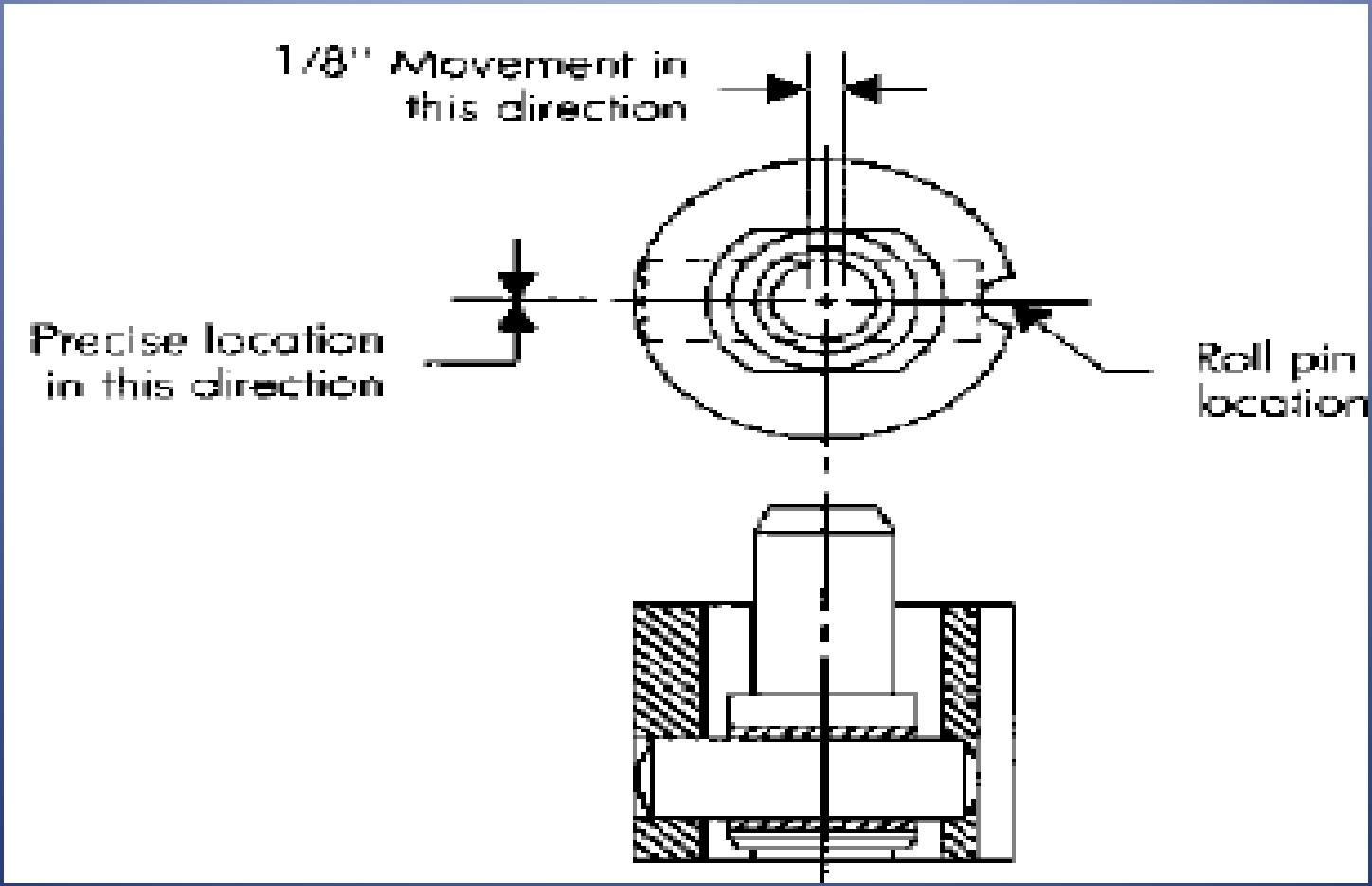
Diamond pin (radial locator)



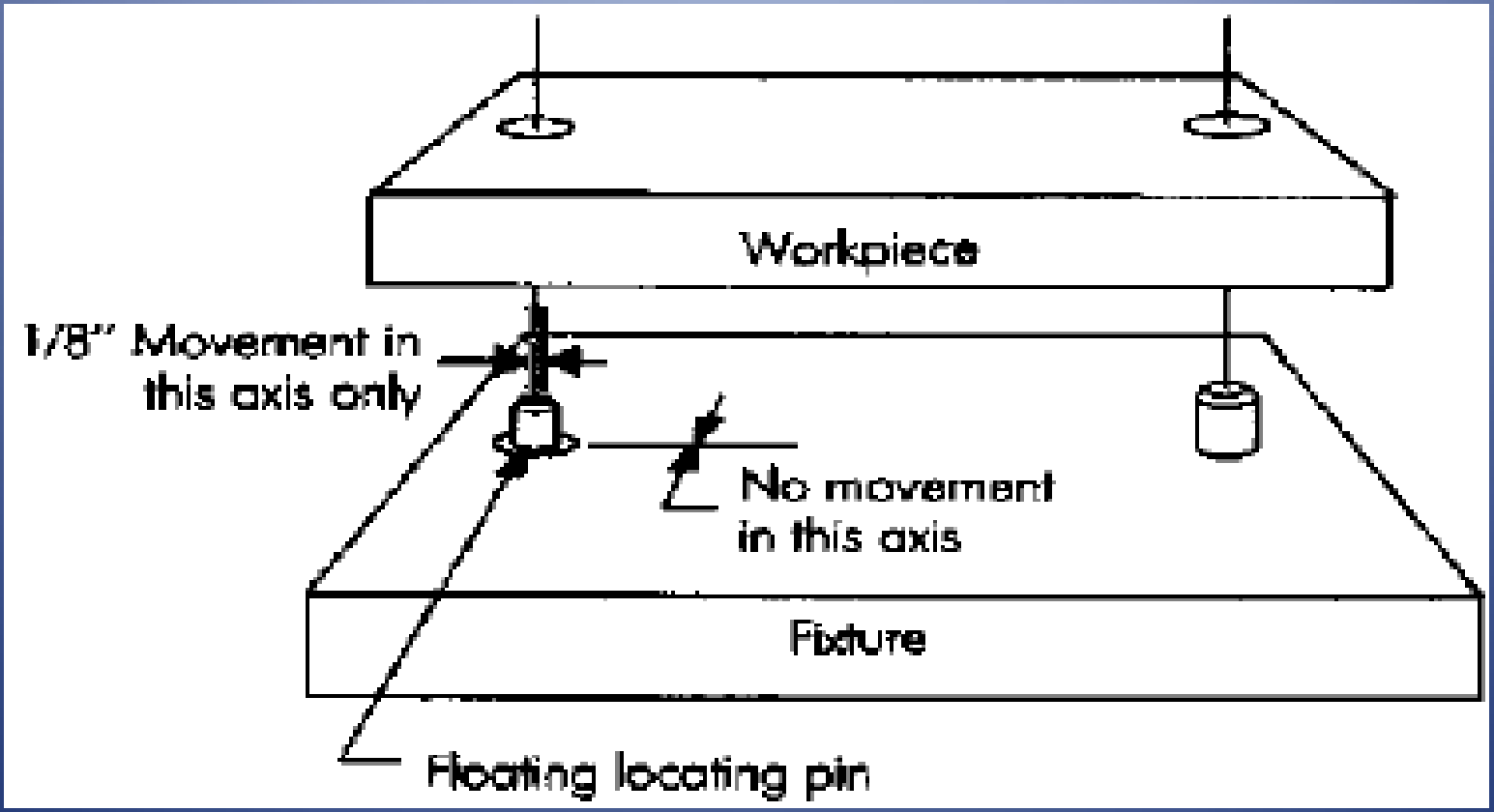
Locating only with diamond pins



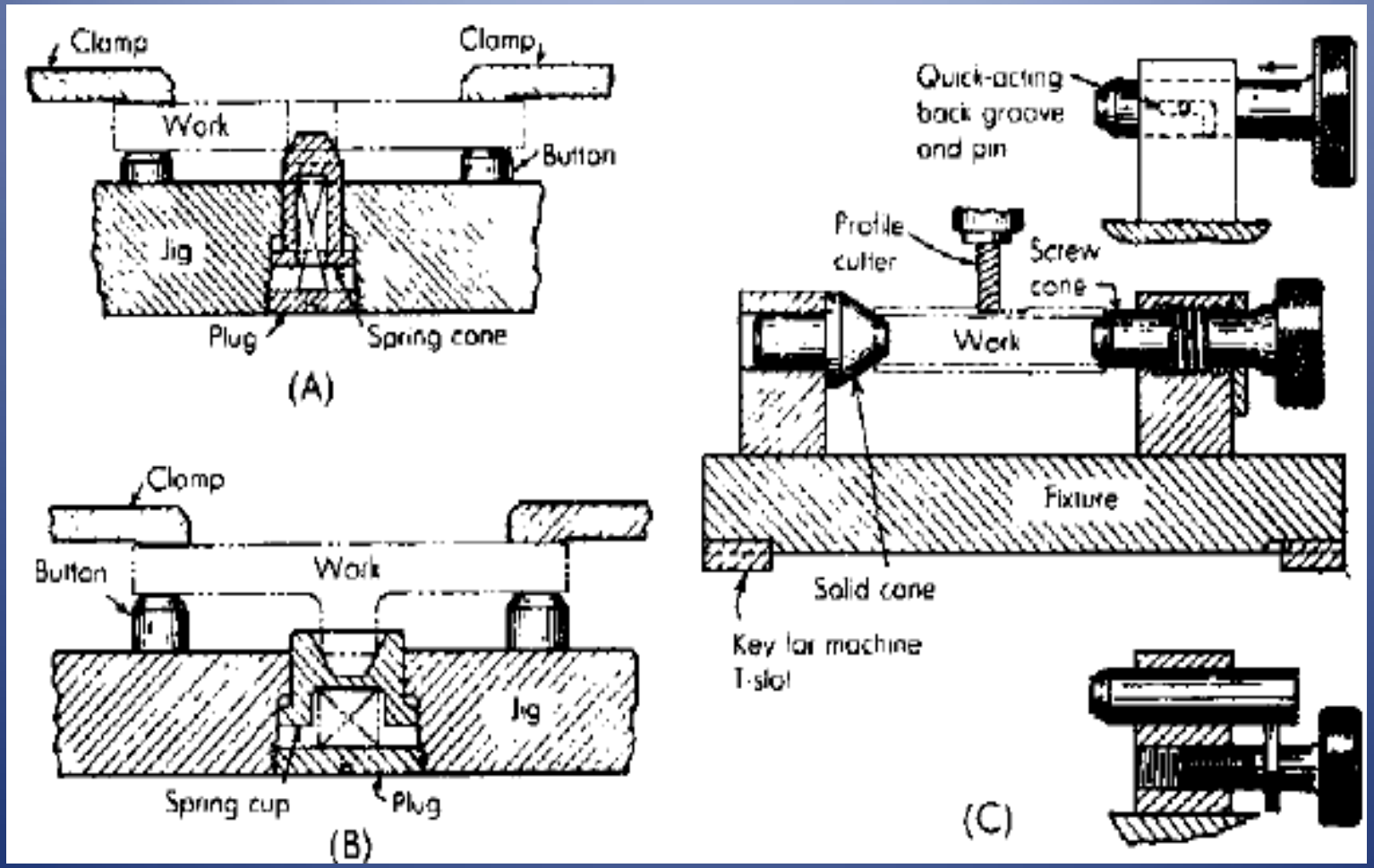
Floating locating pin



Floating and round locating pin combination



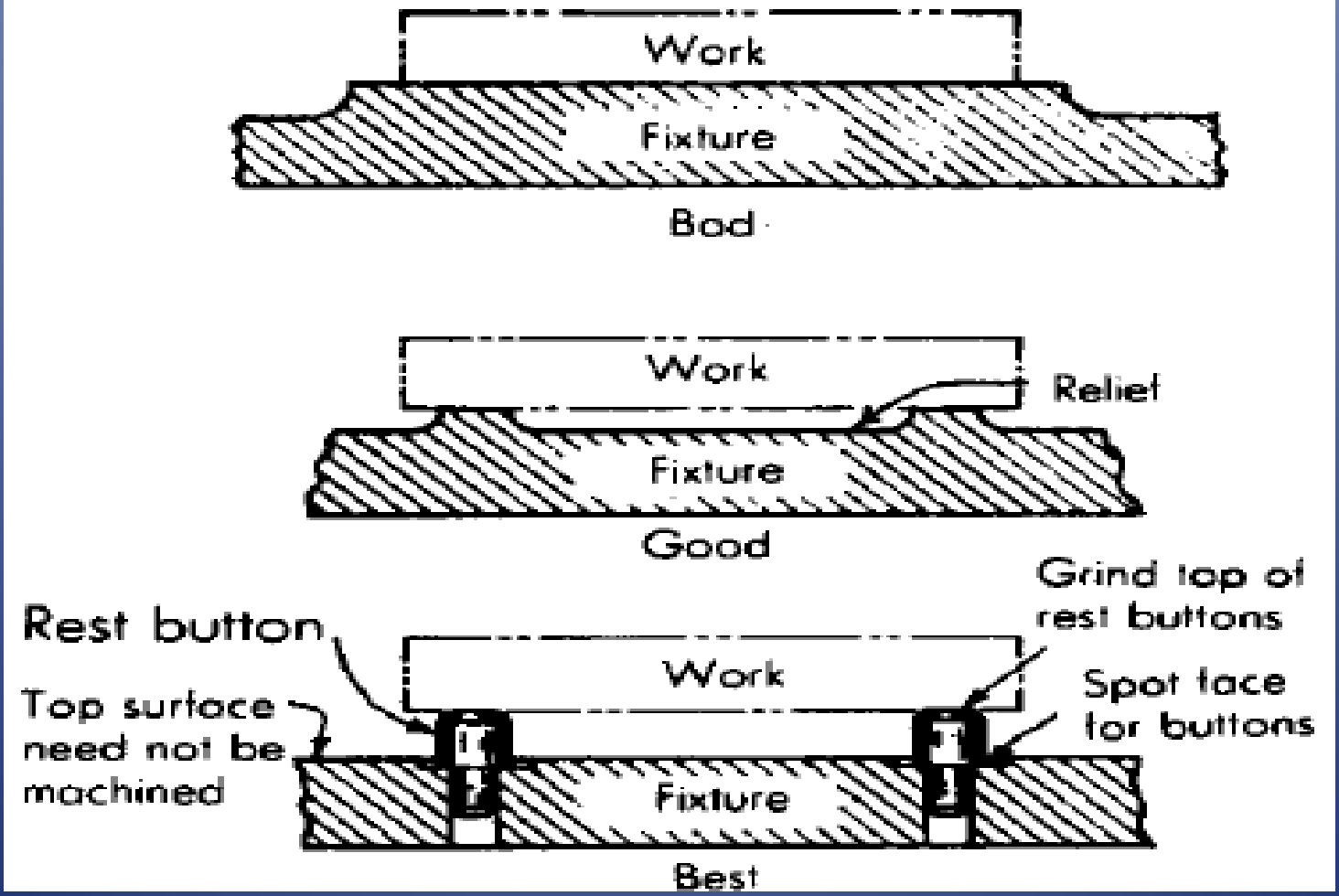
Conical locators



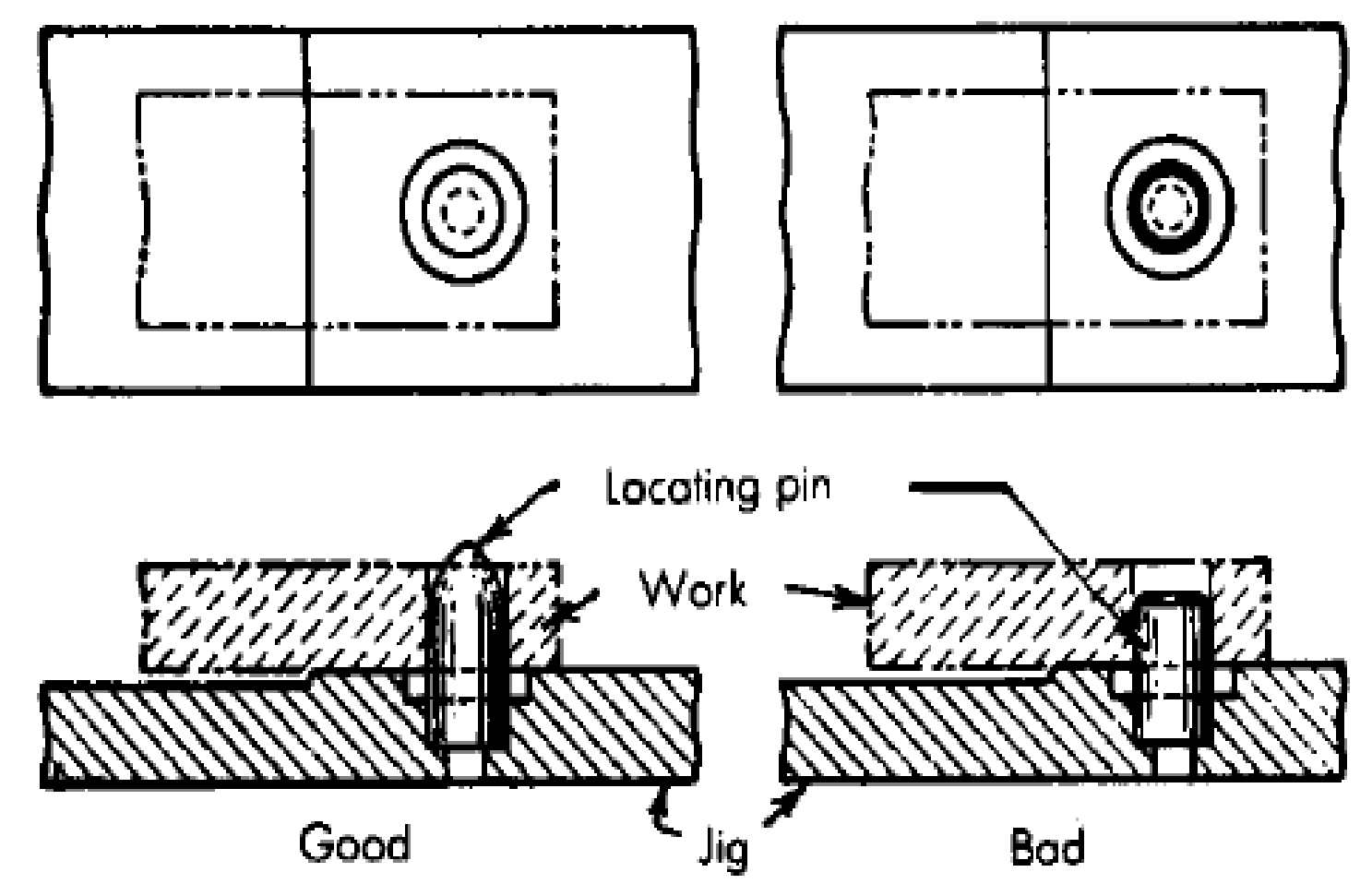
Chip and burr problems

- Make locators easy to clean
- Small and hard
- Open jigs
- Make them self cleaning
- Edge relief around locators
- Wipers
- Protect them

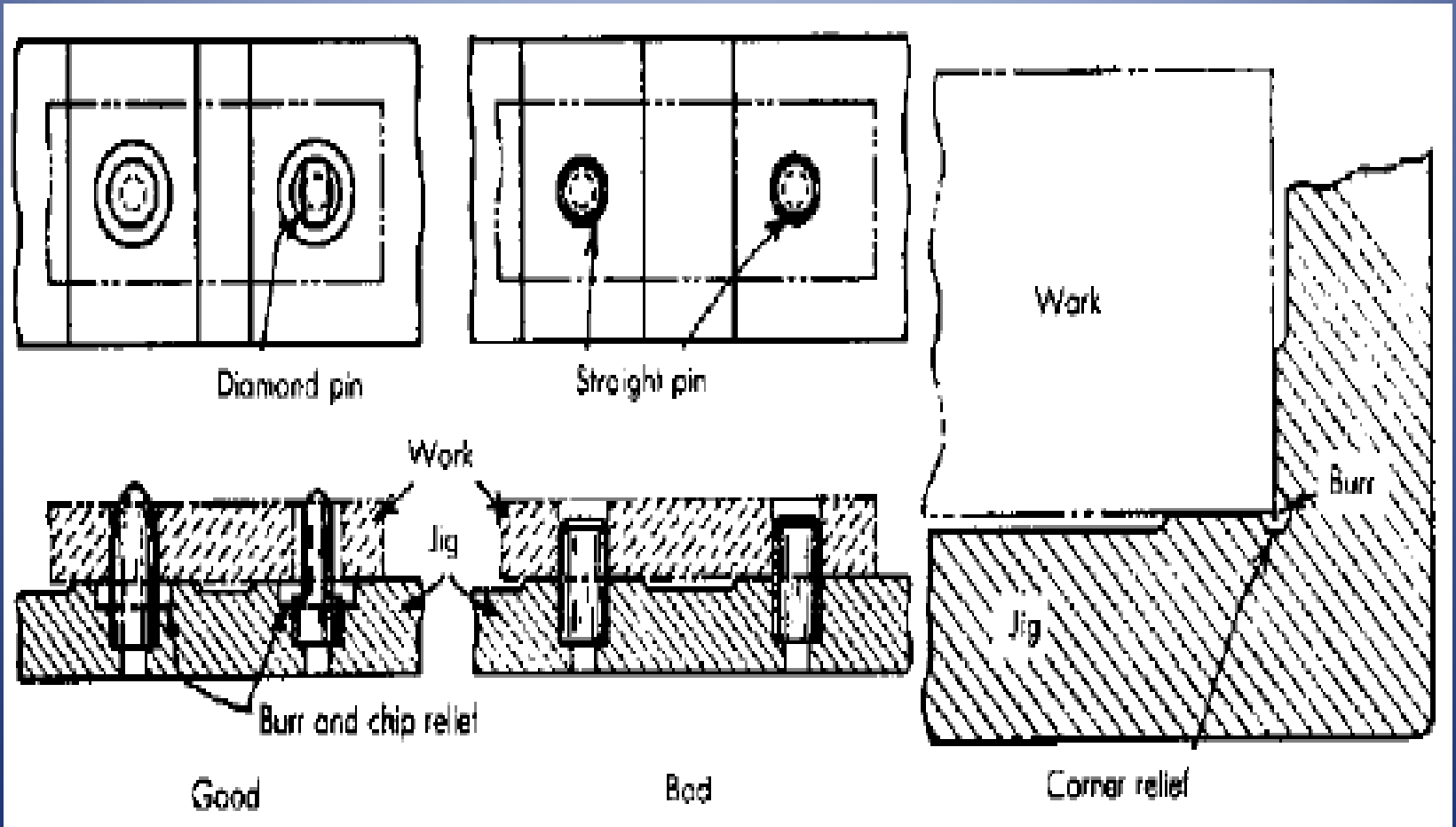
Raised work piece supports



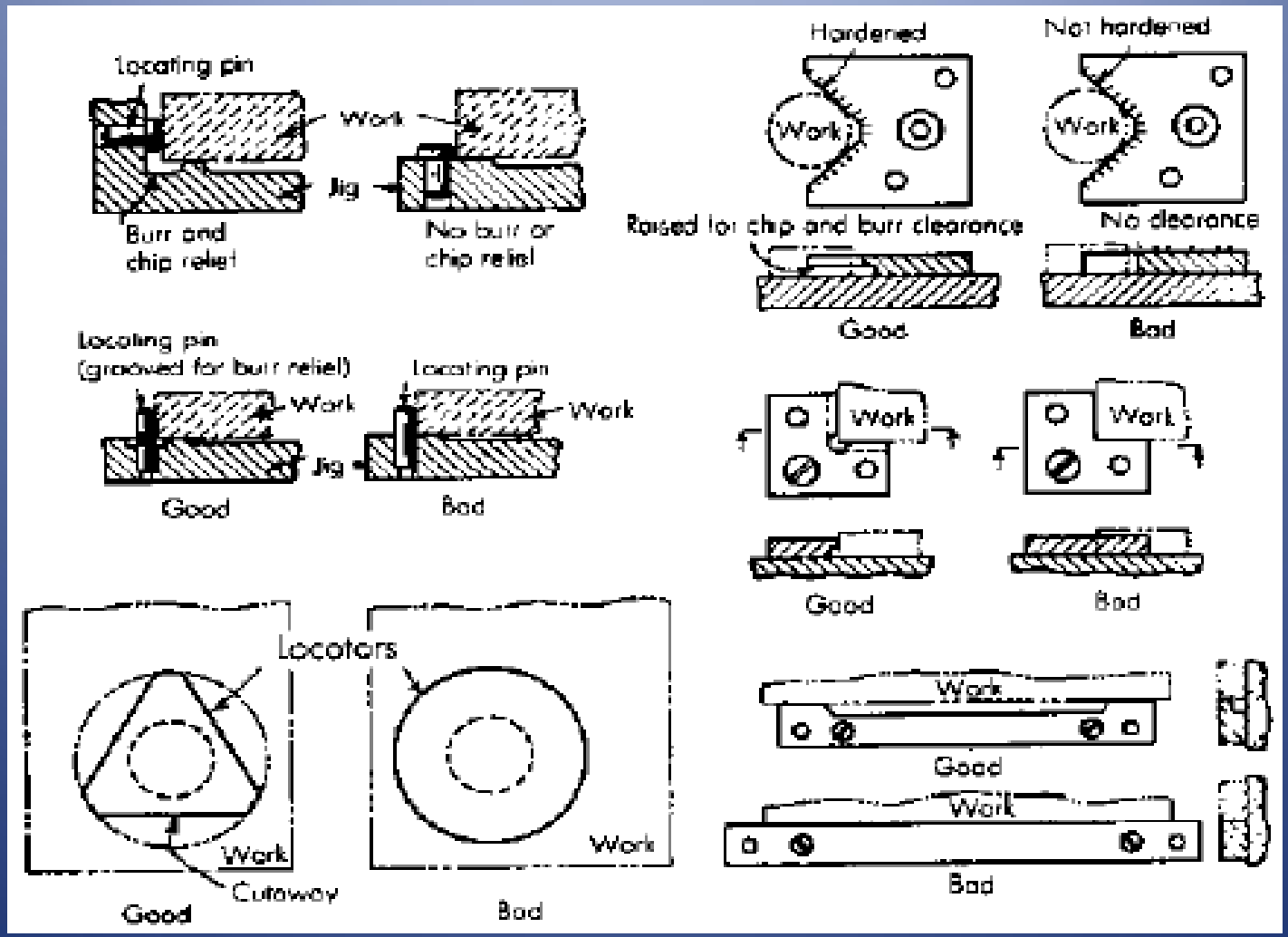
Proper chip clearance



Proper chip clearance (contd.)



Proper chip clearance (contd.)



Clamping surfaces

- Generally the clamping surface should be opposite to that of a location surface for clamping to be effective
- However, normally the surface opposite to location would be the surface to be machined
- Hence this choice would only be possible if all of that surface is not be machined or a parallel surface to this is available

Clamping surfaces (contd.)

- If the surface opposite to the location is not available for clamping, alternate surfaces should be chosen for clamping such that the resultant clamping force is acting against the locators
- As far as possible already machined surfaces should be avoided as clamping surfaces, as they are likely to be spoiled under the clamping forces

Clamping surfaces (contd.)

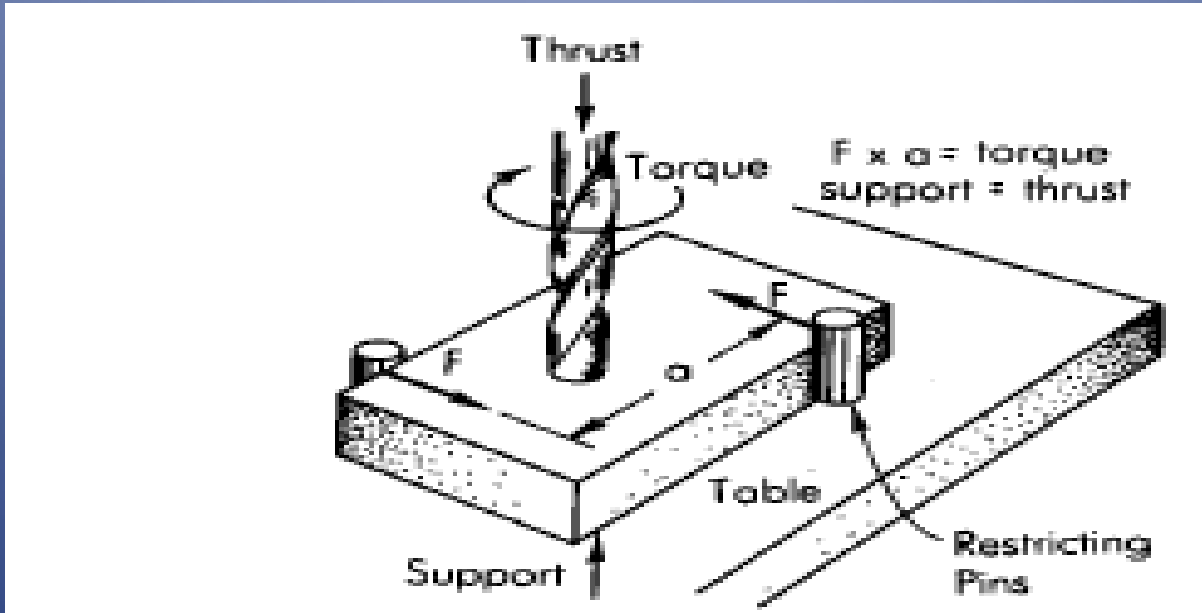
- Care has to be exercised to distribute this large clamping force over a large area of the work piece surface
- Choose a surface with enough rigidity such that no deformation of the component takes place under the clamping forces

Clamping surfaces (contd.)

- Always choose the clamping surface area large enough such that the clamping forces are properly distributed and no surface plastic deformation takes place on the component
- The clamping force used should take care of the cutting forces likely to come and maintain the stability of the workpiece within the fixture

Tool forces

- Magnitude and direction of cutting forces is useful for designing the clamping



Pin-type drill fixture resisting torque and thrust.

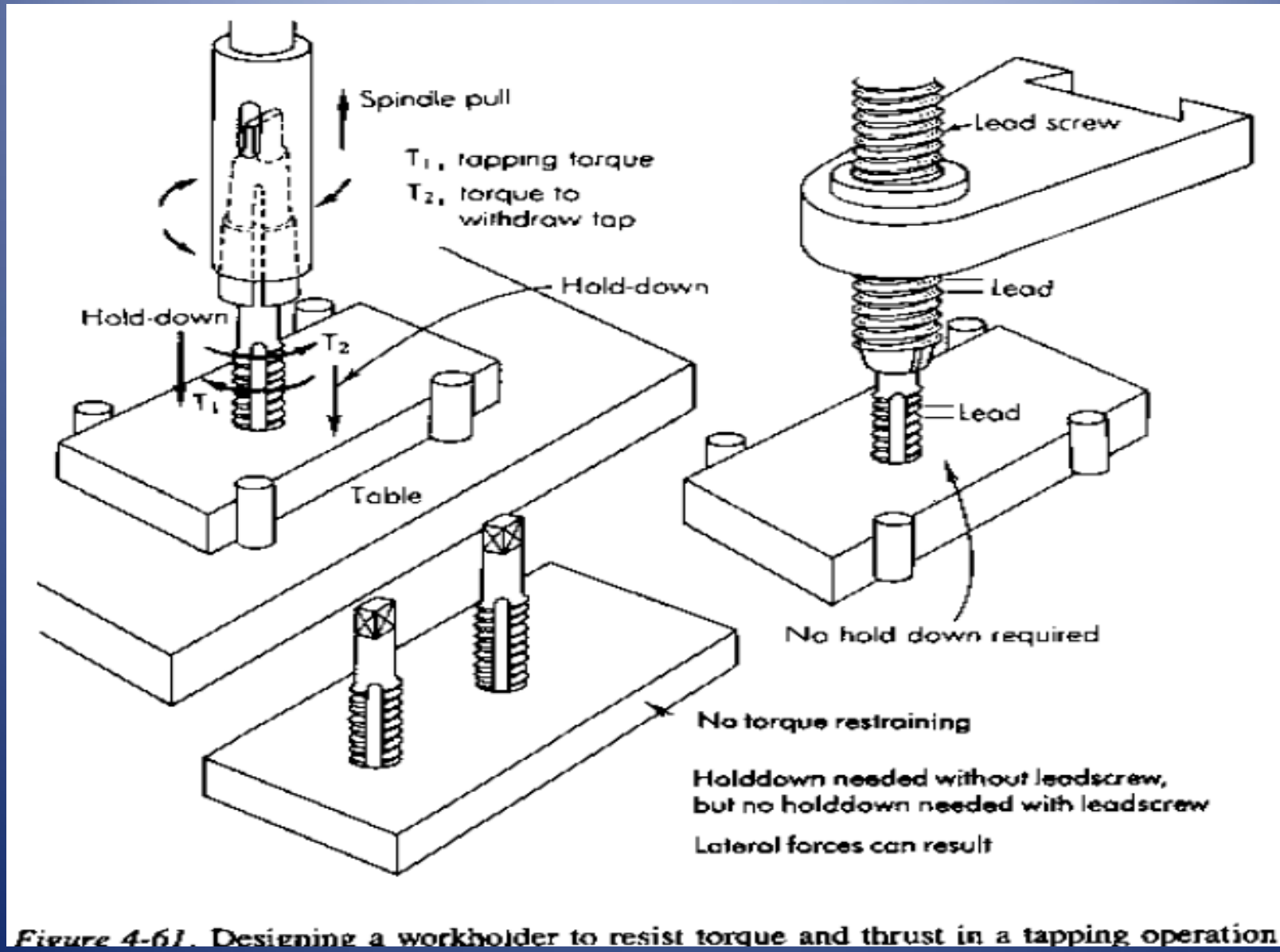


Figure 4-61. Designing a workholder to resist torque and thrust in a tapping operation

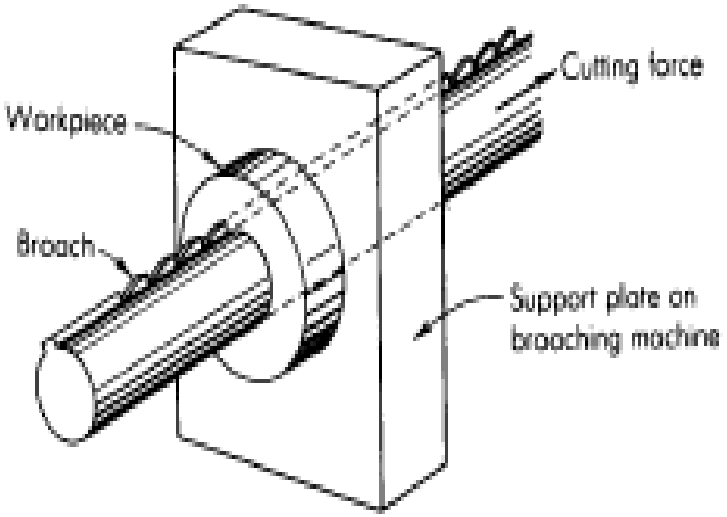


Figure 4-62. Workholder for broaching operation.

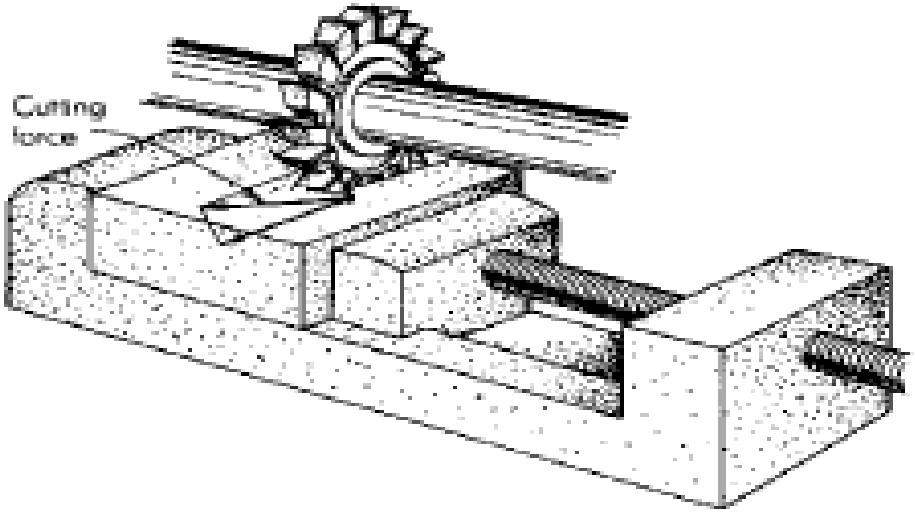
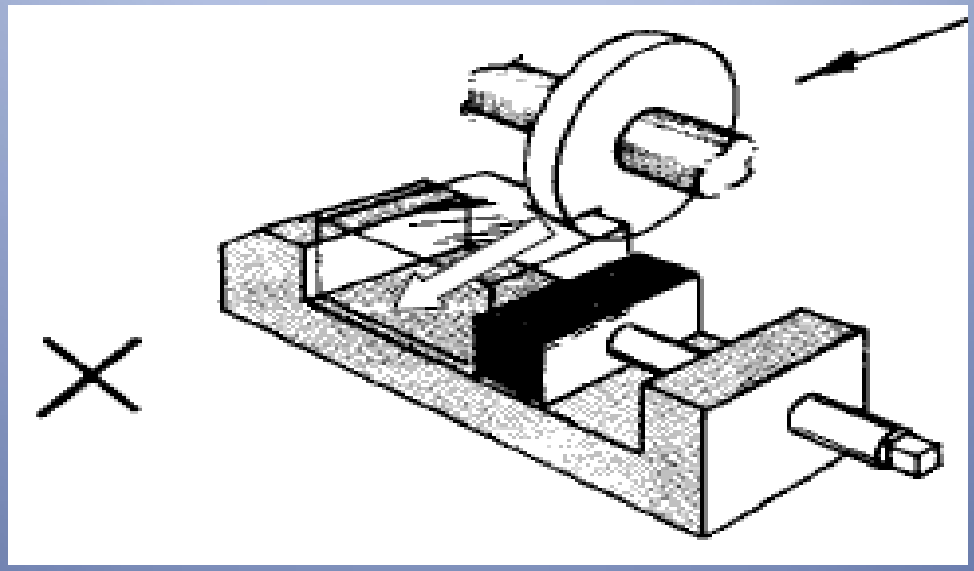
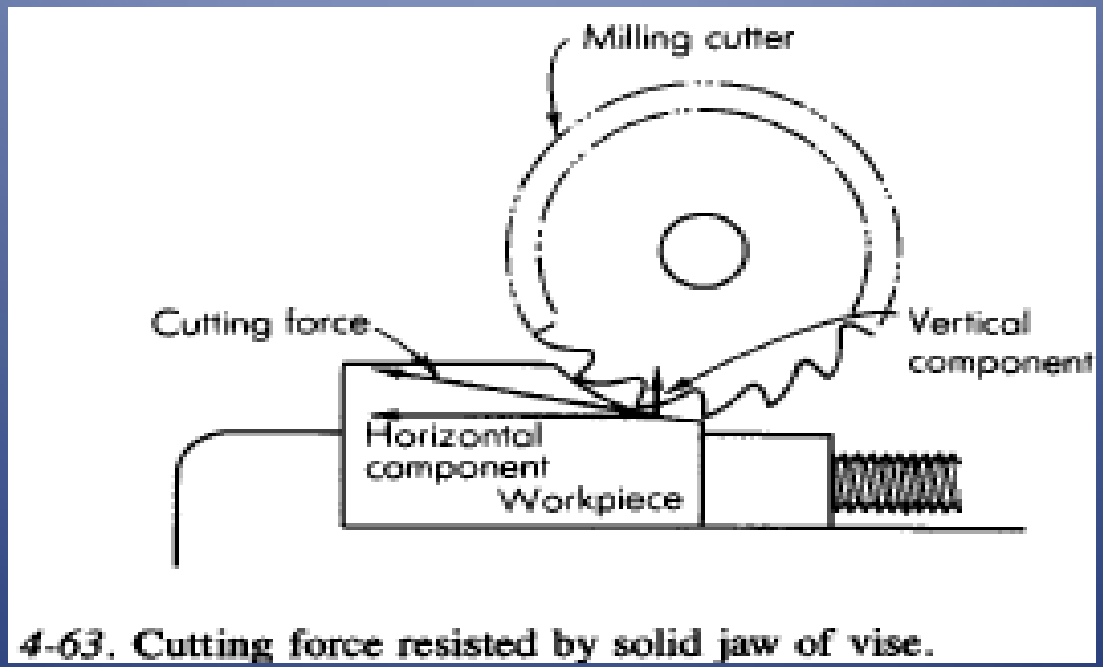
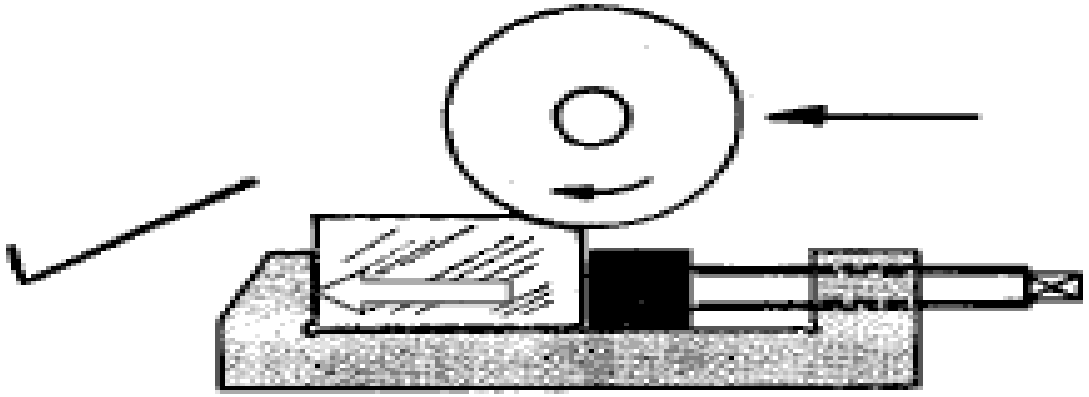


Figure 4-64. Cutting force resisted only by friction.

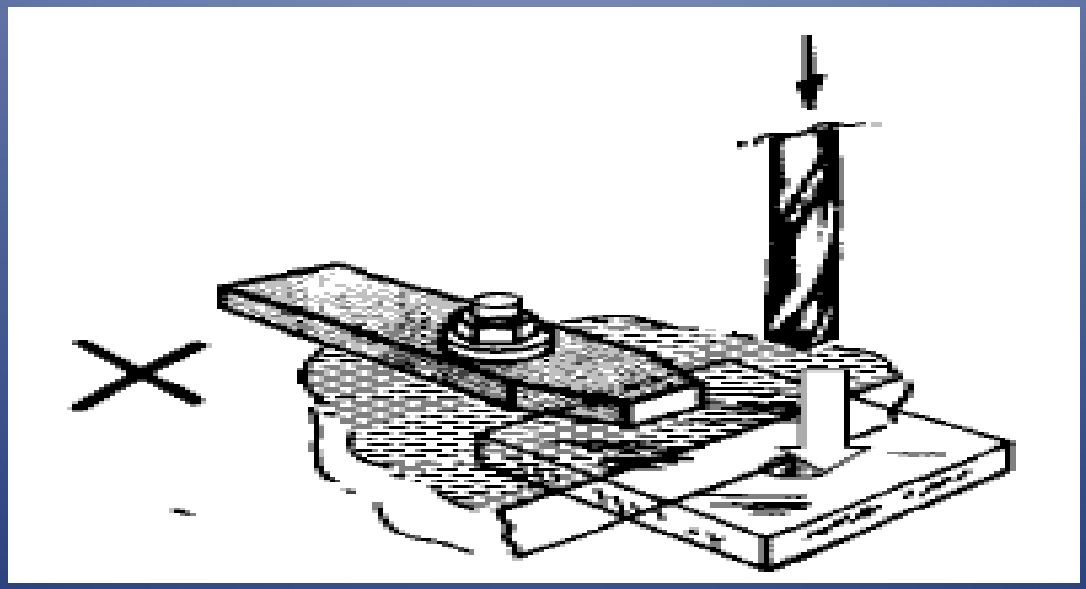


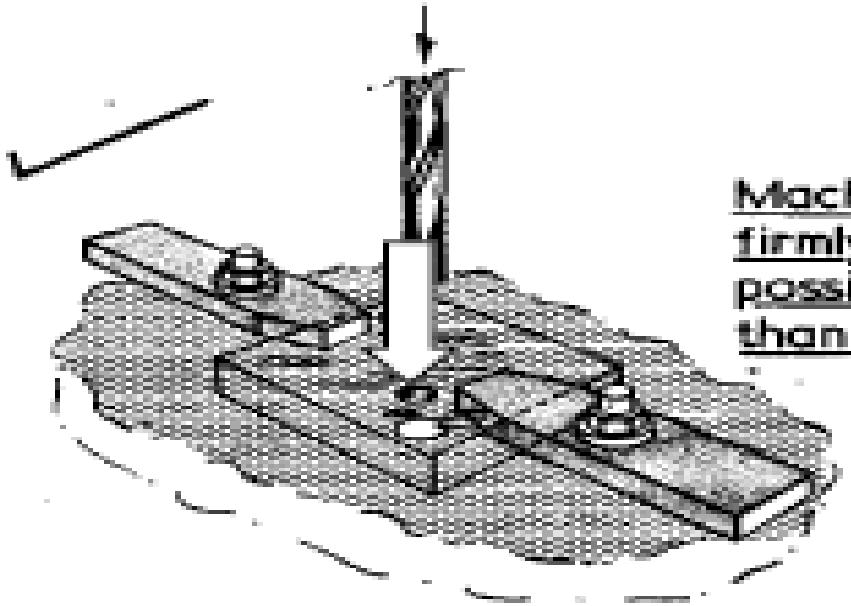


4-63. **Cutting force resisted by solid jaw of vise.**

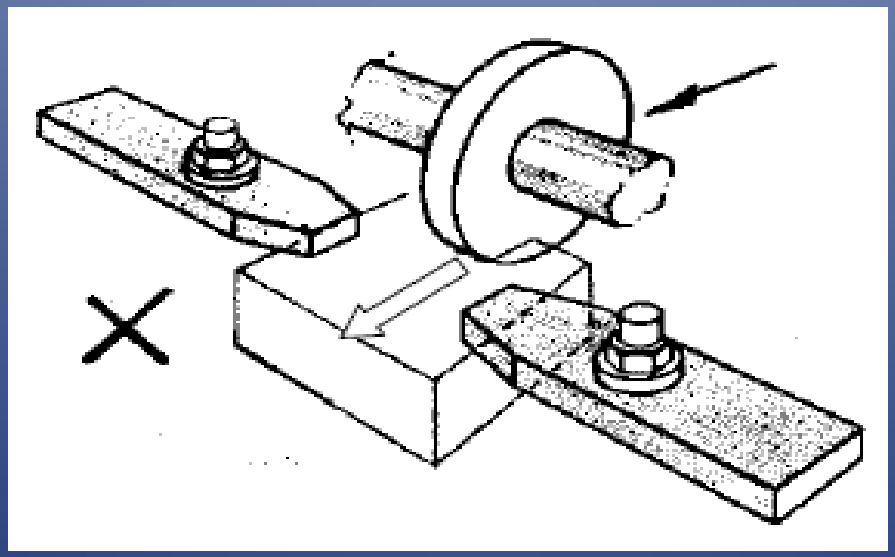


Cutter action should always be against FIXED jaw or location





Machining action should be firmly backed up and where possible clamped in more than one position



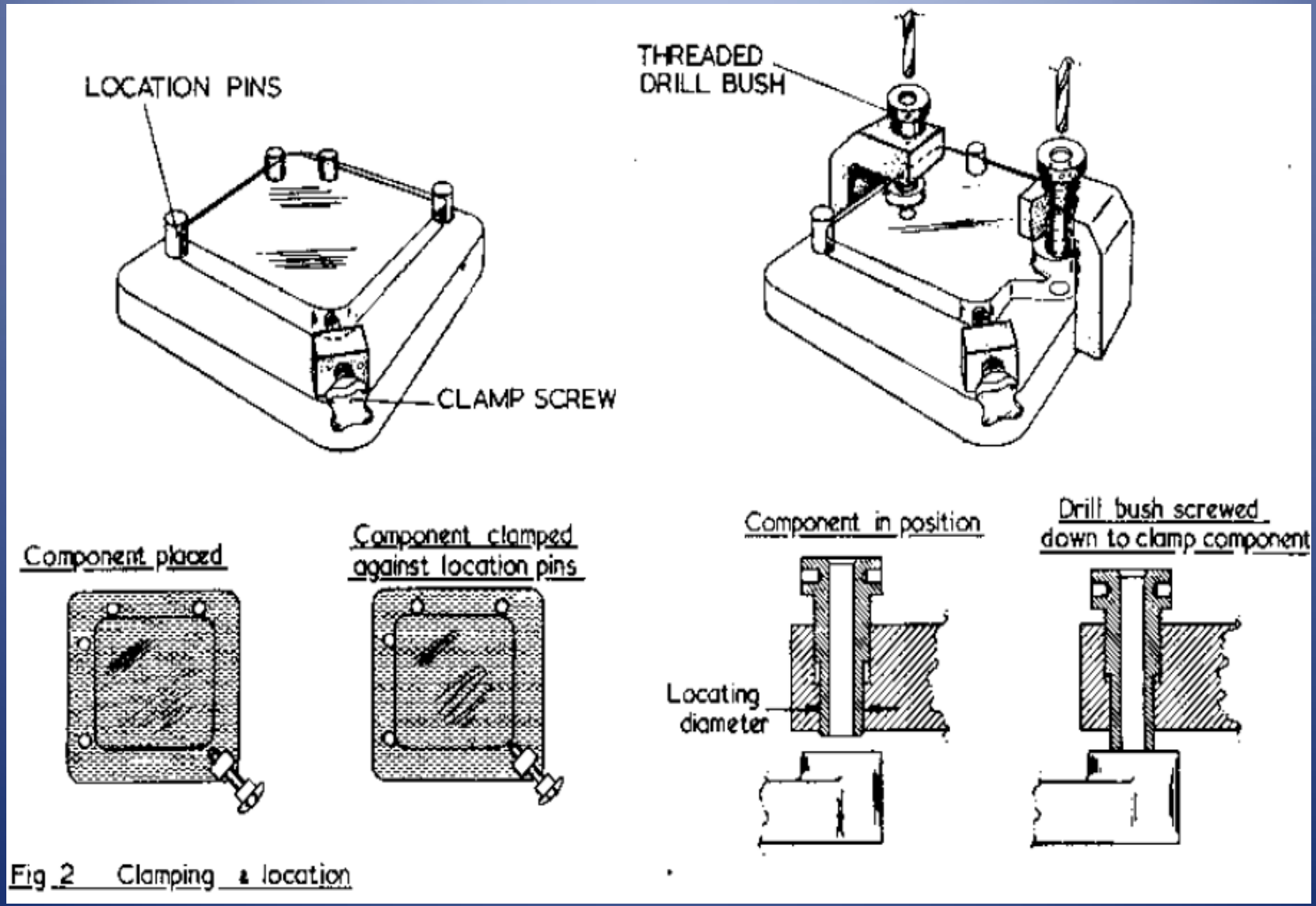
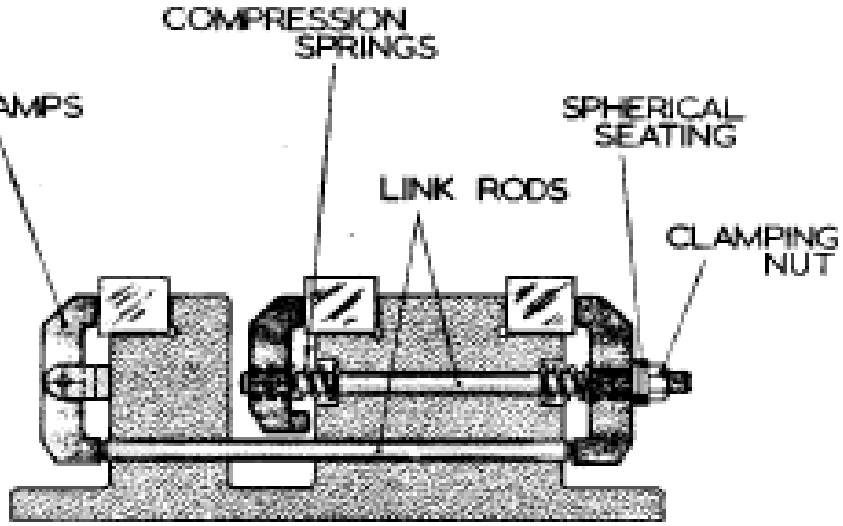
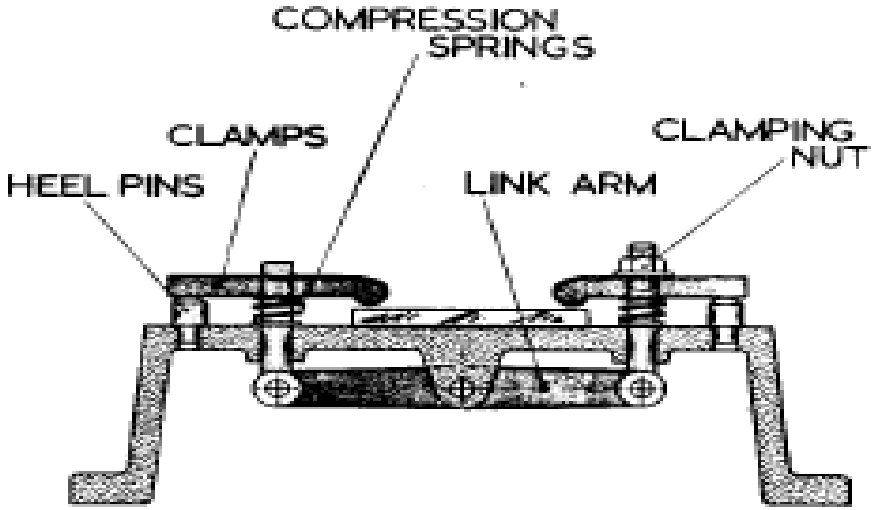


Fig 2 Clamping & location



distributing clamping force to more than one point equally from one point of application



distributing clamping force to more than one point equally from one point of application

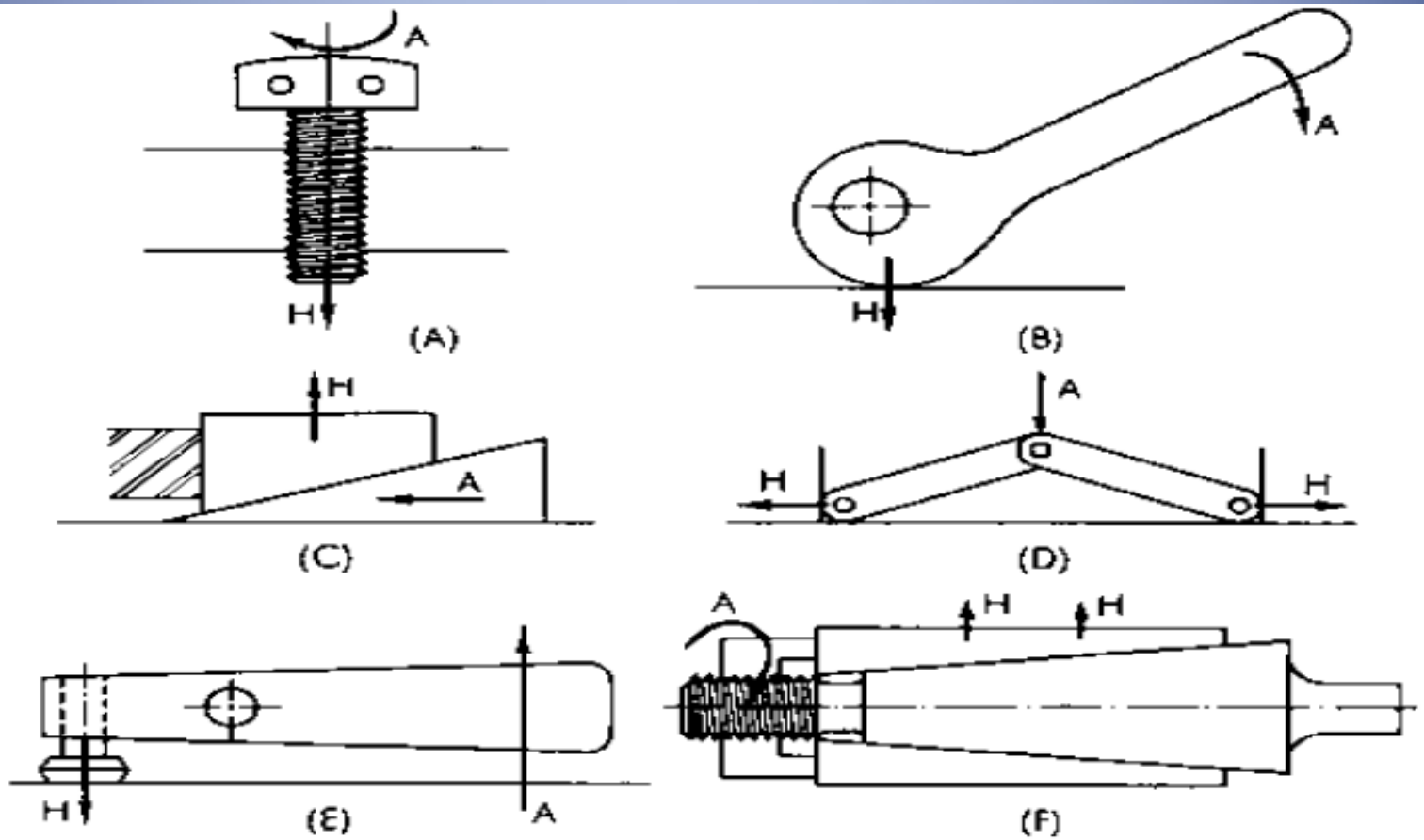
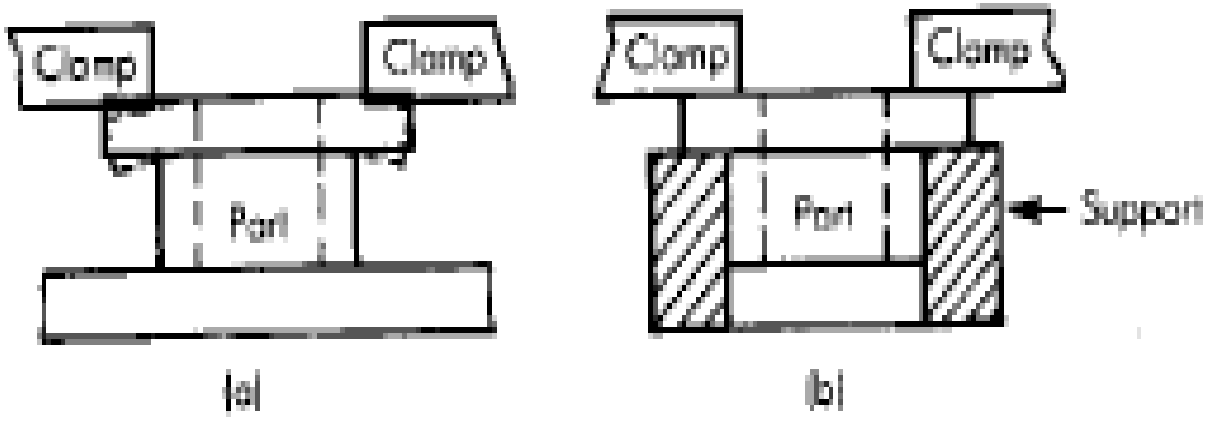


Figure 4-65. Mechanical methods of transmitting and multiplying force: (*A*) screw, (*B*) cam, (*C*) wedge, (*D*) toggle linkage, (*E*) lever, (*F*) combined screw and wedge.



4-66. Positioning clamps.

Factors for Clamping Design

- 1. Simple clamps are preferred because complicated ones lose effectiveness as they wear.
- 2. Some clamps are more suitable for large and heavy work, others for small pieces.
- 3. Rough work pieces call for a longer travel of the clamp in the clamping range, but clamps may be made to dig into rough surfaces to hold them firmly.

Factors for Clamping Design

- 4. The type of clamp required is determined by the kind of operation to which it is applied. A clamp suitable for holding a drill jig leaf may not be strong enough for a milling fixture.
- 5. Clamps should not make loading and unloading of the work difficult, nor should they interfere with the use of hoists and lifting devices for heavy work.
- 6. Clamps that are apt to move on tightening, such as plain straps, should be avoided for production work.
- 7. The anticipated frequency of setups may influence the clamping means. For example, the use of hydraulic clamps, even if simple and of low cost, might be inadvisable if frequent installation and removal of piping and valves is necessary.

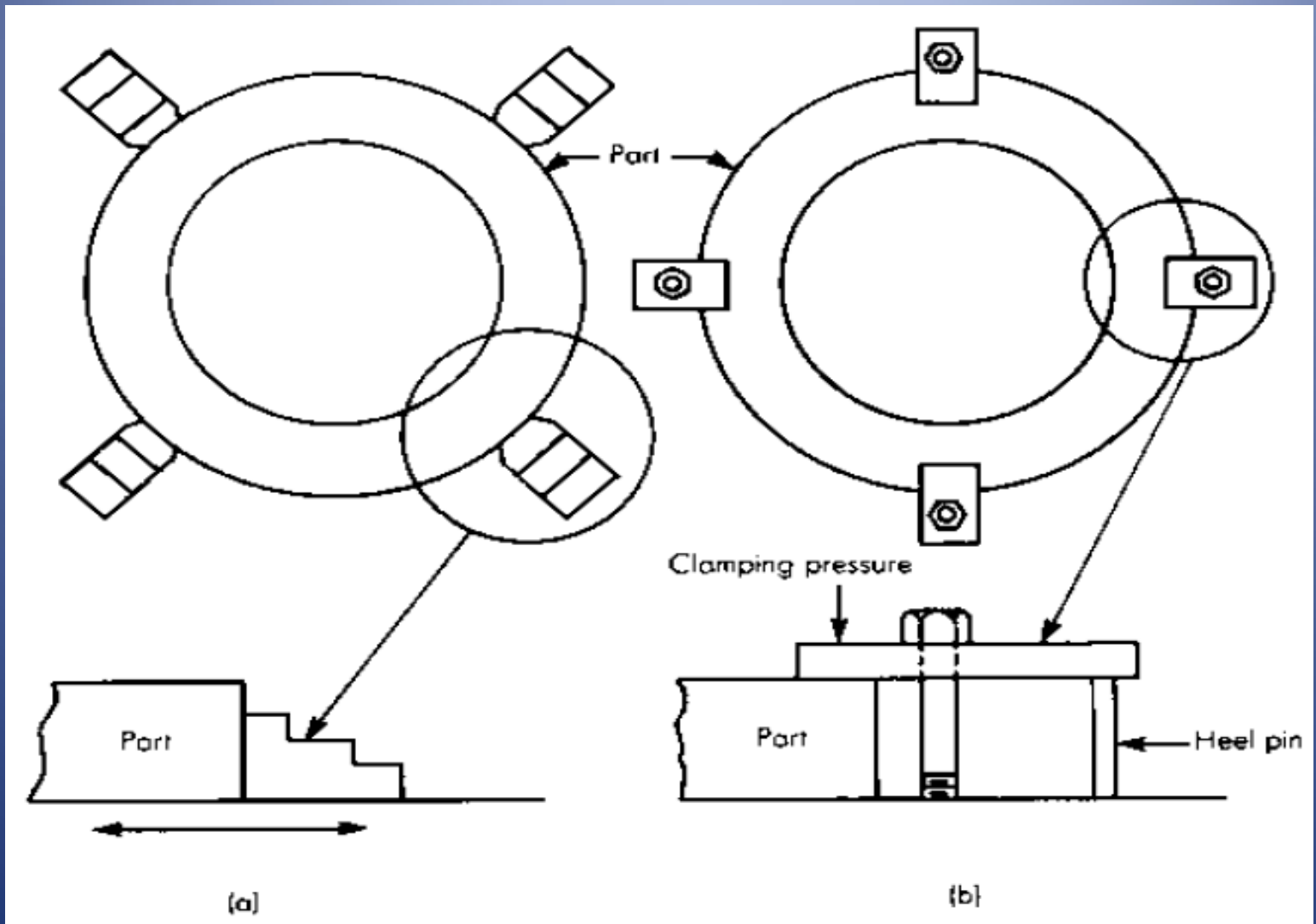


Figure 4-67. Clamping large rings.

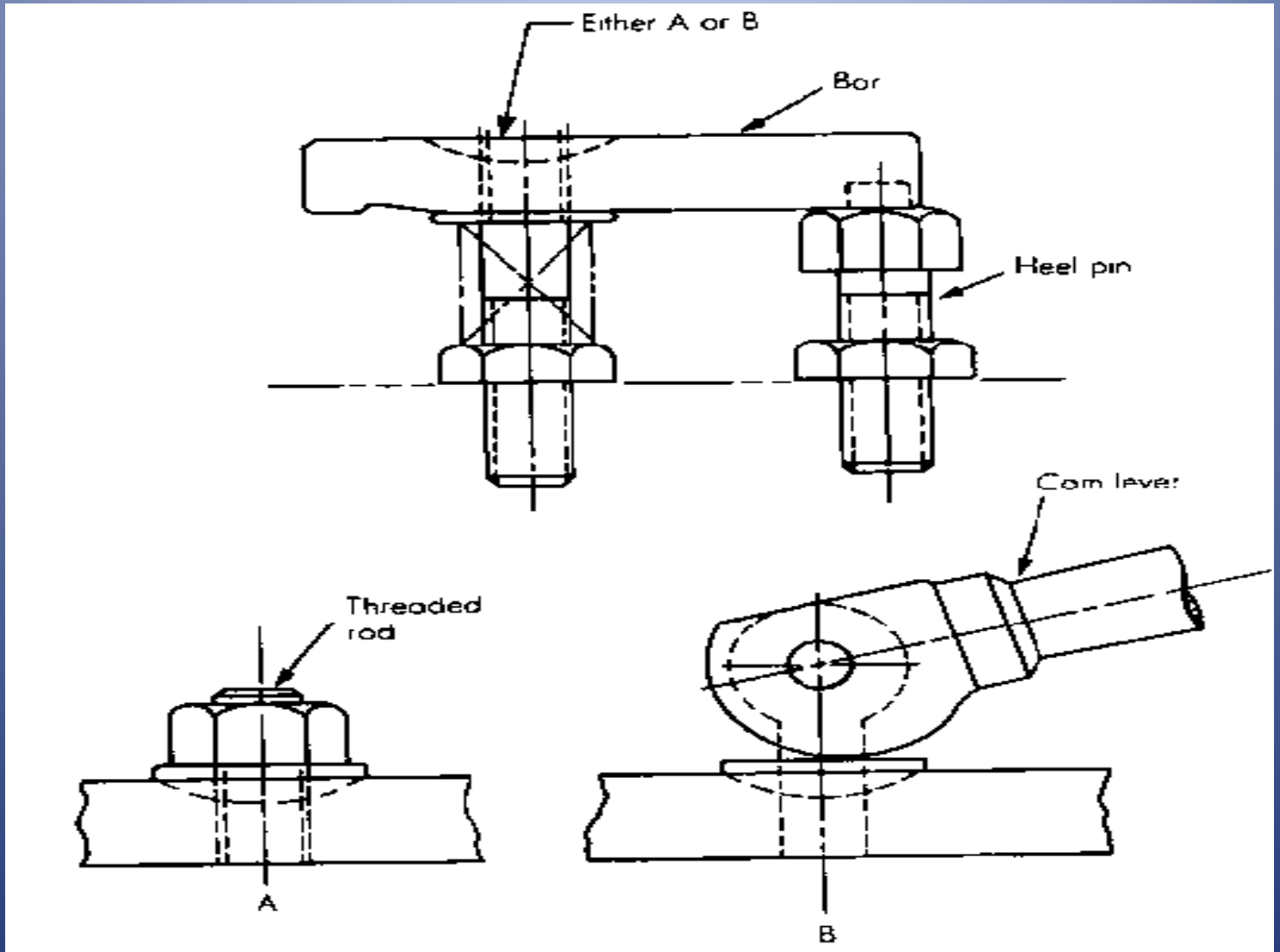
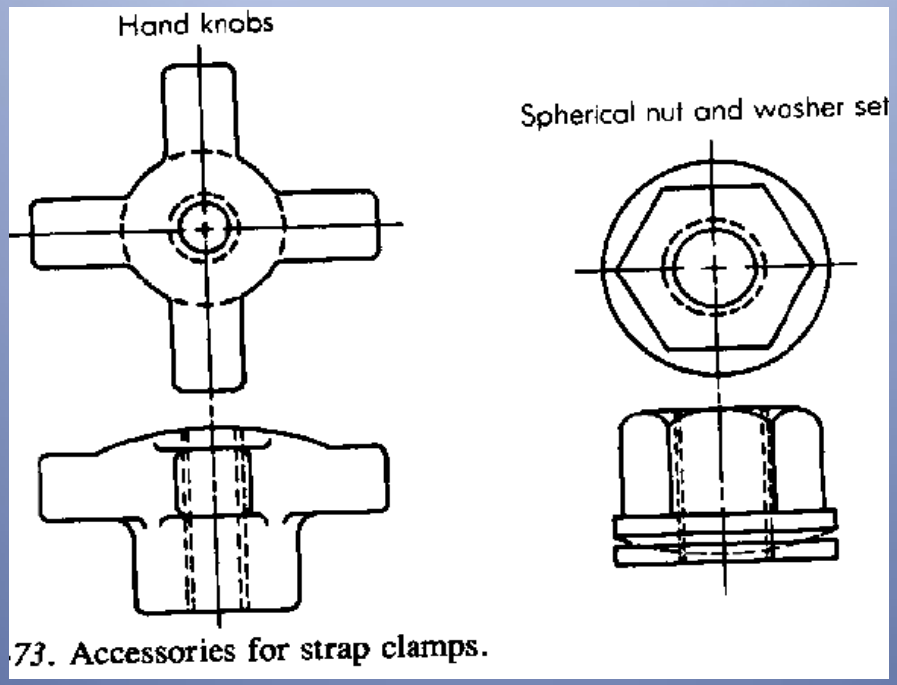
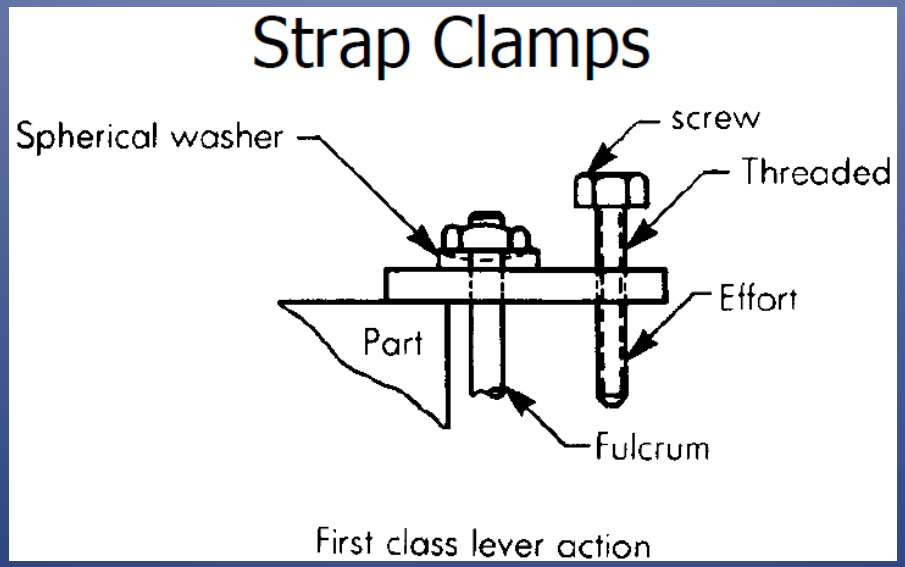


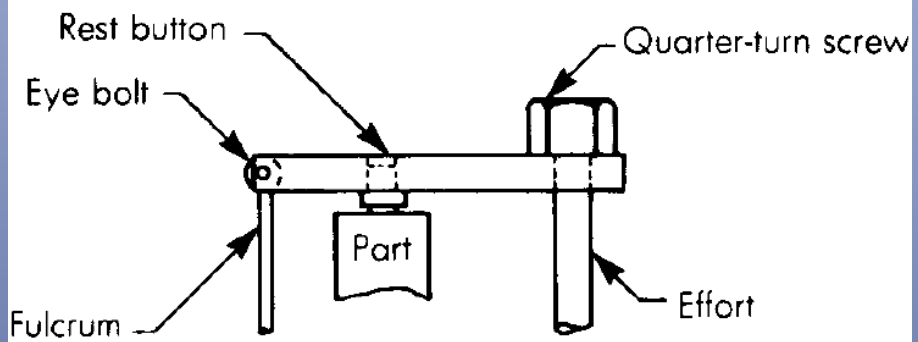
Figure 4-72. **Strap clamps.**



73. Accessories for strap clamps.

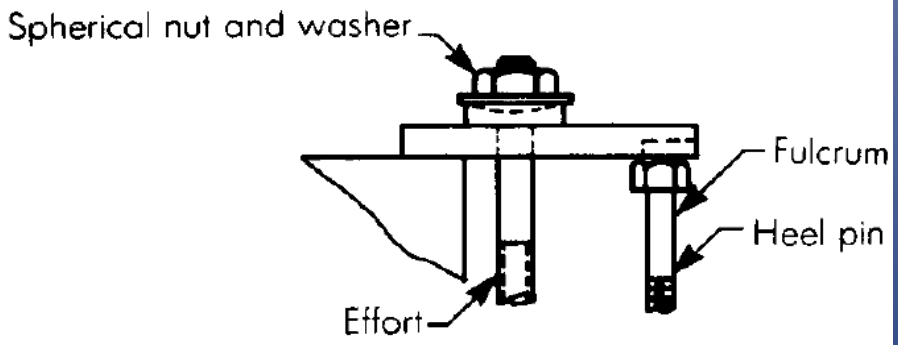


Strap Clamps



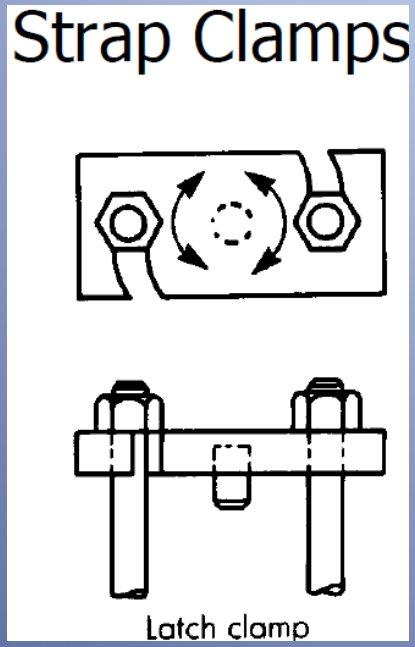
Second class lever action

Strap Clamps

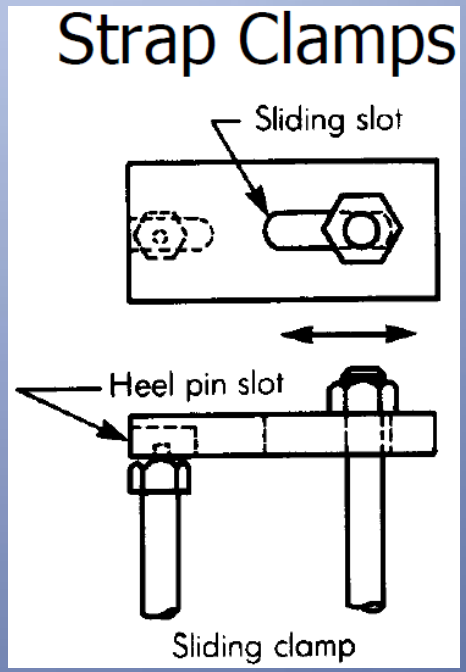


Third class lever action

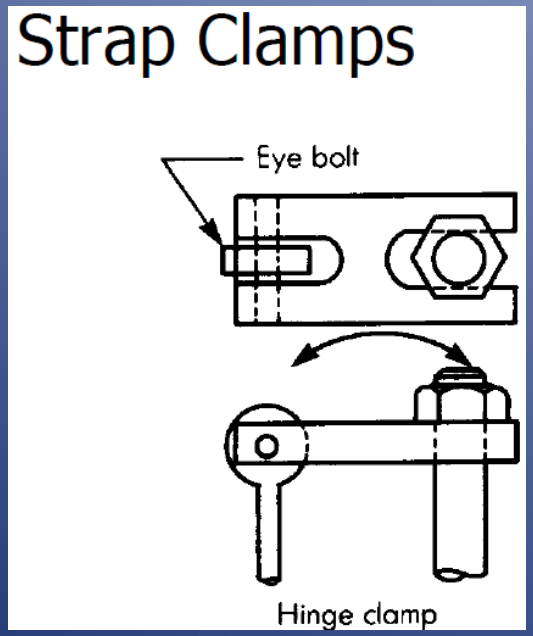
Strap Clamps

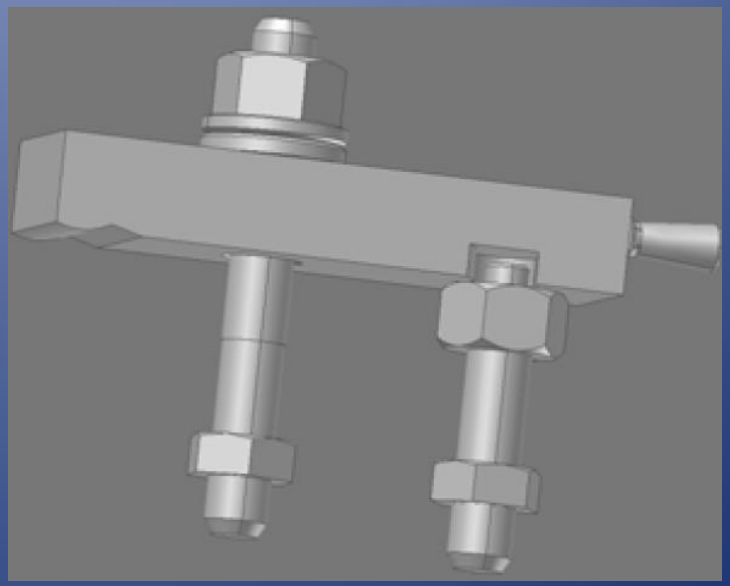


Strap Clamps

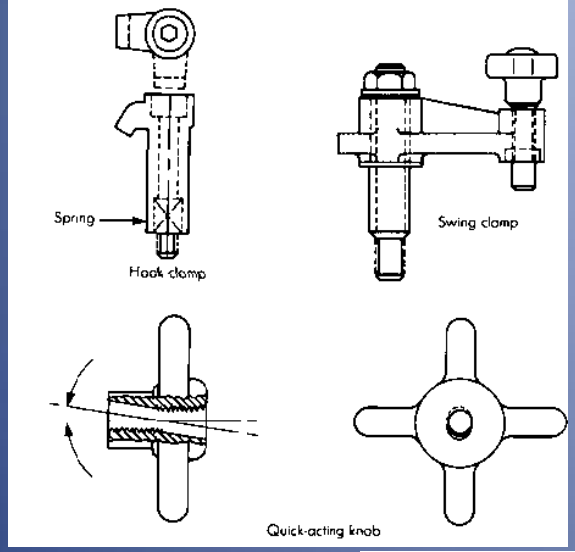


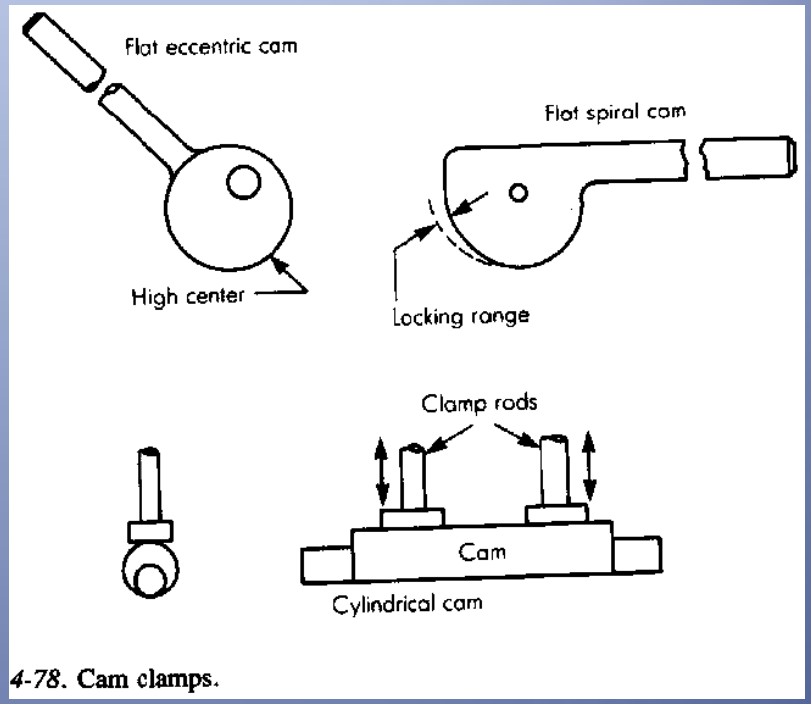
Strap Clamps



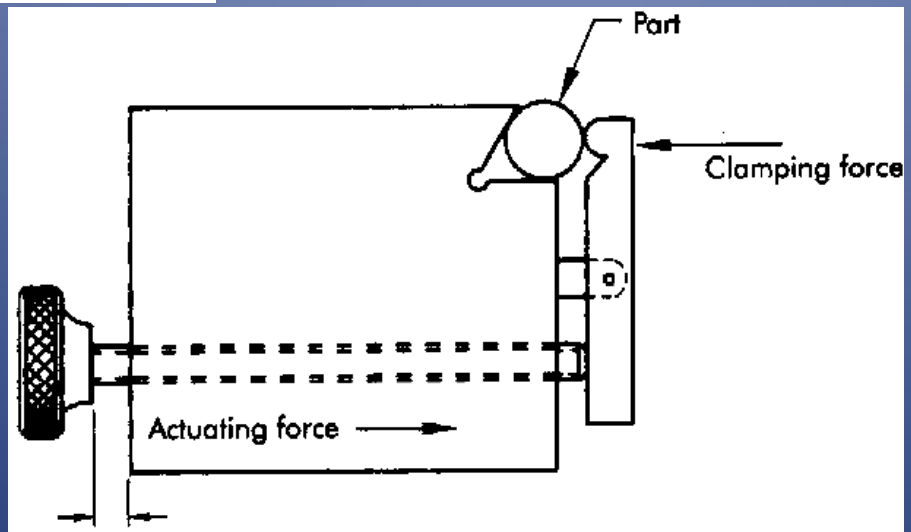


Screw clamps

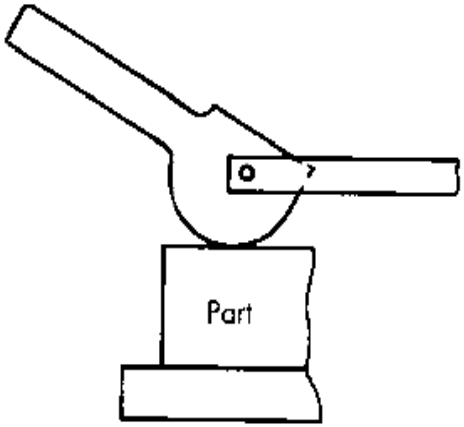


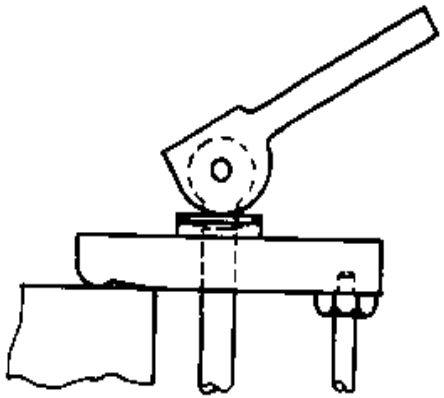


4-78. Cam clamps.

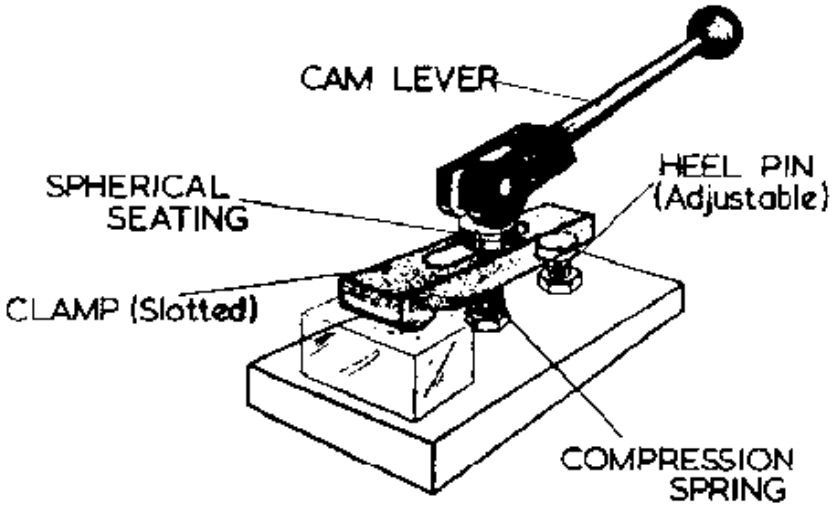


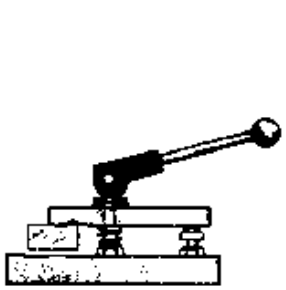
-77. Indirect pressure clamp.



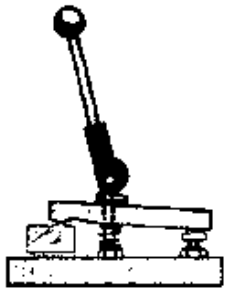


Spiral cams used for direct (top) and indirect (bottom) pressure



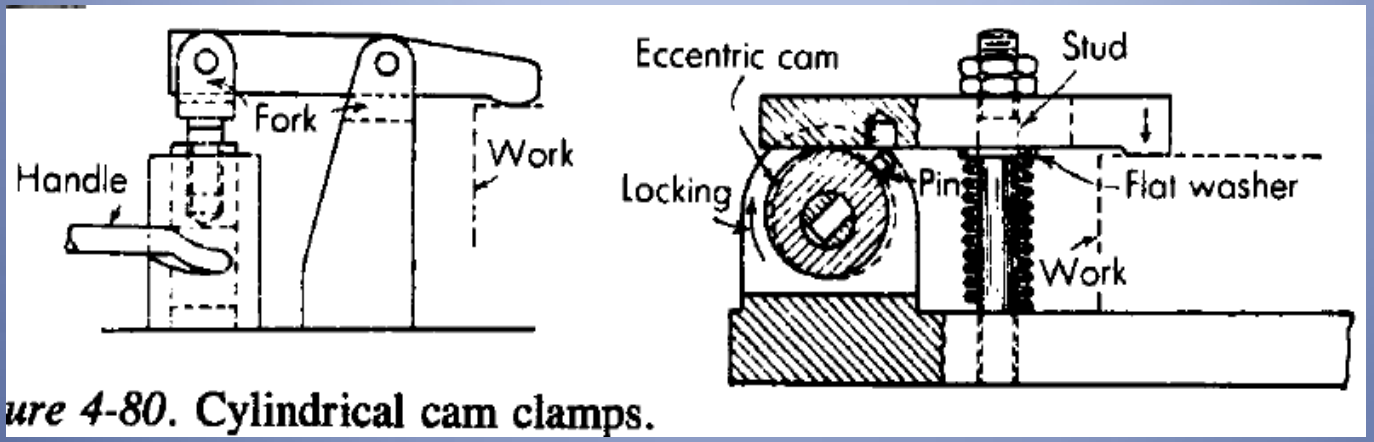


Clamped



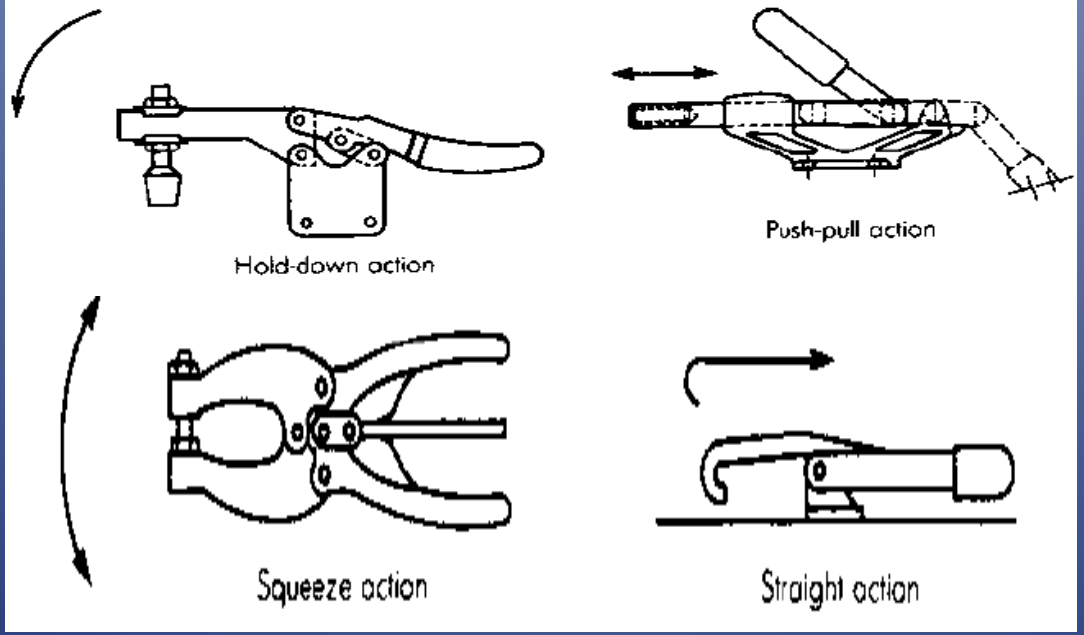
Unclamped

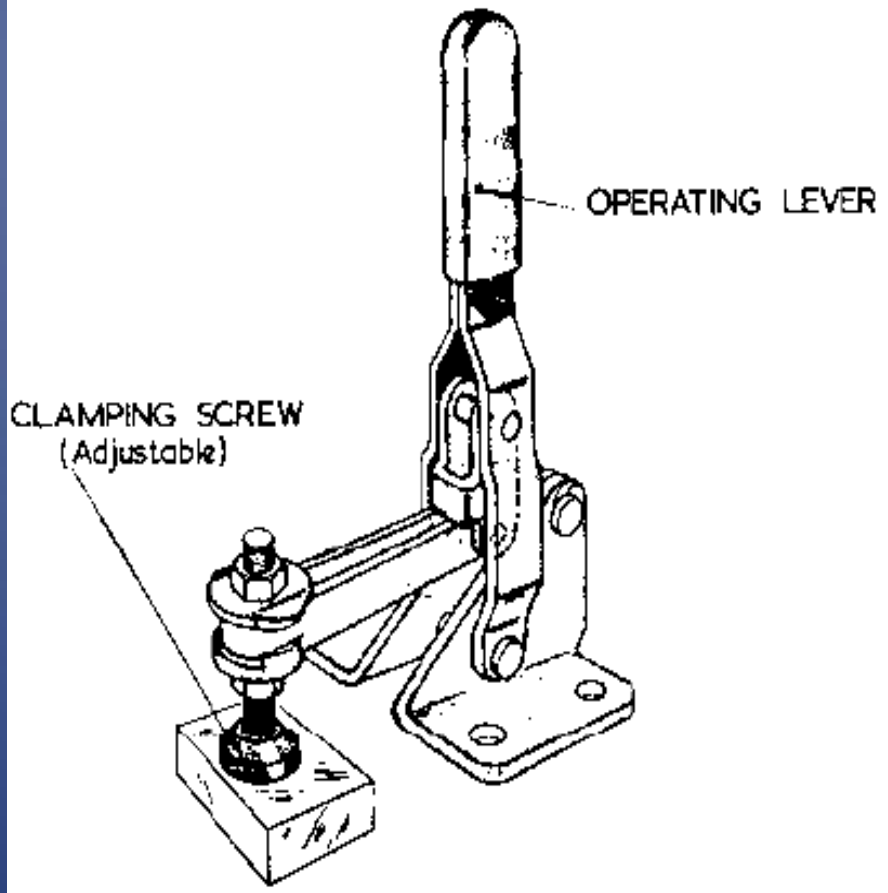
Fig. 7 Cam clamp

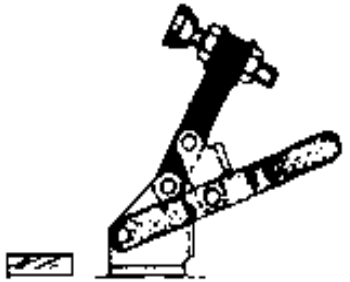


ure 4-80. **Cylindrical cam clamps.**

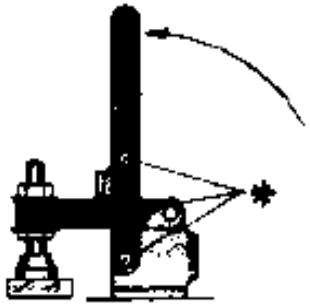
Toggle Clamps







Unclamped



As lever is moved to clamping position the three pivot points * move into vertical alignment to effect locking action

Fig. 5 Toggle clamp

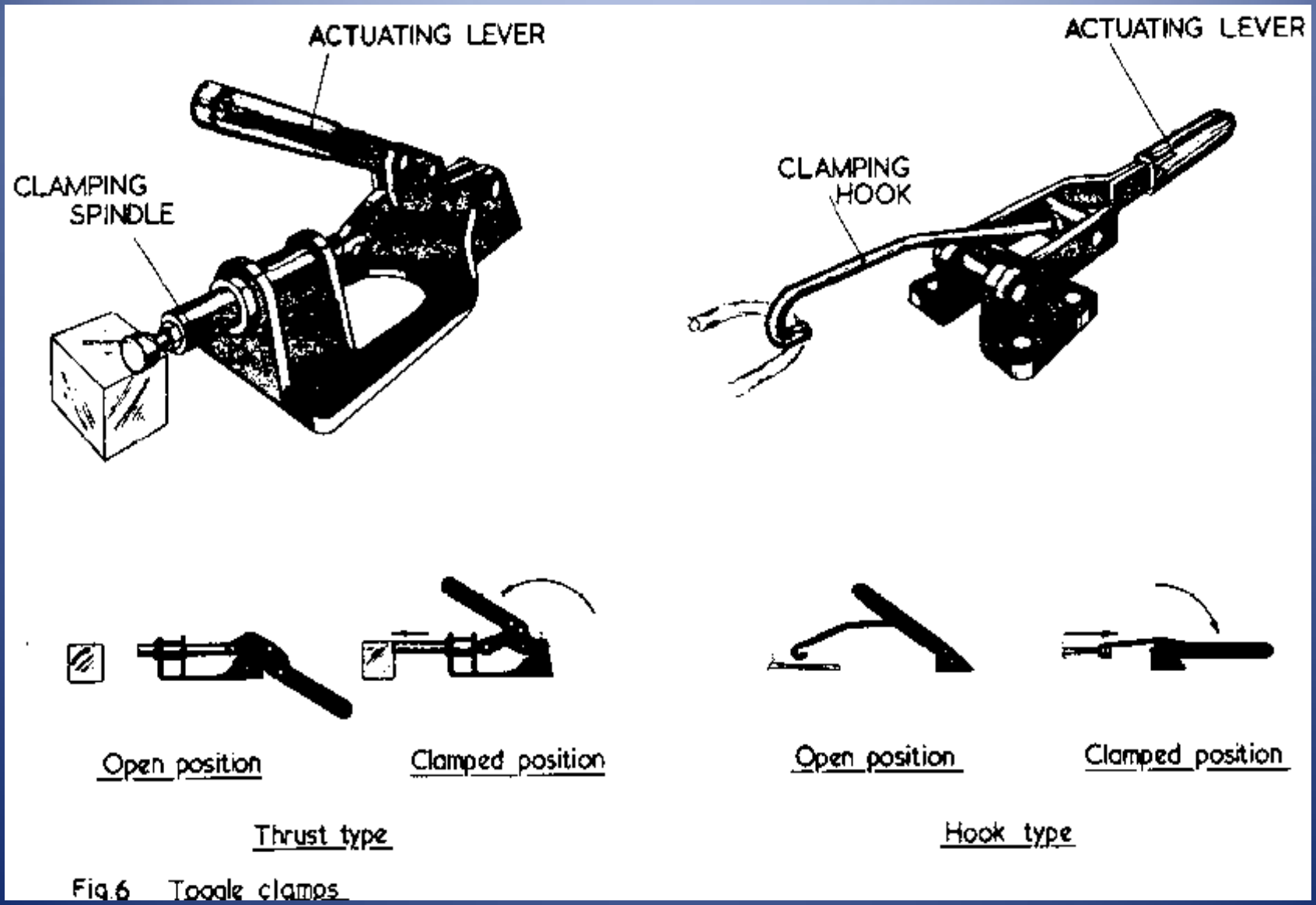
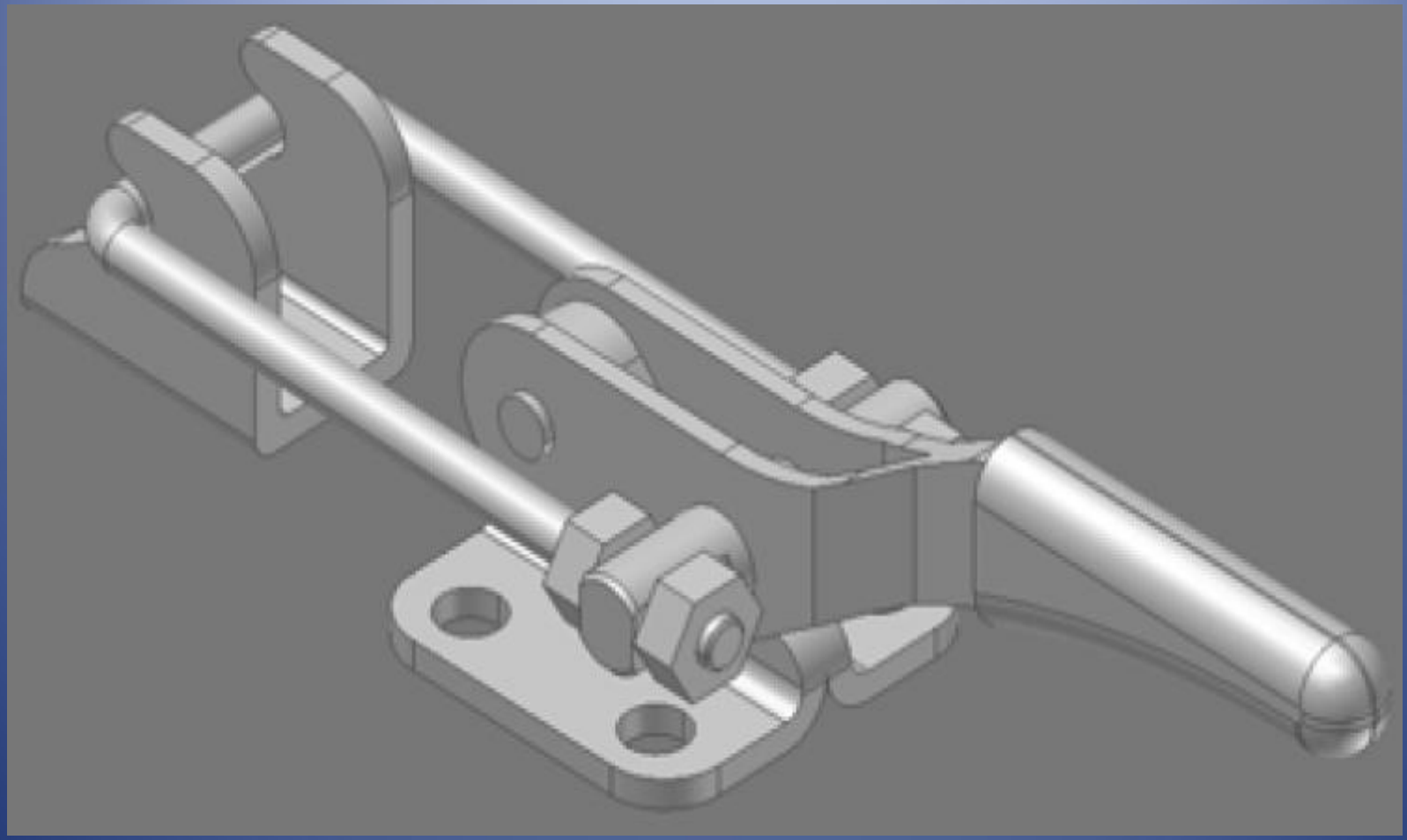


Fig.6 Toggle clamps



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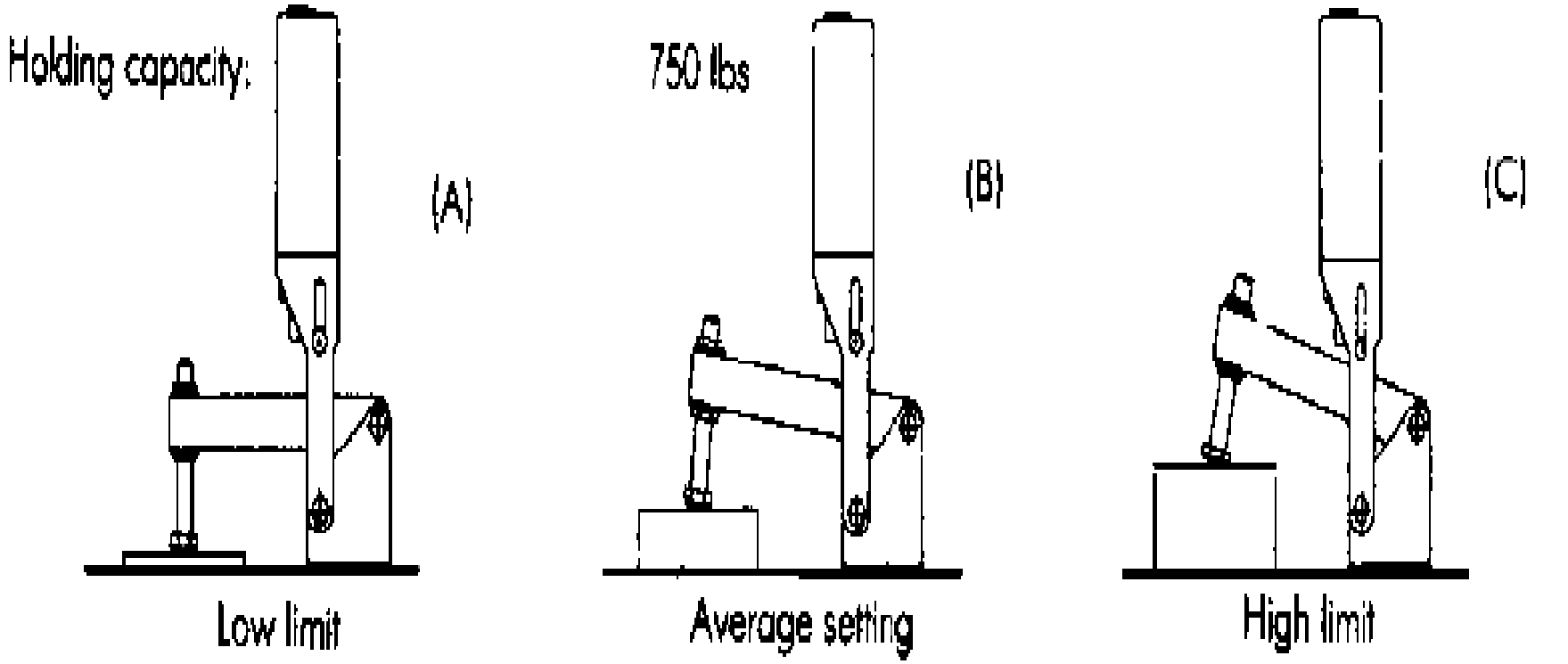
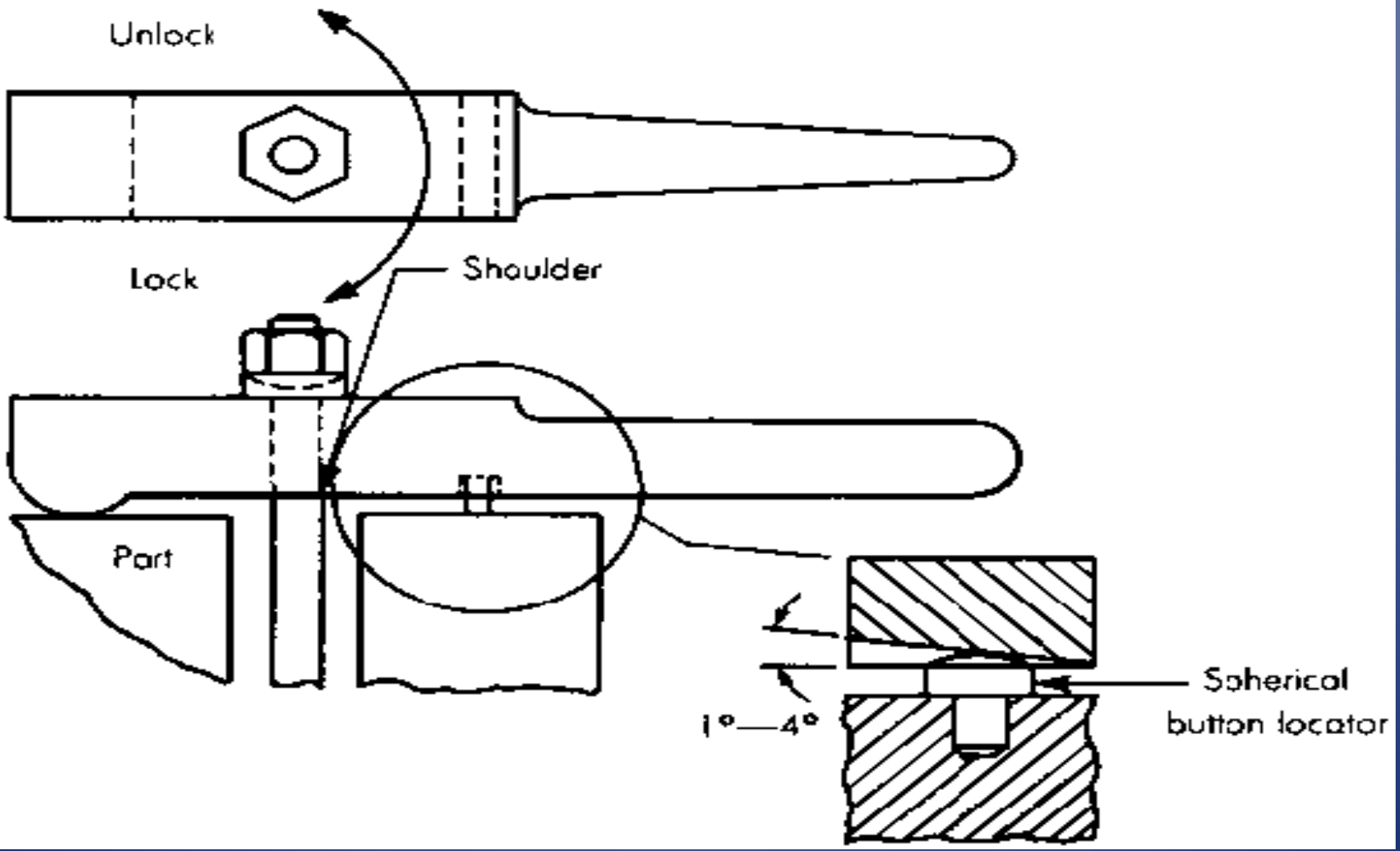


Figure 4-83. Automatic adjustment to workpiece variations. (*Courtesy, Carr Lane Manufacturing Co.*)

Wedge action clamp



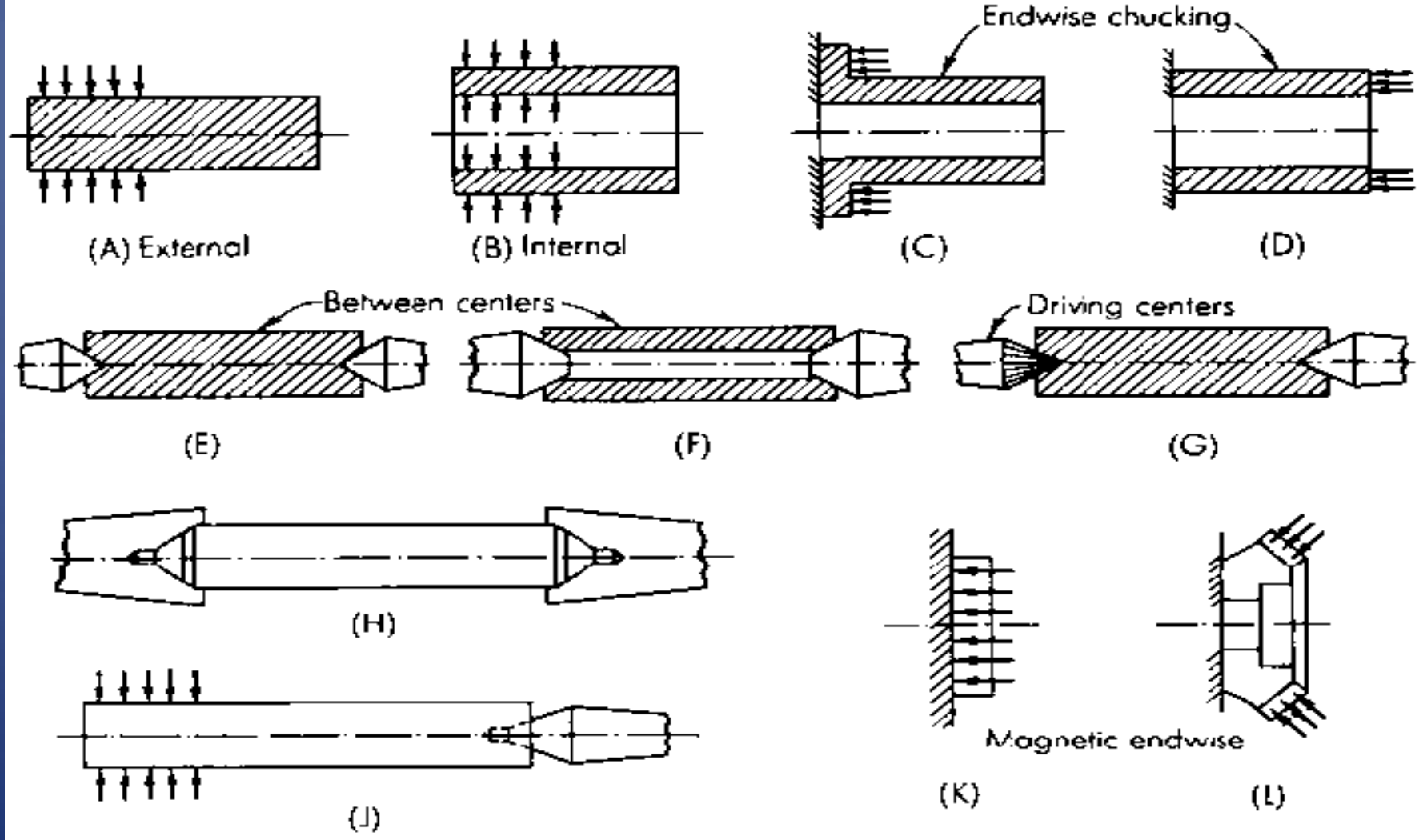
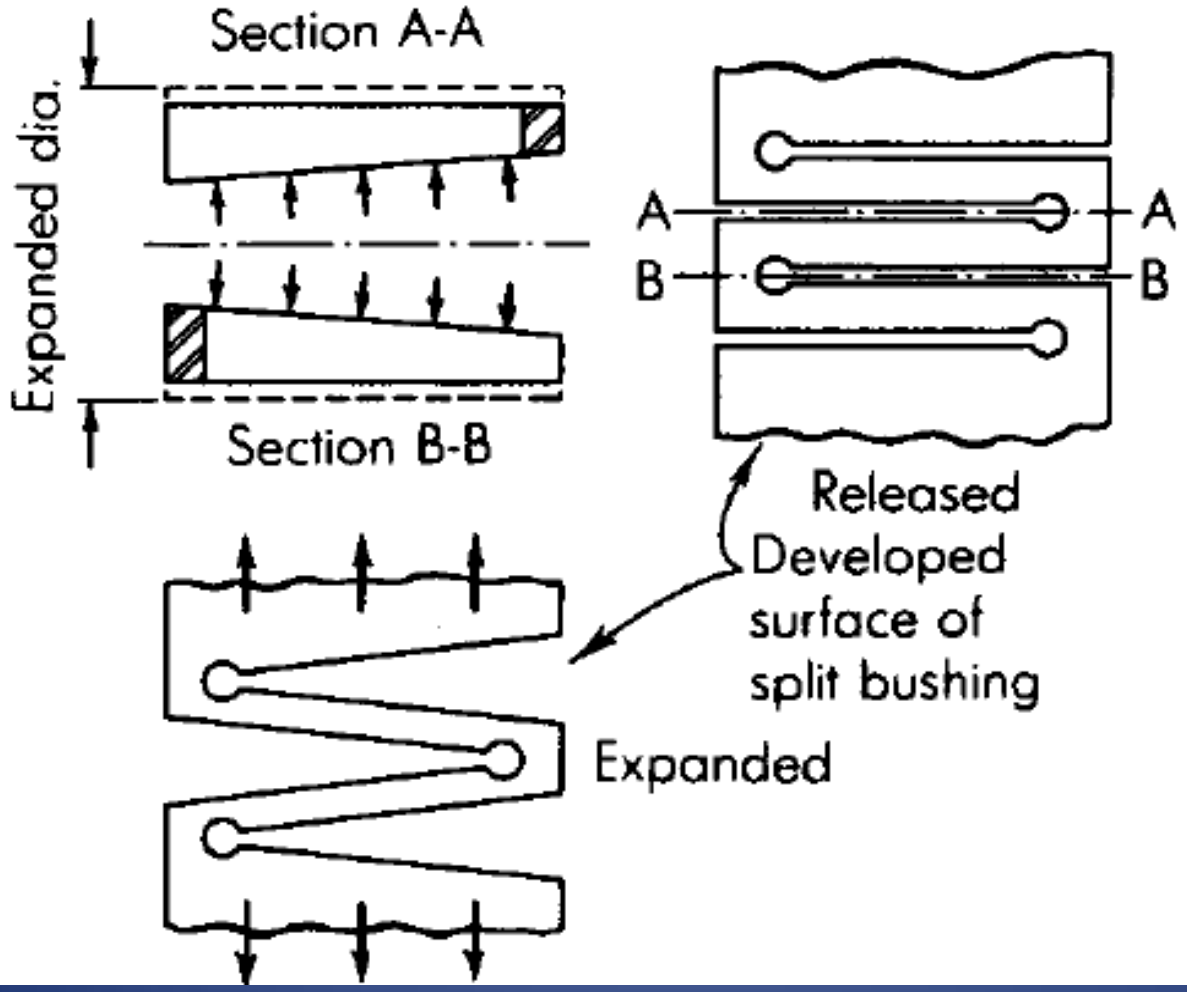
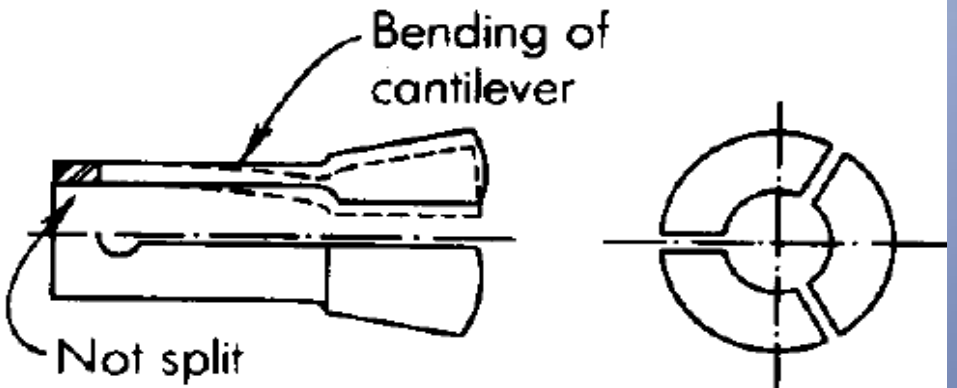


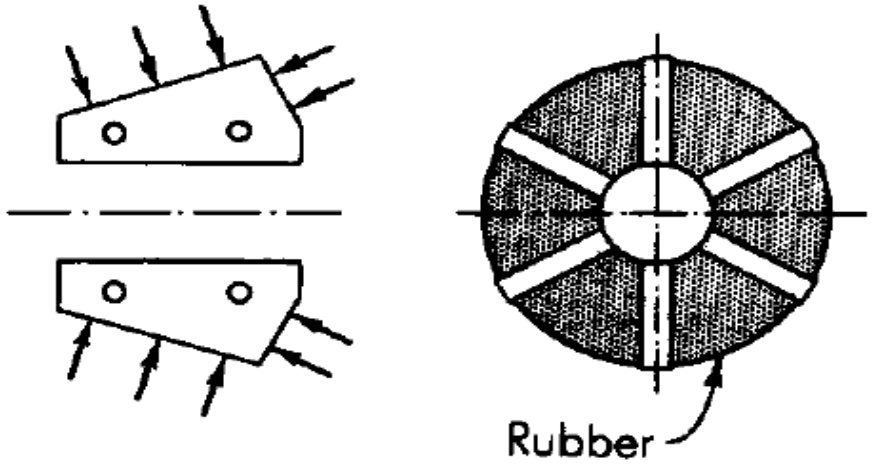
Figure 4-94. Location and clamping of round workpieces.

Expansion of a split bushing





Split collet.



High-range type collet.

Basic construction principles

- Cast
- Stability and vibration damping
- Good material distribution
- Used for high volume production
- Welded
- Easy fabrication and low lead time
- Built-up
- Most versatile
- Frequently used

References

- Fundamentals of Tool Design, Fifth edition, Society of Manufacturing Engineers
- Jergens, Inc.
- Carr Lane Manufacturing Company

Questions ???