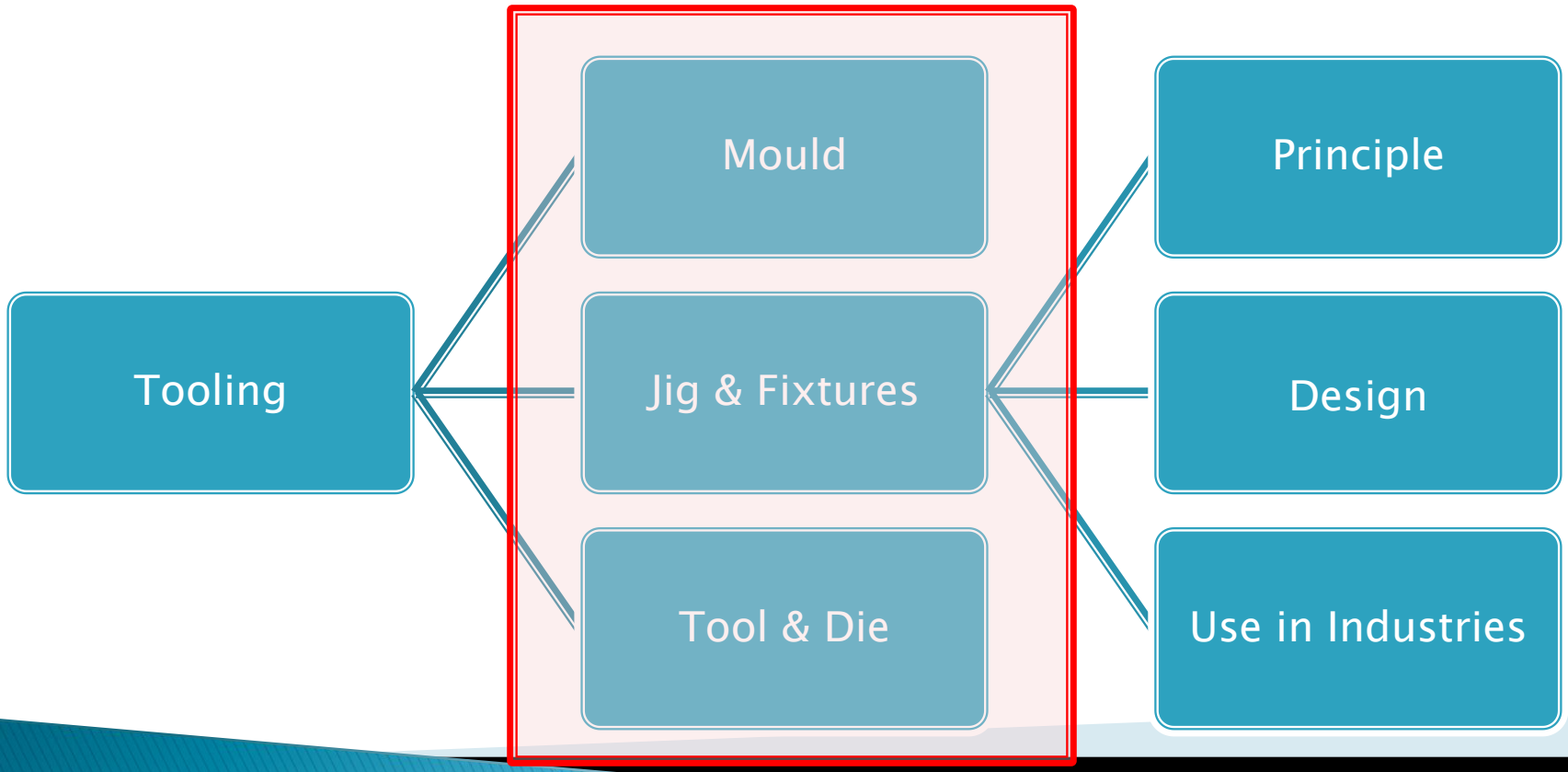
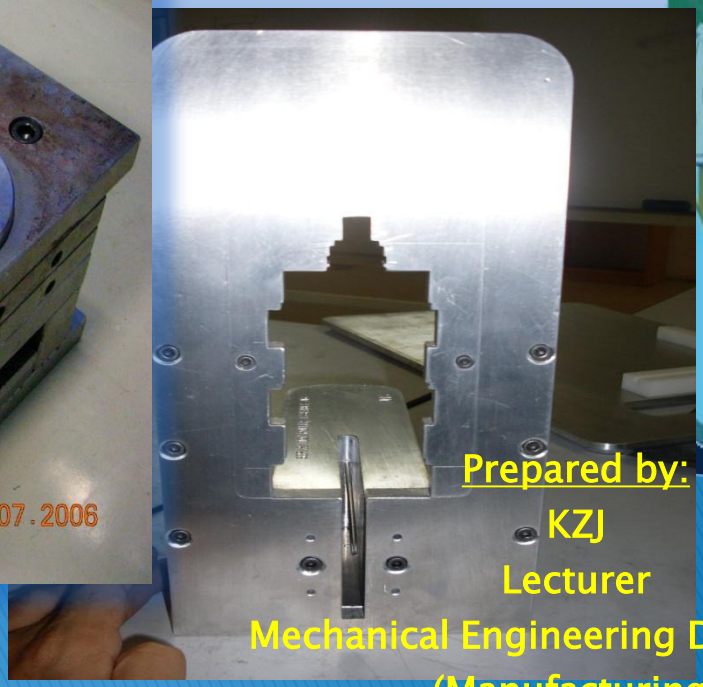
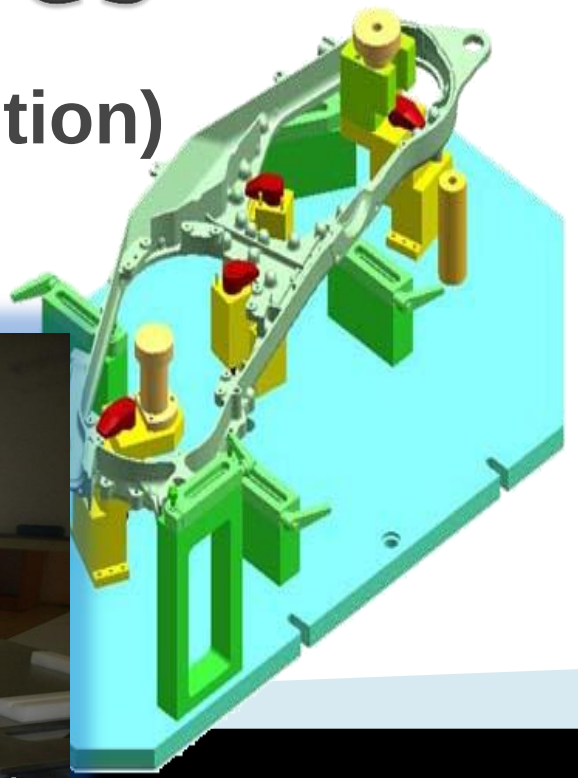
- JJ609-JIG, FIXTURES AND TOOLING DESIGN



Introduction to Jigs and Fixtures

(Jigs & Fixtures Design Second Edition)





Prepared by:
KZJ
Lecturer
Mechanical Engineering Department
(Manufacturing)

TABLE OF CONTENTS

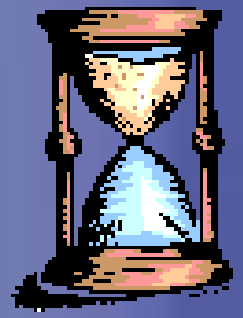
Guidance of subject:

ASSESMENT

- Coursework – 100%
- Final Exam – None

Coursework:

- Quiz – Minimum 4 (20%)
- Assignment – Minimum 3 (20%)
- Lab – Minimum 4 (20%)
- Test – Minimum 2 (40%)



Websites references

- Miscellaneous

  http://www.carrlane.com

  http://www.mcmaster.com

  http://www.jigs-fixtures.com

  http://www.monroeengineering.com

- Chucks, Indexing Tables:

  http://www.haascnc.com

- Vises

  http://www.kurt.com

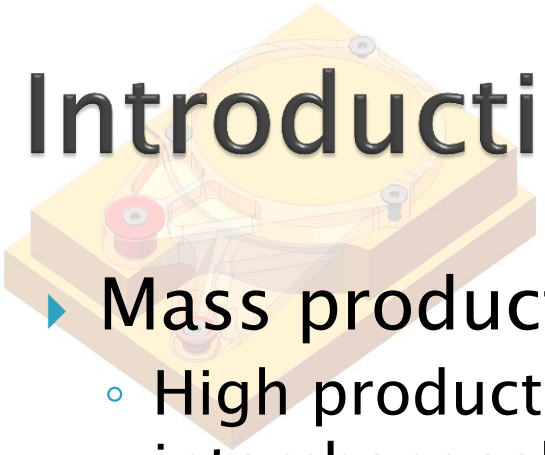
- Extruded Aluminum

  http://www.8020.net

References

- Erik K. Henriksen, Jig and Fixture Design Manual, Industrial Pres Inc.
- Cyrill Donaldson, George H. LeCain, V. C. Goold. (1999-3rd Ed). *Tool Design Manual* Glencoe. Tata, Mc GrawHill. United States.
- David Spitler, Jeff Lantrip, John Nee, and David A Smith. (May 2003). *Fundamentals of Tool Design, Fifth Edition*. Society of Manufacturing Engineers; 5th edition.ISBN-10: 087263650X, ISBN-13: 978-0872636507
- Edward G.Hofman (1984), *Fundamental of Tool Design (5th ed.).*Delmar Learning Drafting series. ISBN: 1-4018-1107-8
- Herman W. Pollach (1998), Tool Design (2nd ed.) Prentice Hall
- Paul. D.Q. Campbell,(1994) *Basic Fixtures Design*, Industrial Press Corp. New York, ISBN:0-8311-3052-0
- Robert A. Malloy (1994), *Plastic Part Design for Injection Moulding: an Introduction*, Hanser Gardner Publications, Inc, Cincinati. ISBN : 1-56990-129-5
- Smith, William Fortune, (2nd Ed, 1990), *Principles of Materials Science and Engineering*, Mc-Graw Hill Int. Ed. ISBN: 0-07-059169-5

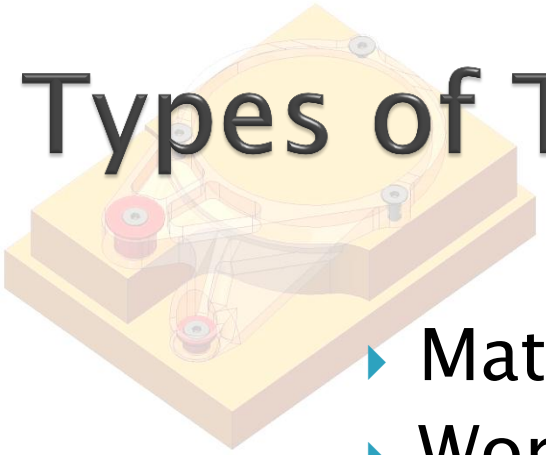
Introduction



- Mass production aims:
  - High productivity to reduce unit cost and interchangeability to facilitate easy assembly

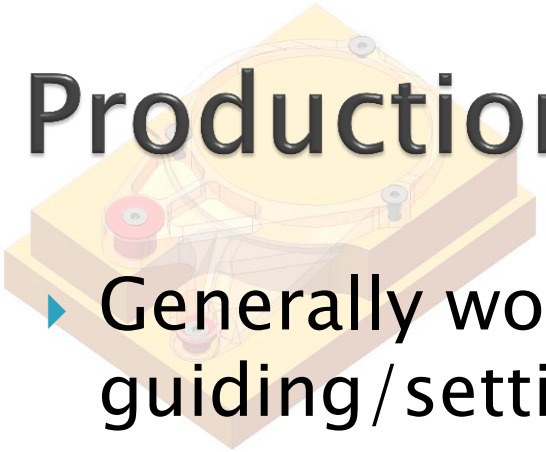
- Necessitates production devices to:
  - Increase the rate of manufacture and inspection devices to speed-up inspection procedure

Types of Tools



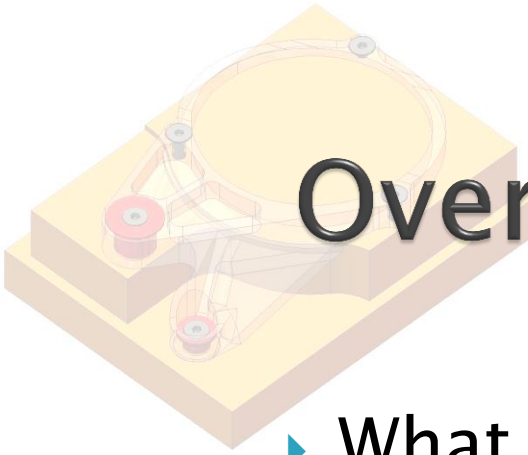
- Material Cutting Tools
- Workholding Devices
- Pressworking Tools
- Bending, Forming and Drawing Dies
- Tool Design for Inspection and Gaging
- Tool Design for Joining Process
- Tooling for Casting

Production devices ?



- Generally workholders with/without tool guiding/setting arrangement.

- These are called **JIGS** and **FIXTURES.**



Overview

- What are Jigs and Fixtures
- Why they are important
- Basic jigs and fixtures available
- Specific Application
- Resources for selecting & purchasing

What are Jigs and Fixtures

- Anything used to hold a workpiece in a desired location
  - Locate parts for precision
  - Repeating process on a series of parts
  - Holding parts for machining, painting, assembly

Jigs

- Provided with tool guiding elements such as drill bushes
- Guiding the tool to the correct position on the workpiece
- Rarely clamped on the machine table because it is necessary to move the jig on the table to align the various bushes in the jig with the machine spindle

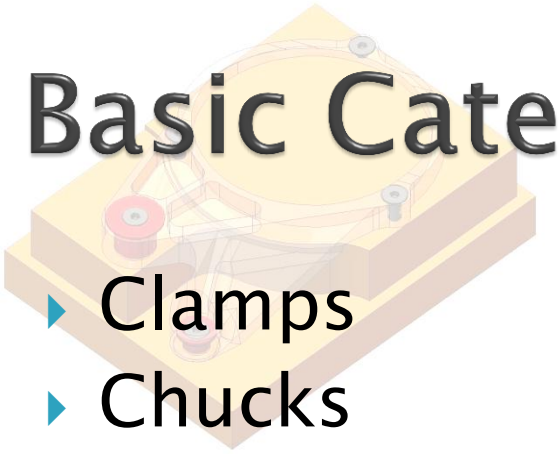
Fixtures

- Hold the workpiece securely in the correct position with respect to the machine/cutter during operation
- Used for setting the tool with respect to the workpiece/fixture
- Not used as guided in a jig
- Often clamped to the machine table

Why are they important in Machine design ?

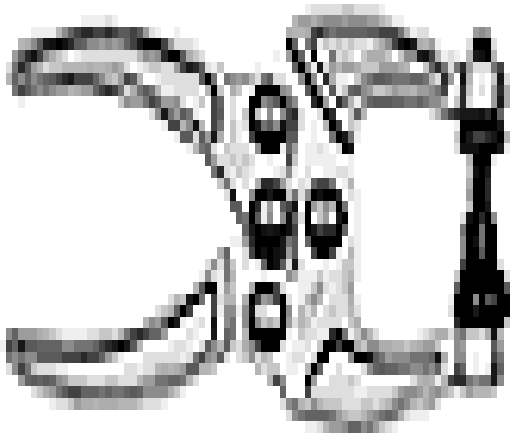
- Parts should be designed to accommodate standard fixturing components
- Designs should accommodate fast and repeatable fixturing

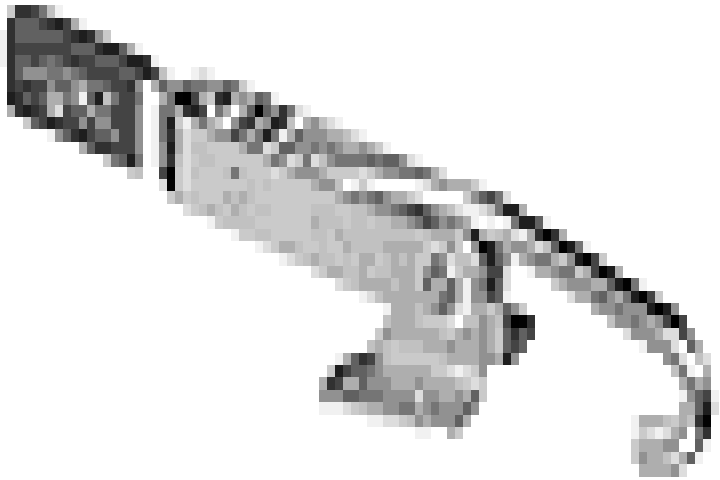
Basic Categories of Jigs



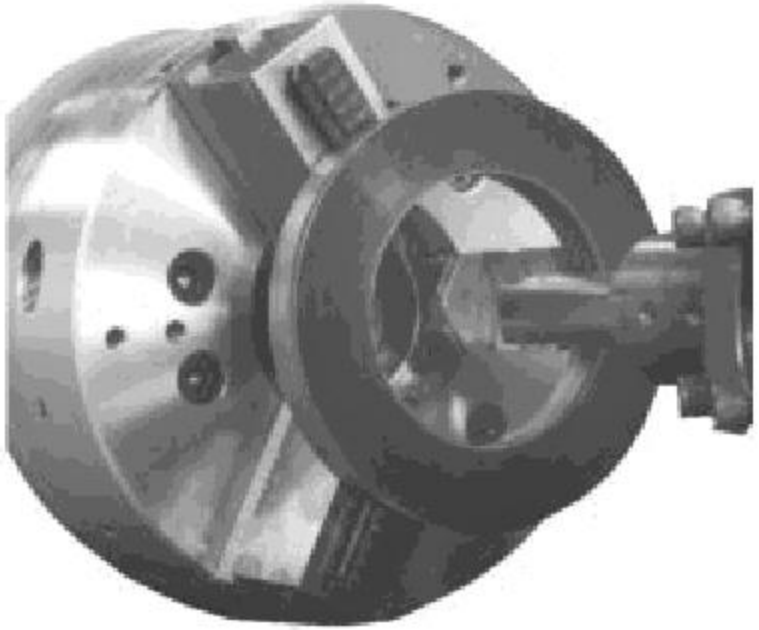
- Clamps
- Chucks
- Vises
- Bushings
- Modular Fixtures

Clamps





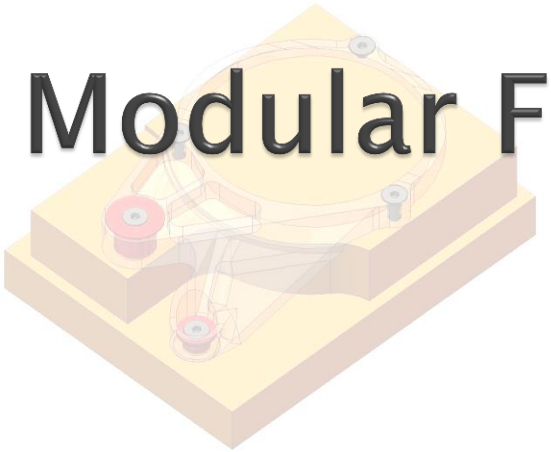
Chucks

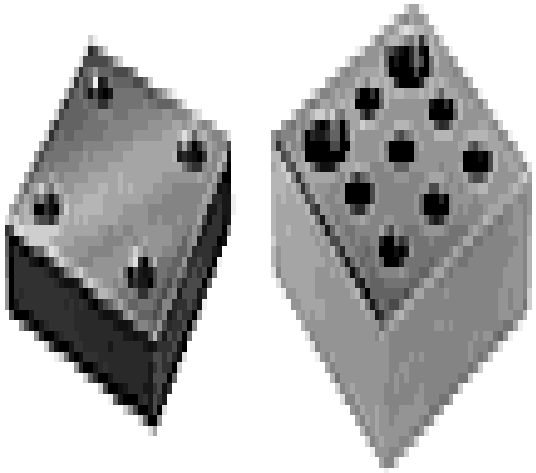


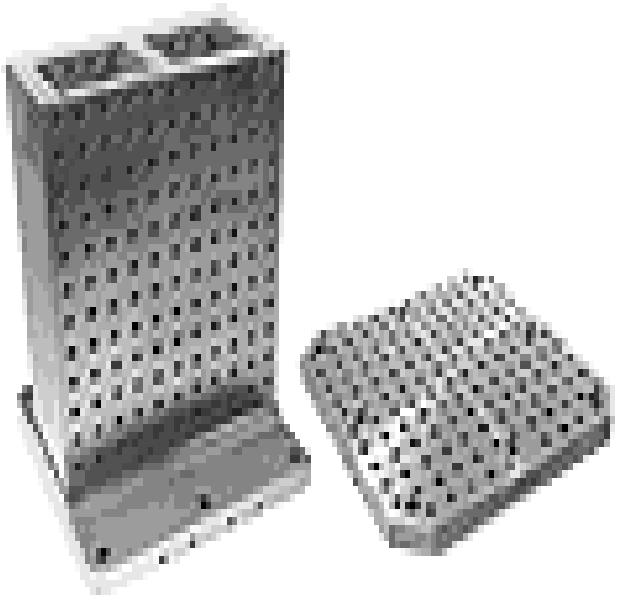
Vises

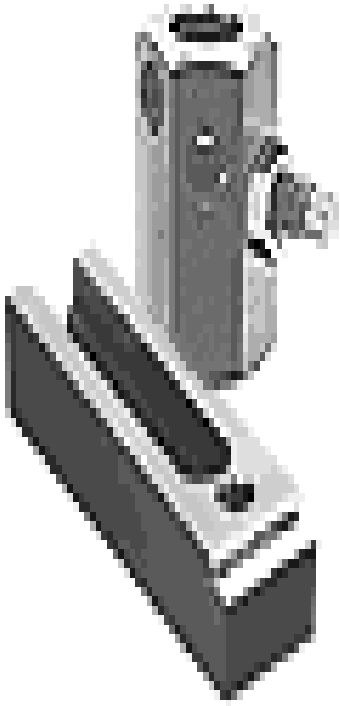
Bushings

Modular Fixturing

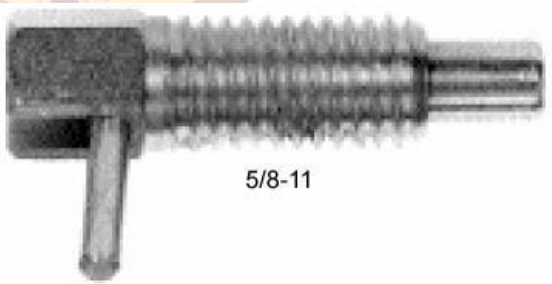


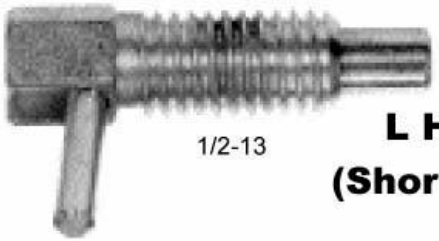




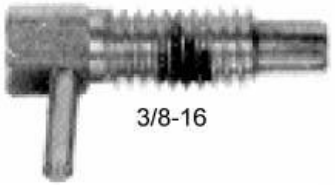


Application





L Handle
(Short Stroke)



Resources

- Catalogs
- Websites
- Journal Articles

Definition

Definitions

Jig:

A Jig is defined as the device which holds and positions the workplace, locates or guides the cutting tool related to the workplace and usually is not fixed on the machine table.

Fixture:

A fixture is a work holding device which holds and positions the workplace, but does not guide or locate or position the cutting tool.

Differentiate between Jigs and Fixture

Jigs:

From the construction point of view:

- Jigs are lighter in weight.
- Jigs hold the work piece, locate and guide the tool.
- Used for particularly drilling, taping operations.

Differentiate between Jigs and Fixture

- *Fixtures:*
- The fixtures hold the work and position the work but do not guide the tool .
- They are generally heavier and are bolted rigidly on the machine table.
- They are utilized for holding the work in milling, grinding, planing or turning operation.

Elements of Jigs and Fixtures

Generally all the jigs and fixtures consist of:

- *1. Locating elements*
  - These position the workpiece accurately with respect to the tool guiding or setting elements in the fixture.
- *2. Clamping Elements*
  - These hold the workpiece securely in the located position during operation.
- *3. Tool Guiding and Setting Elements*
  - These aid guiding or setting of the tools in correct position with respect to the workpiece.
    - Drill brushings guide the drills accurately to the workpiece.
    - Milling fixtures use setting pieces for correct positioning of milling cutters with respect to the workpiece.

Advantages

Productivity

- Jigs and fixtures eliminate individual marking, positioning and frequent checking.
- This reduces operation time and increases productivity. In fact they increase productivity due to increase in the speeds, feeds and depth of cut, because of high clamping rigidity.
- They increase productivity because of the possibility of machining two or more workpieces simultaneously as well as the reduction in handling time.
- The use of jigs and fixtures enables heavy and complex shaped parts to be machined by being held rigidly to the machine.

Advantages

Interchangeability

- Jigs and fixtures facilitate uniform quality in manufacture (machinery accuracy).
  - no need for selective assembly.
  - Any parts of the machine fit properly in assembly and all similar components are interchangeable.
- It eliminates marking out, measuring and setting methods before machining.

Advantages

Skill Reduction

- Jigs and fixtures simplify locating and clamping of the workpieces.
- Tool guiding elements ensure correct positioning of the tools with respect to the workpieces.
- They make the use of lower skilled labor possible

(There is no need for skillful setting of the workpiece of tool. Any average person can be trained to use jigs and fixtures the replacement of a skilled workman with unskilled labor can effect substantial saving in labor cost).

Advantages

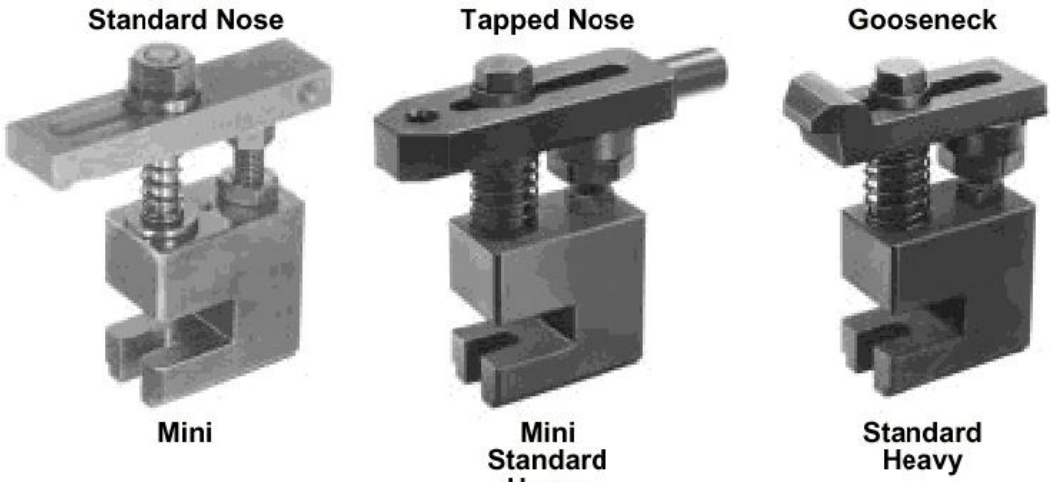
Cost Reduction

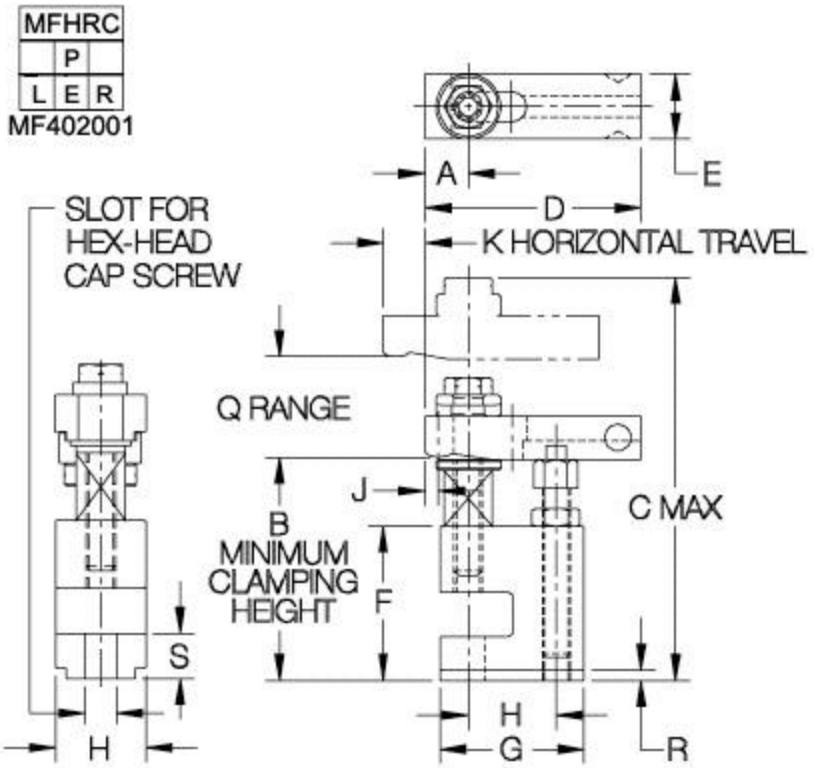
- Higher production, reduction in scrap, easy assembly and savings in labor costs result in substantial reduction in the cost of workpieces produced with jigs and fixtures. They decrease the expenditure on the quality control of machine parts.

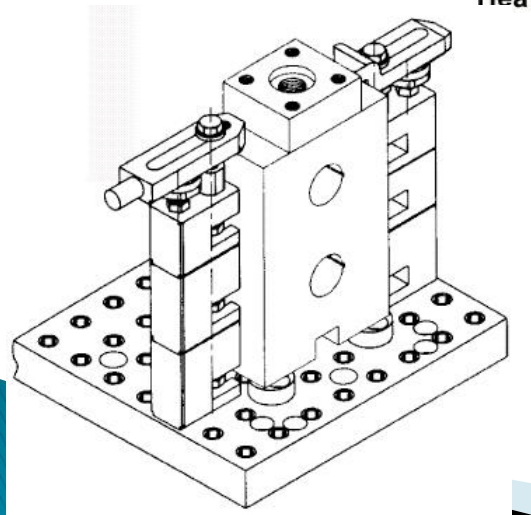
Examples – I

- High Rise Clamps

- http://www.carrlane.com/Catalog/index.cfm





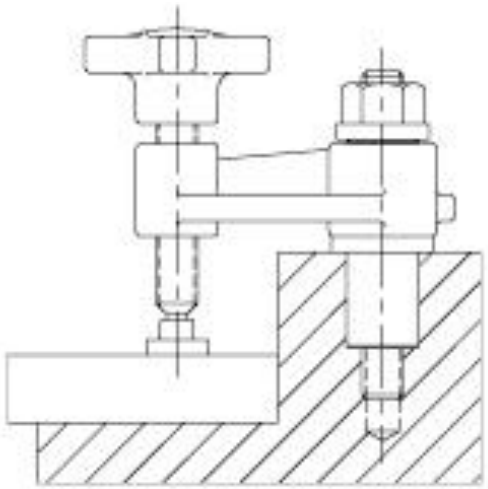


- High-Rise Clamps can be stacked on Narrow Riser Blocks and Spacer Blocks to reach tall workpieces

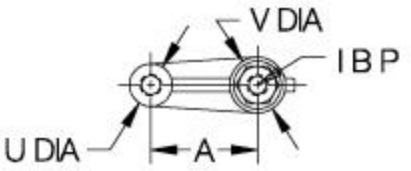
Examples II

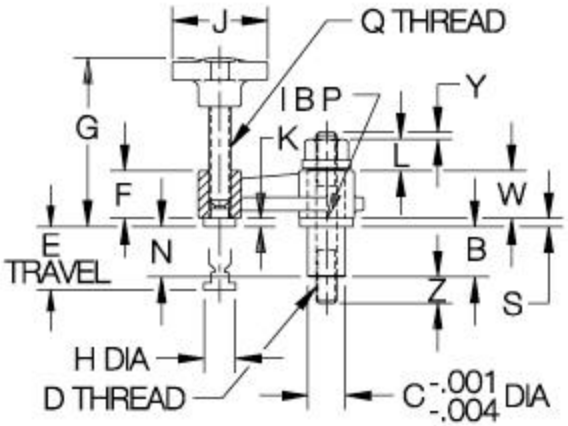
- Swing Clamp

Knob Handle
Post Mounted



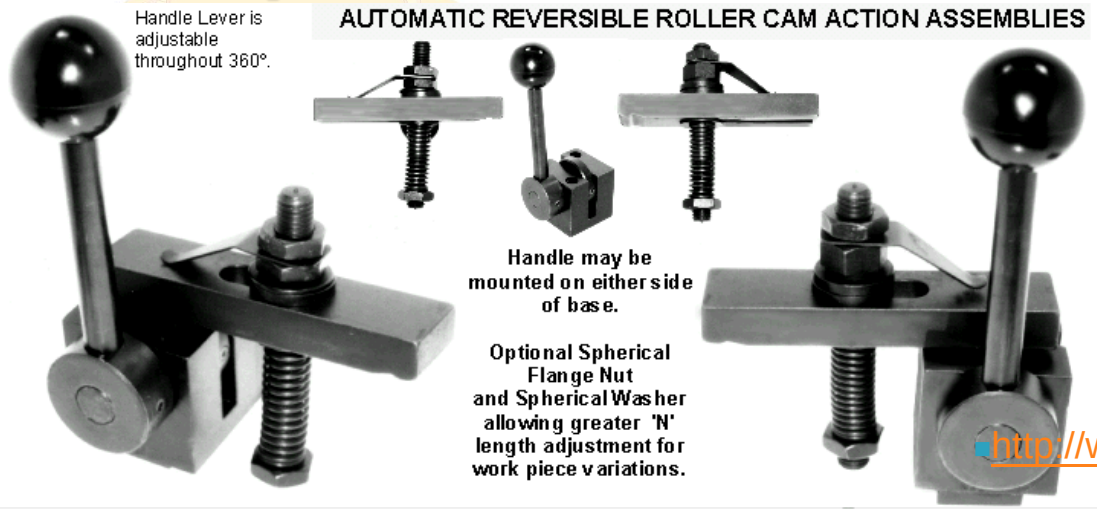
- Please refer to the price list also!





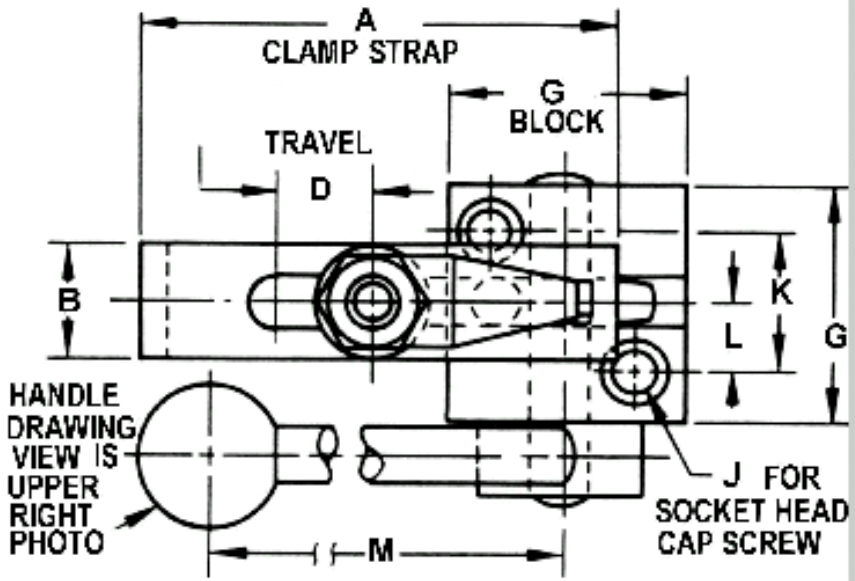
- ARM: MODULAR IRON PER ASTM A536 GRADE 65-45-12, ZINC PLATED CLEAR CHROMATE
- ALL OTHER PARTS: MILD STEEL BLACK OXIDE FINISH

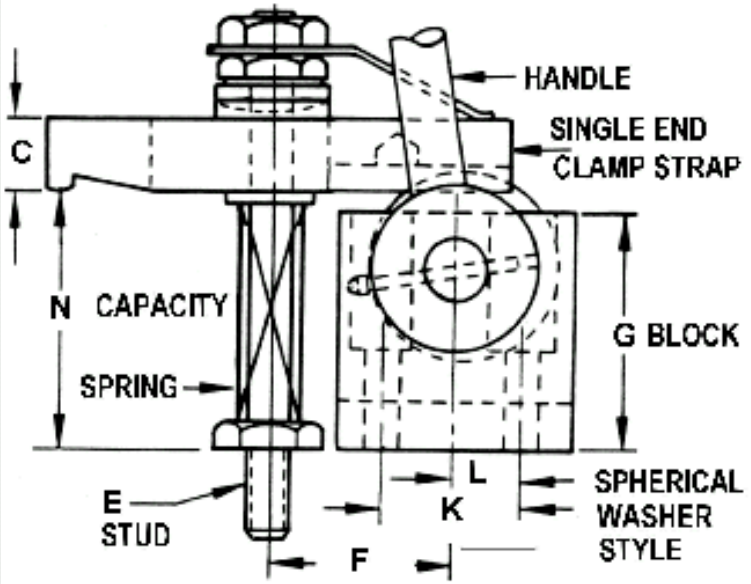
Examples III



Automatic Reversible Cam Action Workholding Assemblies

http://www.youtube.com/watch?v=vrrjLYn-6WY





All machinery parts are manufactured from steel and hardened. Black Oxide finish per Mil-Spec CB 924A

The end

General Considerations (design)

- Safety and Ergonomics
- Tool Materials
- Heat Treatment
- Surface Roughness and Finish
- Tolerances and Fits
- Tooling Economics
- Material Handling

Safety and Ergonomics (I)

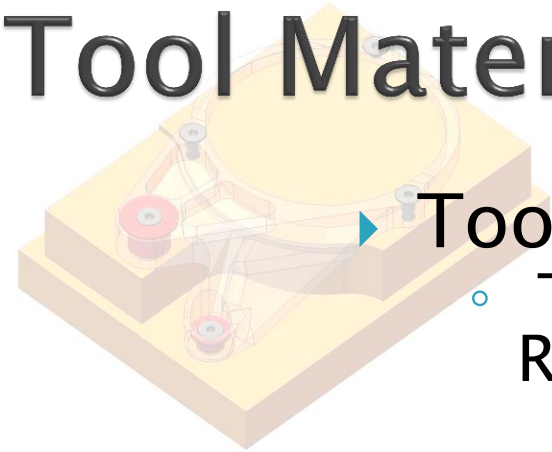
- Safety should be built into the design with due respect to legal requirements
- Sufficient clamping and rigidity of the tool design is necessary
- Guards should be introduced to movable parts of the machine
- Limit switches to protect workers and product against moving parts
- Electrical equipment should be properly grounded

Safety and Ergonomics (II)

- Exhaust system for air polluting system
- All adjustments and clamping should be easily accessible
- Quick release or emergency braking mechanism may be needed for special cases
- Prevent severe burns or eye injury for welding or thermal process
- Provision for handling pressurized and toxic equipment

Tool Design

Tool Materials (I)



- Tool steels (principal materials)
  - Tool and Die Steel (typical hardness RC40~60)
    - W, Water-Hardening Tool-Steels
    - O, Oil-Hardening Tool-Steels
    - A, Air-Hardening Medium Alloy Die-Steels
    - D, High-Carbon High-Chromium Die Steels
    - S, Shock-Resisting Tool-Steels
    - H, Hot-Work Die Steels
    - P, Low-Carbon Mold Steels
    - T and M, Tungsten and Molydenum High-Speed Steels
    - L, Low-Alloy Tool-Steels
    - F, Carbon-Tungsten Finishing Steels
- Cast Iron
- Stainless Steel

Tool Materials (II)

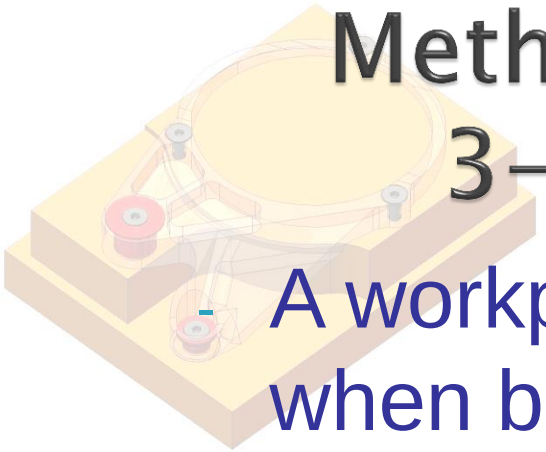
- Non-ferrous materials – limited productions only (Aluminum, Magnesium, Zinc, Lead, Beryllium, Bismuth)
- Composite materials – soft tools for limited run

Workholding Devices

Workholding Devices –

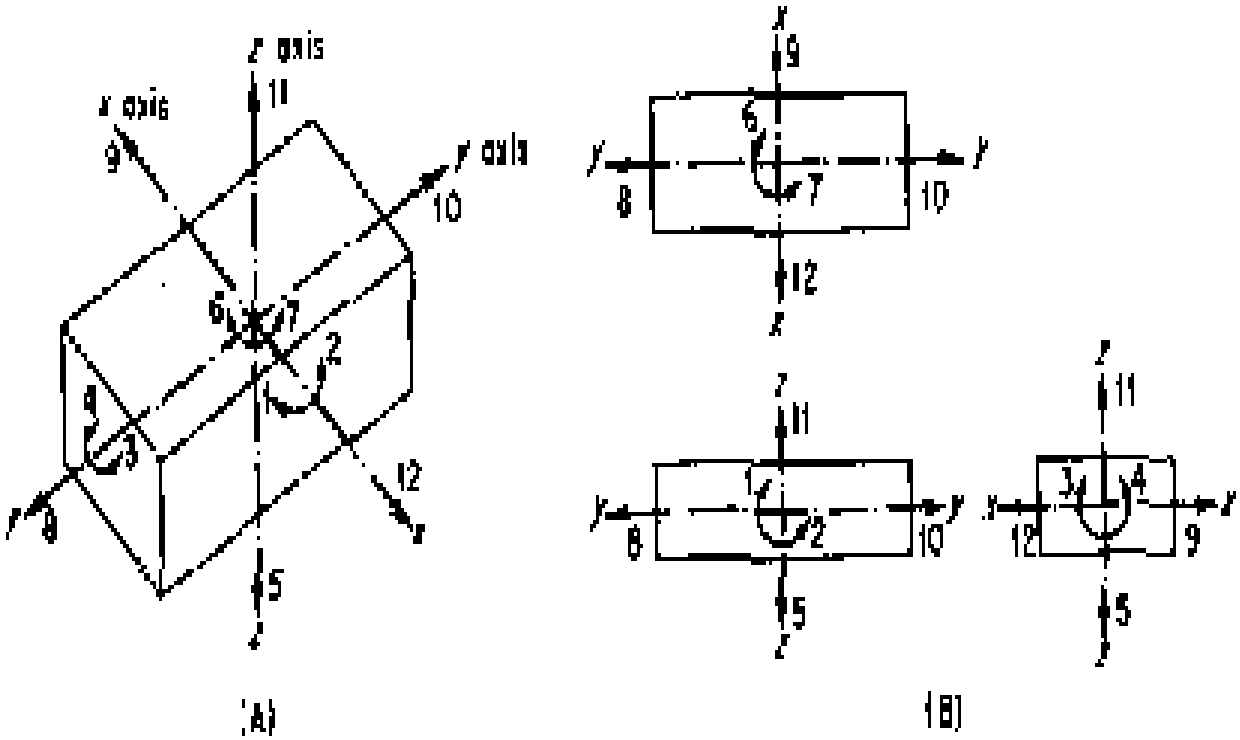
All devices that hold, grip, or chuck a workpiece in a prescribed manner of firmness and location, to perform on it a manufacturing operation.

Methods of Location
3-2-1 Principle



- A workpiece will be completely confined when banked against:
  - 3 points in one plane
  - 2 points in another plane
  - 1 point in a third plane
  - If the planes are perpendicular to each other
- Buttons should be as far apart as possible
  - Greater spread, Less alignment error

Methods of Location Principle



- 12 degrees of freedom

Methods of Location I

X and Y axes. The prism cannot rotate about the X and Y axes and it cannot move downward in the direction of freedom 5. Therefore, freedoms 1, 2, 3, 4, and 5 have been restricted.

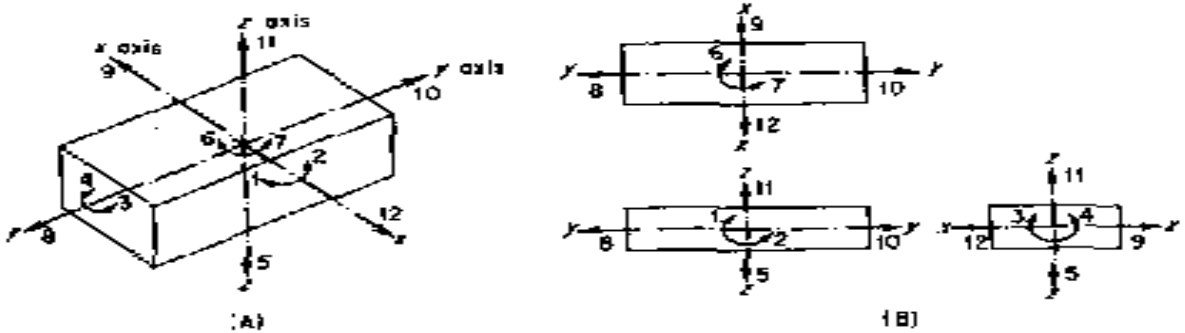


Fig. 2-6. Twelve degrees of freedom.

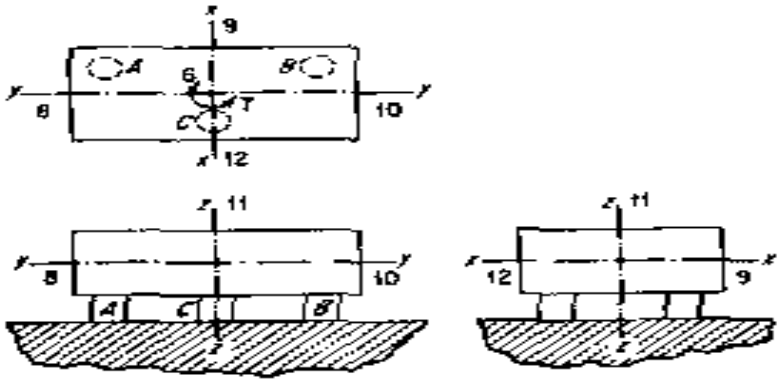


Fig. 2-7. Three pins arrest five degrees of freedom.

- 3 pins arrest 5 dof

Methods of Location II

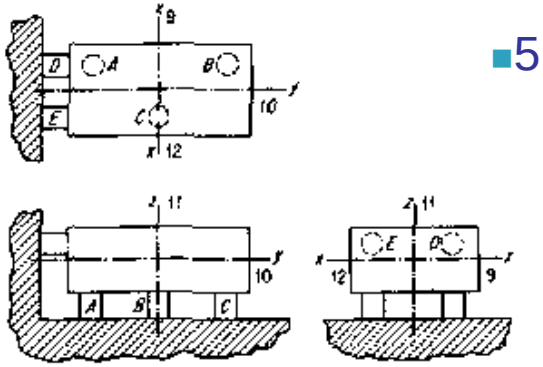
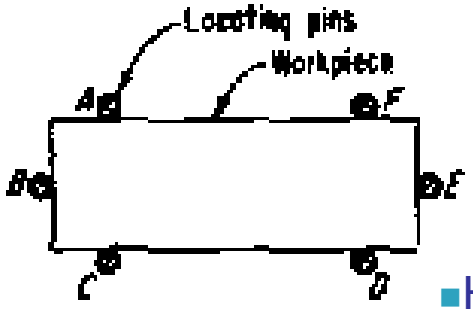
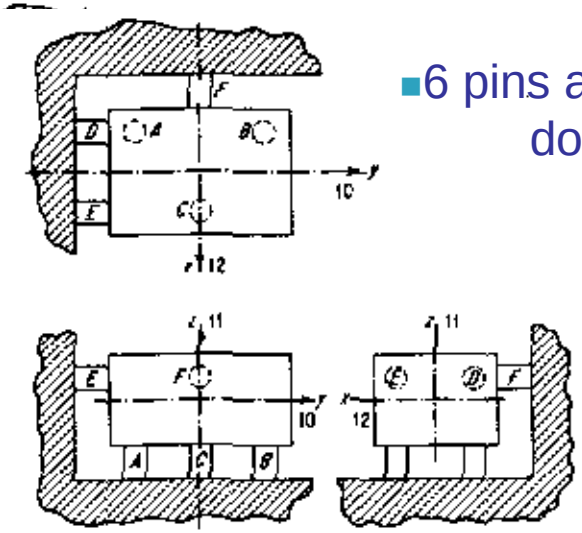


Fig. 2-8. Five pins arrest eight degrees of freedom.

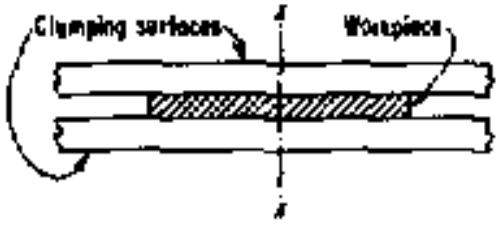
- 5 pins arrest 8 dof



- Horizontal workpiece

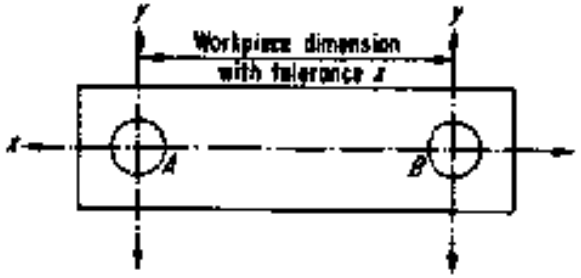


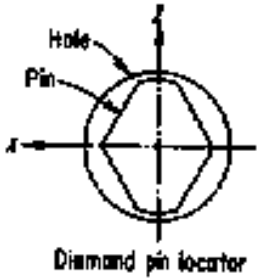
- 6 pins arrest 9 dof



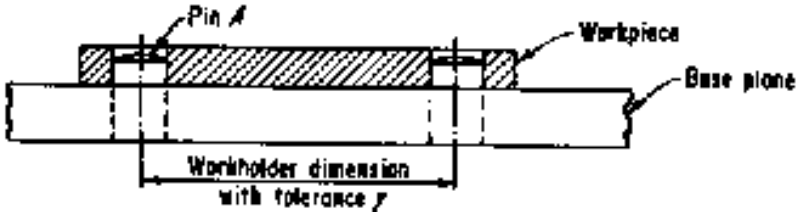
- Vertical workpiece

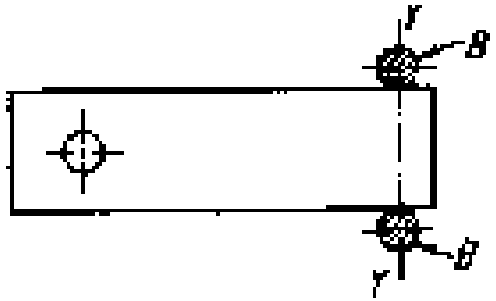
Methods of Location III



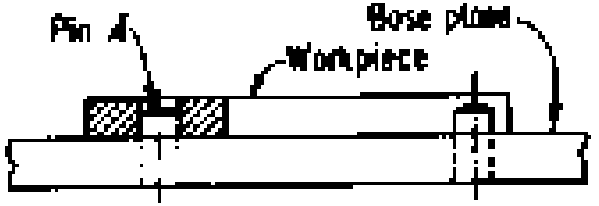


- Radical location with internal pins or plug

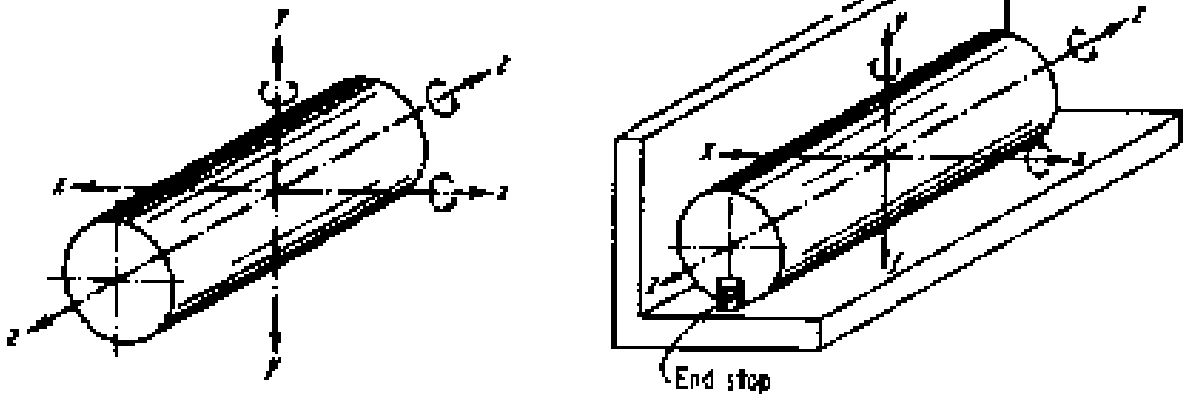




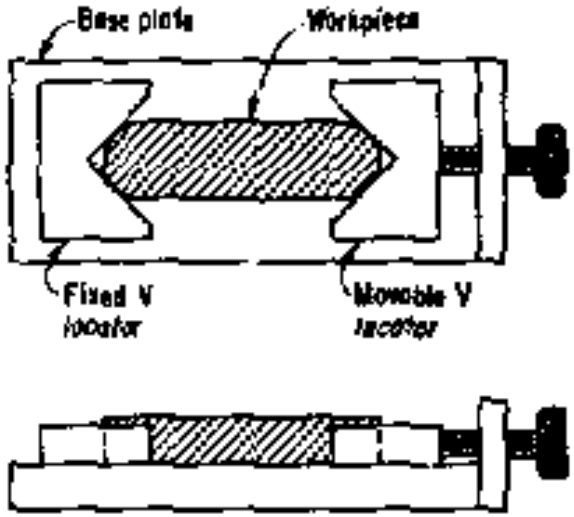
- Radical location by external pins



Methods of Location IV

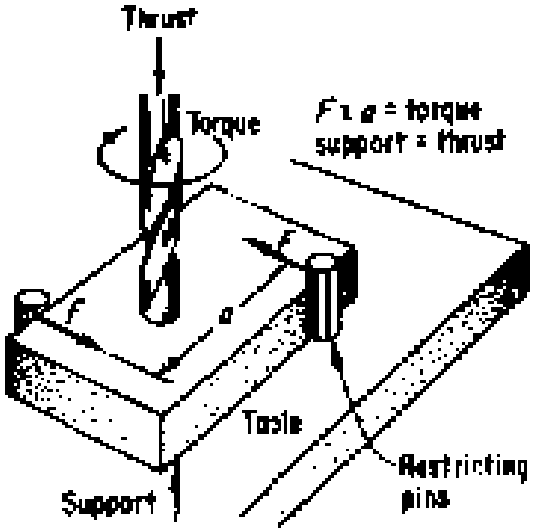


- 7 dof arrested by V locator with stop pin

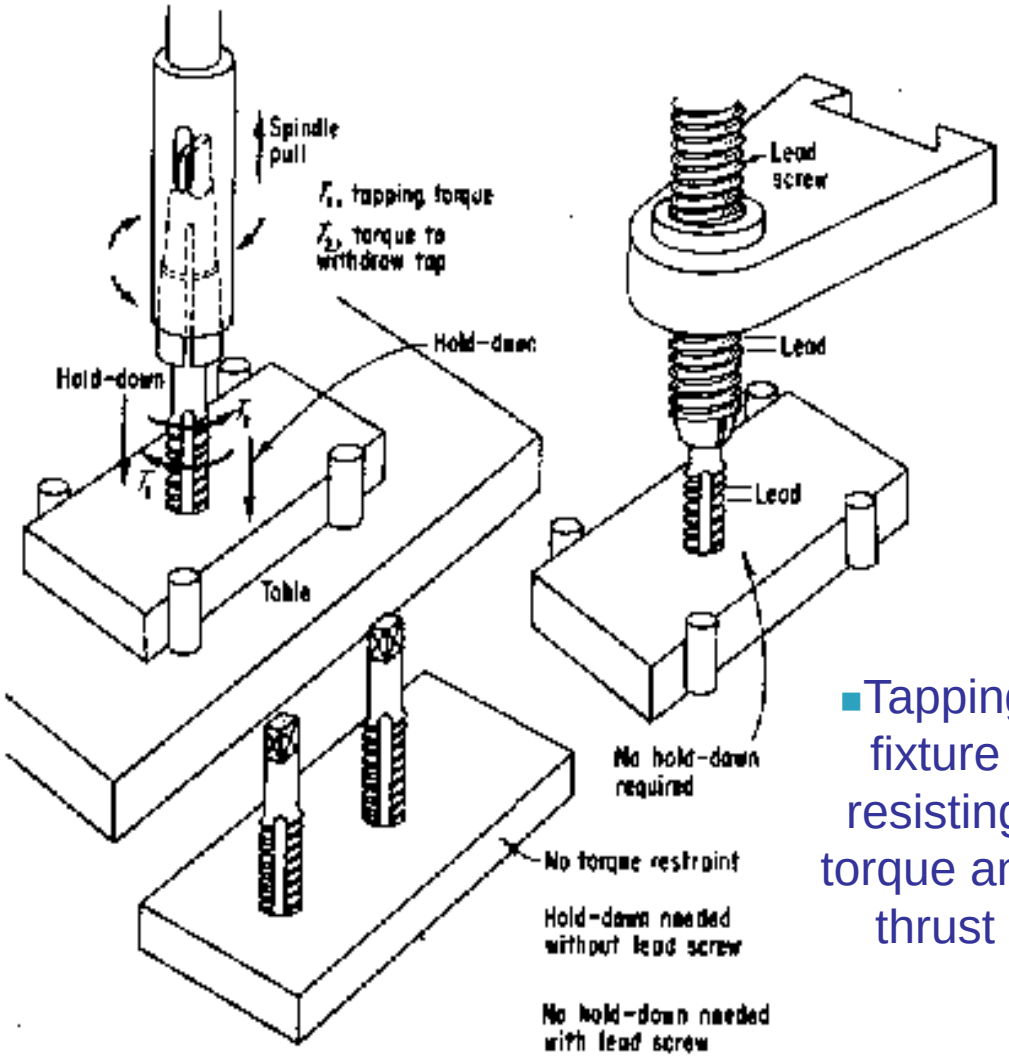


- Workholder with multiple V locators

Tool Forces I

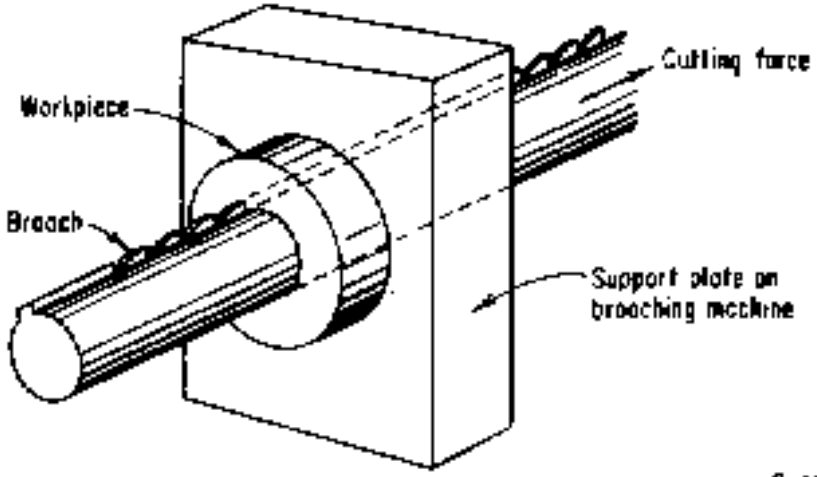


- Pin-type drill fixture resisting torque and thrust

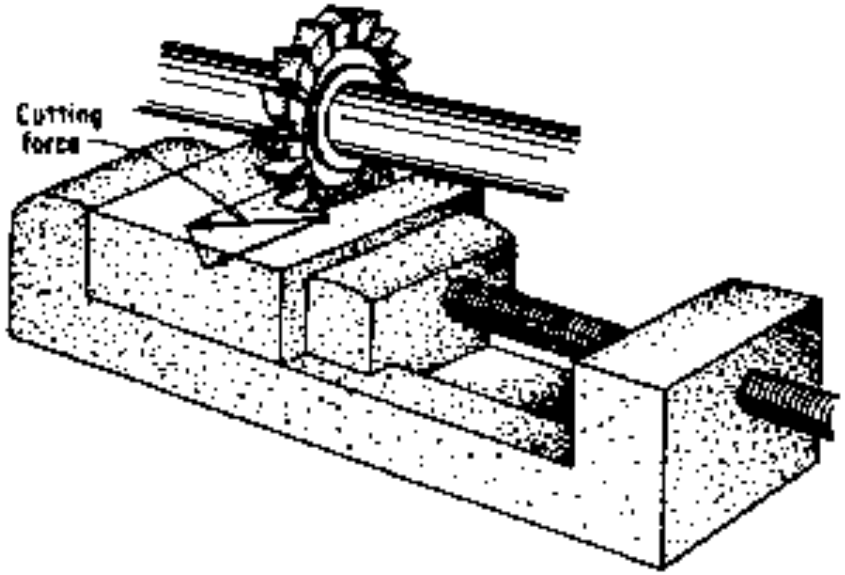


- Tapping fixture resisting torque and thrust

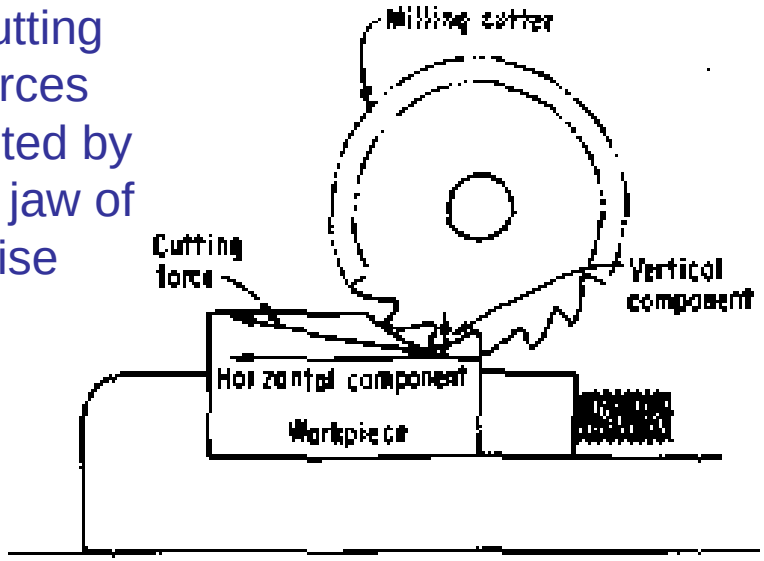
Tool Forces II



- Workholder for broaching operation

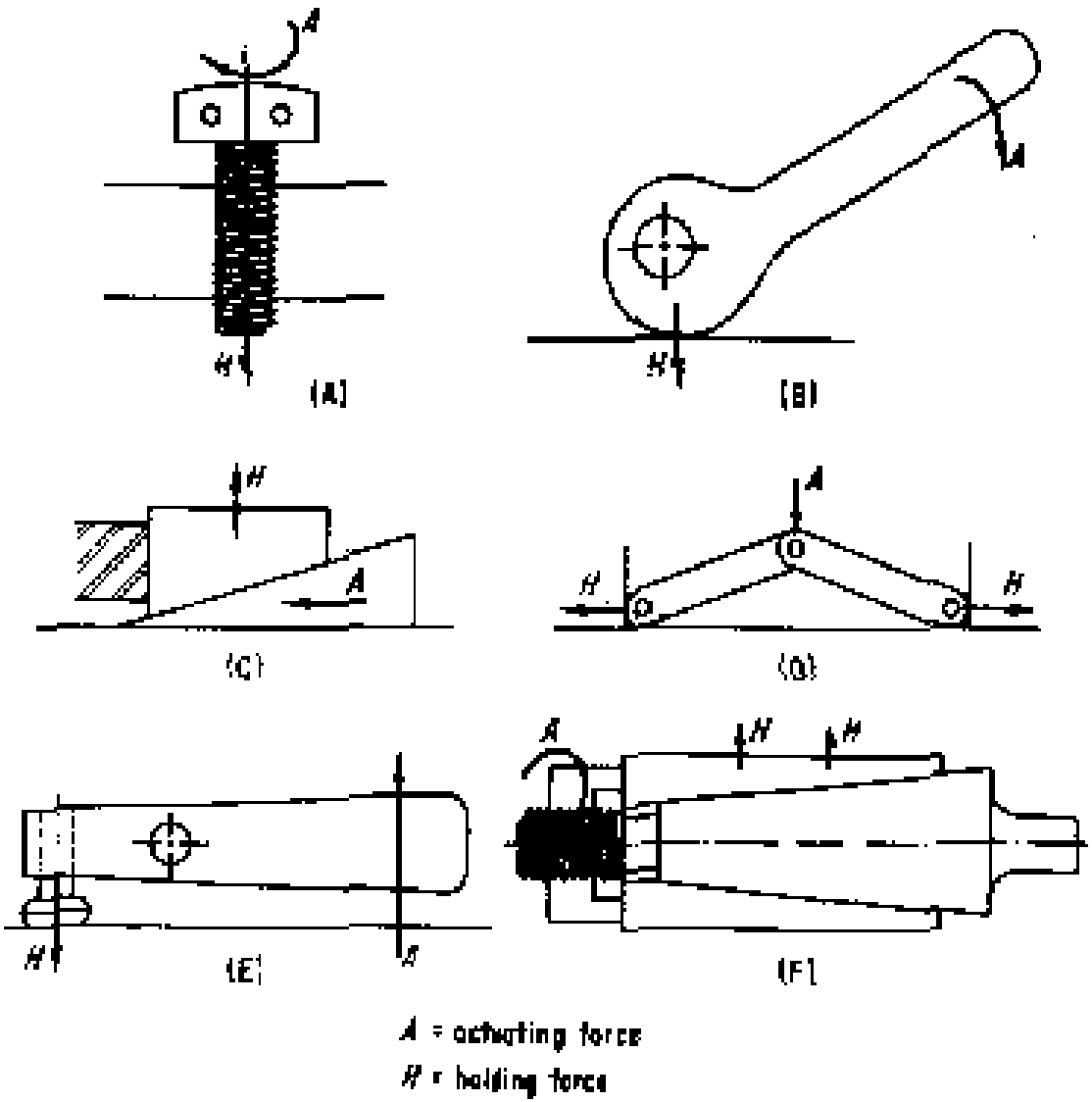


- Cutting Forces resisted by solid jaw of vise



- Cutting force resisted only by friction

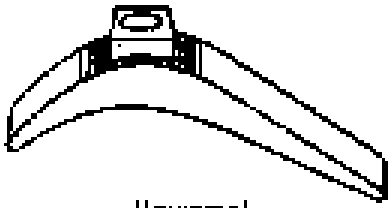
Tool Forces III



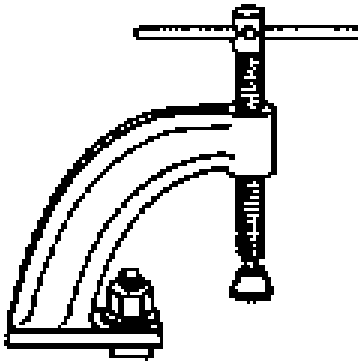
- Mechanical methods of transmitting and multiplying force

A. Screw
B. Cam
C. Wedge
D. Toggle link
E. Lever
F. Combined screw and wedge

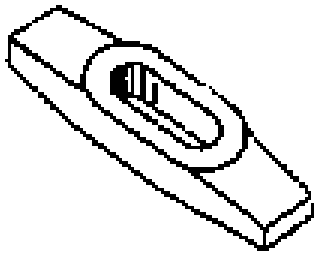
Clamping Forces I



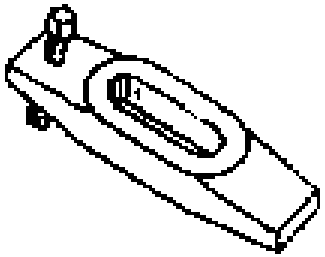
Universal adjustable clamp



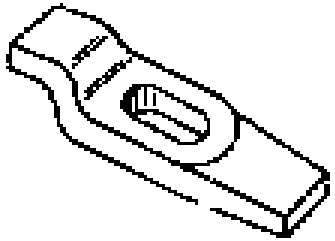
T slot clamp



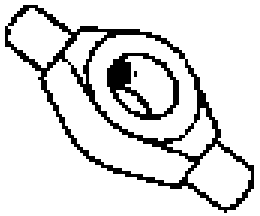
Plain clamp



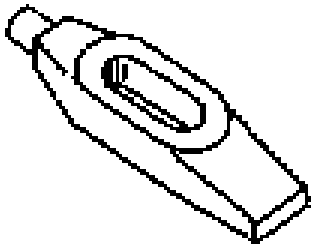
Screw heal clamp



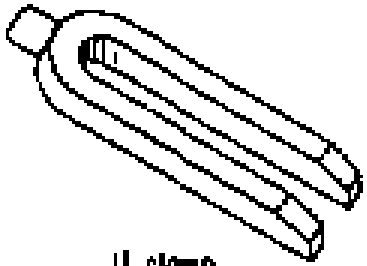
Goose neck clamp



Double finger clamp



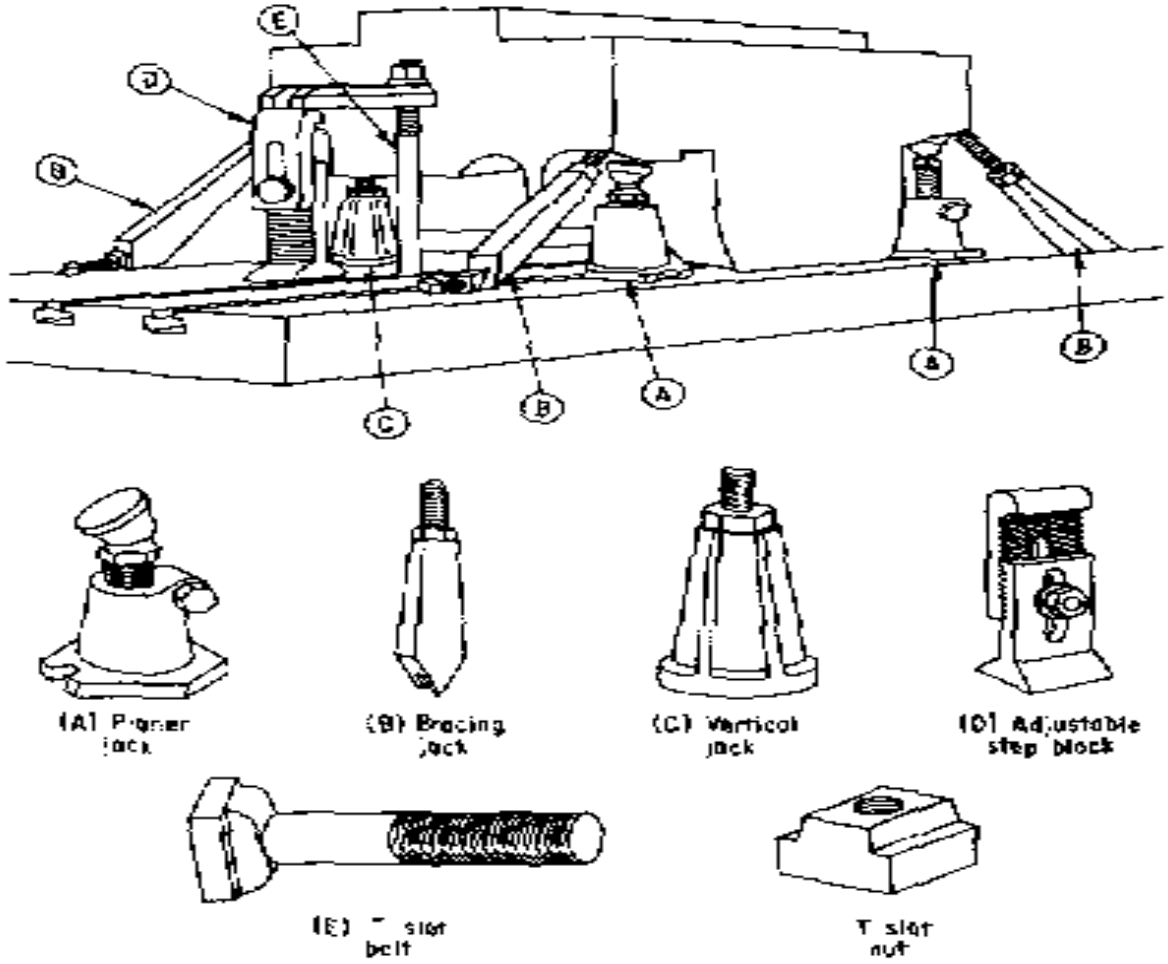
Finger clamp



U clamp

Fixture components

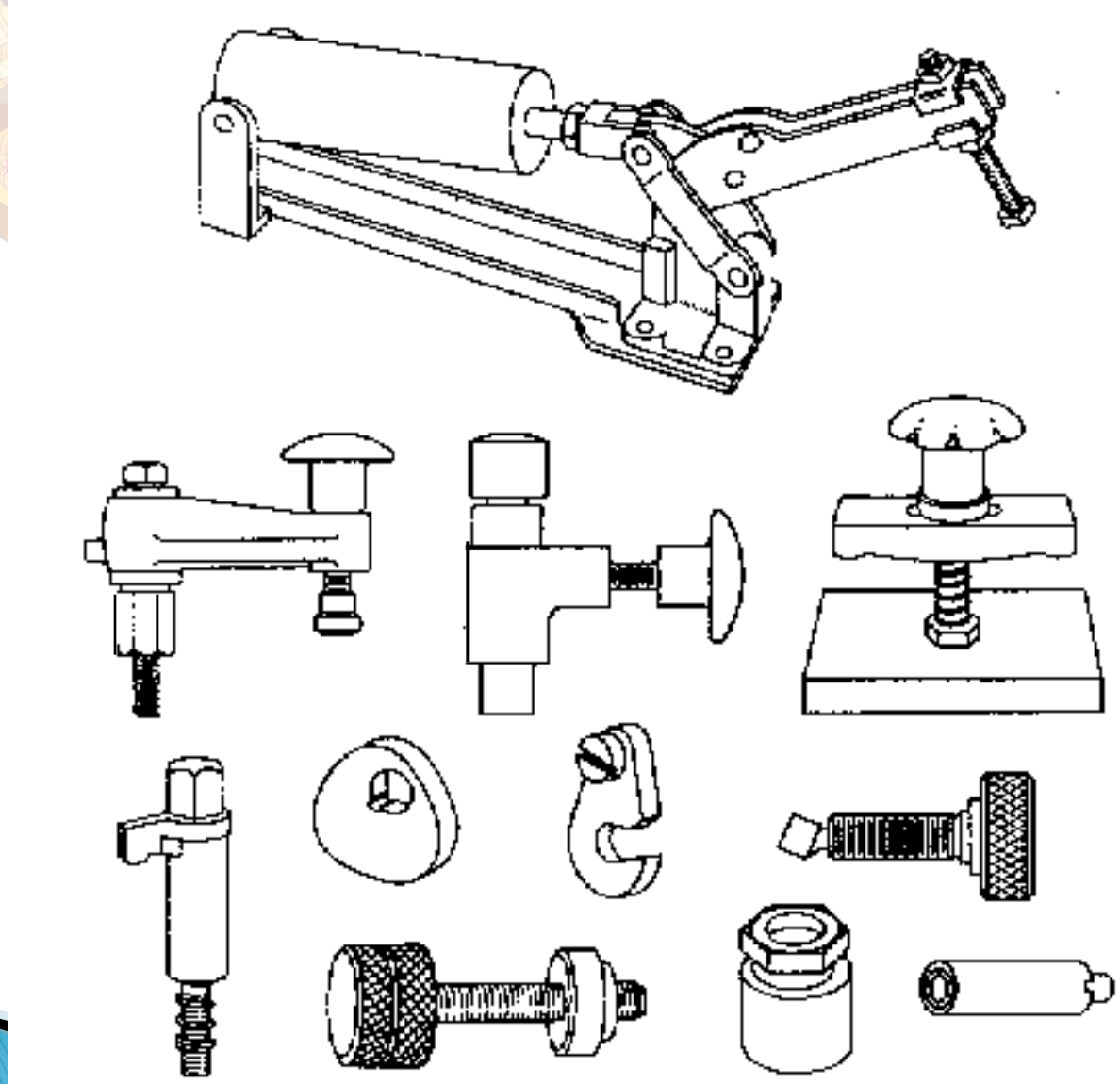
Clamping and Support



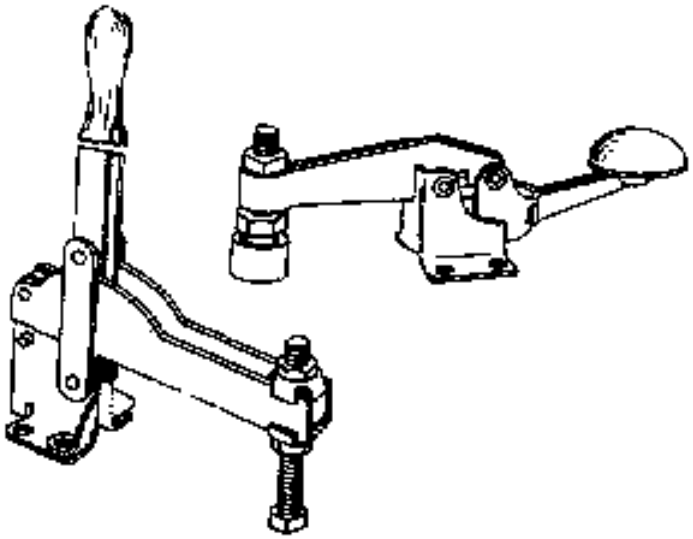
Clamping and support of large workpiece

The end

Fixture Components

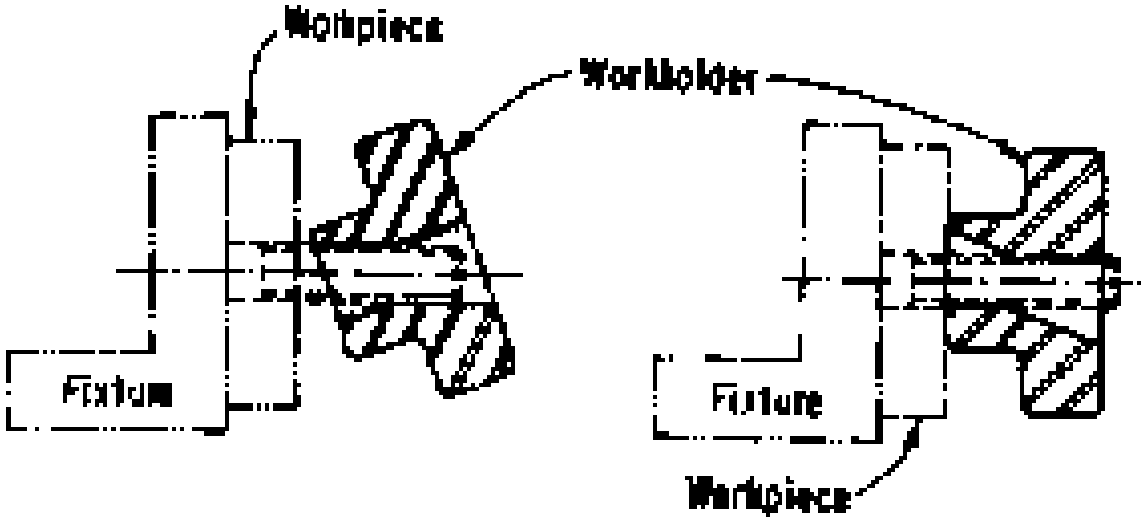


Fixture Components



- Toggle clamp

- Quick-acting screw

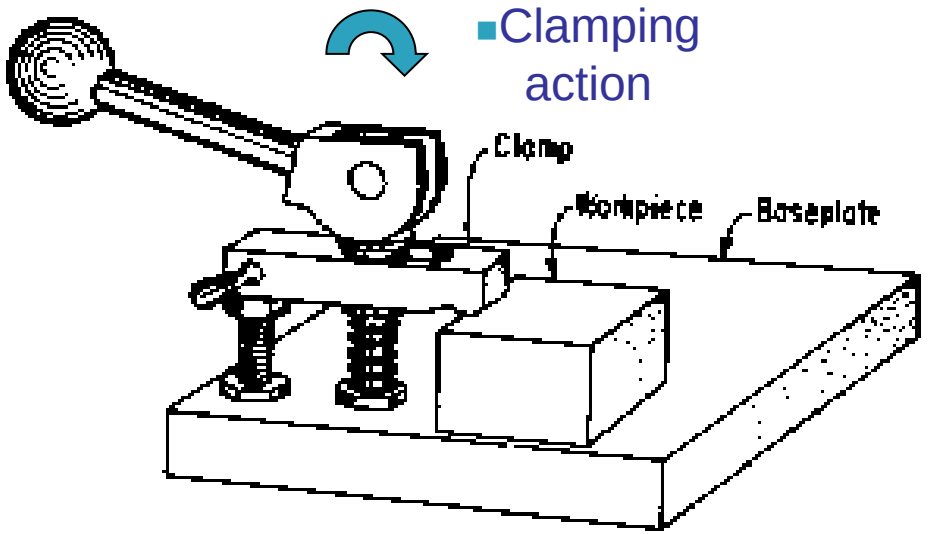


Jigs and Fixture Design Principles

- Review the workpiece to determine the manufacturing processes
- Decide on the number of setups
- Determine for each setup
  - Reference surface
  - Workpiece location
  - Workpiece clamping and rigidity
  - Ergonomics and safety

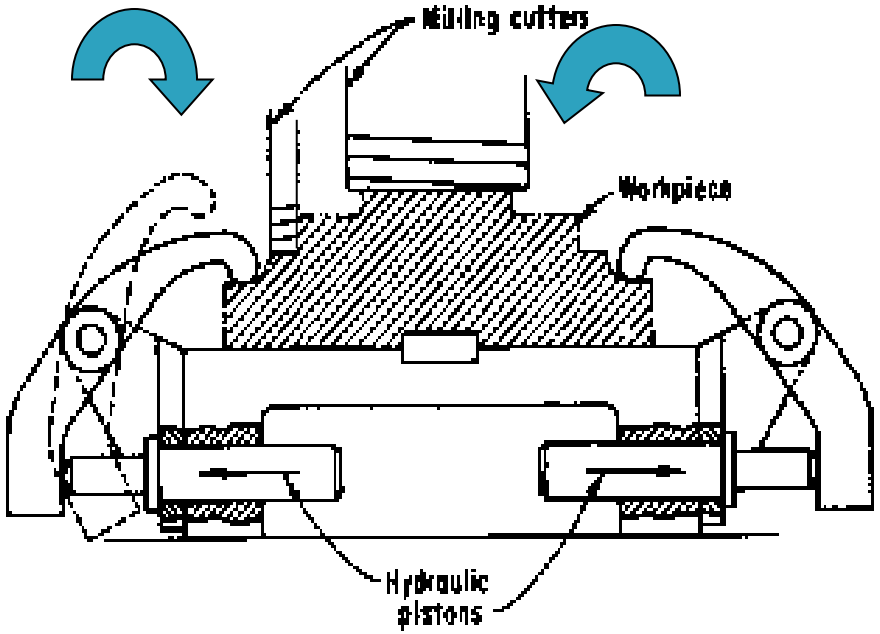
Fixture for Rectangular Components

- Location and holding for flat surface
- Base plate – reference surface for setup
- Clamp – quick action cam-based clamp

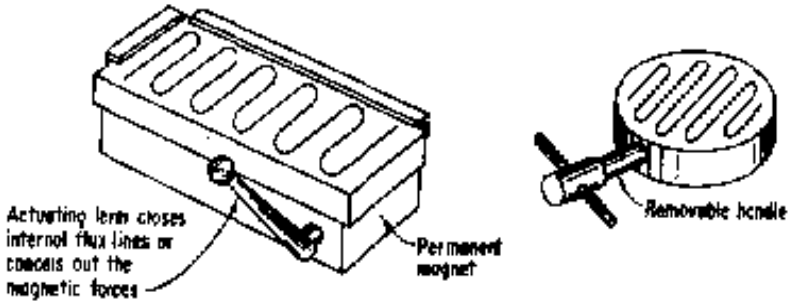


Fixture for Rectangular Components

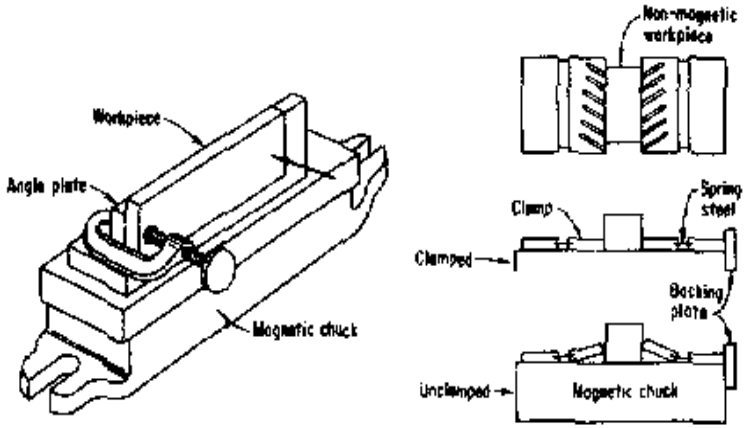
- Hydraulic clamp for larger clamping force
- Swing clamp

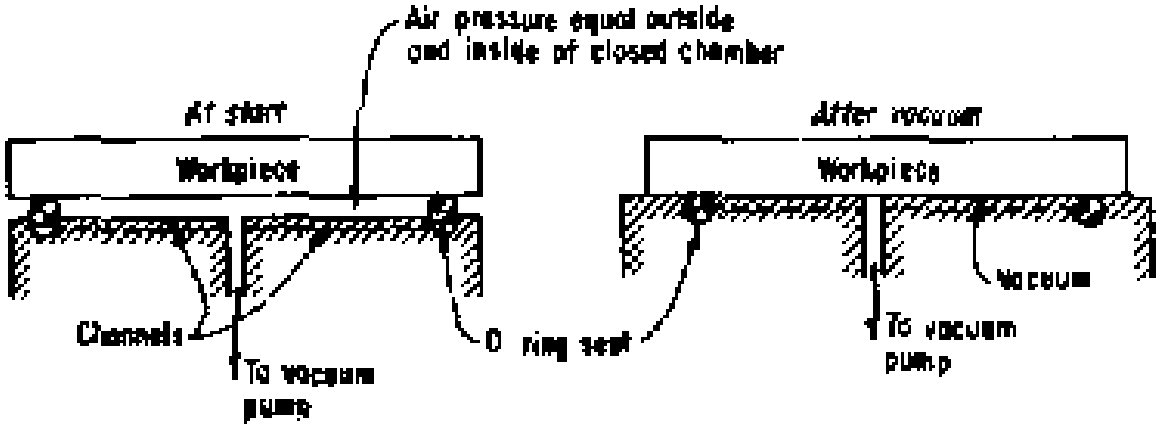


Fixture for Rectangular Components



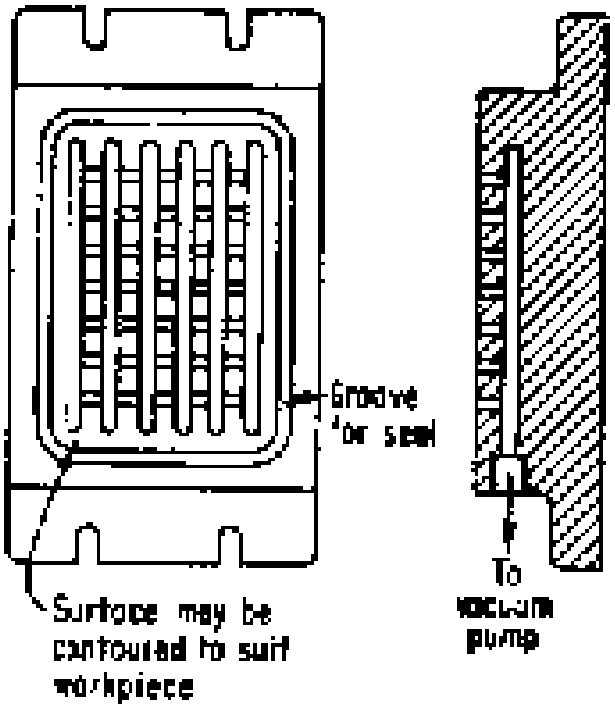
- Magnetic chuck



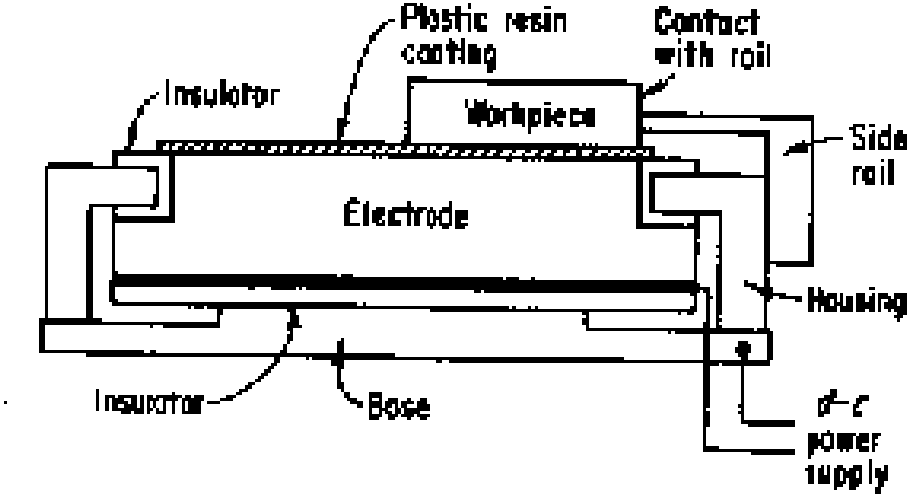


- Vacuum chuck

Fixture for Rectangular Components

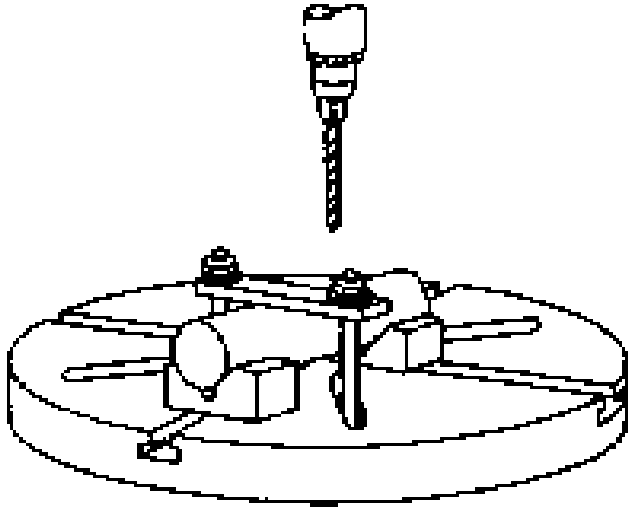


- Vacuum chuck

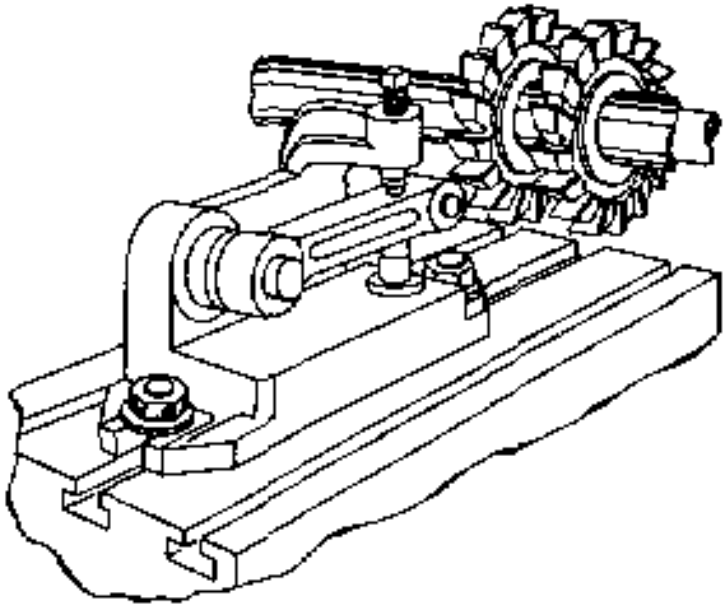


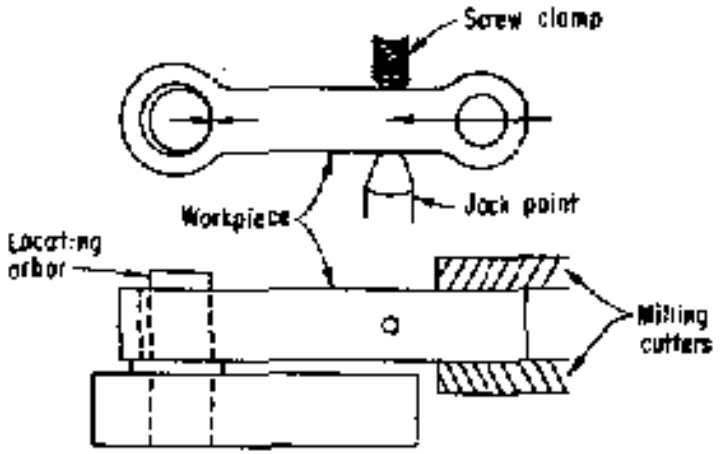
- Electrostatic chuck

Fixture for Circular Components



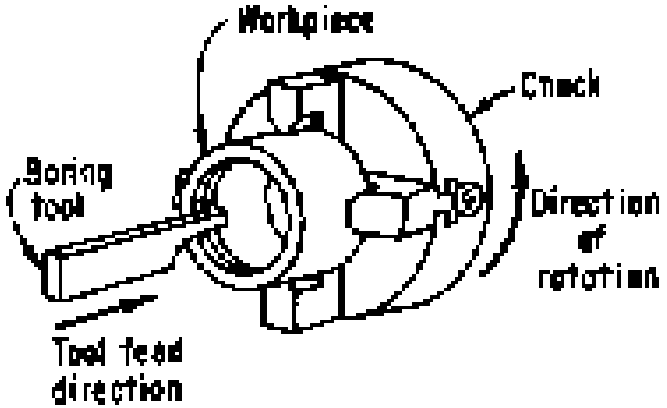
- Round workpiece held with strap clamp and T bolts



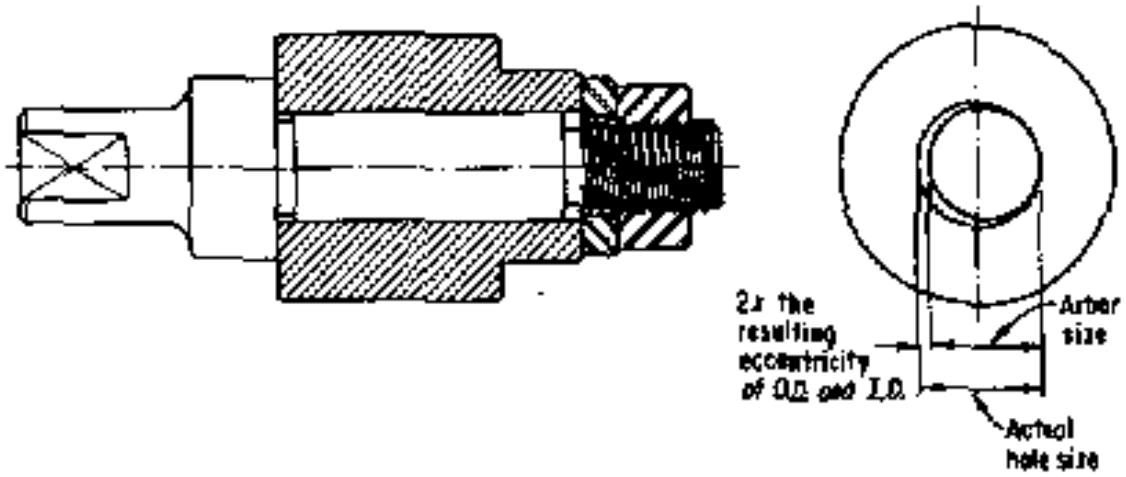


- Fixture for straddle milling connecting rod

Fixture for Circular Components

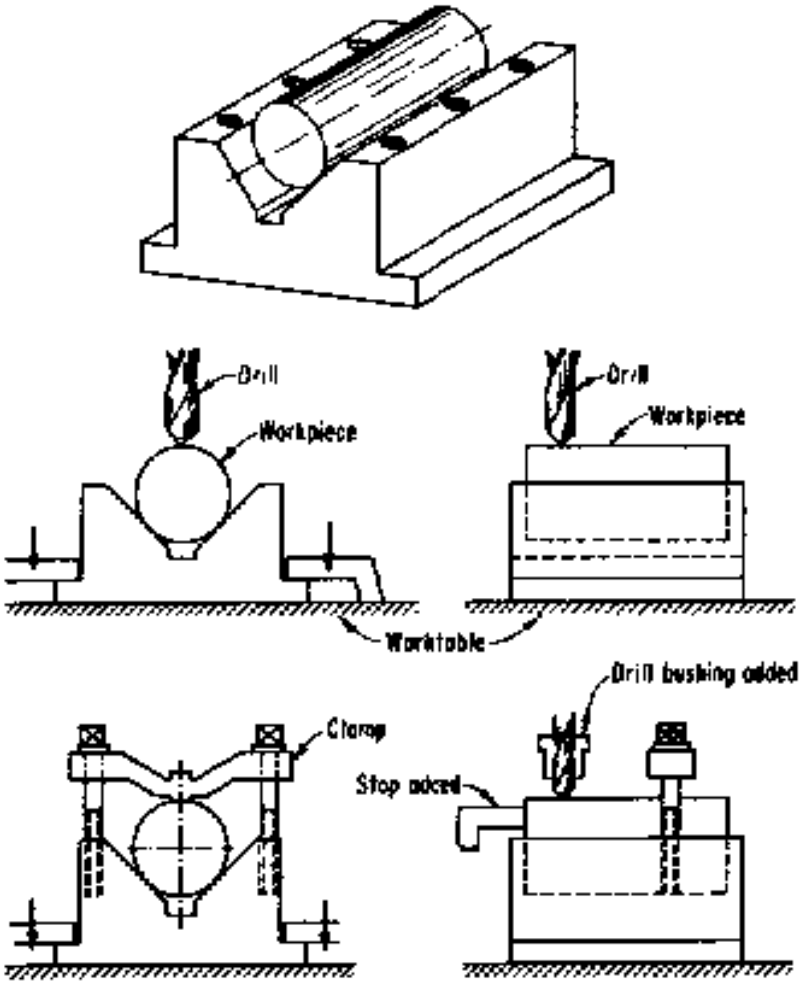


- Workpiece held in a 4-jaw chuck for a boring operation

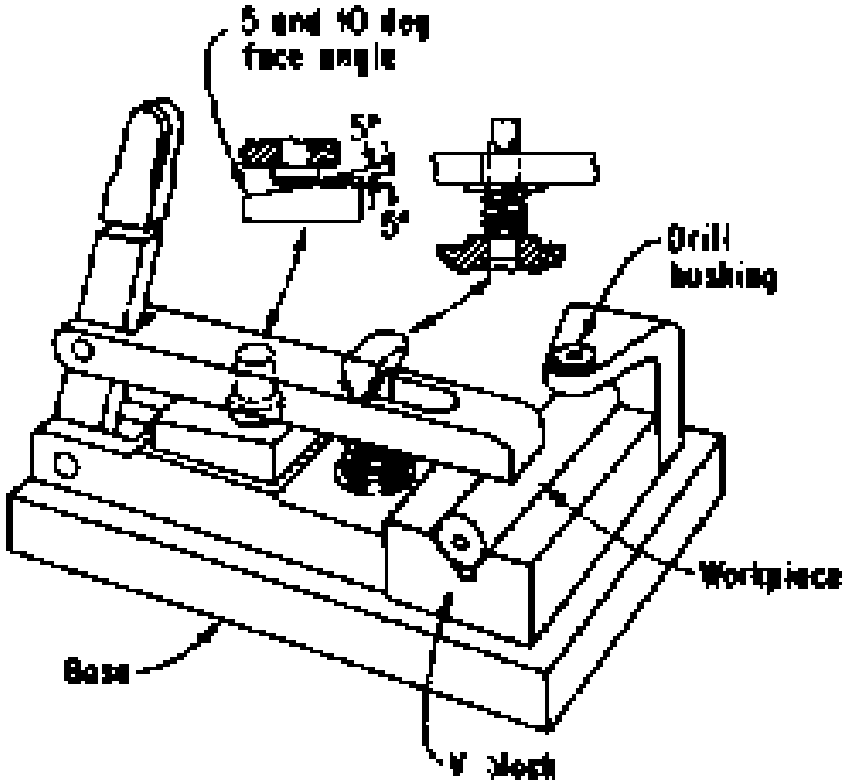


- Nut arbor

Fixture for Circular Components

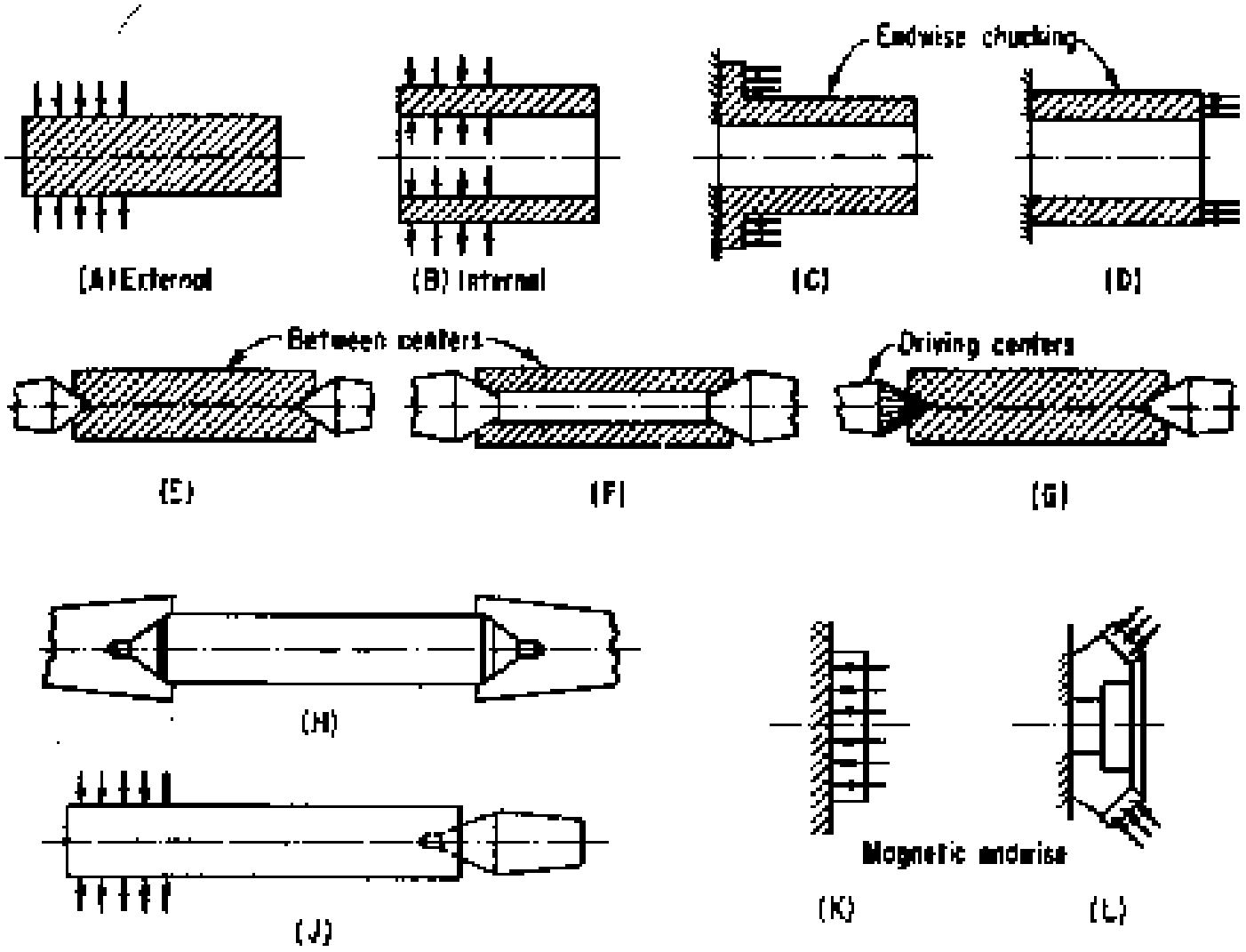


- V block



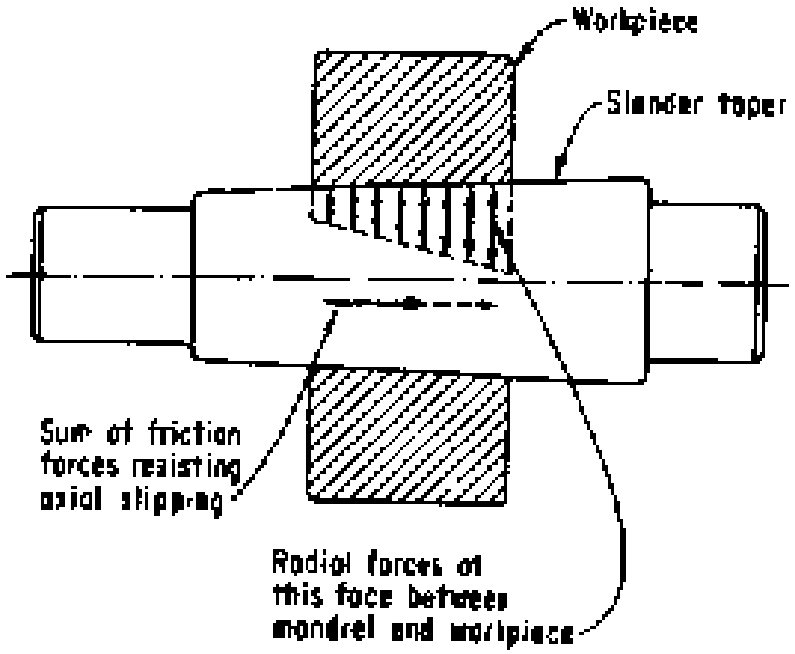
- Drill jig – V block, quick-acting clamp, and drill bushing combination

Fixture for Circular Components

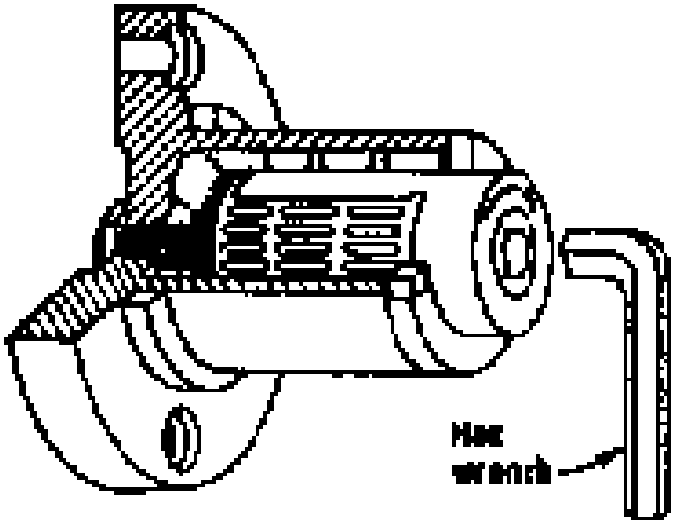


- Internal and endwise chucking
- Between centers and combination with chucking

Fixture for Circular Components



- Solid mandrel



- Roll lock type expanding mandrel

Fixture for Circular Components

- Split busing and split collet

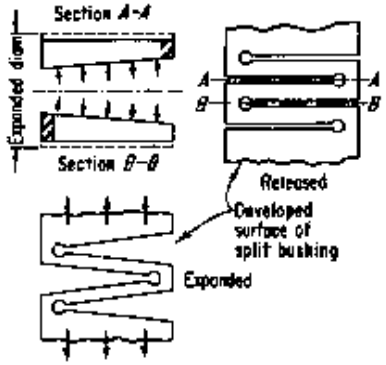


Fig. 2-63.

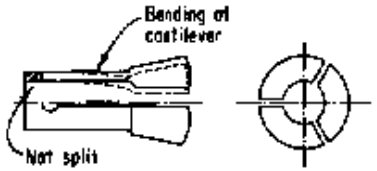
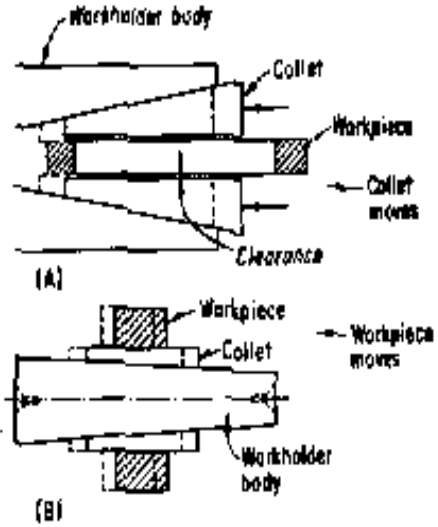


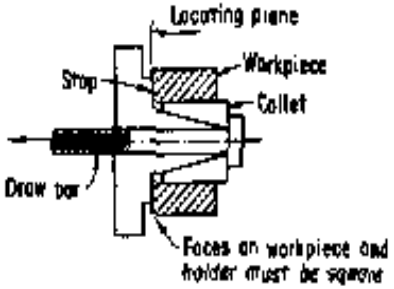
Fig. 2-64.

Fig. 2-63. Expansion of a split bushing.

Fig. 2-64. Split collet.

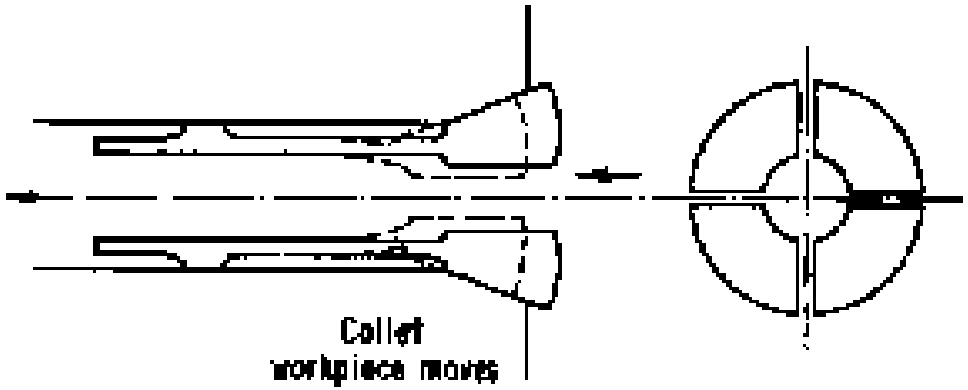


- Axial location by collet

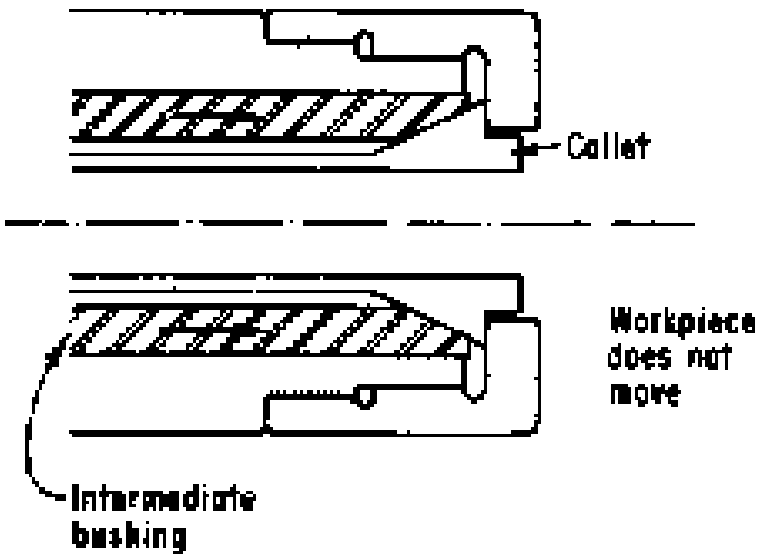


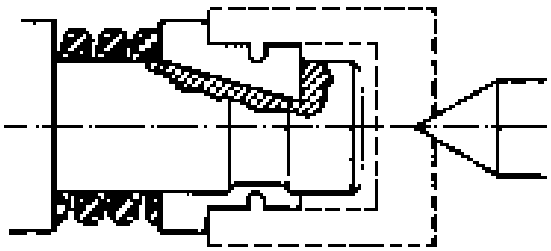
- Collet with stopper

Fixture for Circular Components



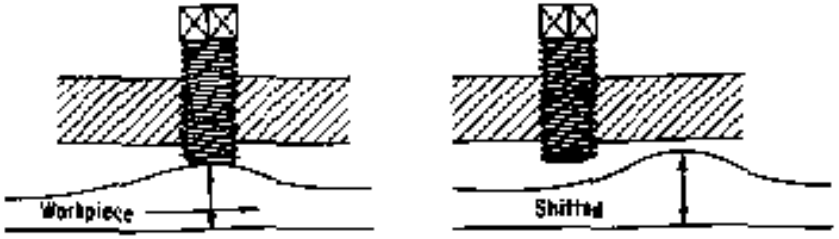
- Collet with immediate bushing to eliminate axial shift



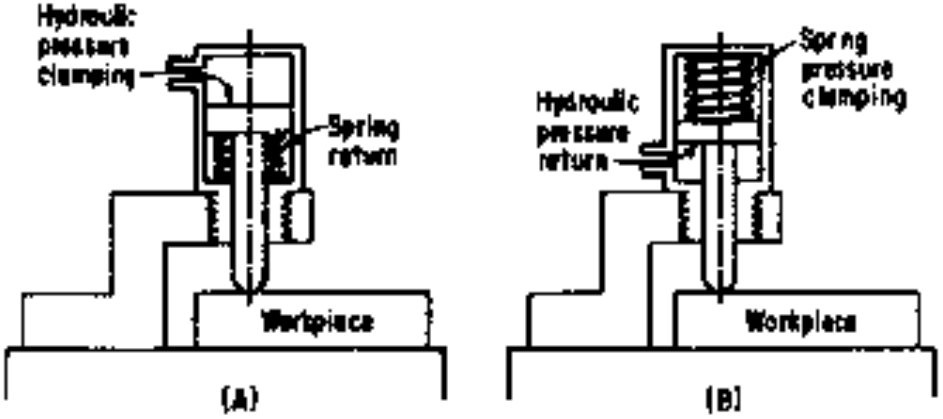


- Collet for internal chucking

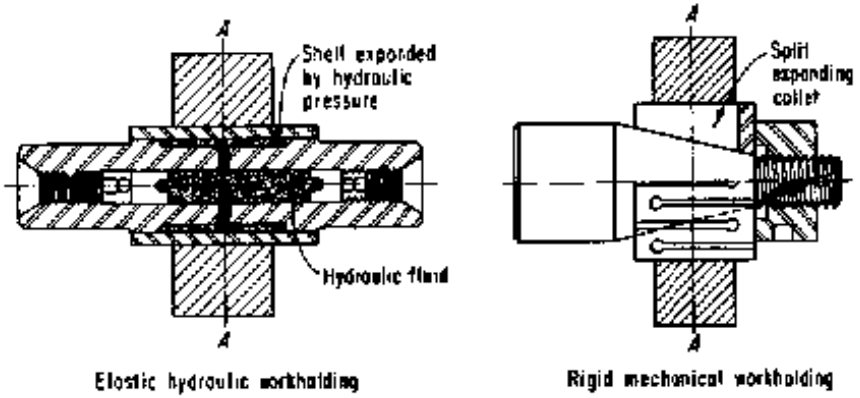
Rigid and Elastic Workholding



- Rigid workholding

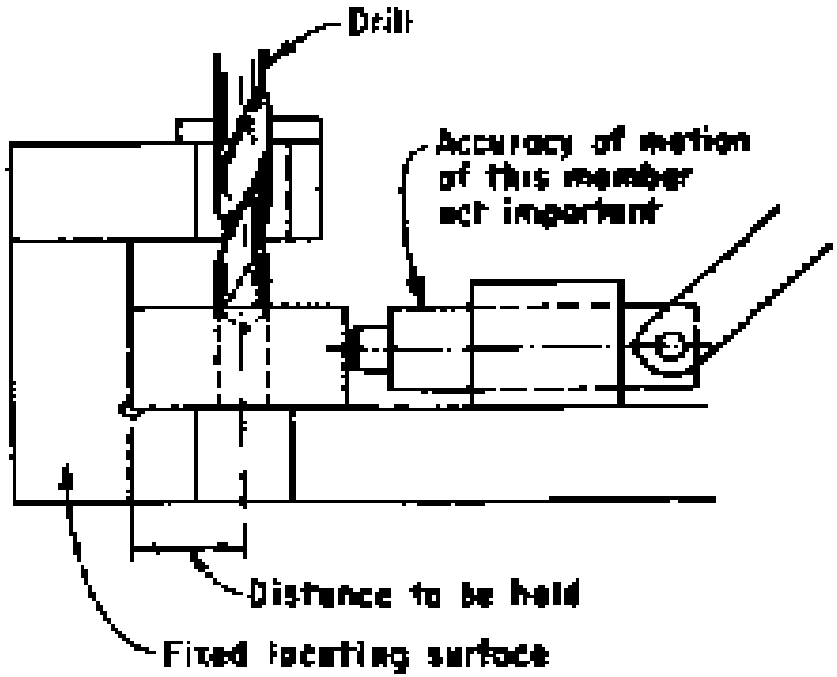


- Elastic and spring workholding

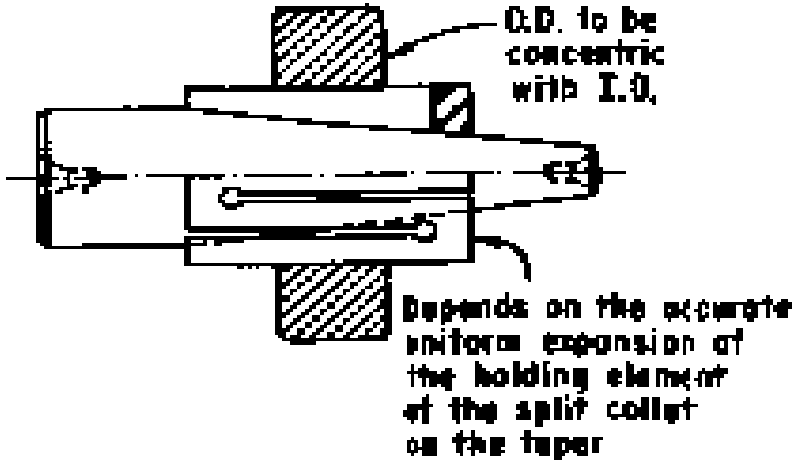


- Rigid/hydraulic workholding

Accuracy of Work Location

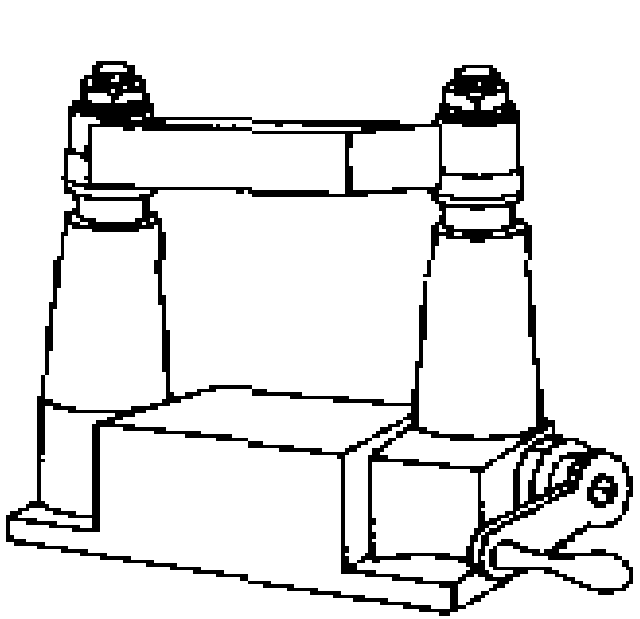


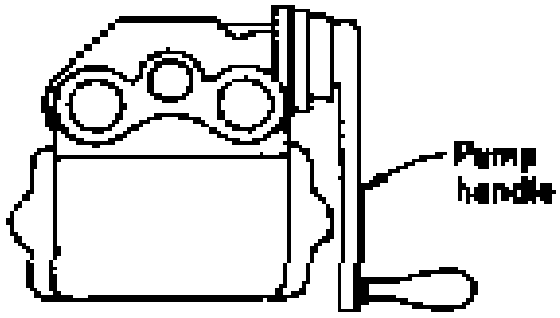
- Accuracy of work location

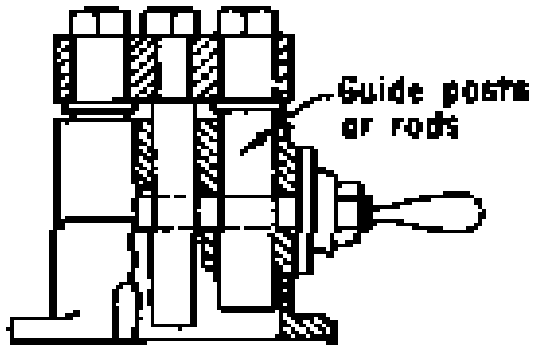


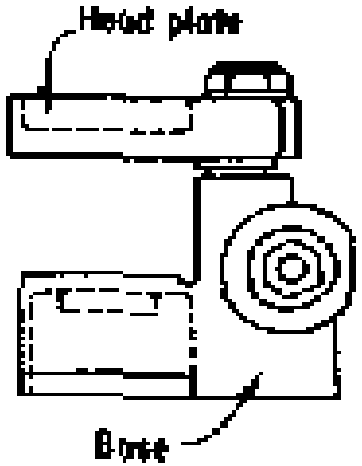
- Concentricity of workpiece by collet

Workholders for Irregular Workpiece



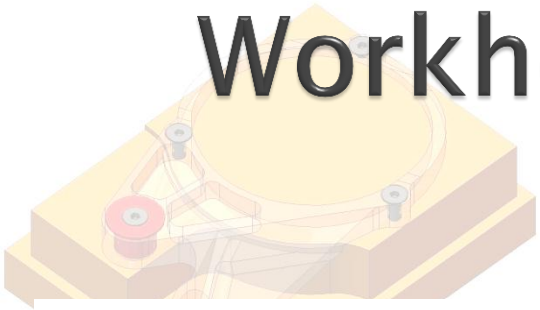


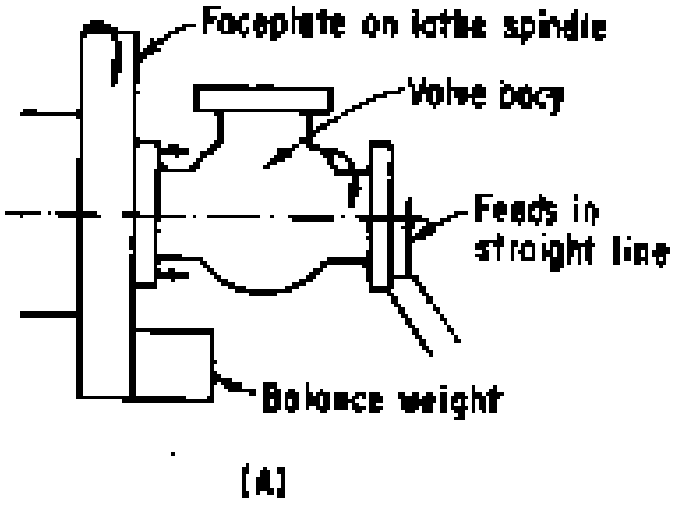




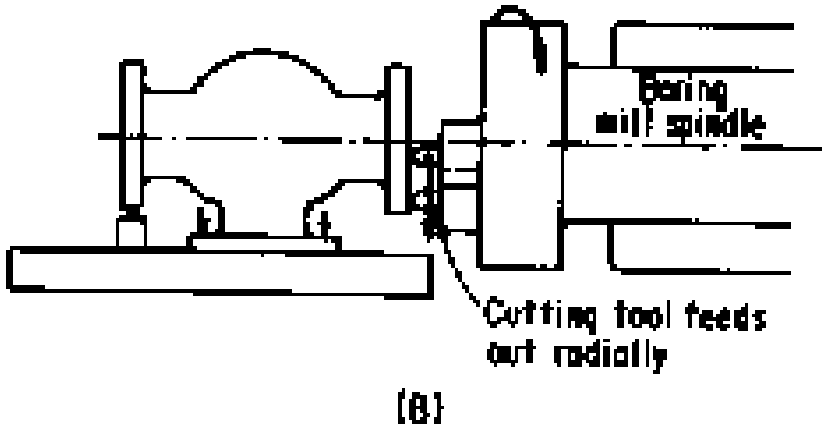
- Pump-type jigs

Workholding Selection



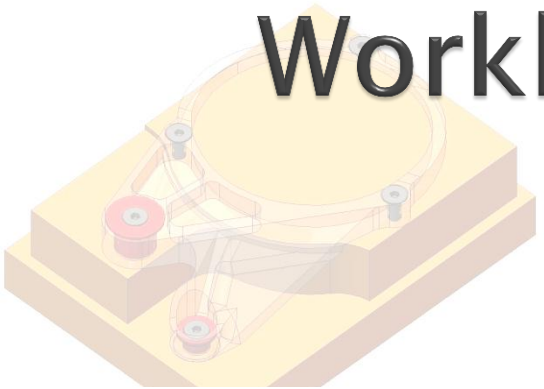


- Workpiece rotation



- Tool rotation

Workholding Selection



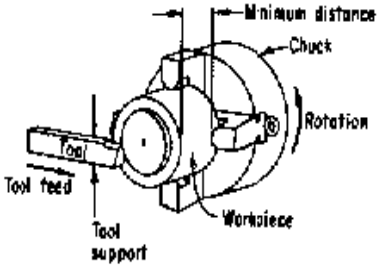


Fig. 2-76.

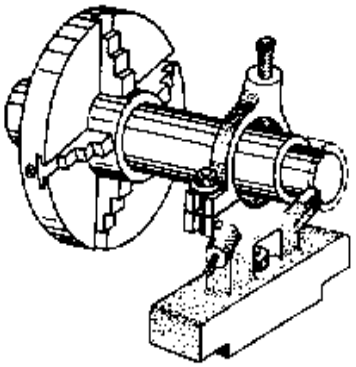
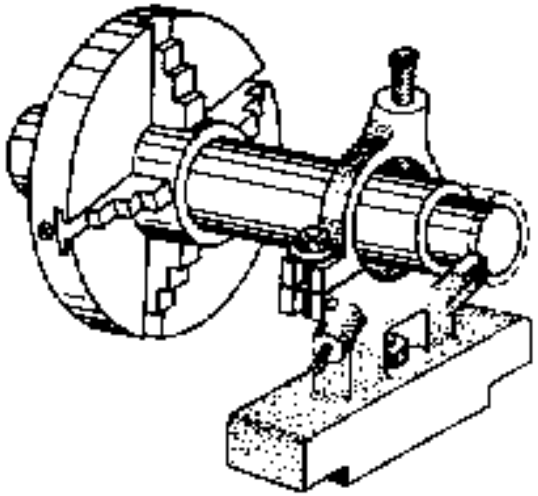


Fig. 2-77.

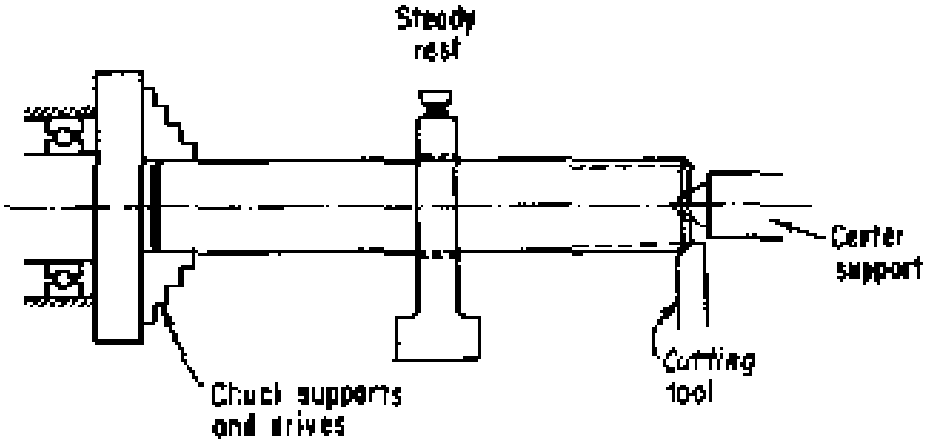
Fig. 2-76. Minimizing cutting force by applying holding force as near as possible to point of tool application.

Fig. 2-77. Steady rest used to support workpiece in area of cutting-force application.

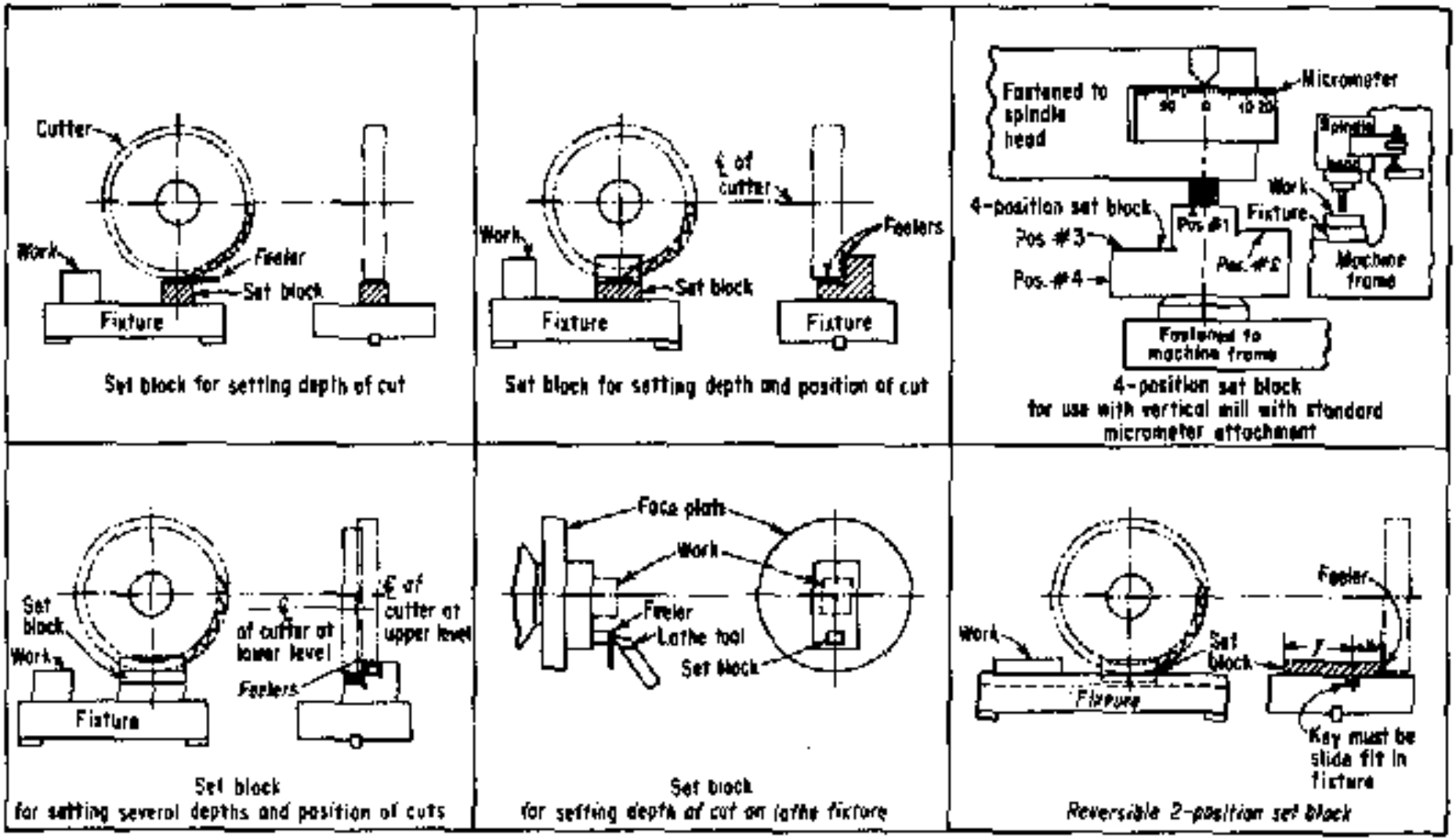
- Minimizing cutting force by applying holding force close to point of tool application



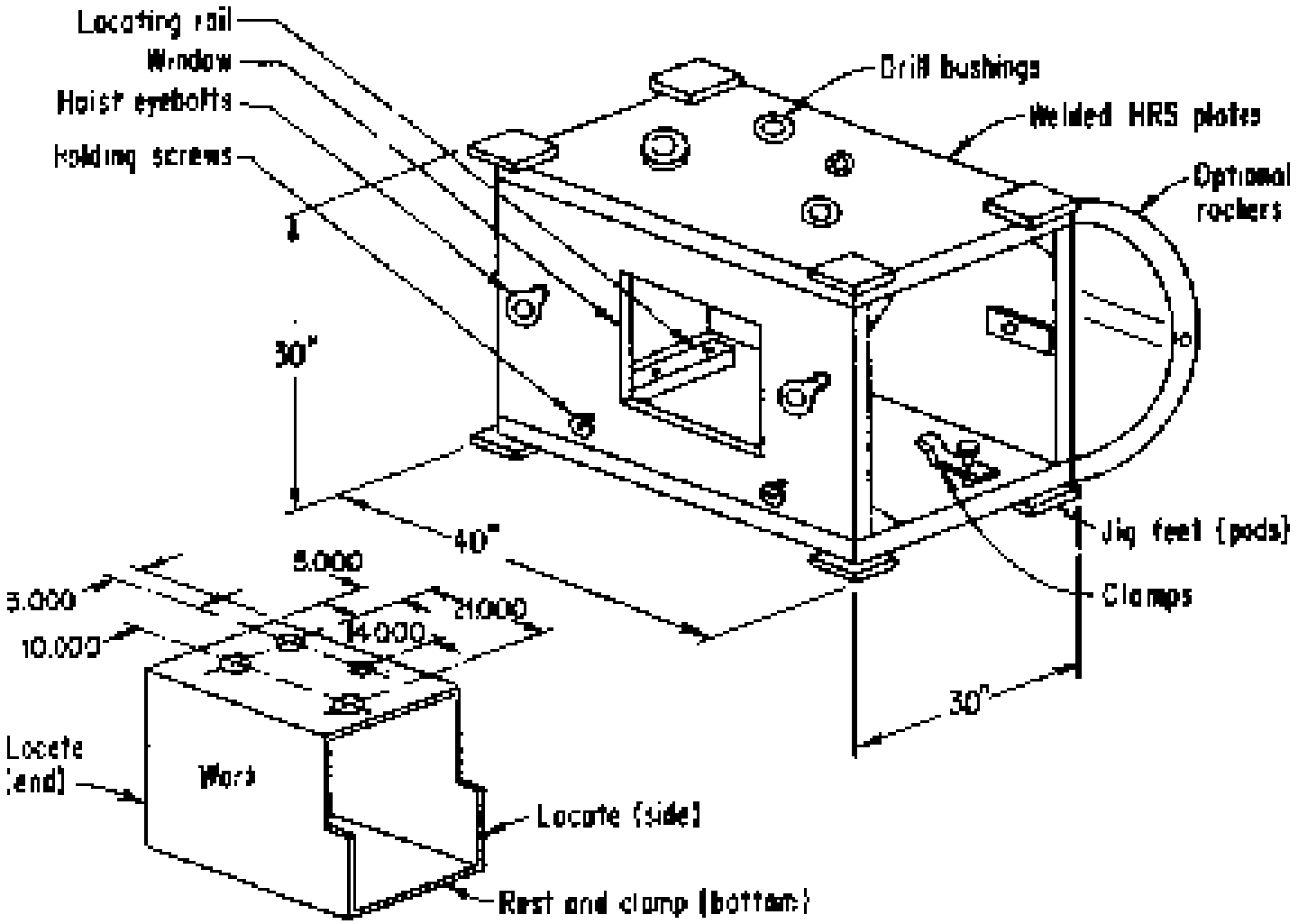
- Steady to reduce workpiece vibration



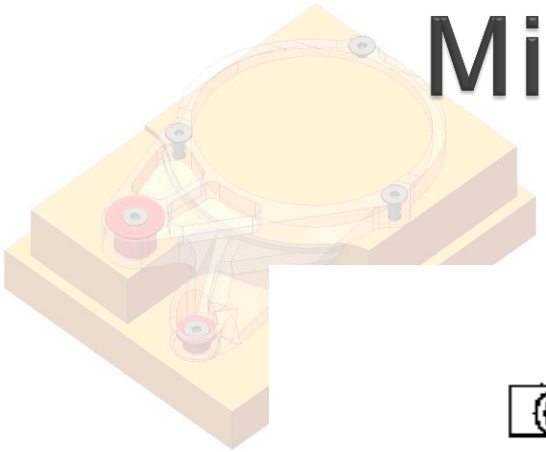
Cutter Setup

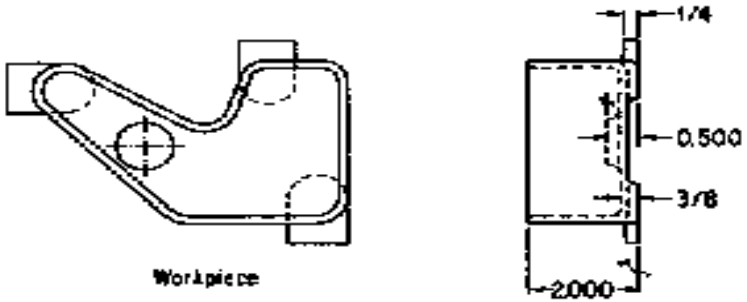


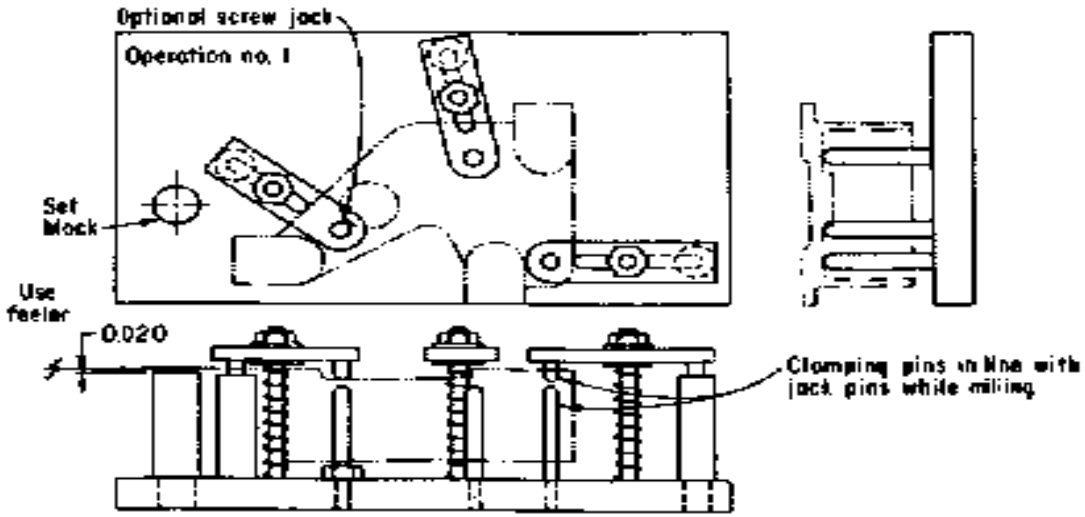
Box-Type Drill Jigs



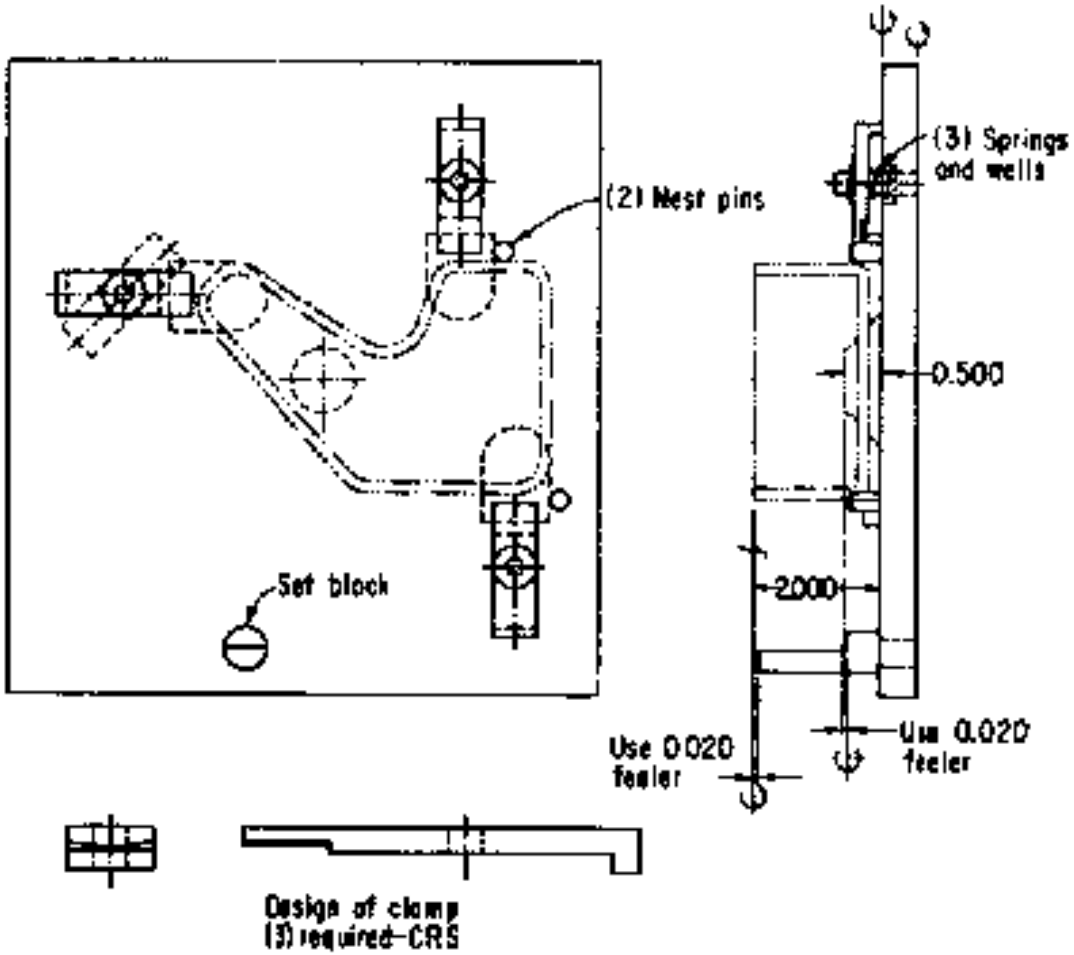
Milling Fixture







Milling Fixture



Milling Fixture

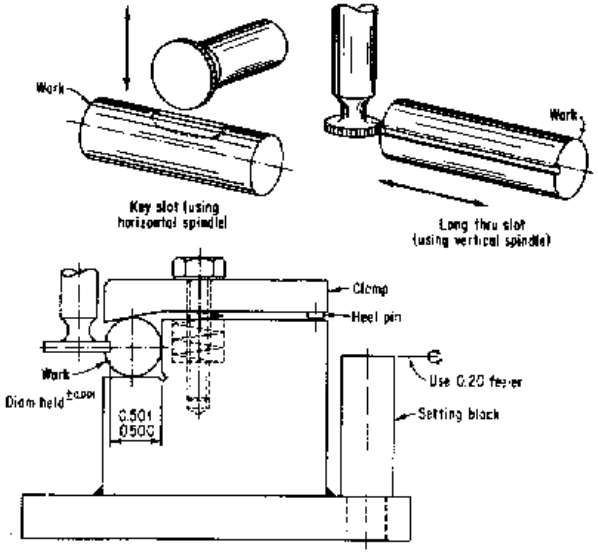


Fig. 2-93. Methods of milling key slots and vertical milling fixture.

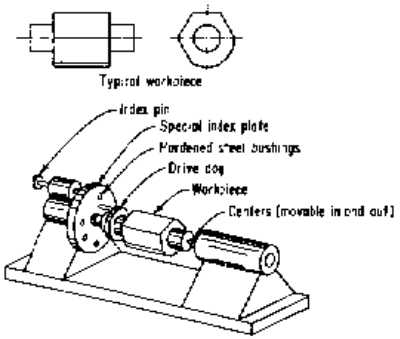
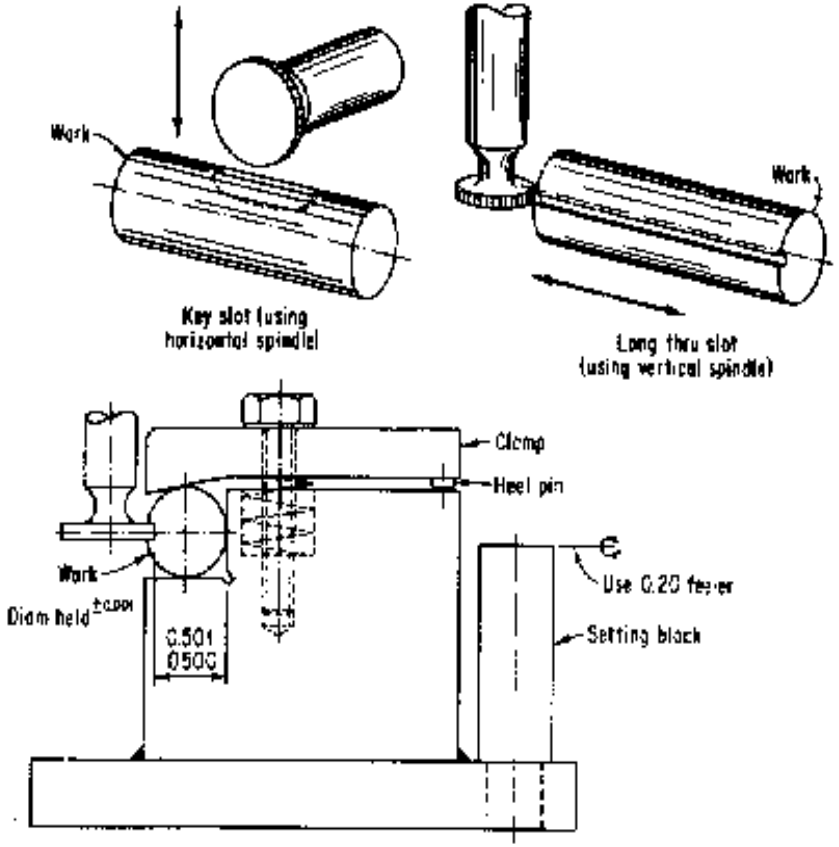


Fig. 2-94. Indexing fixture for milling flats on shafts.

- Key slot milling



- Indexing fixture

Milling Fixture