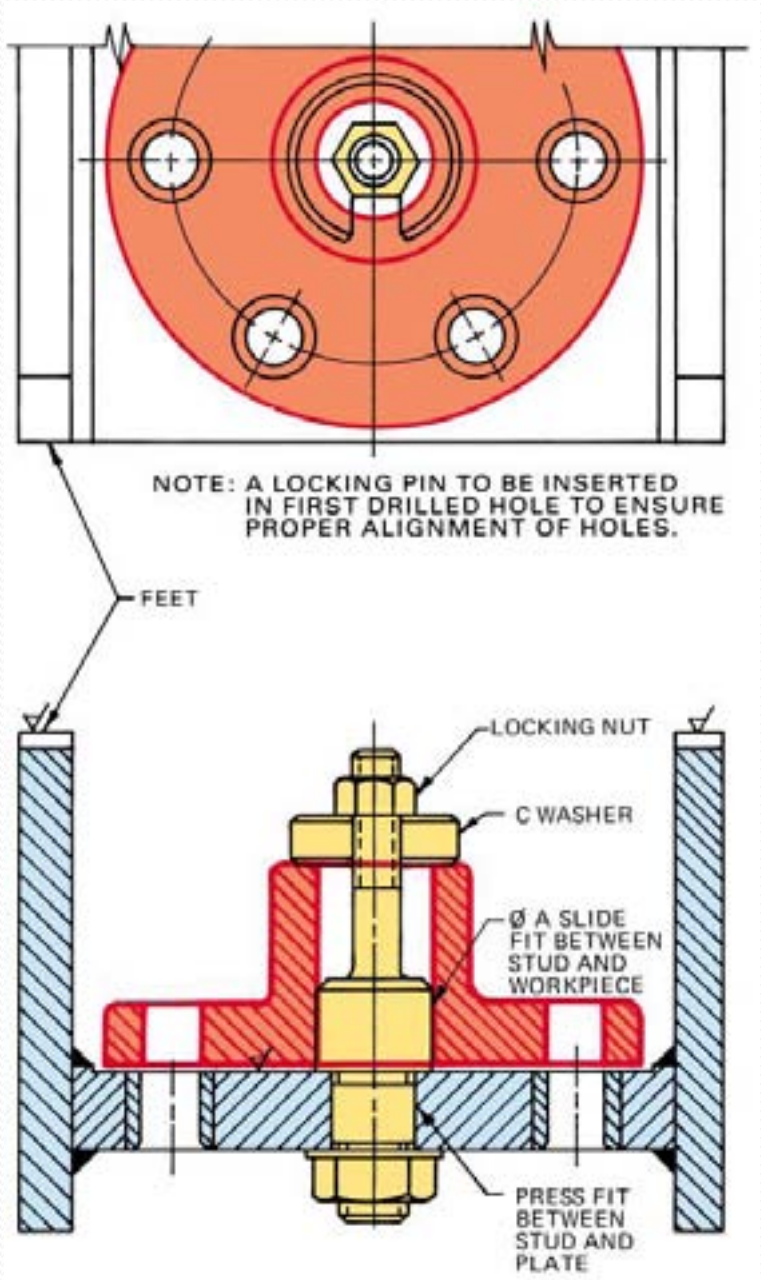
Jig Design

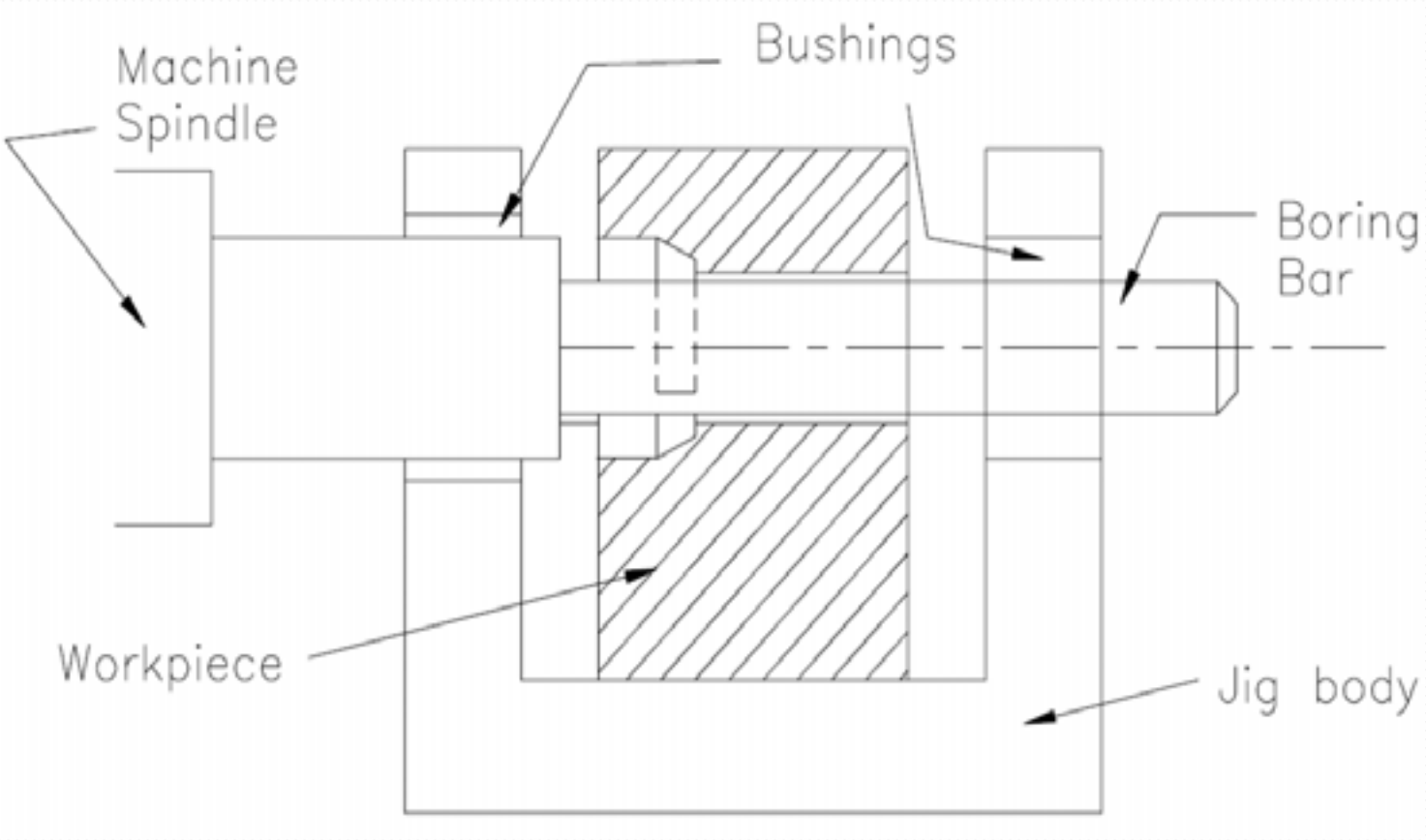
ITCD – 301-001

Jigs and Fixtures

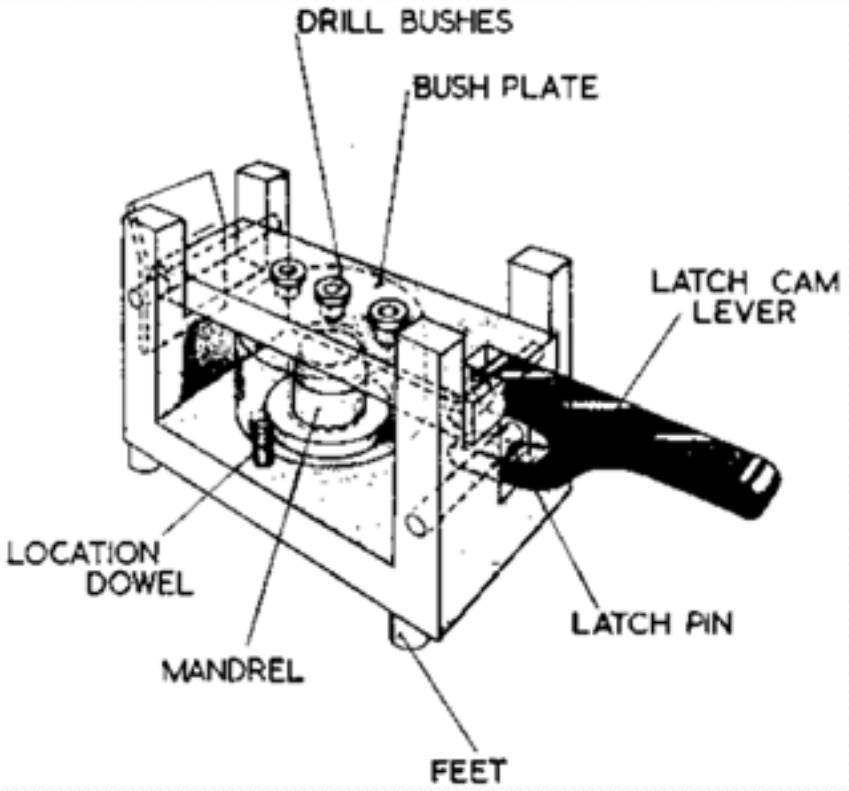
- Fixture – Means through which a part is securely fastened to the machine tool table to accurately locate, support and hold the part during the machining operation
- Jig – A special class of fixture which in addition to providing all the functions above, also guides the cutting tool during machining. Used for drilling, boring, reaming, tapping, counter boring, etc.

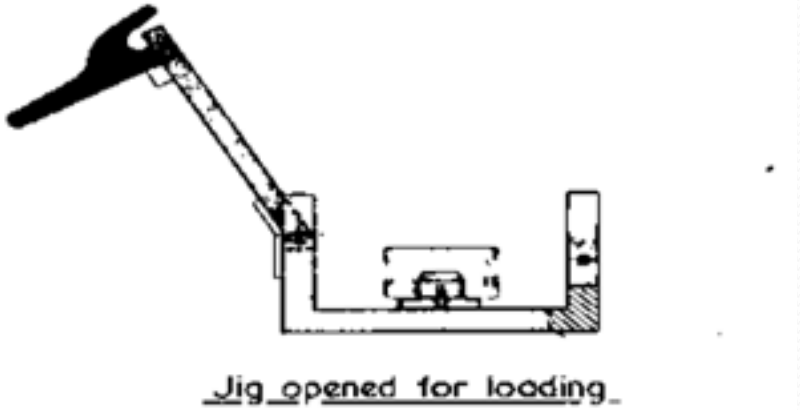

NOTE: A LOCKING PIN TO BE INSERTED IN FIRST DRILLED HOLE TO ENSURE PROPER ALIGNMENT OF HOLES.
FEET
LOCKING NUT
C WASHER
Ø A SLIDE FIT BETWEEN STUD AND WORKPIECE
PRESS FIT BETWEEN STUD AND PLATE

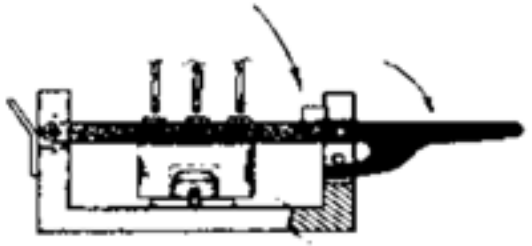
Typical jig used for boring operation



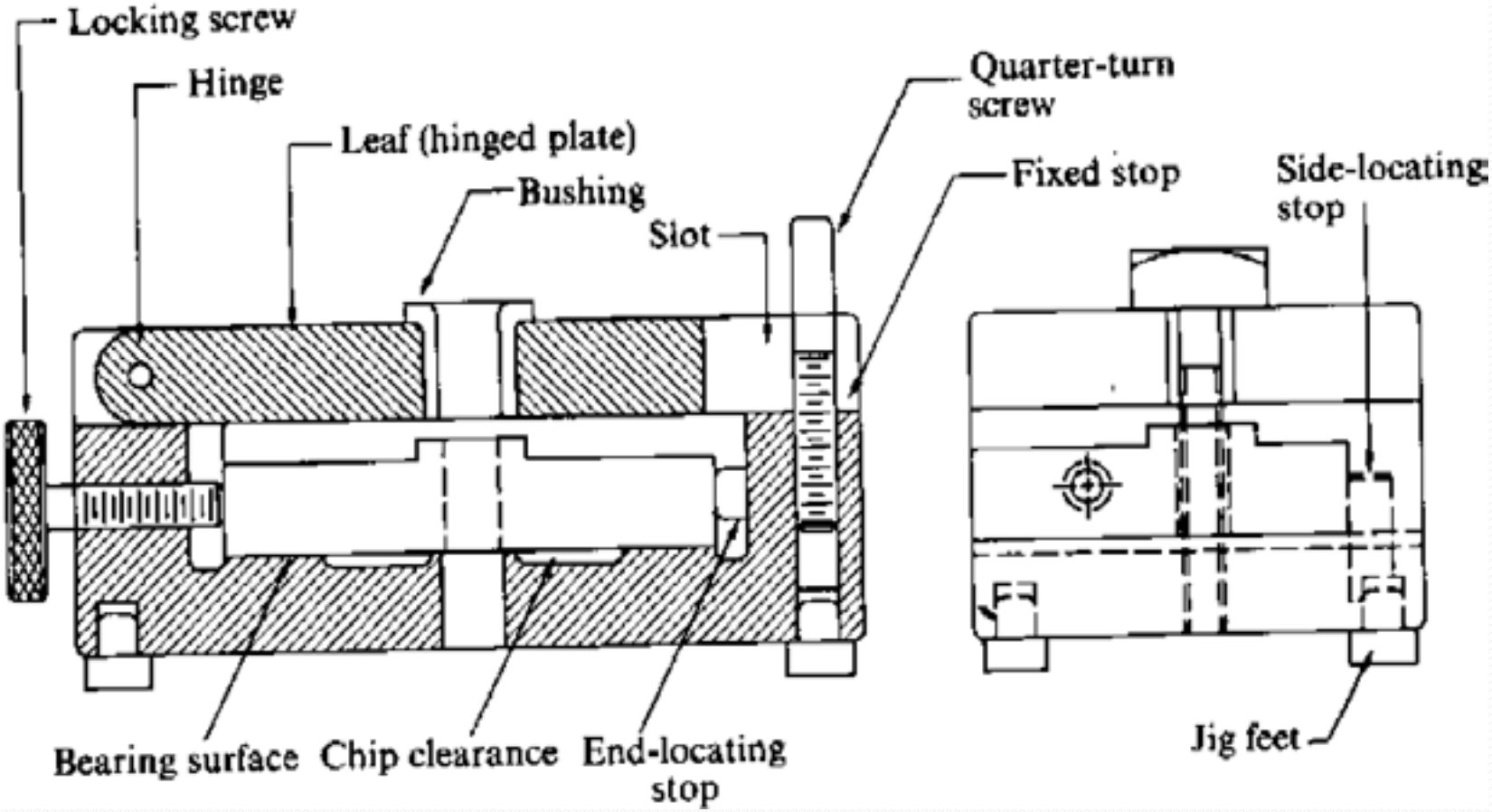
Drill jig with swinging bush plate and latch cam closure




Jig opened for loading


Bush plate lowered & latch cam lever locked in position

Simple leaf jig



Functions of a jig

- Provide methods to
- Correctly locate the workpiece with respect to the tool
- Securely clamp and rigidly support the workpiece during the operation
- Guide the tool
- Position and/or fasten the jig on a machine

Advantages

- Minimize tool breakage
- Minimize the possibility of human error
- Permit the use of less skilled labor
- Reduce manufacturing time
- Eliminate retooling for repeat orders

Considerations

- Machine considerations

- Horsepower
- Size limitations
- Weight limitations
- Cutting tools
- Special machinery

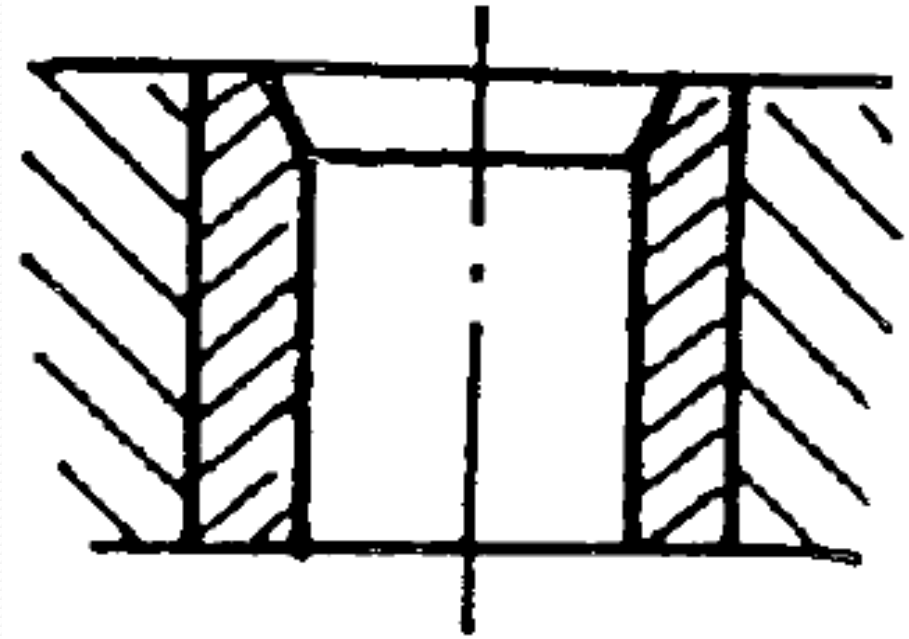
- Process considerations

- Types of operations (drilling, reaming etc.)
- Number of operations
- Similar vs. different
- Sequential vs. simultaneous
- Sequence
- Inspection requirements

Jig Bushes

- To position and guide the cutting tool for cutting
- Materials
  - Hardened steel
  - Carbide
  - Bronze
  - Stain

Headless Bush

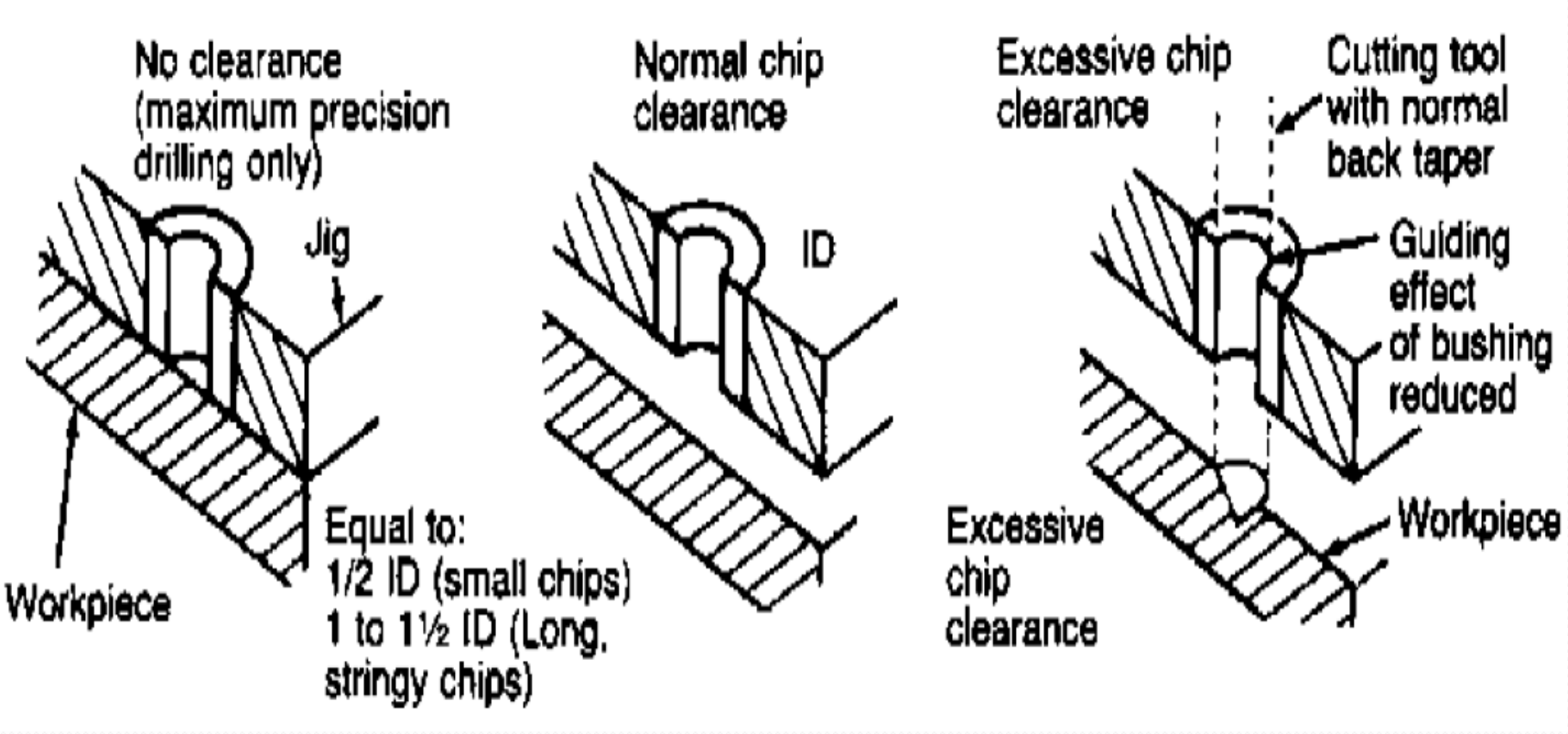


Most popular and least expensive

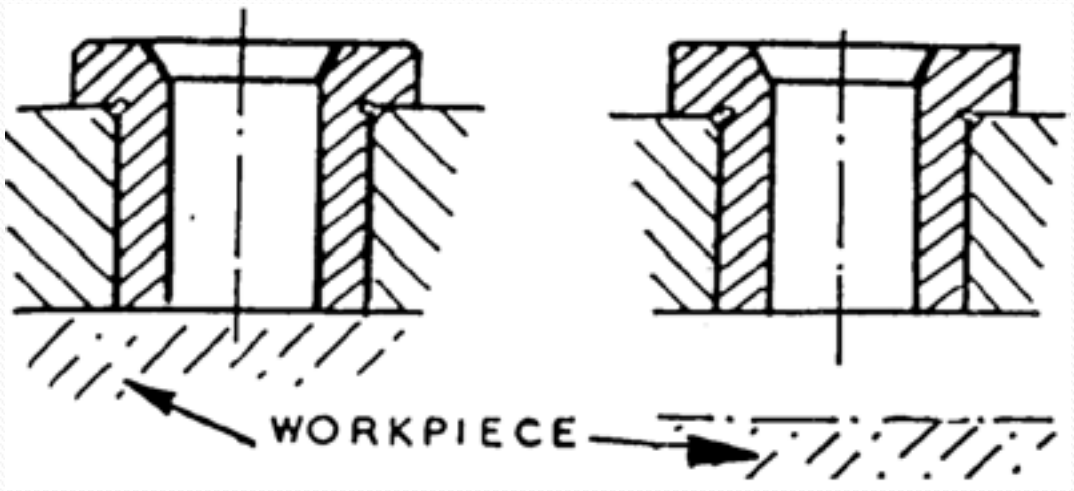
Light axial load is expected

- *Drill bushings*
  - Precision tools that guide cutting tools such as drill and reamers into precise locations in a workpiece.

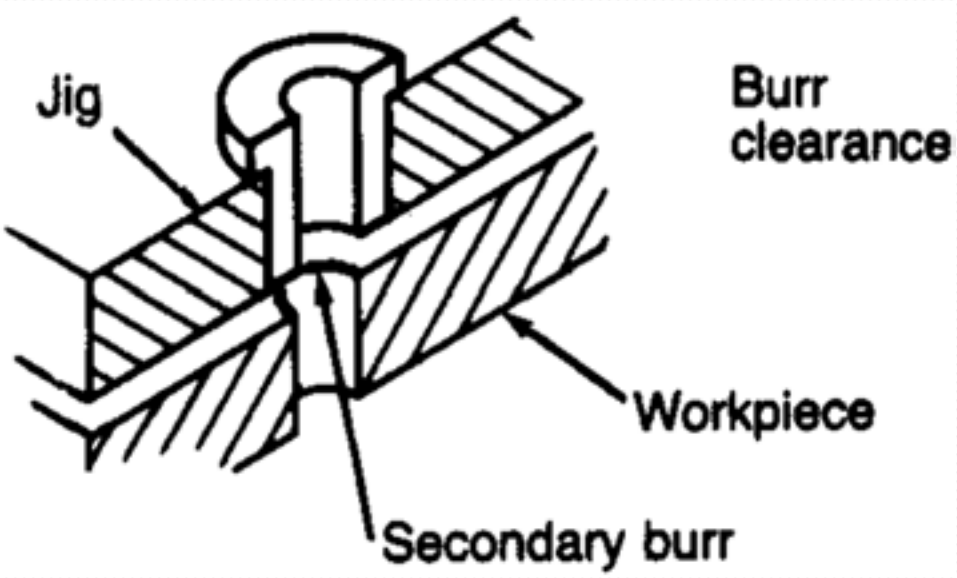
Clearance between bush and part

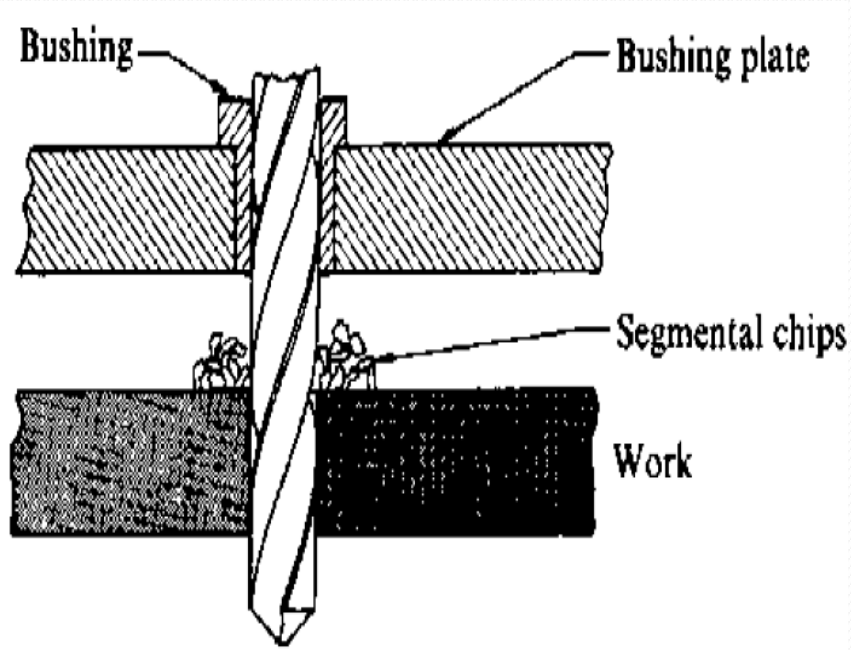


Headed drill bush

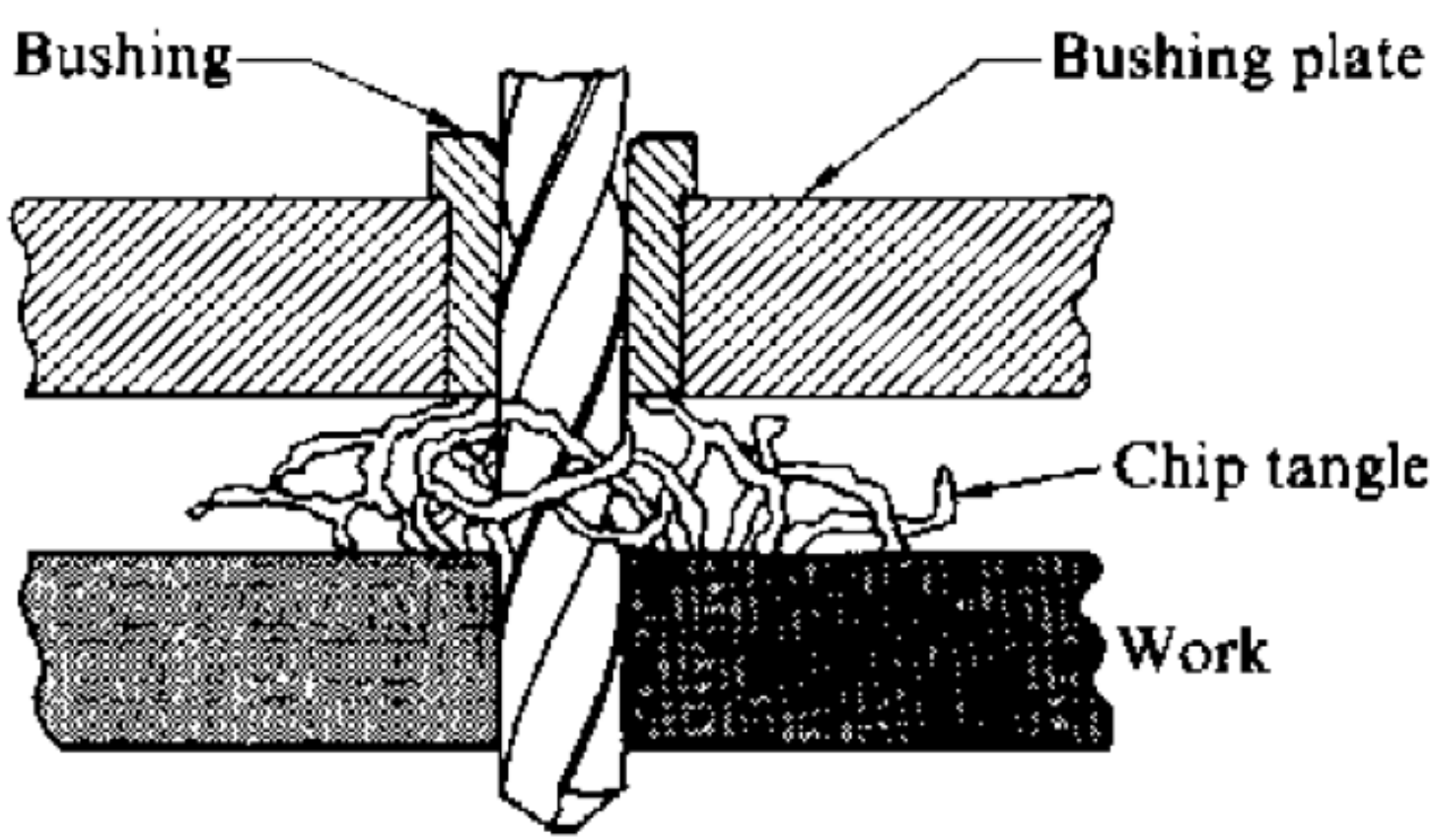


Burr Clearance

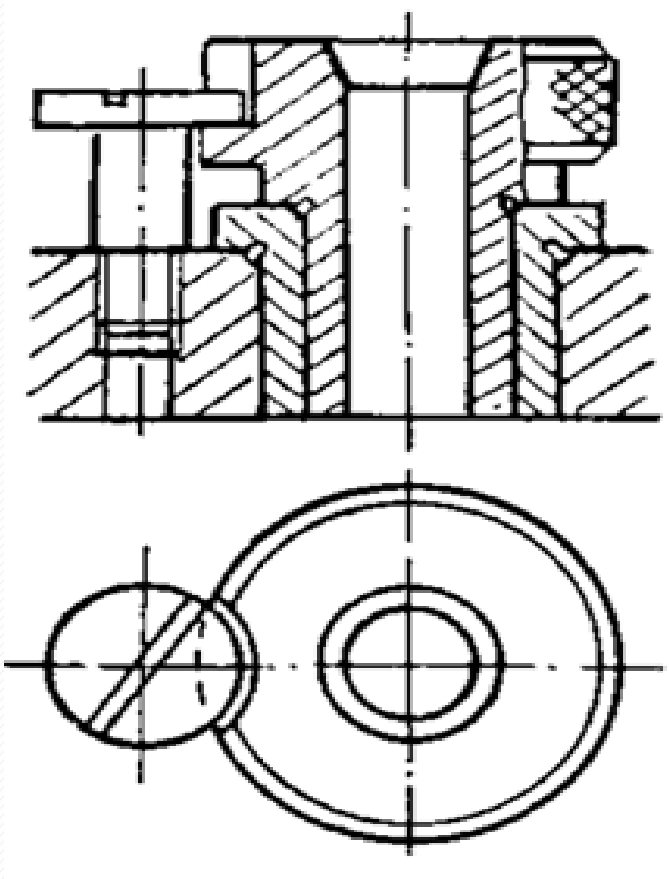




Chip tangle

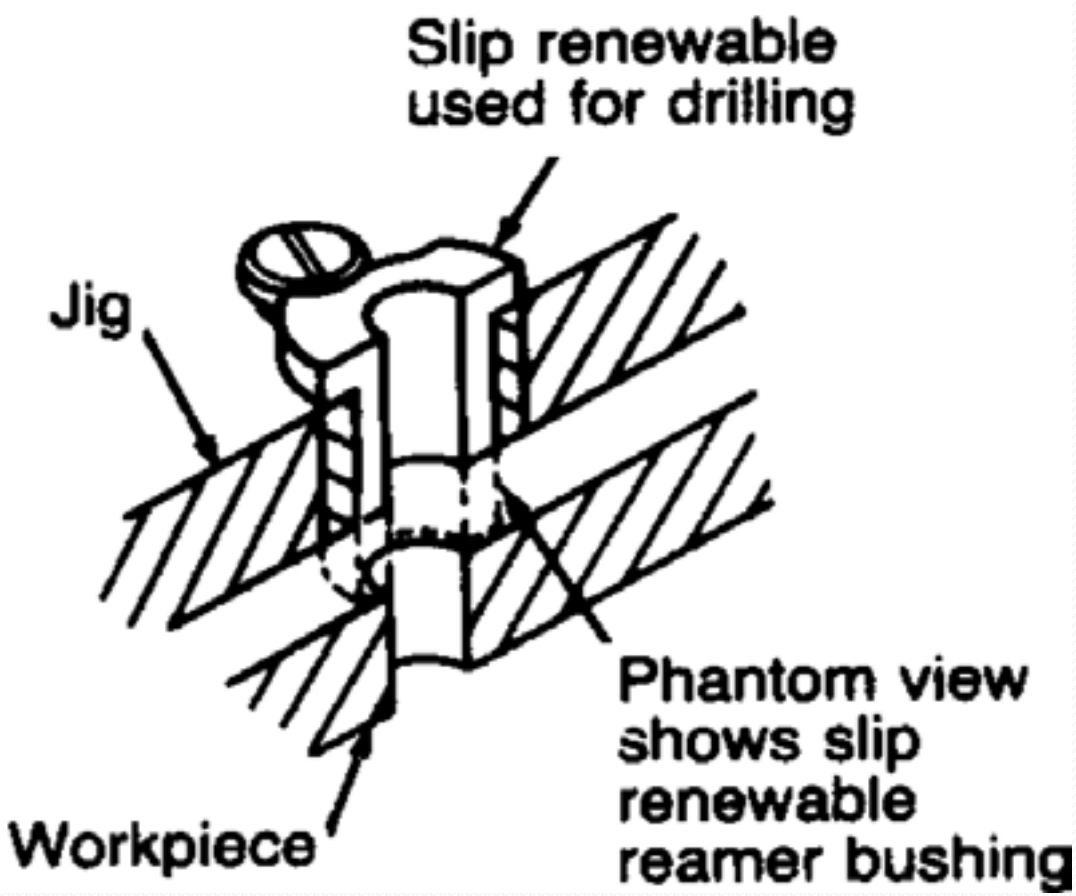


Slip renewable bush

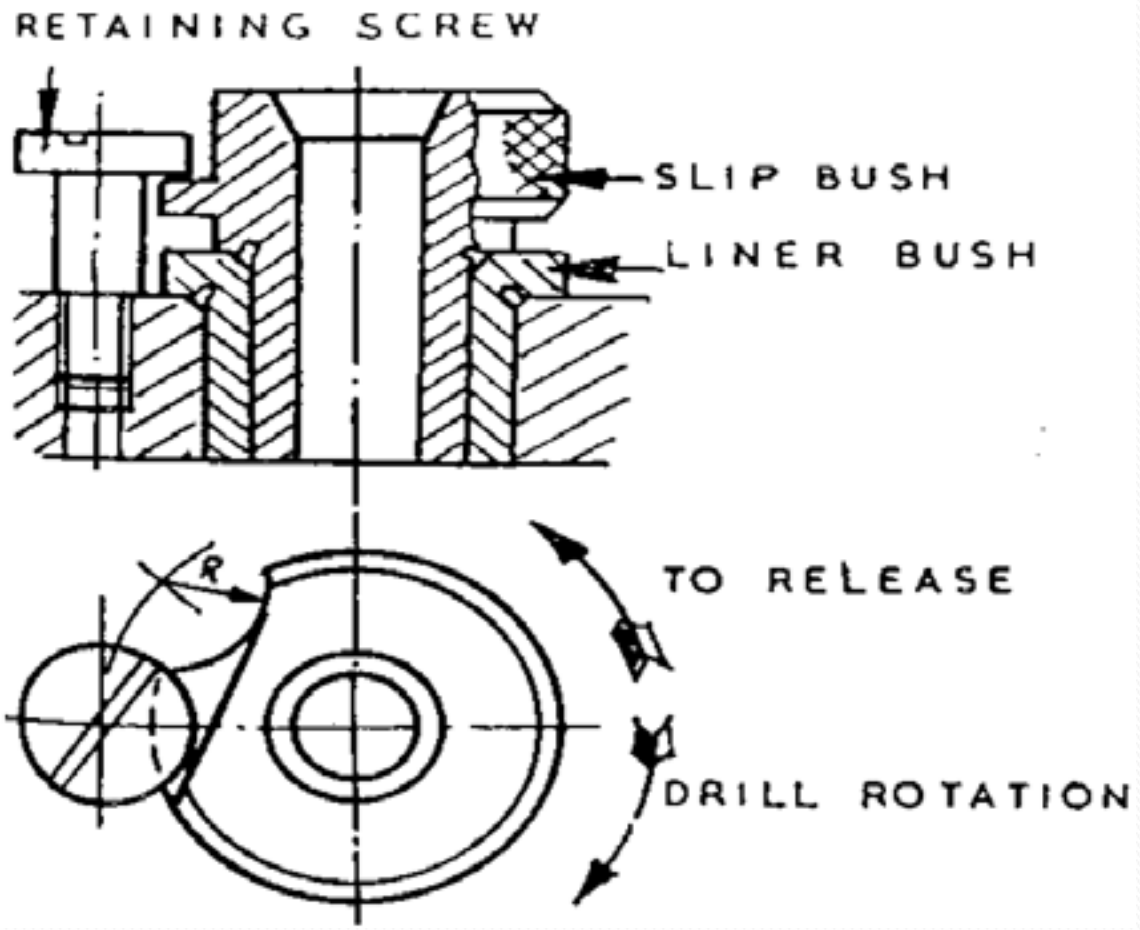


Used for multiple operations such as drilling followed by reaming

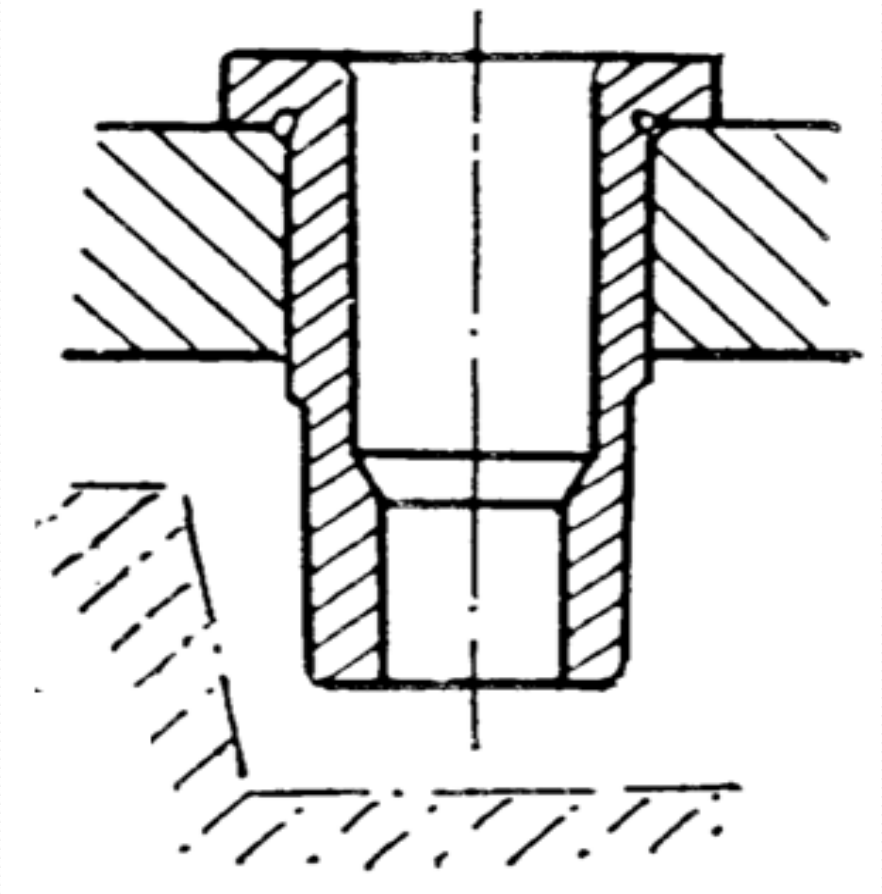
Chip clearance for multiple operations



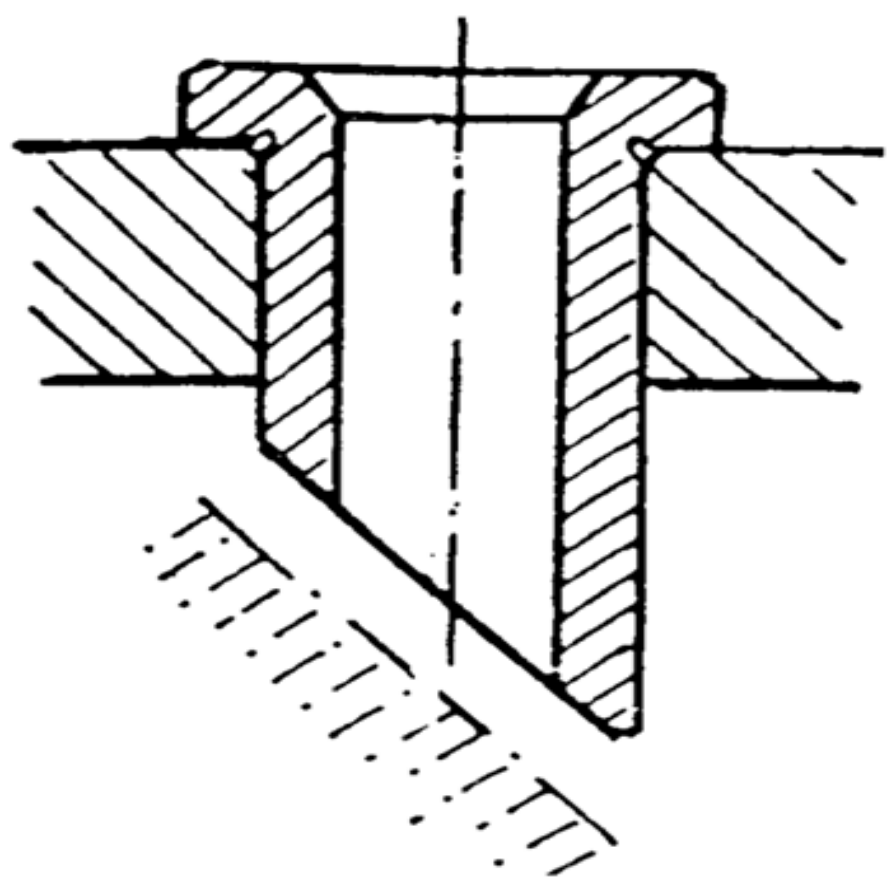
Slip bush arrangement



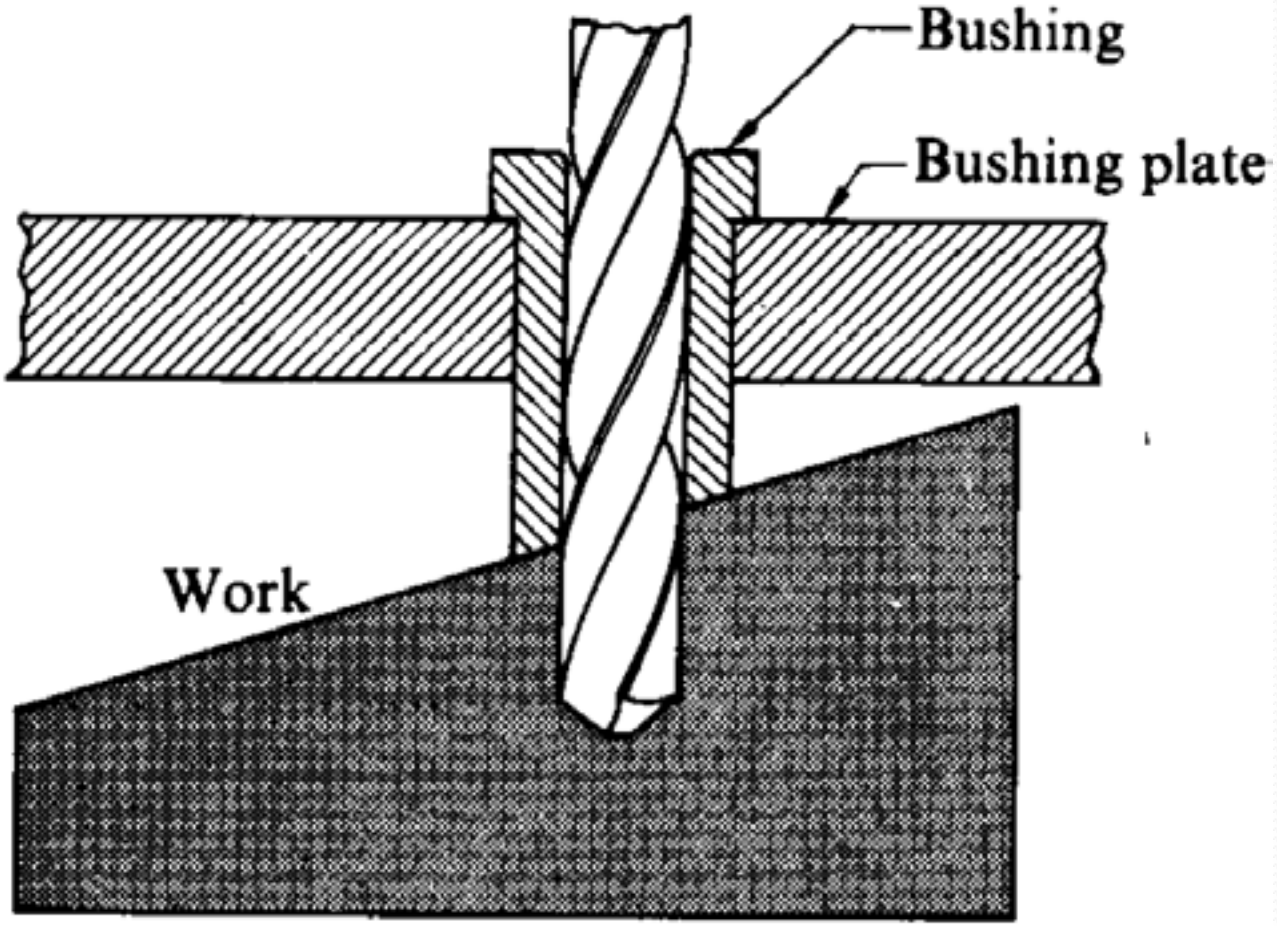
Extended drill bush



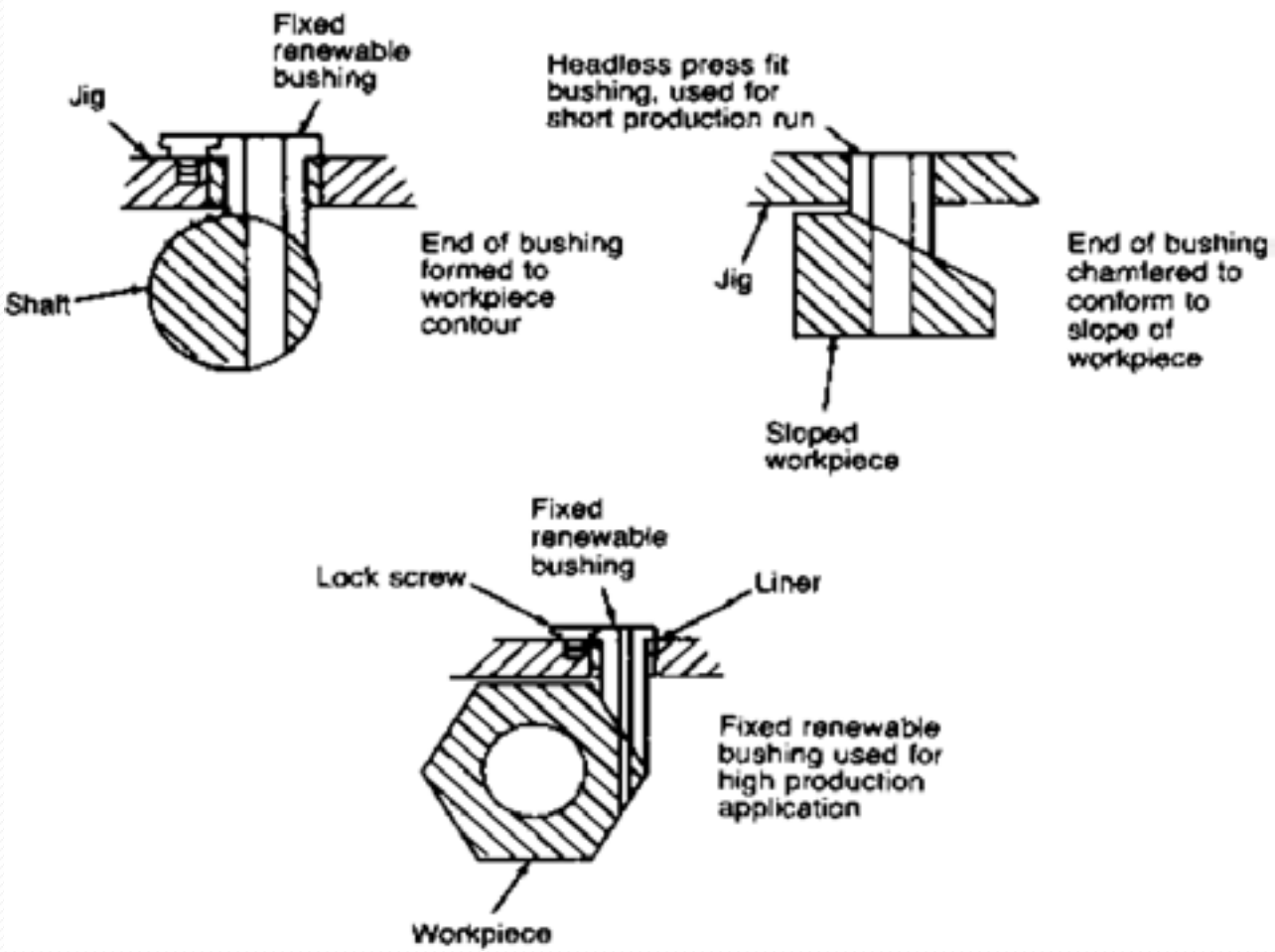
Shaped drill bush



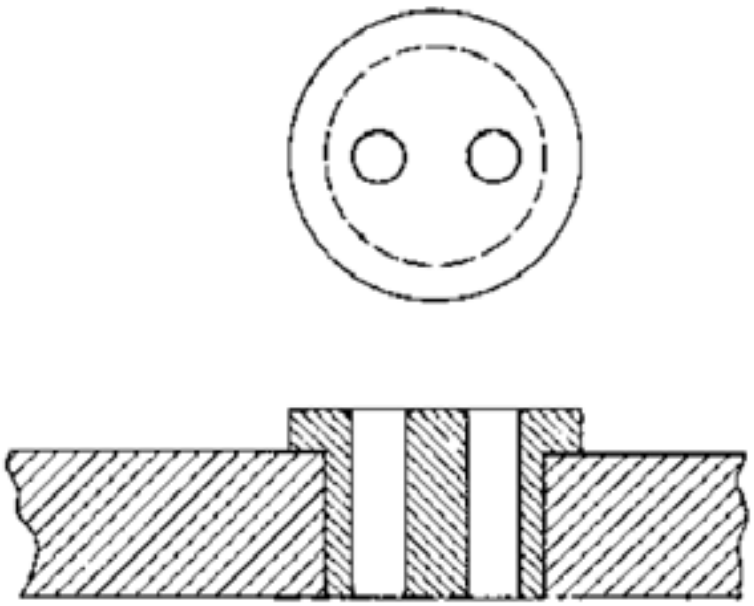
Drill bushing position for angular drill entry



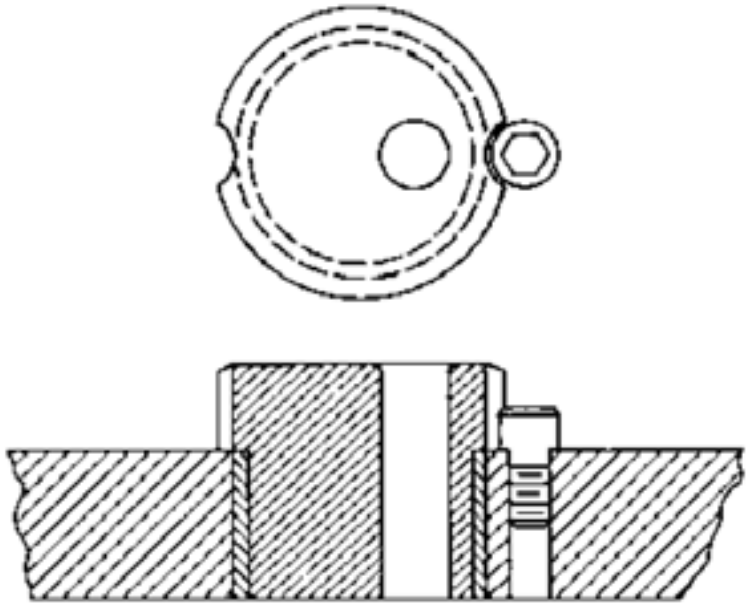
Drilling irregular work surfaces



Different applications

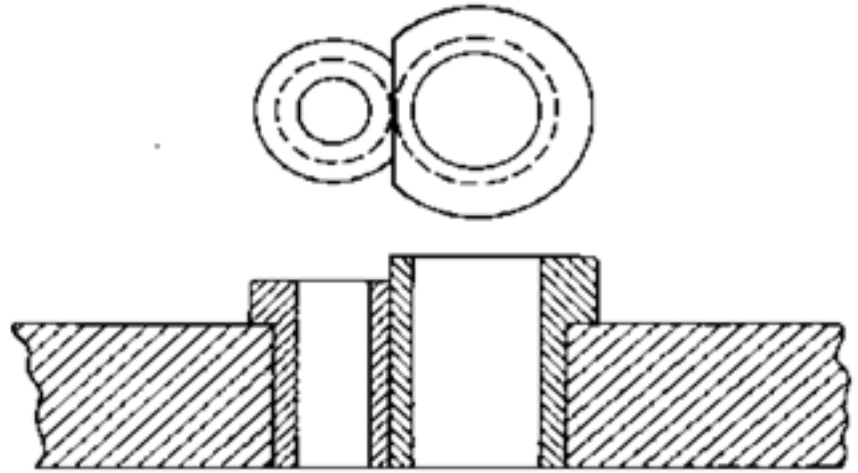


Use of two holes in one bushing

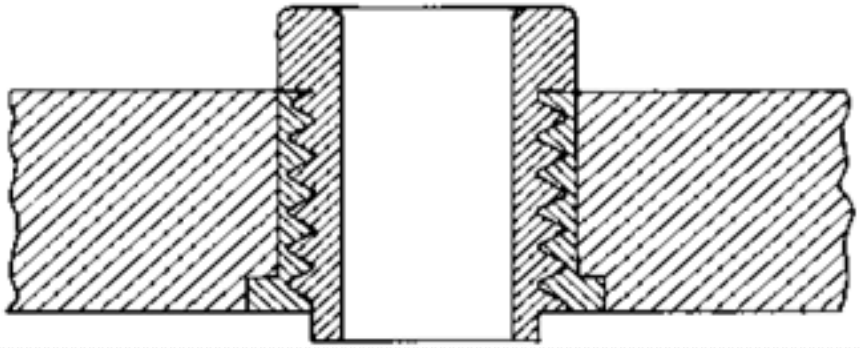


Use of eccentric for close hole drilling

Modifications



Modification of standard bushings for close hole drilling



Plain screw bushing

Drill-jog bushings

Jig components

- Locators
- Clamps
- Jig plate with bushes
- Jig body
- Other elements as required
  - Supports
  - Jig feet

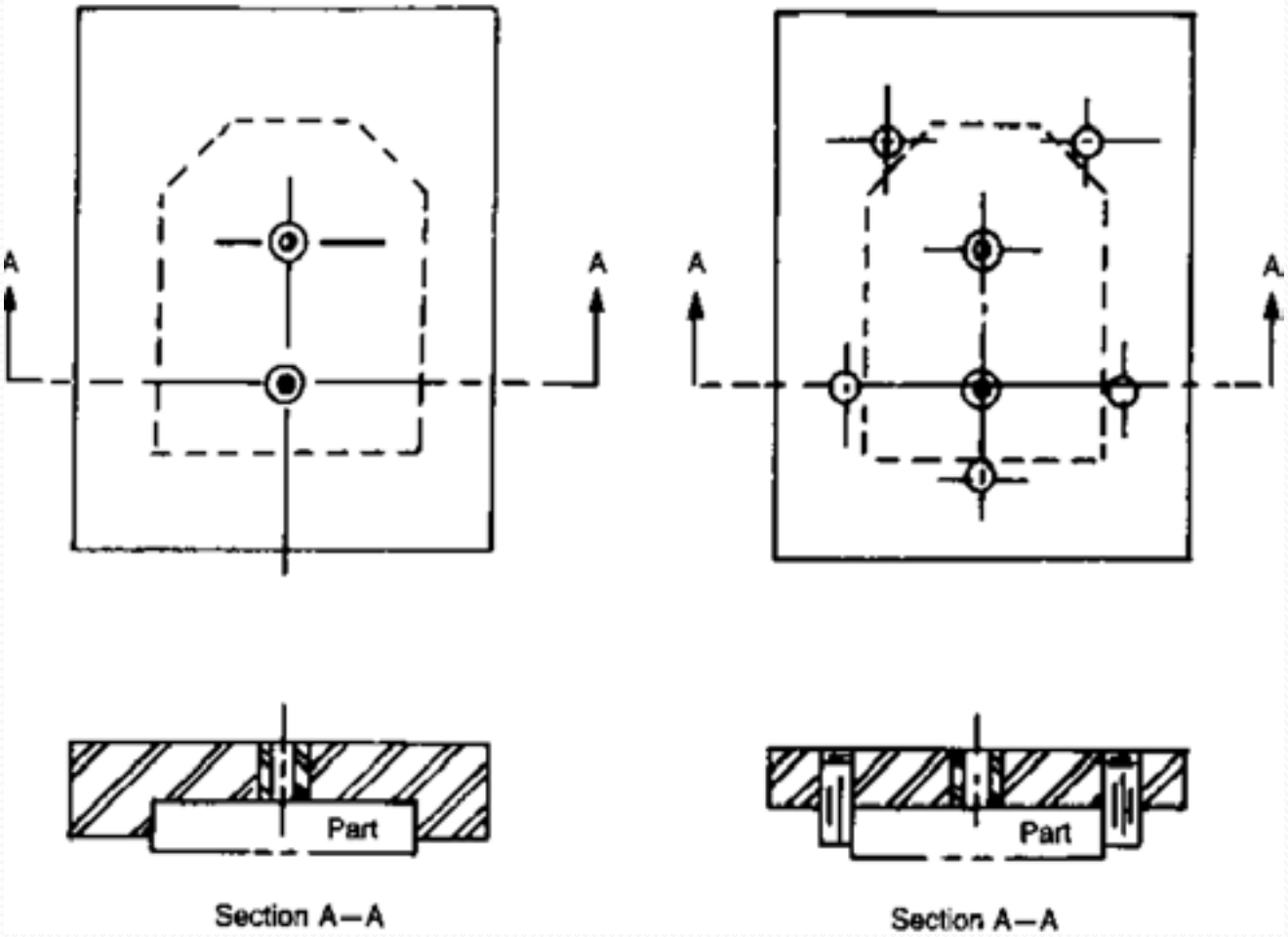
Types of Jigs

- Template jigs
- Plate jigs
- Universal jigs
- Leaf jigs
- Channel and tumble jigs
- Indexing jigs
- Miscellaneous jigs

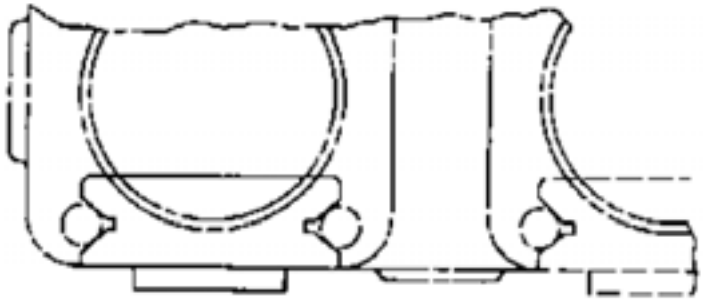
Template Jigs

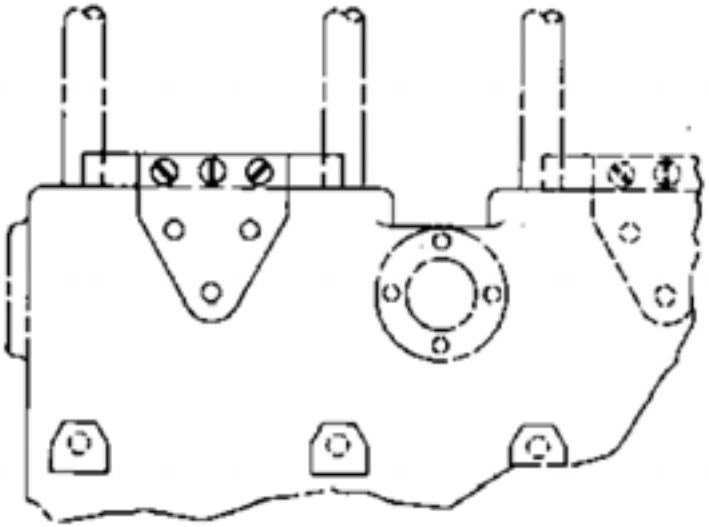
- No clamping arrangement
- Plates with bushing to guide the tool
- Directly placed on the part
- Simple
- Least expensive

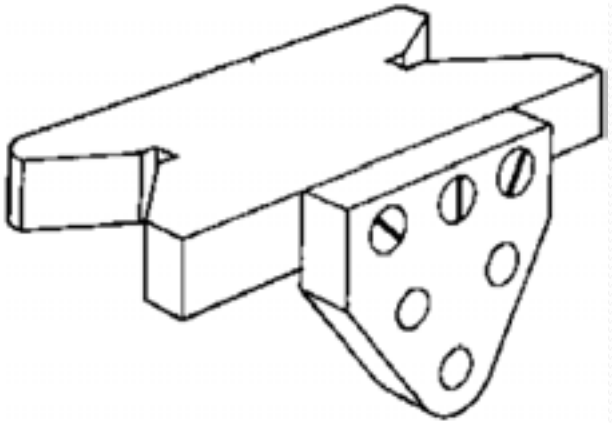
Nesting template drill jigs



Template Jig







Disadvantages of Template Jigs

- Not as foolproof as other types
- Orientation of the hole pattern to the workpiece datum may not be as accurate as other types
- Impractical when locating datum's, are dimensioned, regardless of feature size

Plate jigs

A template jig with workpiece clamping system

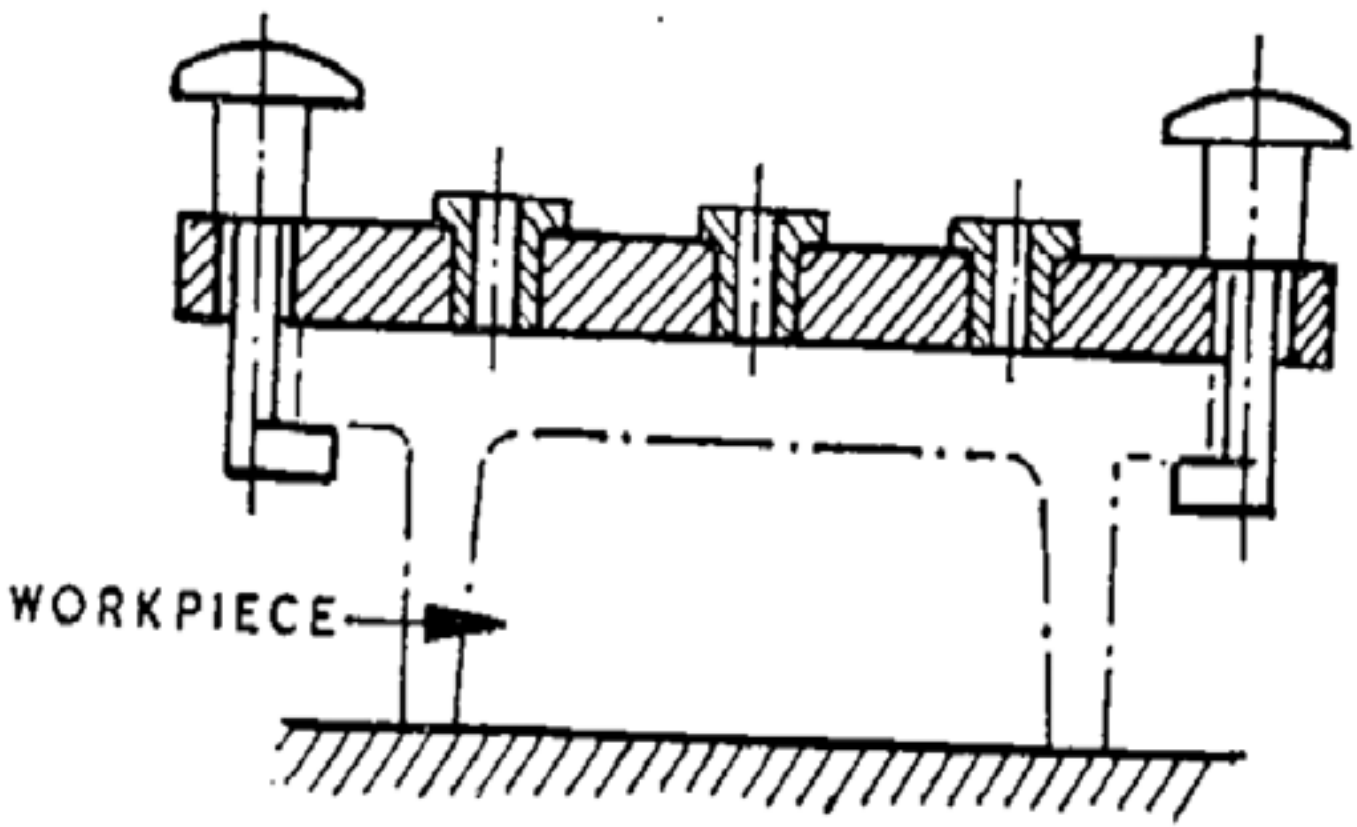
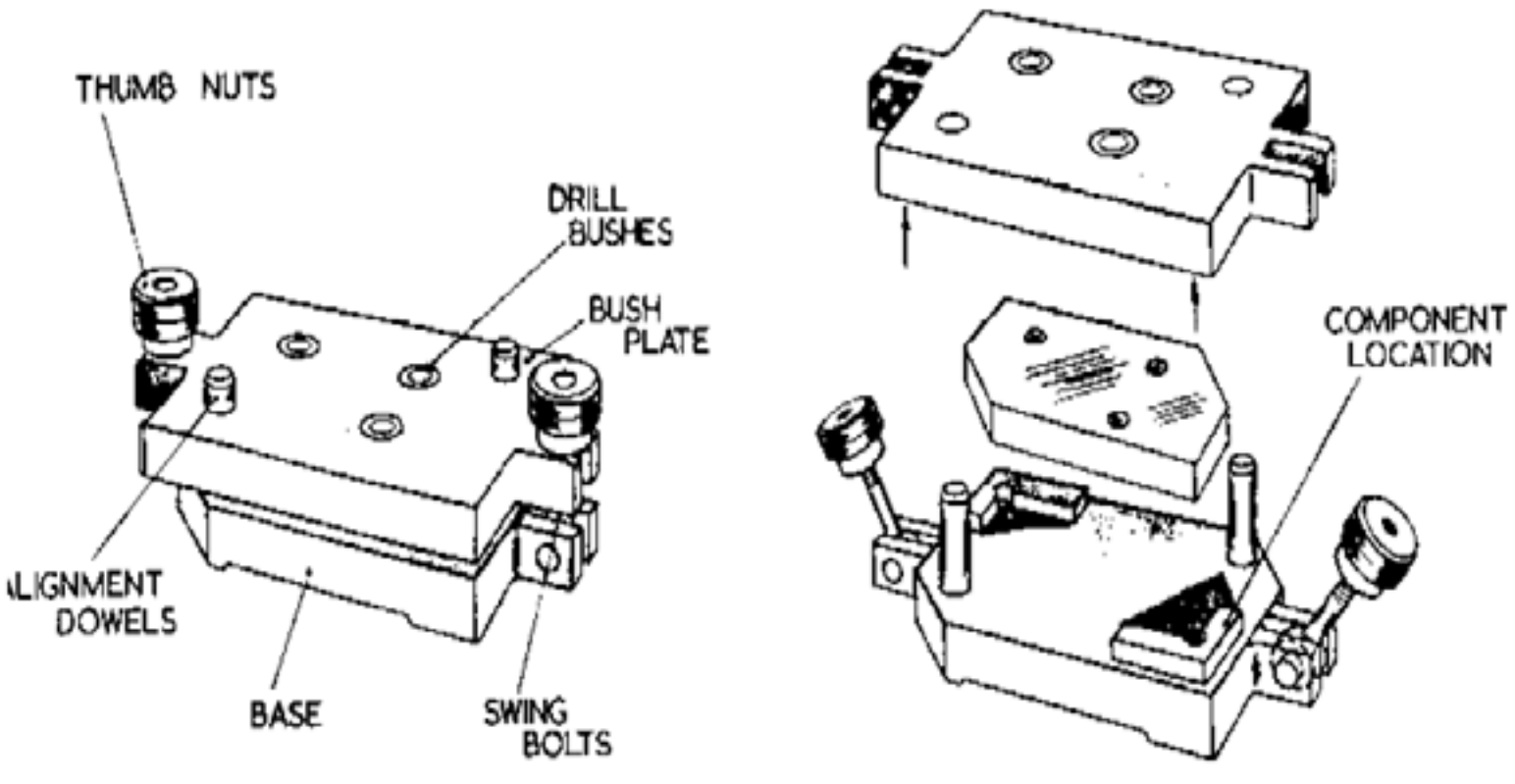
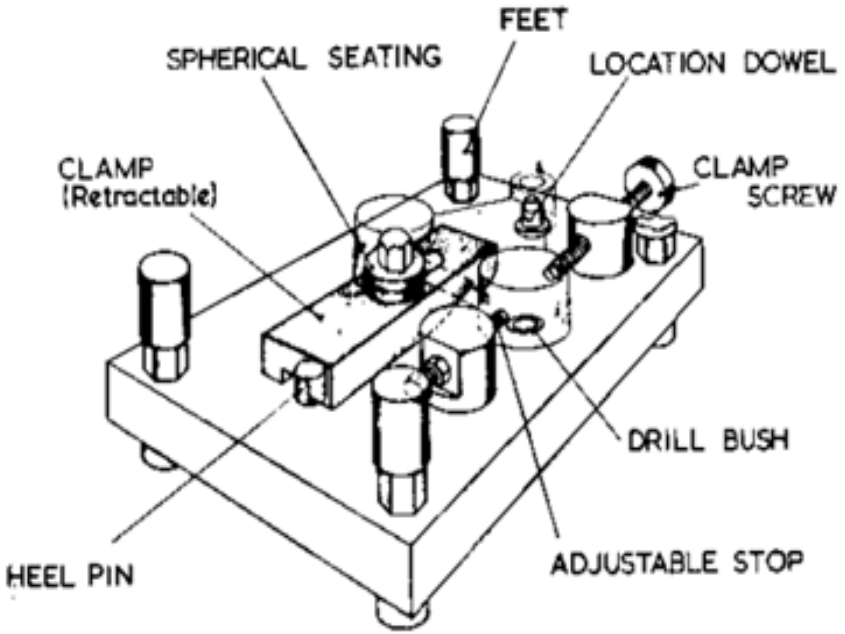
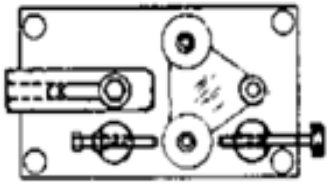


Plate drill jig

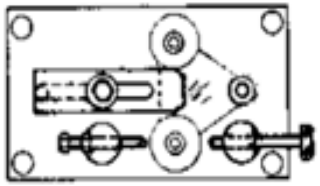


Drill jig – plate type

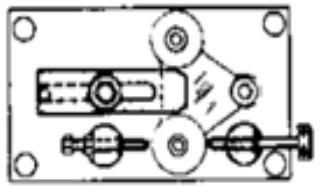




Component located on dowel



Clamp slid forward



Clamp screw tightened to locate component before main clamp is applied

Plate jigs

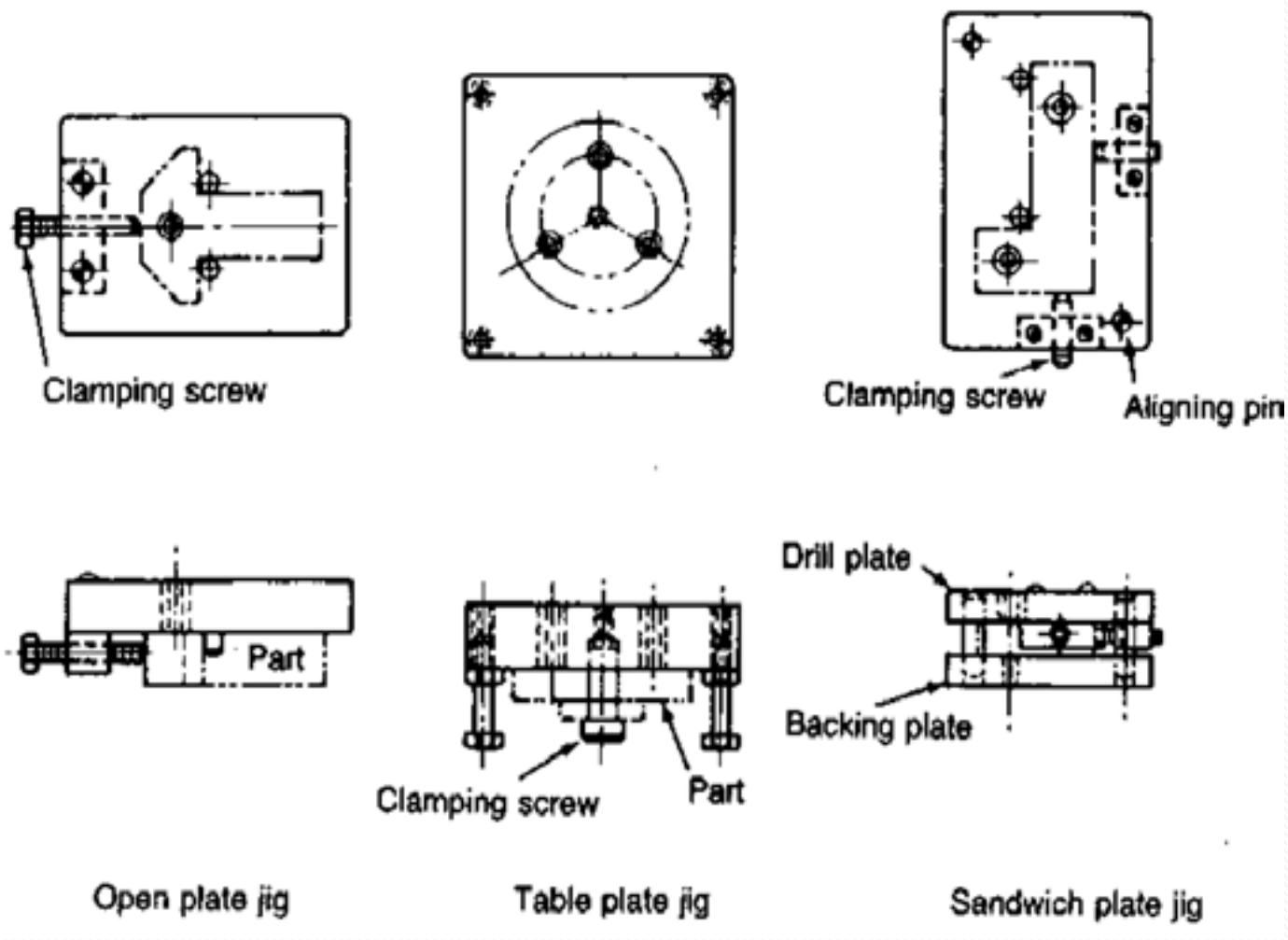

Clamping screw
Clamping screw
Aligning pin
Part
Clamping screw
Part
Drill plate
Backing plate
Open plate jig
Table plate jig
Sandwich plate jig

Plate jig with quick-acting cam

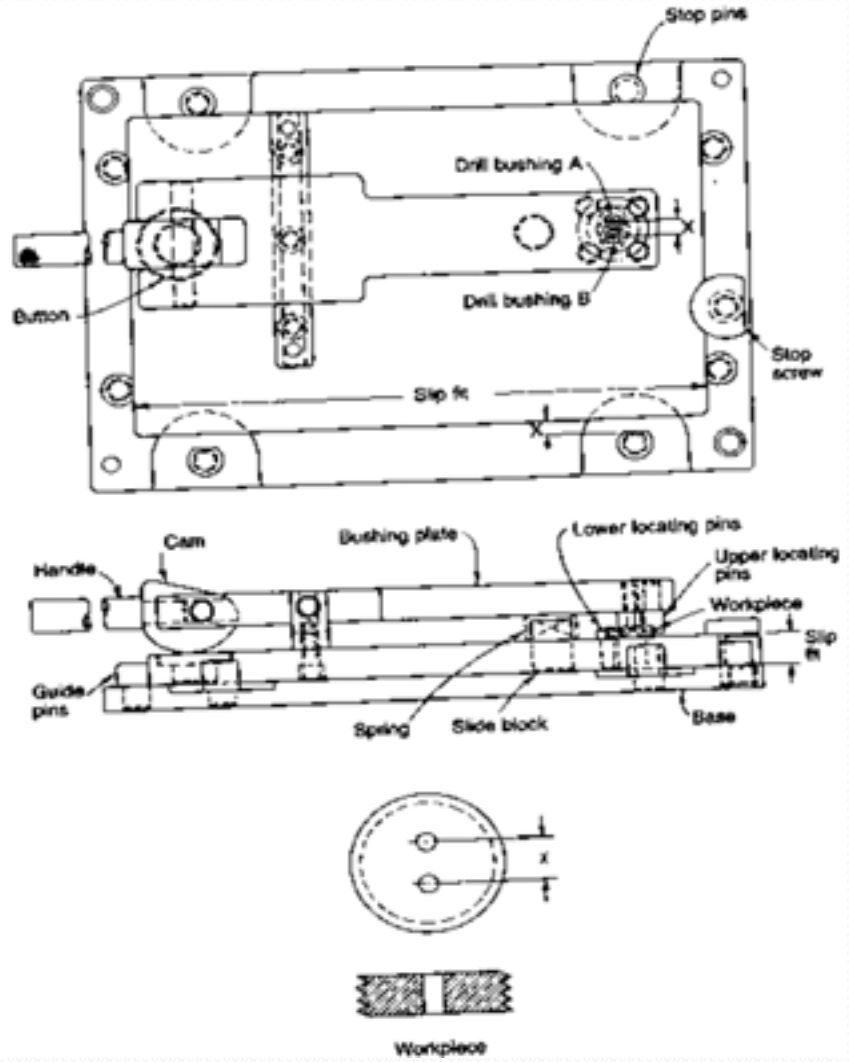


Plate jig for cross-hole drilling

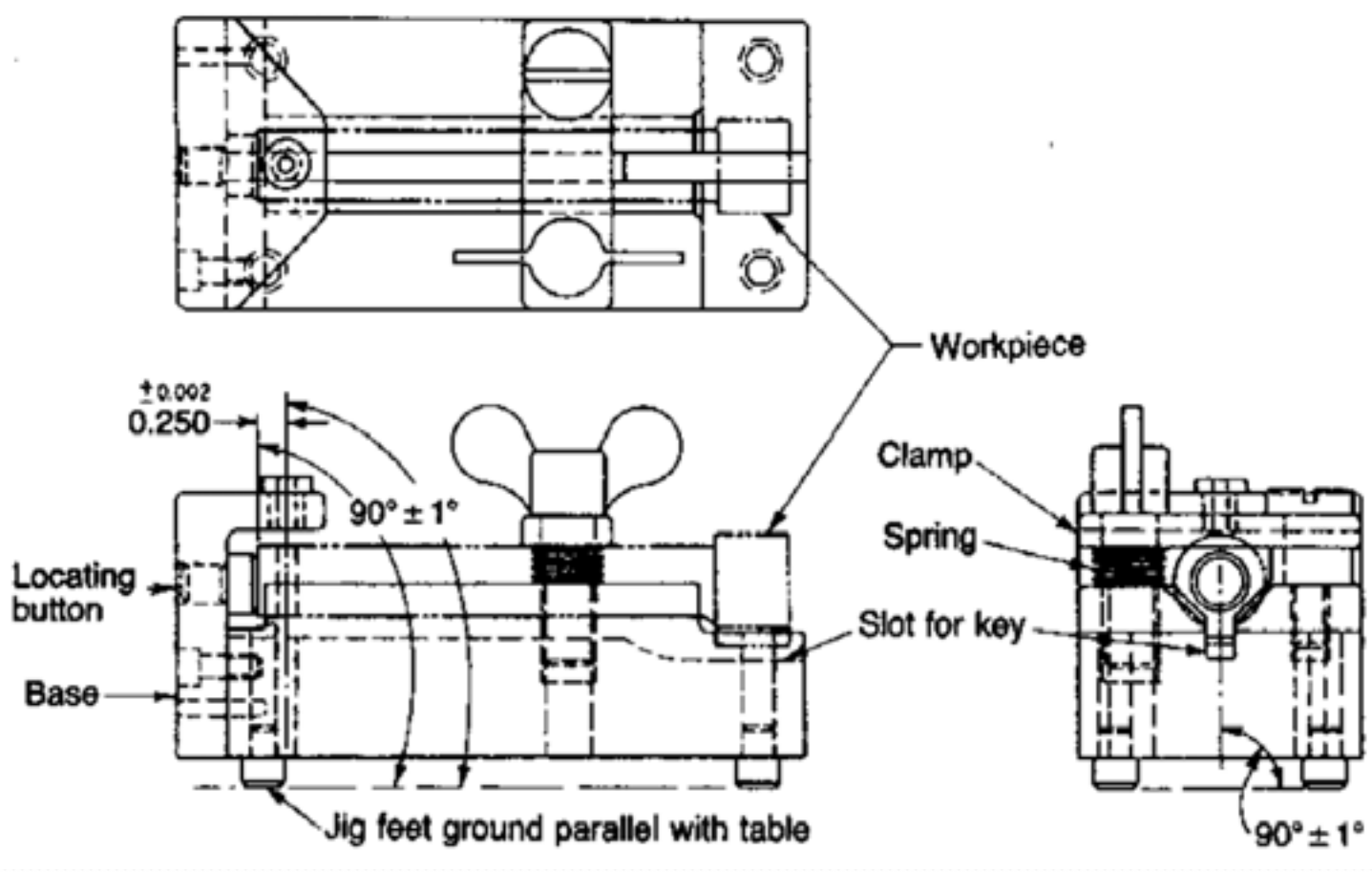
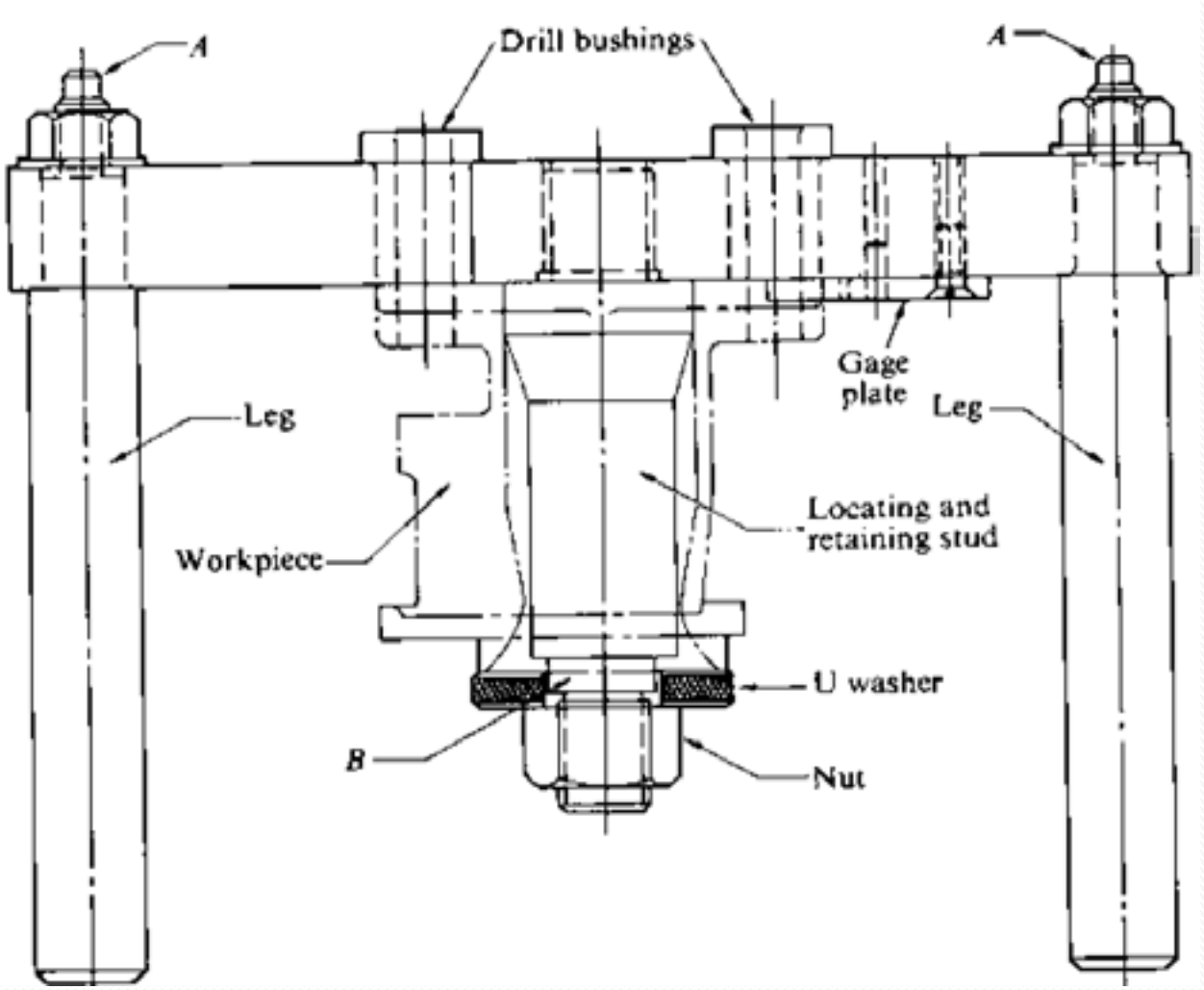
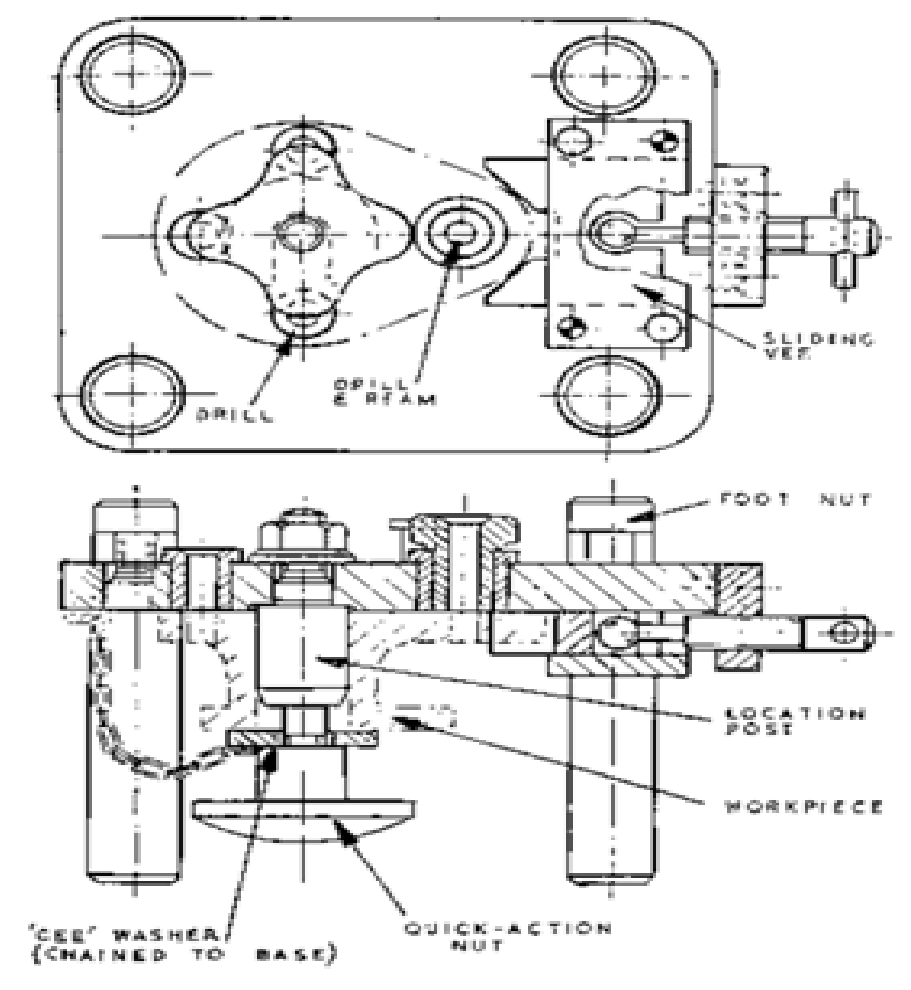


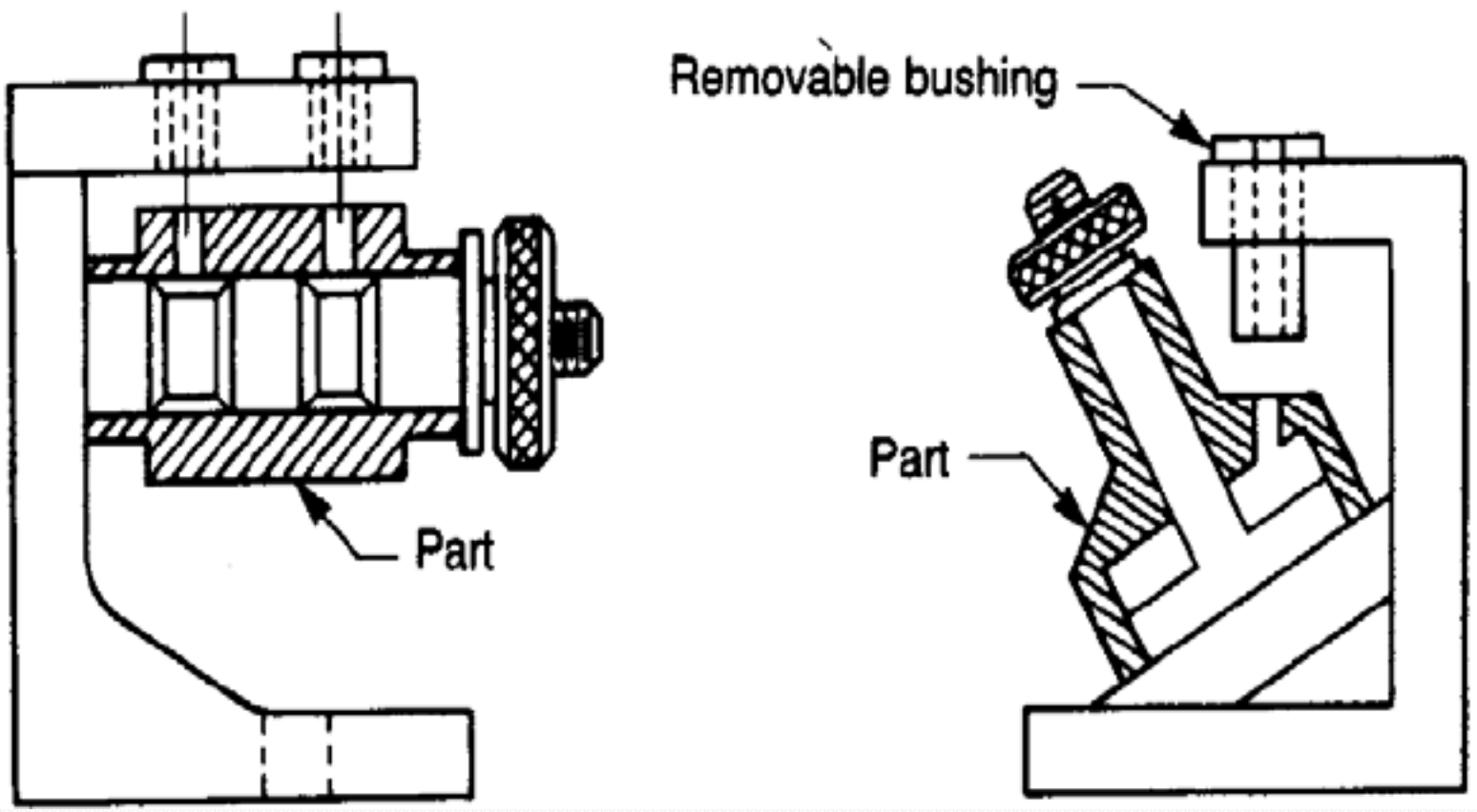
Plate jig


A
Drill bushings
A
Gage plate
Leg
Leg
Workpiece
Locating and retaining stud
U washer
B
Nut

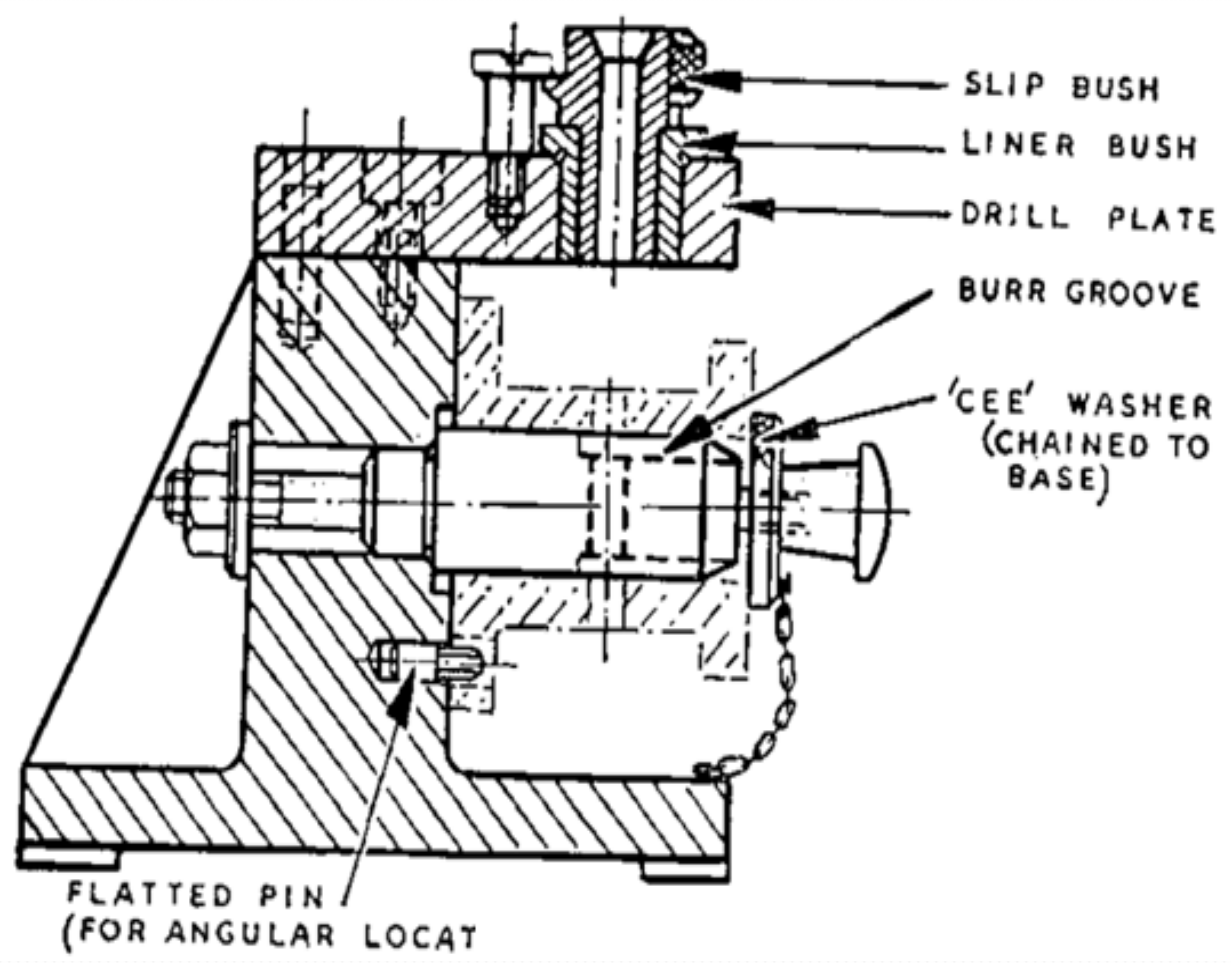
Turnover Jig



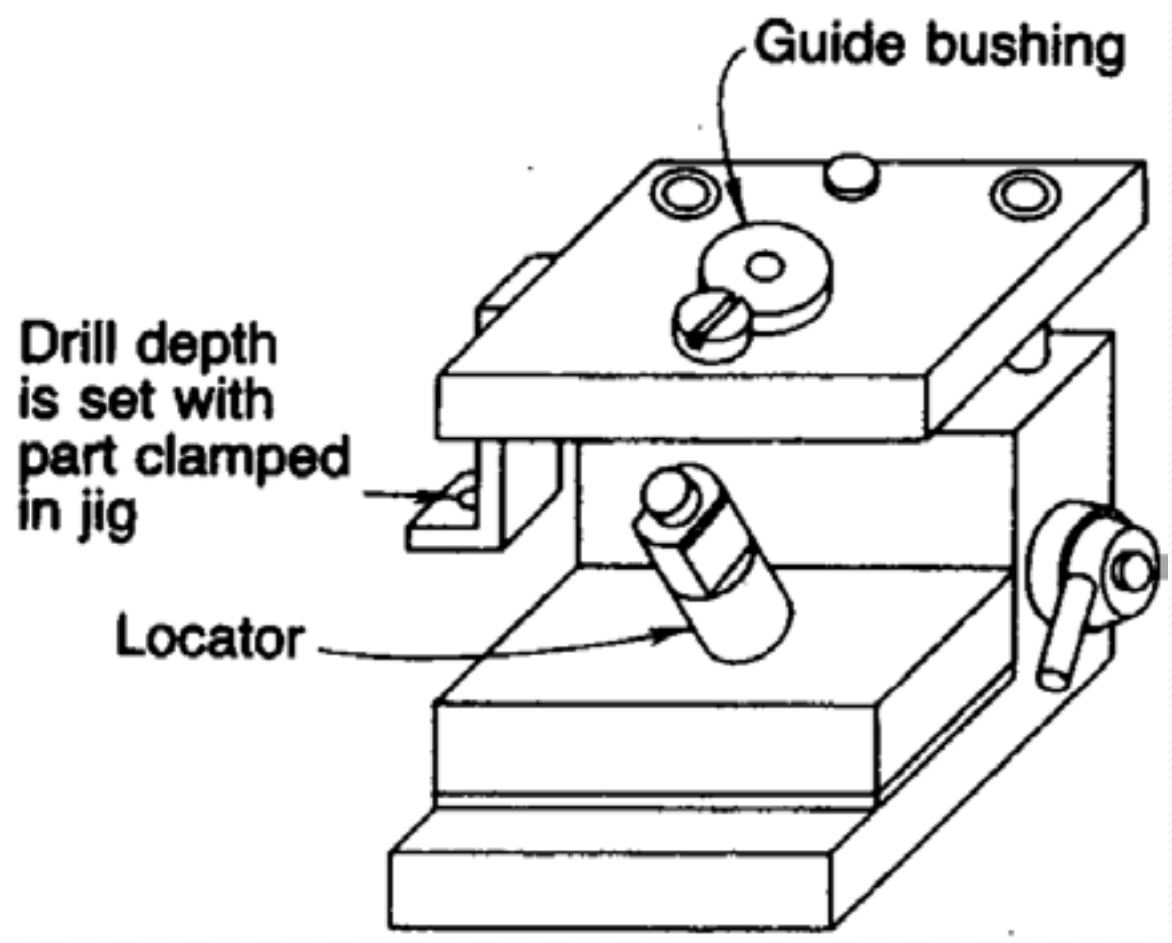
Angle plate Jigs



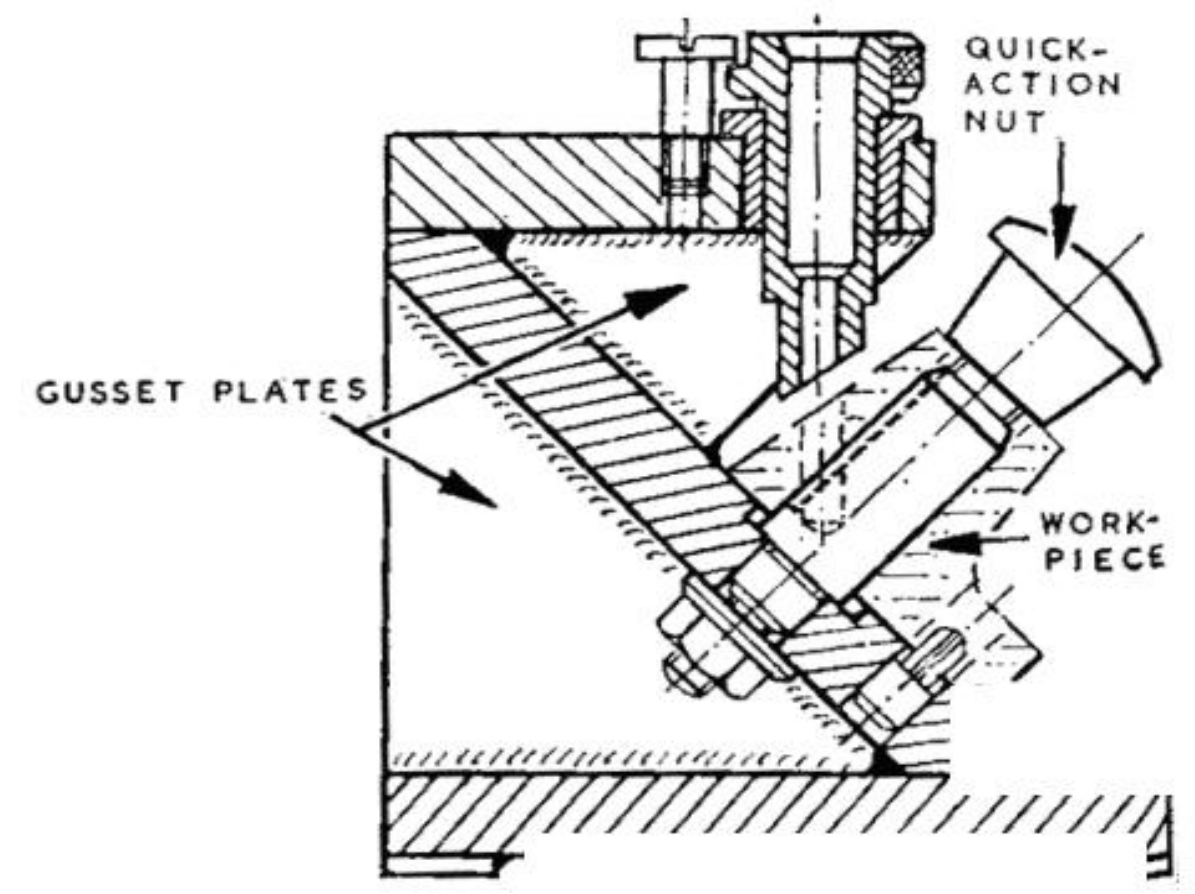
Post Jig


SLIP BUSH
LINER BUSH
DRILL PLATE
BURR GROOVE
'CEE' WASHER
(CHAINED TO
BASE)
FLATTED PIN
(FOR ANGULAR LOCAT

Pump jig for drilling a hole at 60^0 angle



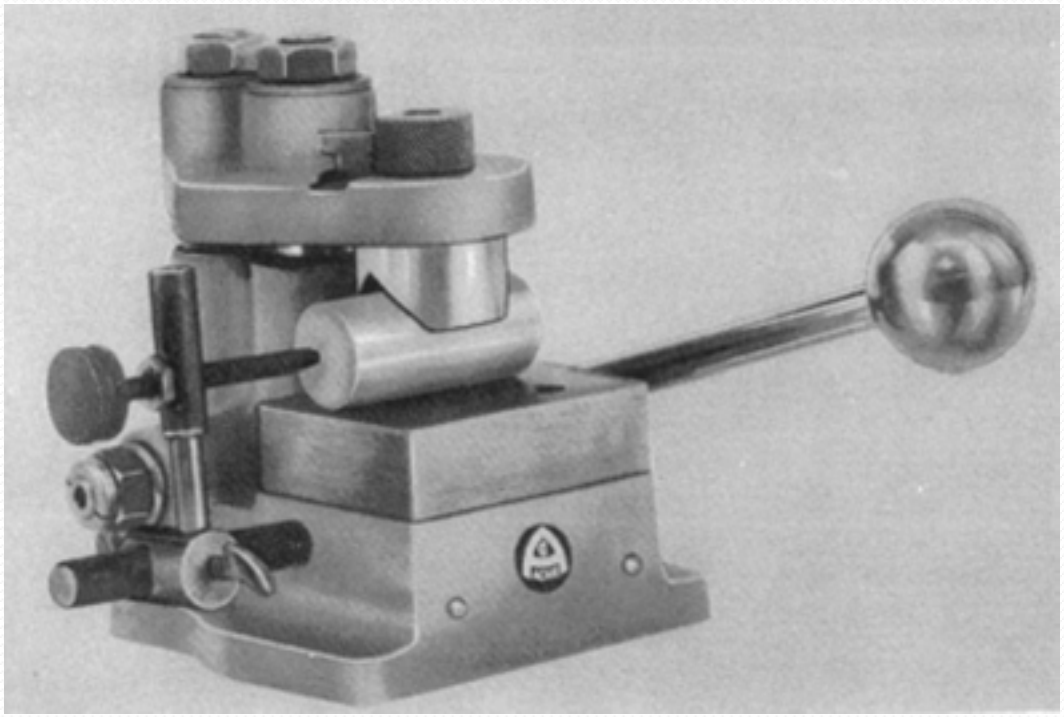
Angular-post Jig



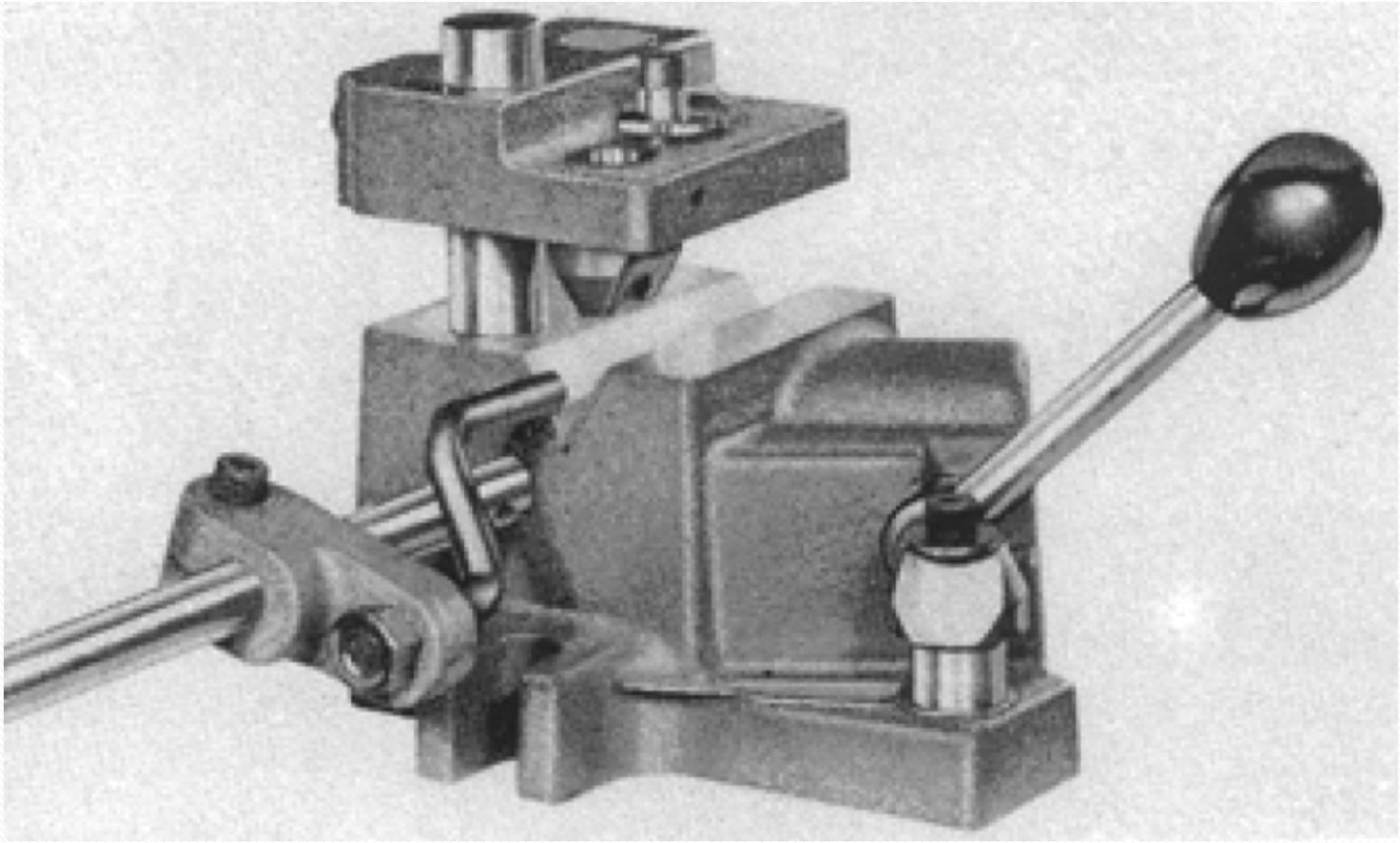
This illustrates a welded construction

Universal Jigs

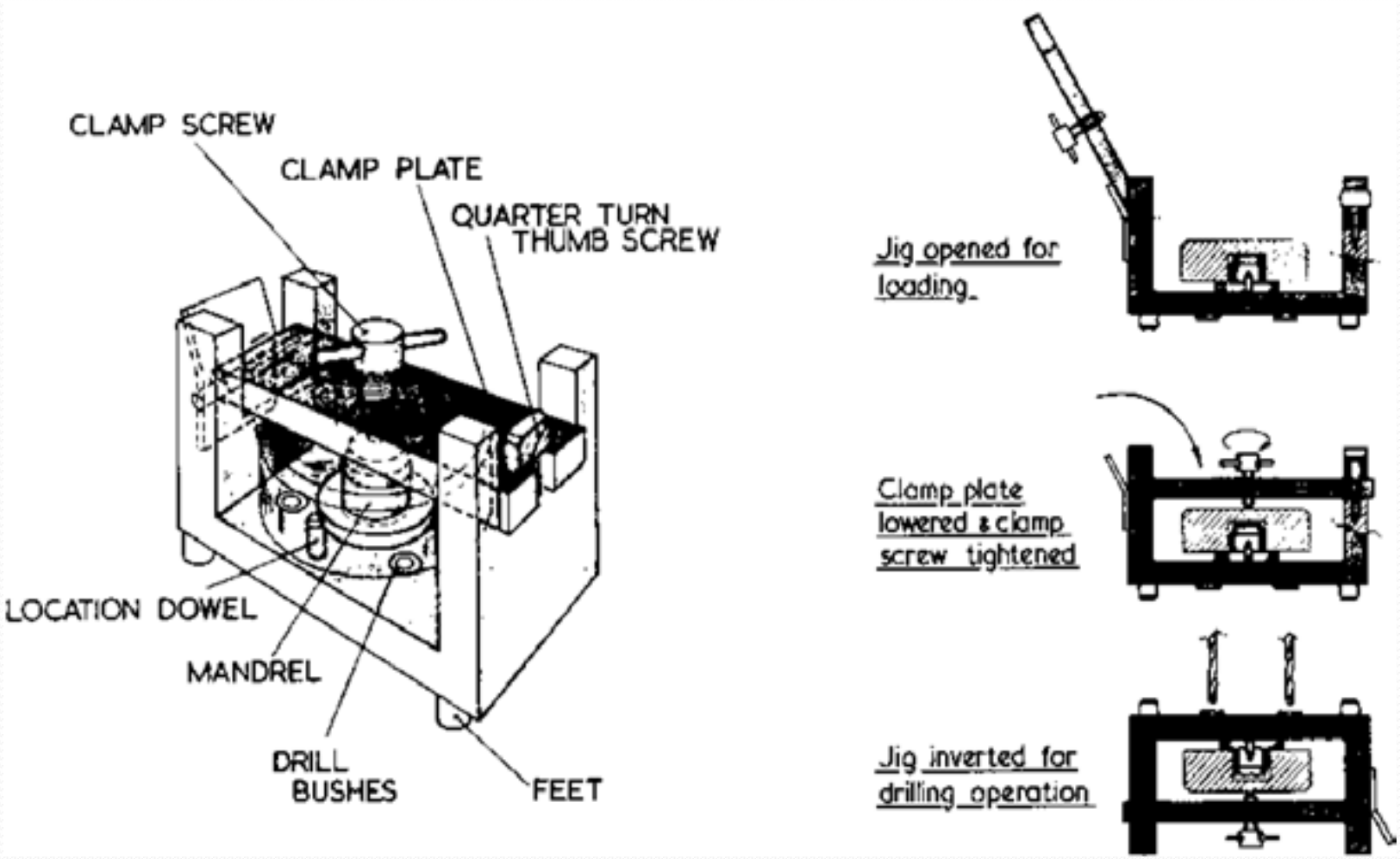
- Also called as pump jigs
- Universal that can be used for any given part by adding the necessary locators and bushes



Adjustable cross-hole drill jig

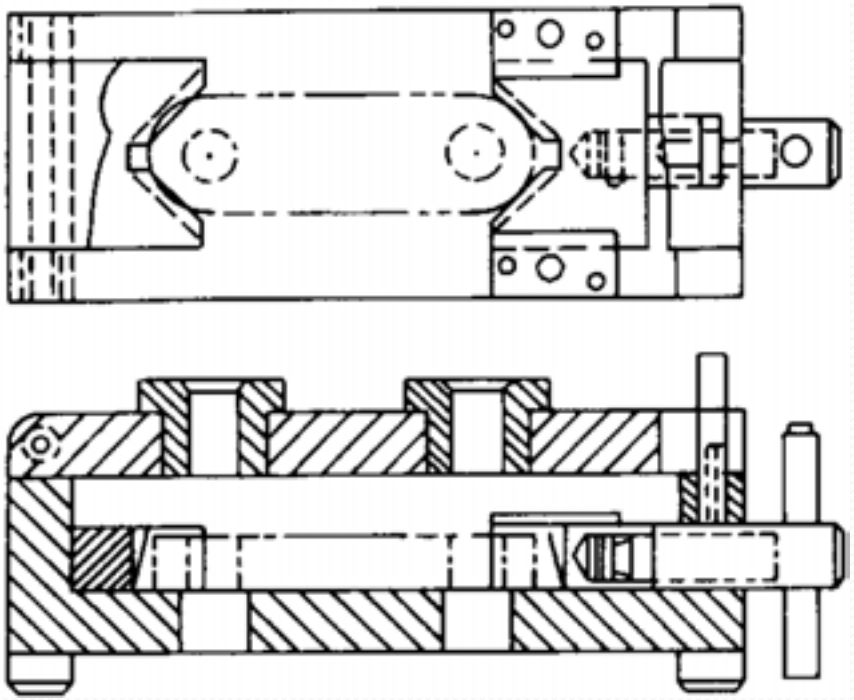


Drill jig with swinging camp plate



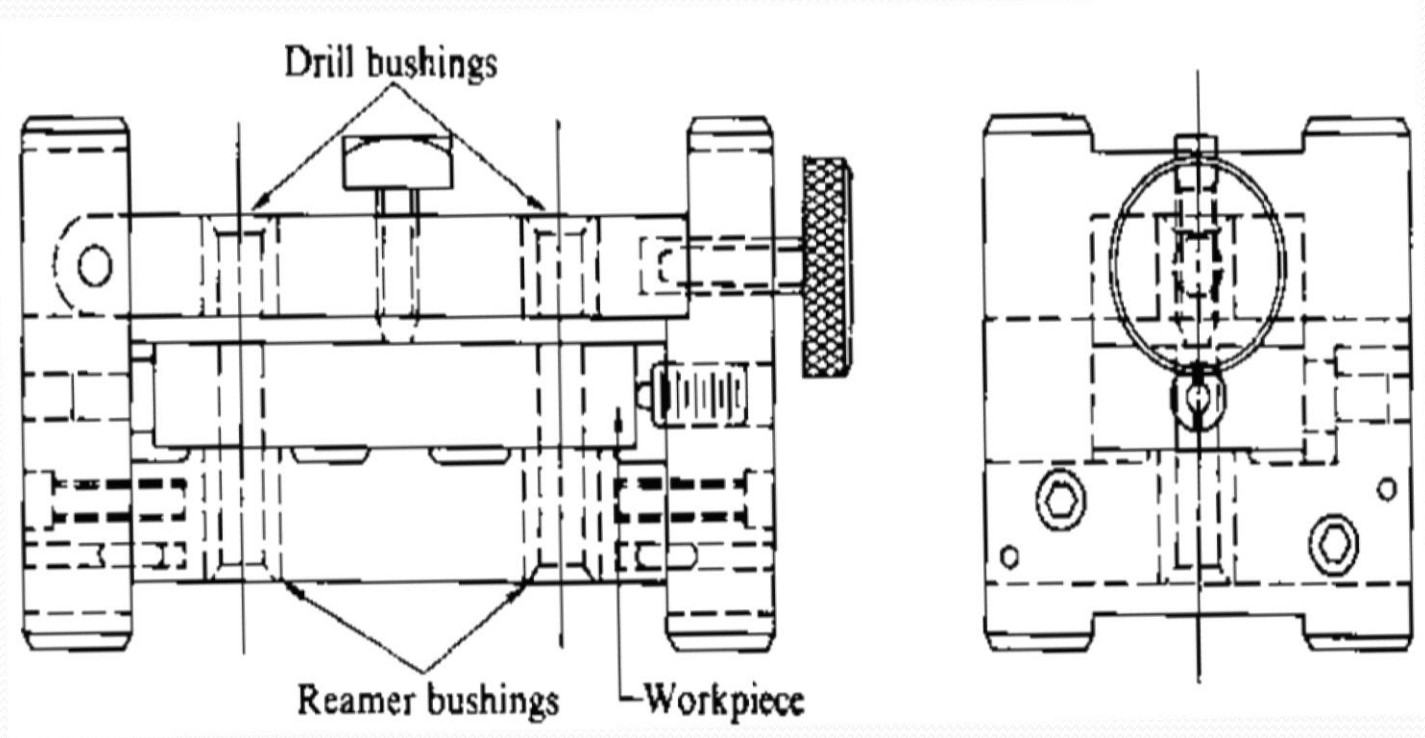
Leaf Jigs

- Small
- Hinged leaf with bushes which also applies the clamping force



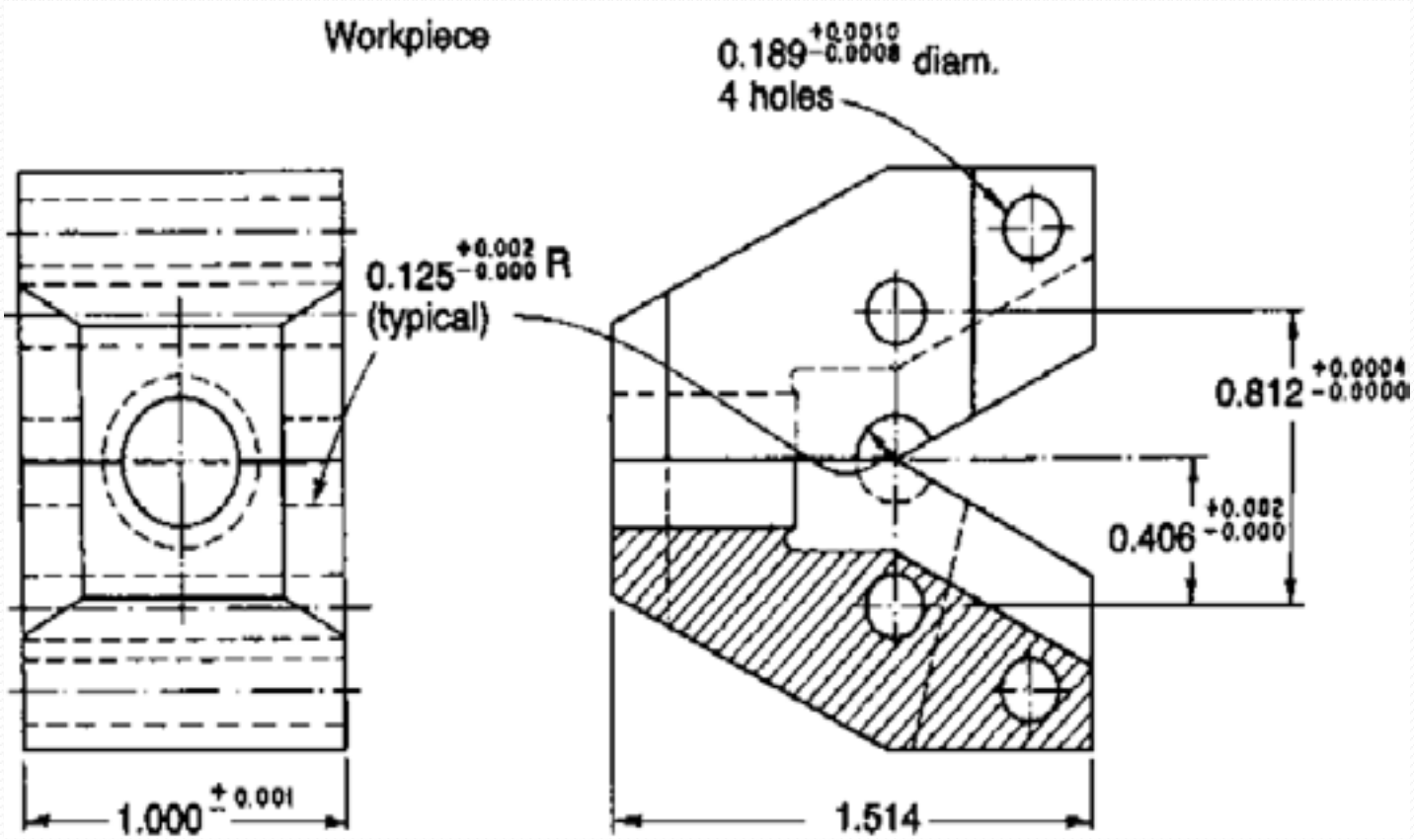
Leaf jig for drilling two holes in a connecting rod

Leaf Jigs (contd.)



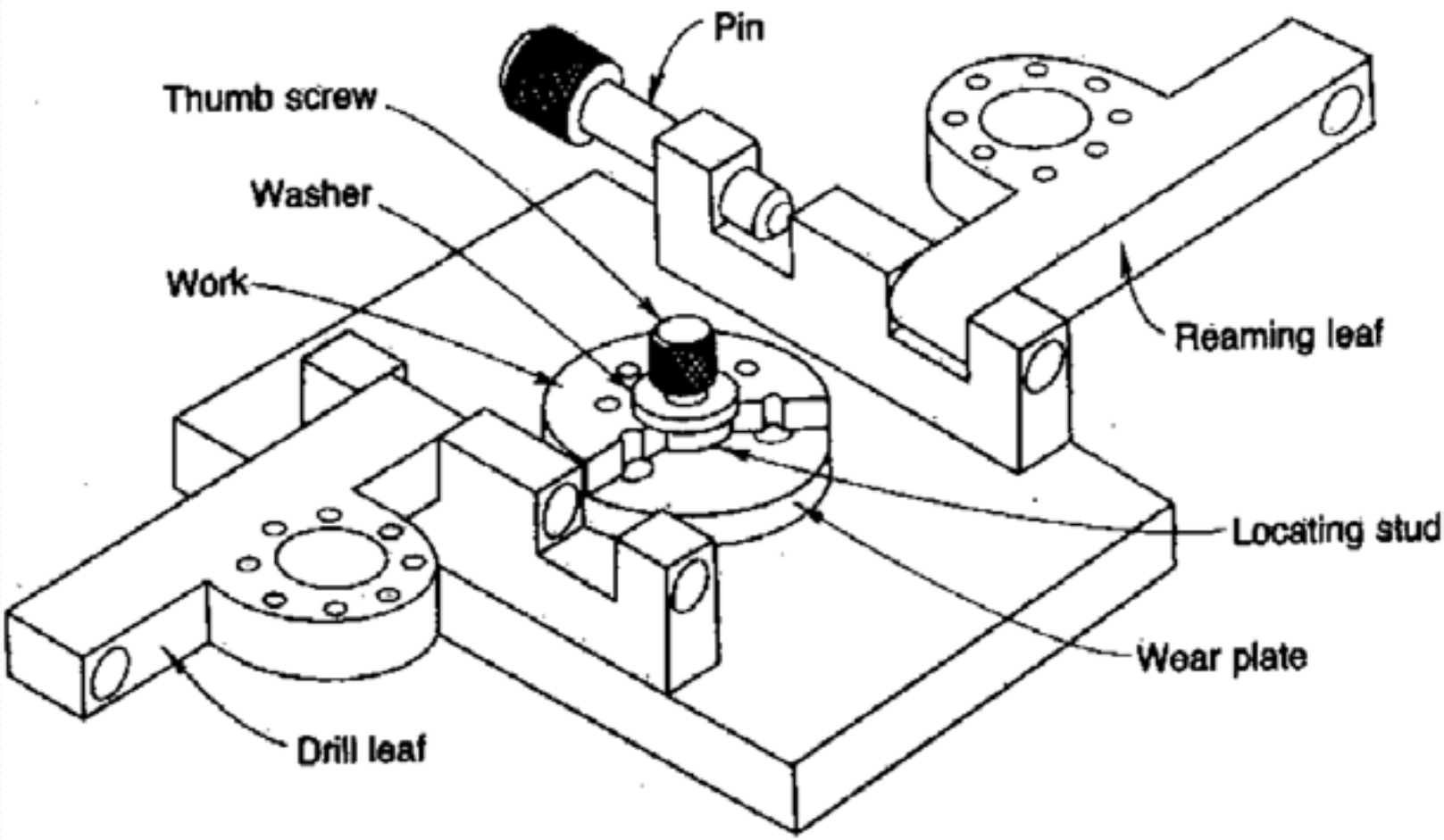
Leaf jig utilizing drill bushings in hinged plate and reamer bushings in base

Leaf Jigs (contd.)



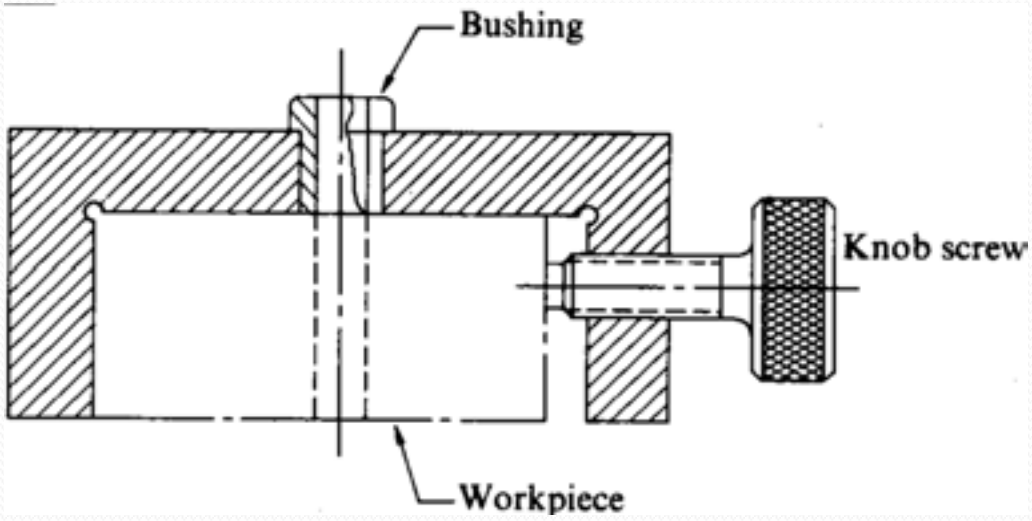
Workpiece and leaf jig for workpiece-assembly drilling

Double leaf jig

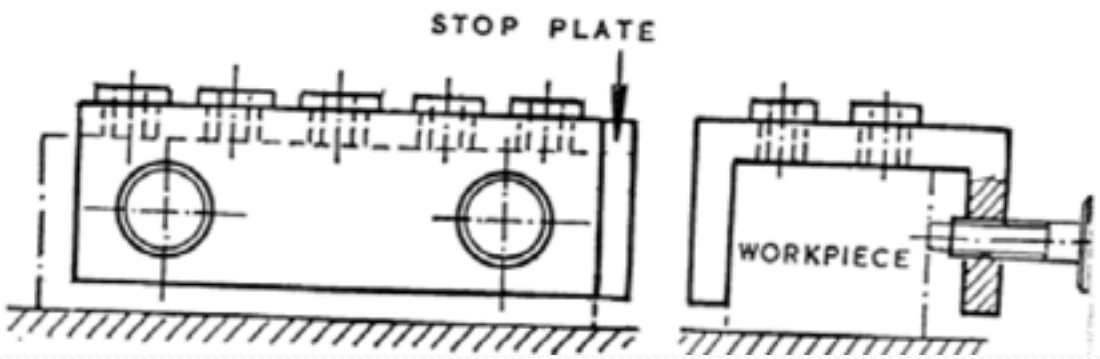


Channel and tumble jigs

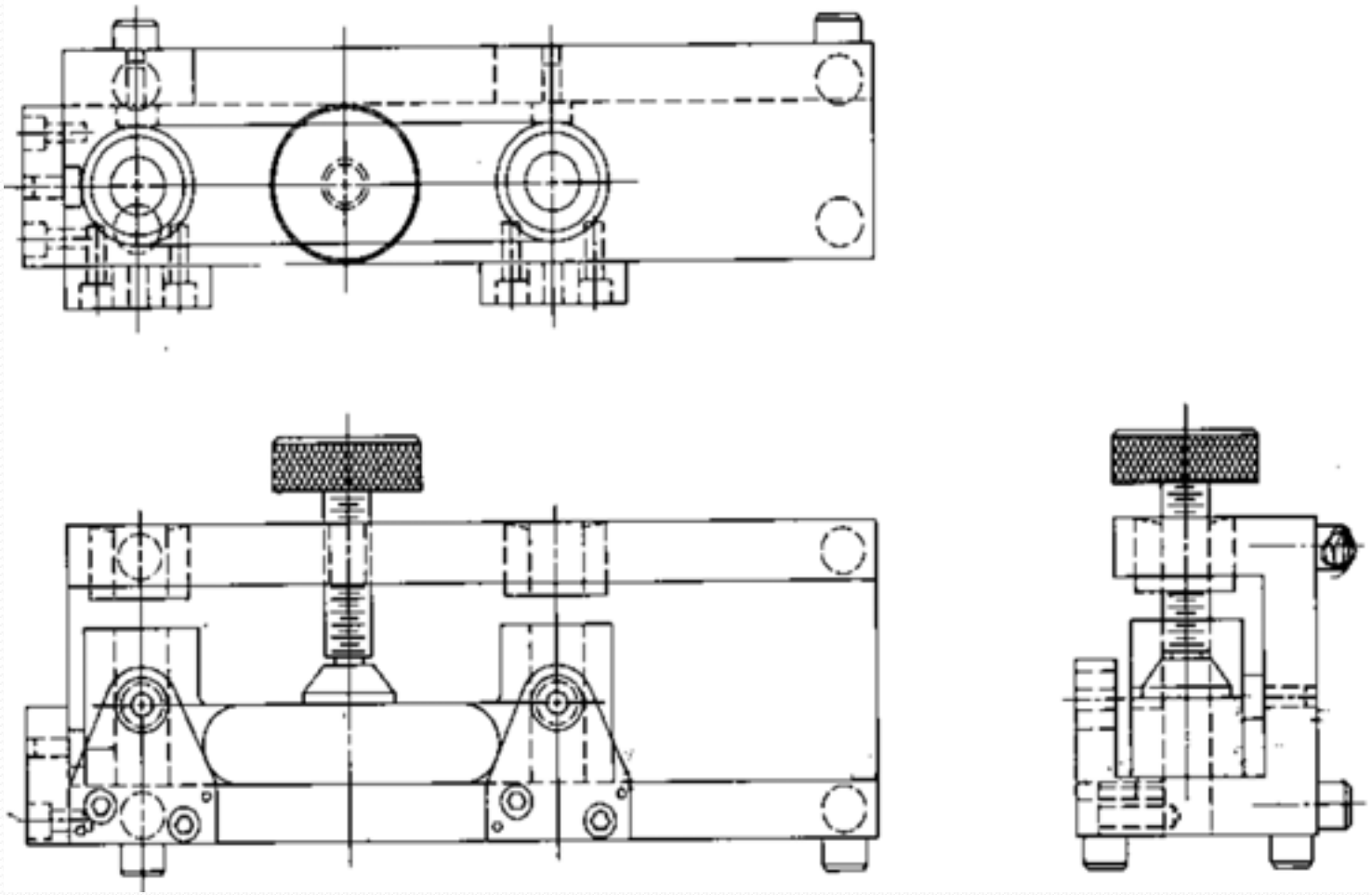
- For drilling in more than one surface
- Complicated and expensive



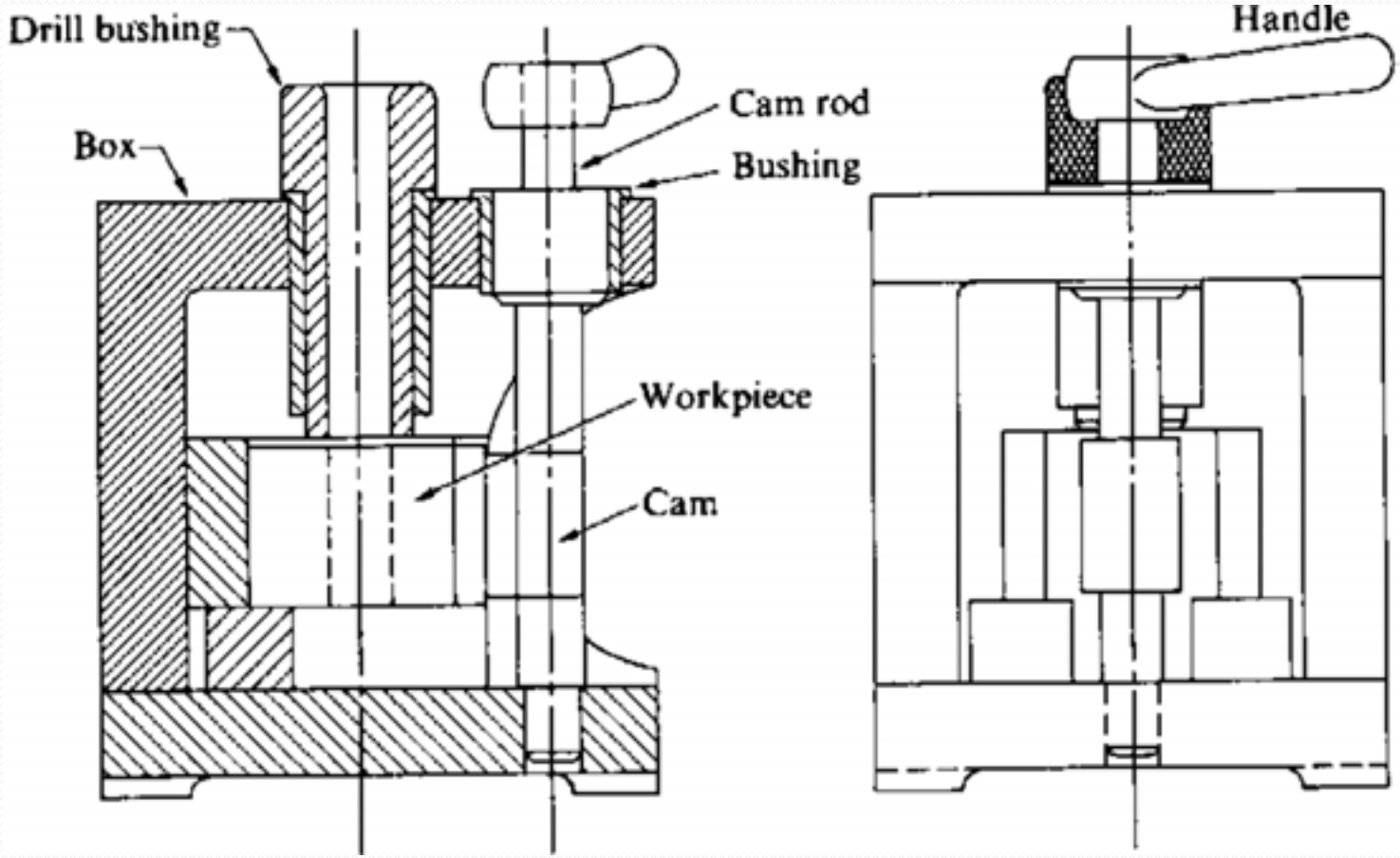
Channel Jigs



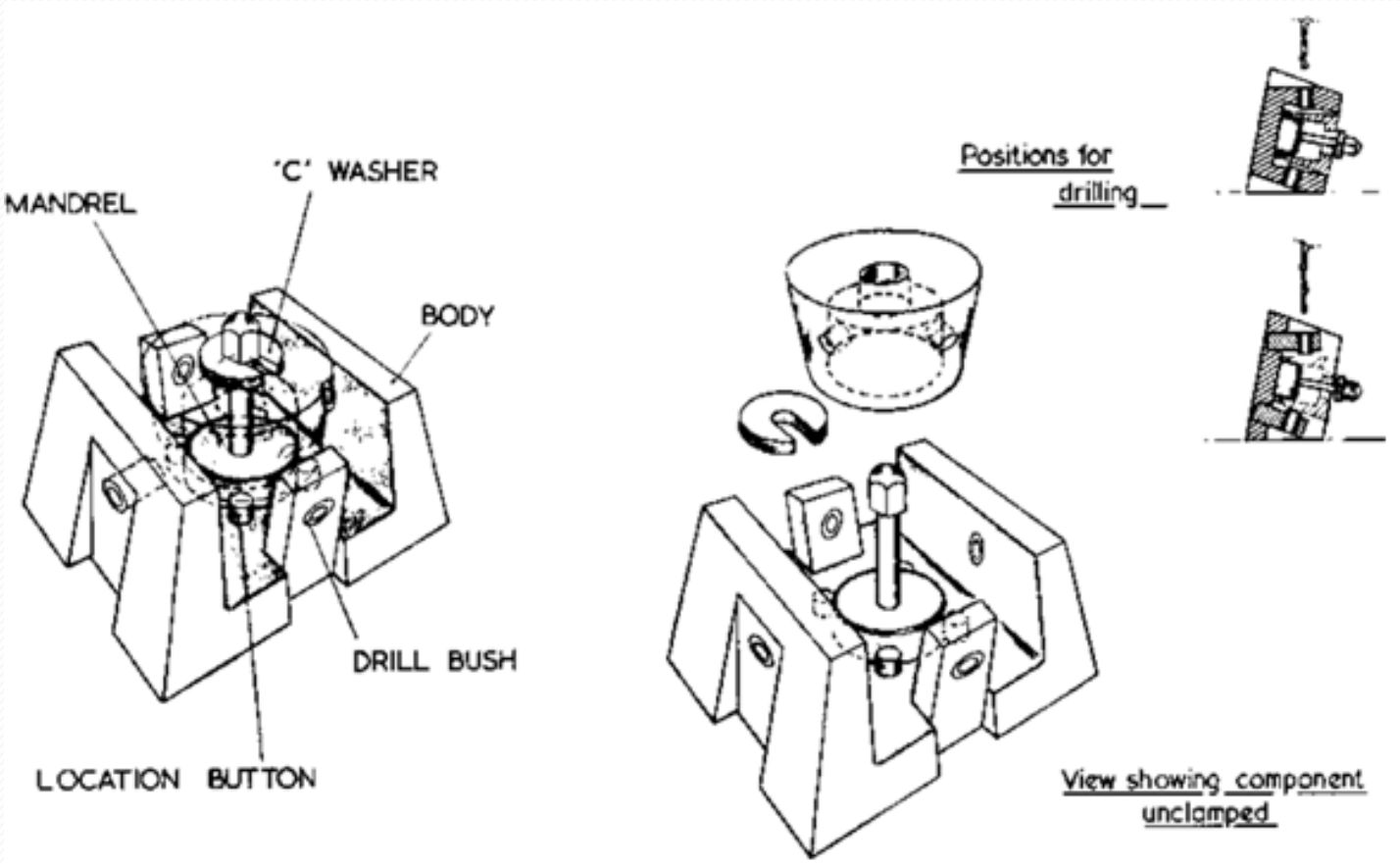
Box type tumble jig



Box jig

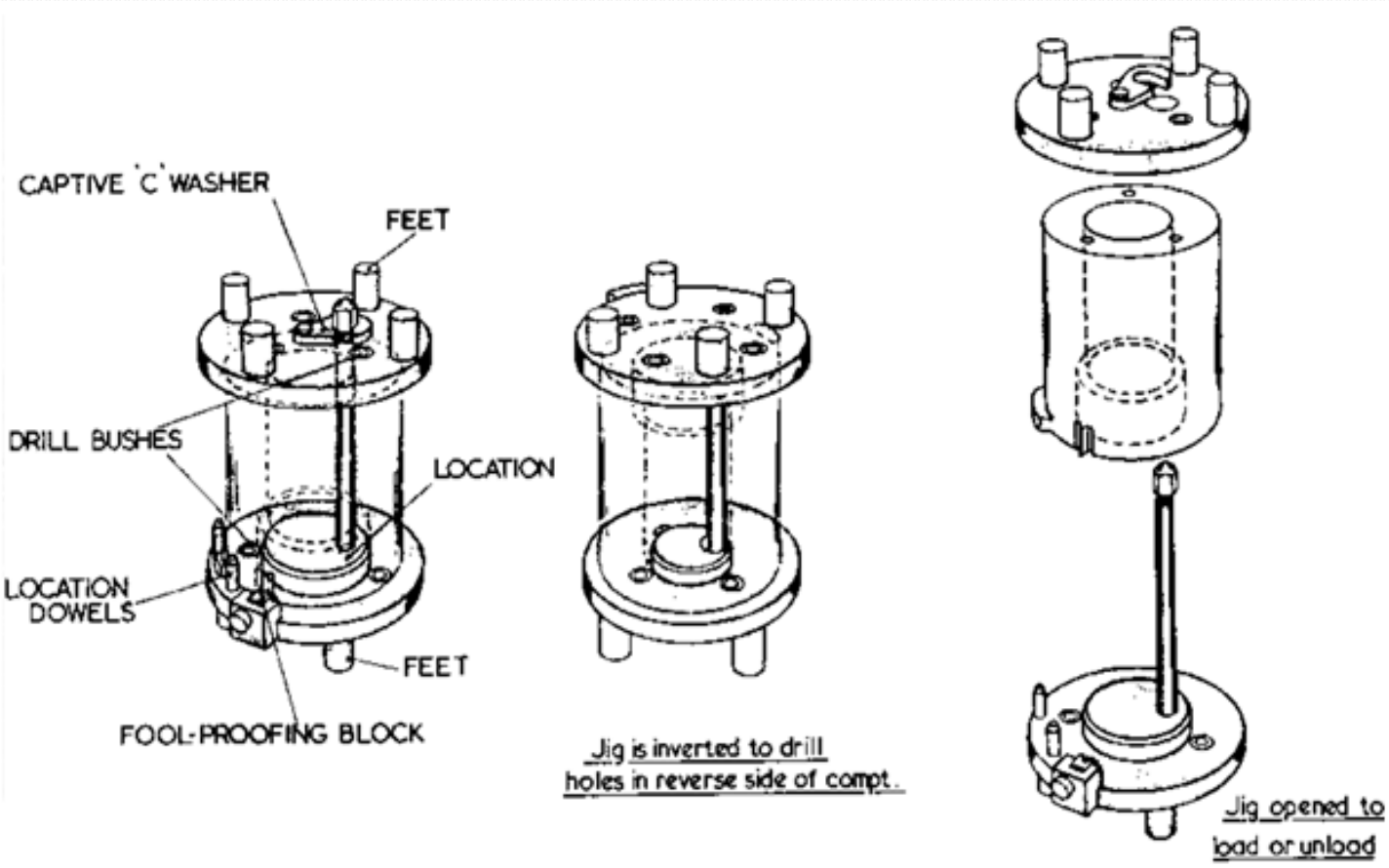


Drilling jig



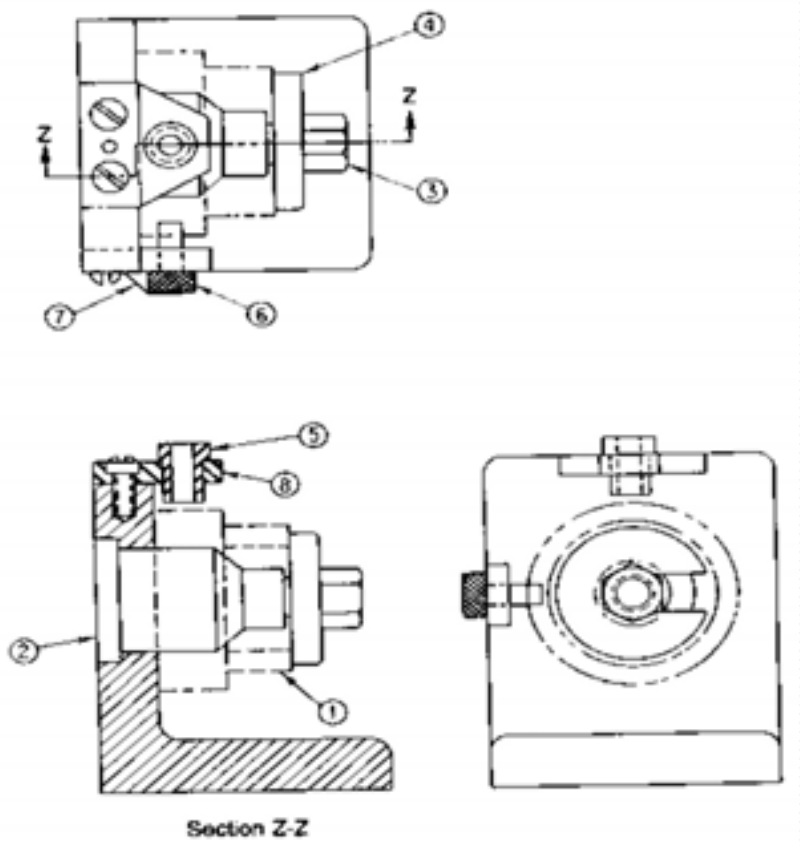
The example above shows a drill jig designed to drill 4 holes equally spaced around the tapered hub of a hand-wheel at right angles to the hub diameter

Drilling jig (contd.)



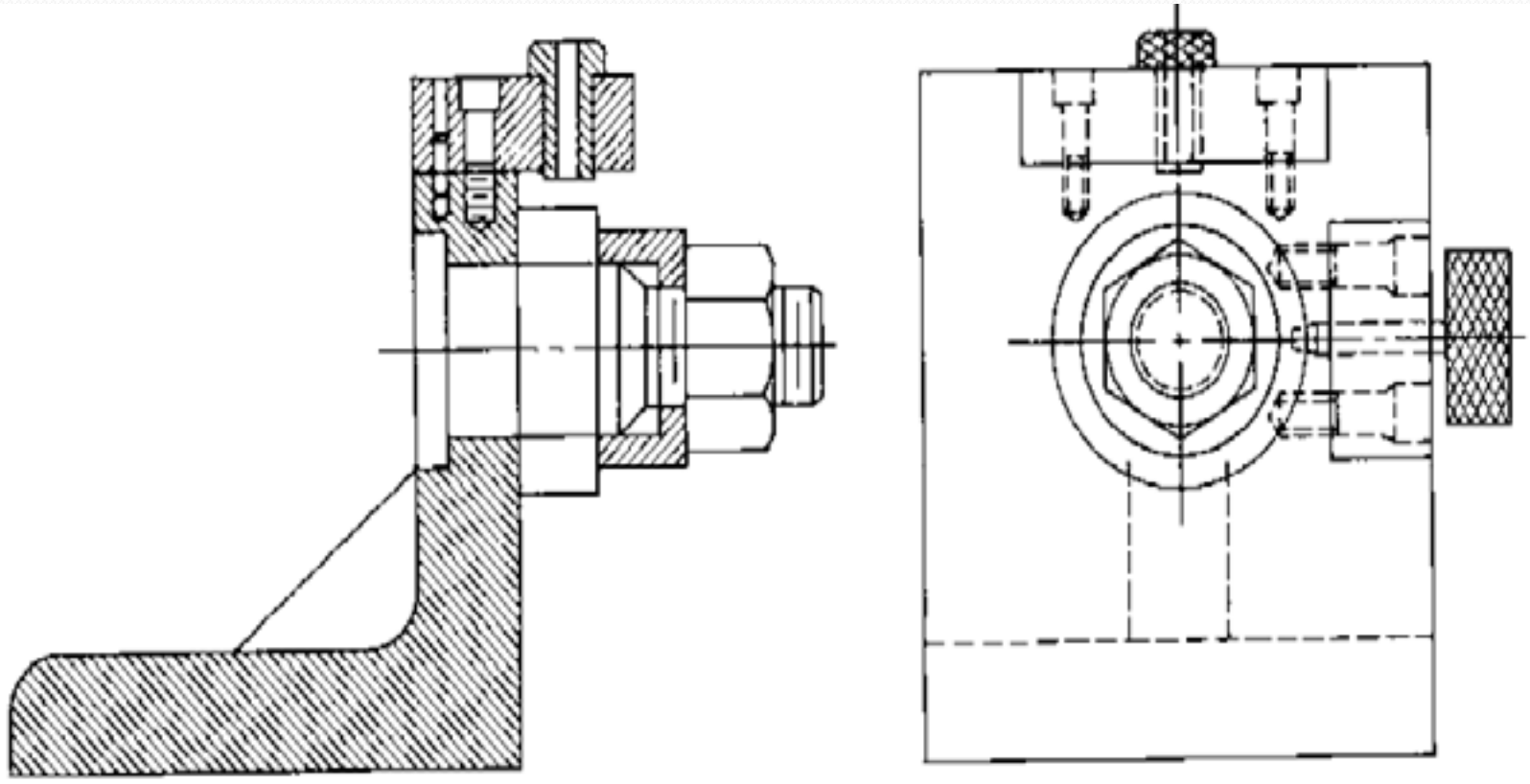
Indexing Jigs

- To drill holes in a pattern
- Indexing arrangement



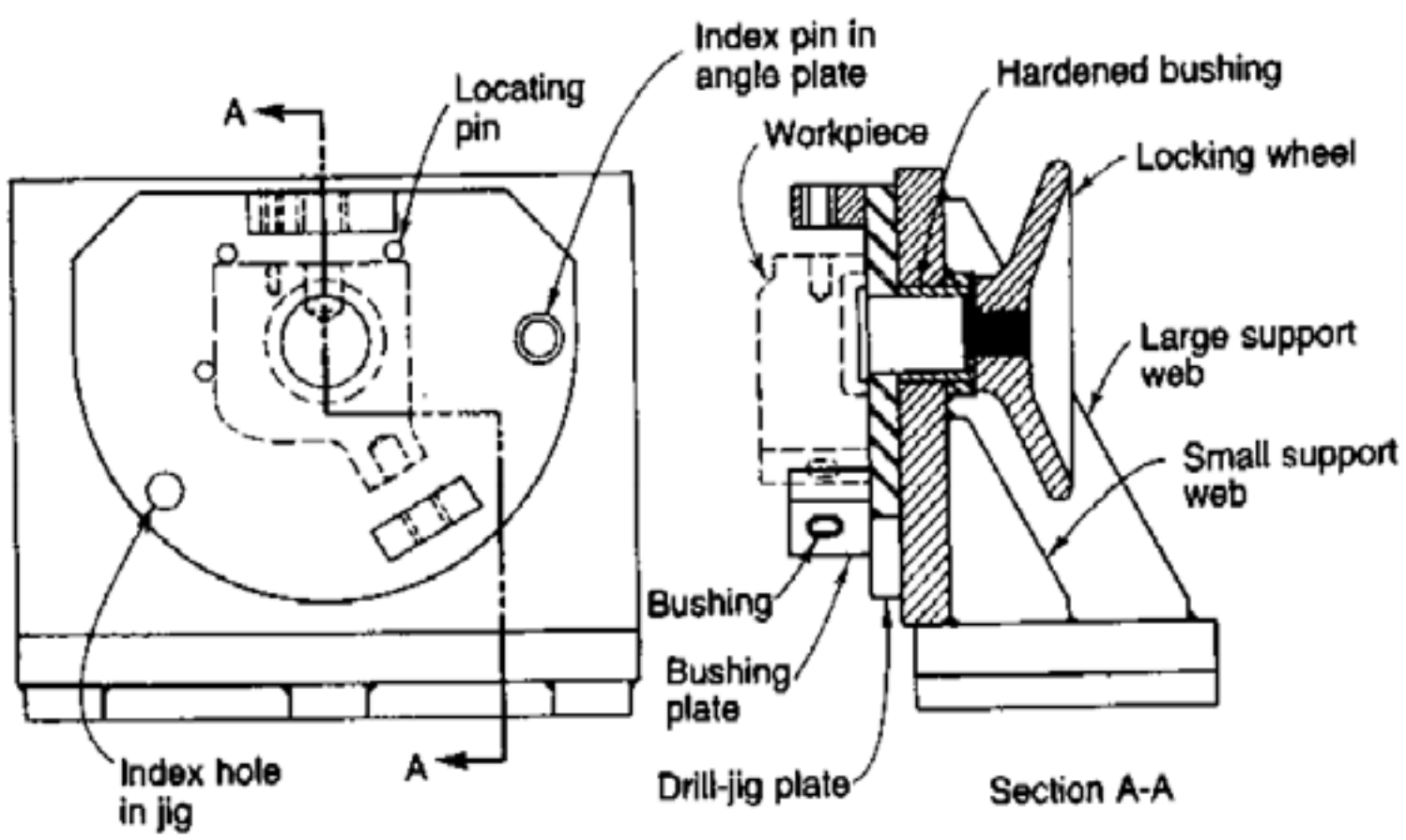
Standard indexing jig with a base of standard angle iron

Indexing Jigs (contd.)

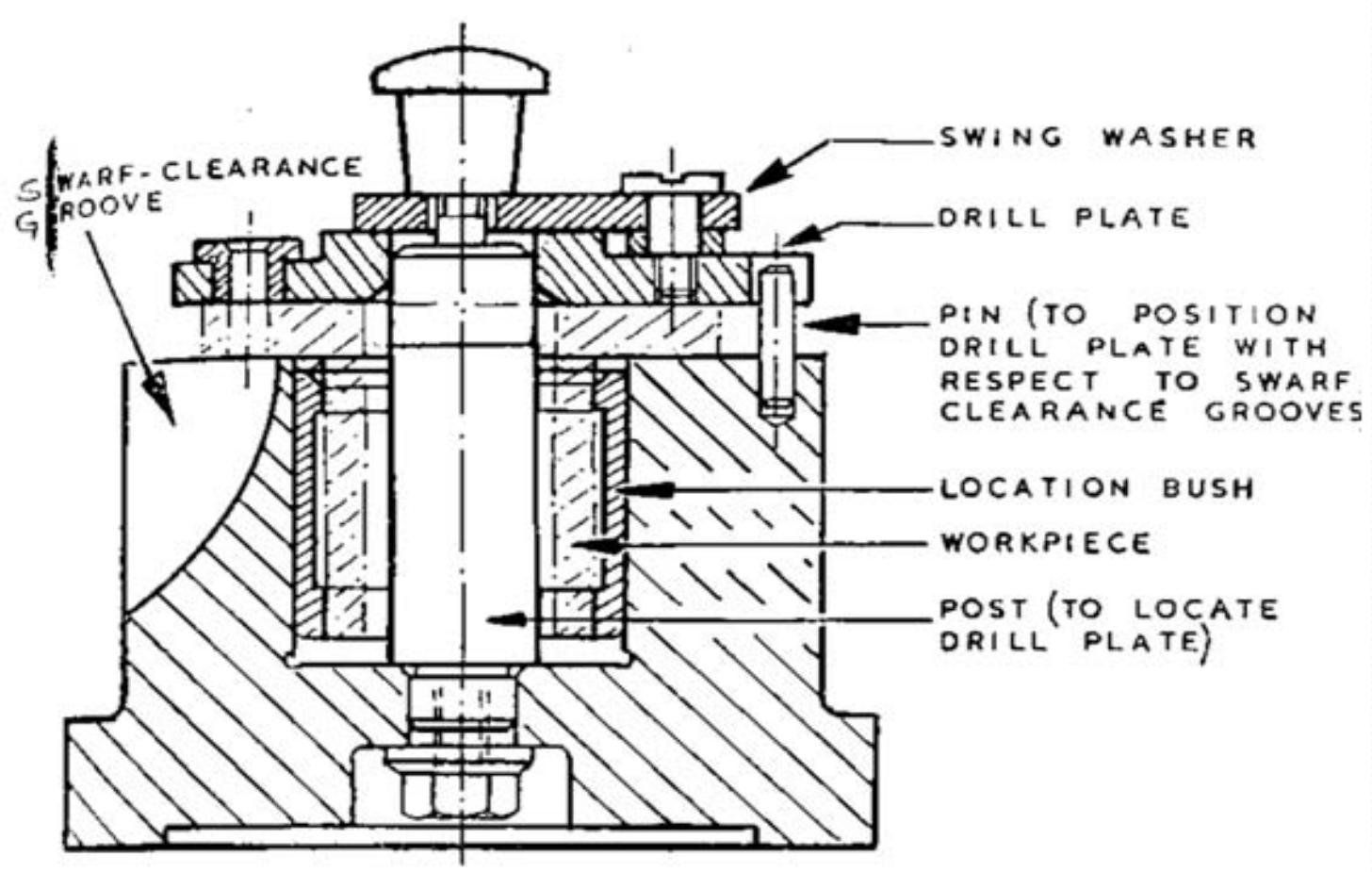


Simple indexing jig designed for drilling four holes in a steel collar

Indexing Jig of welded construction

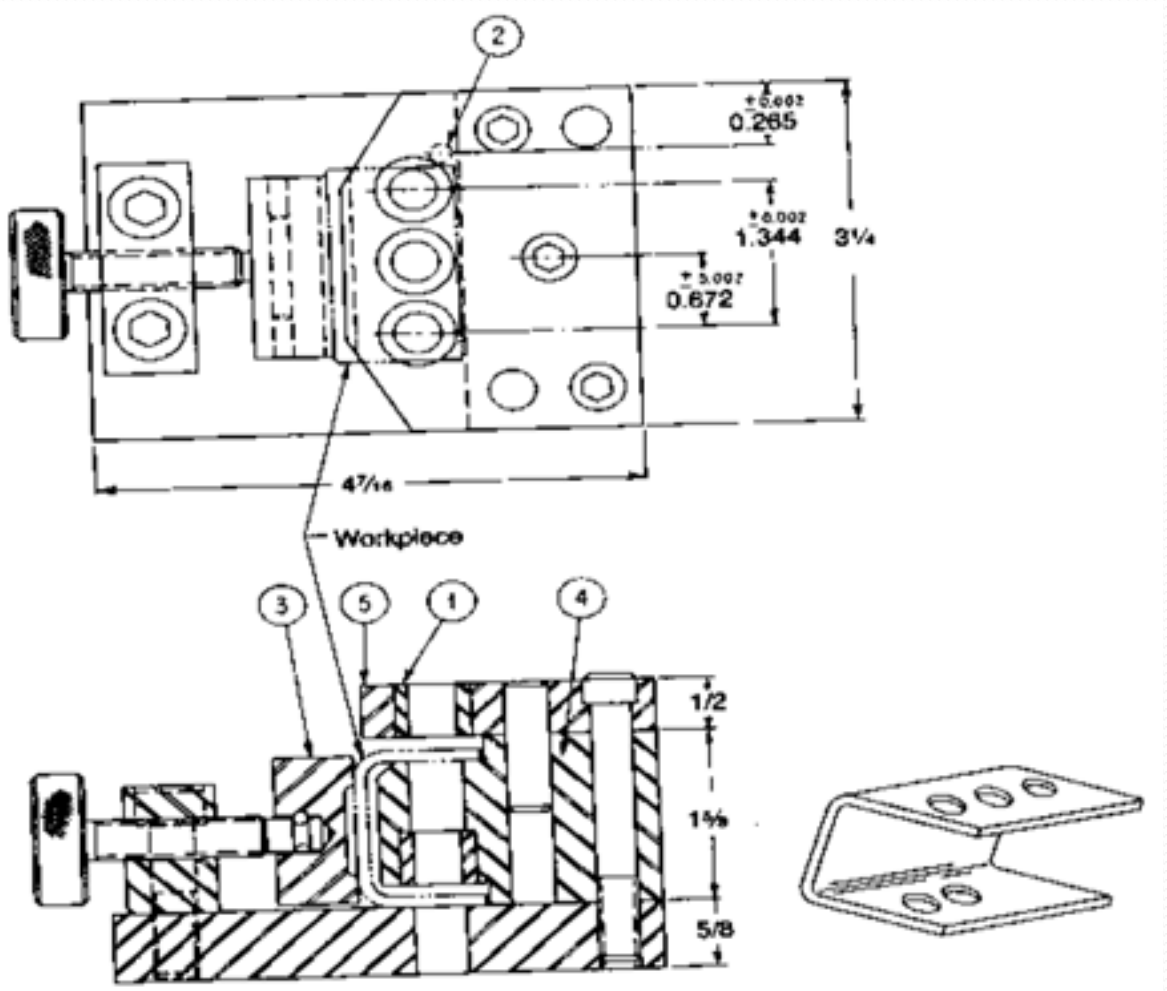


Miscellaneous Jigs

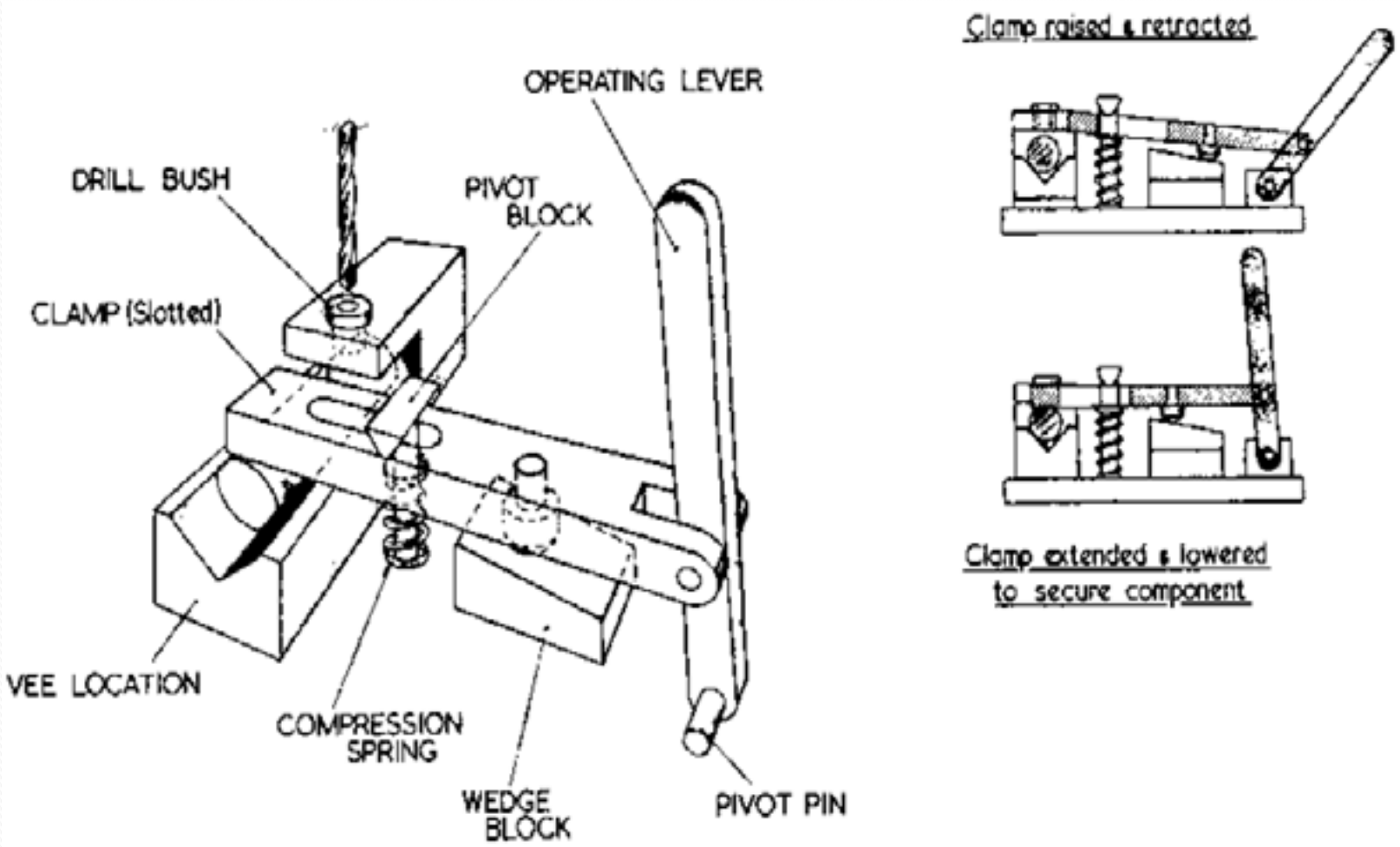


Pot Jig

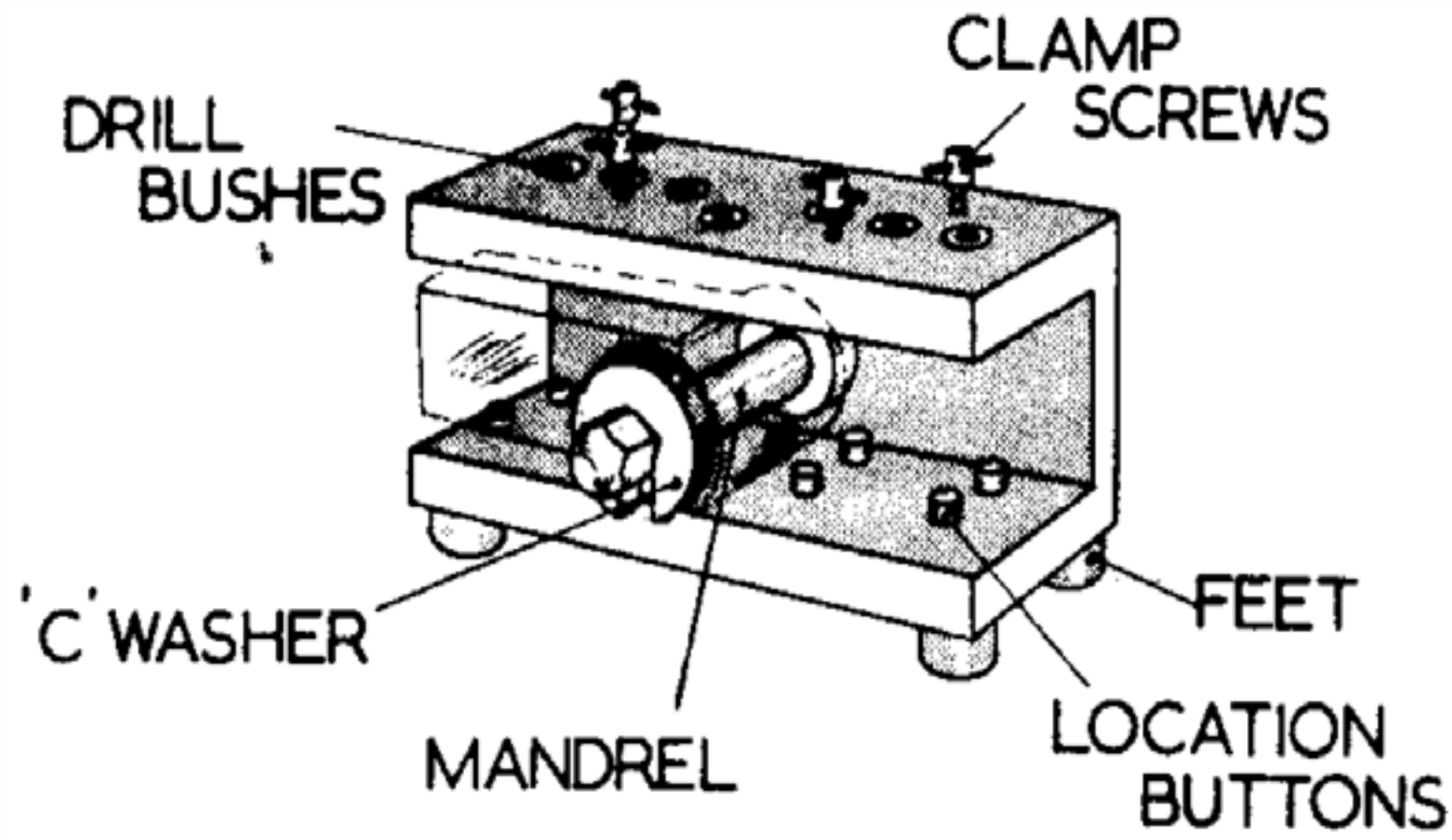
Jig for drilling a channel



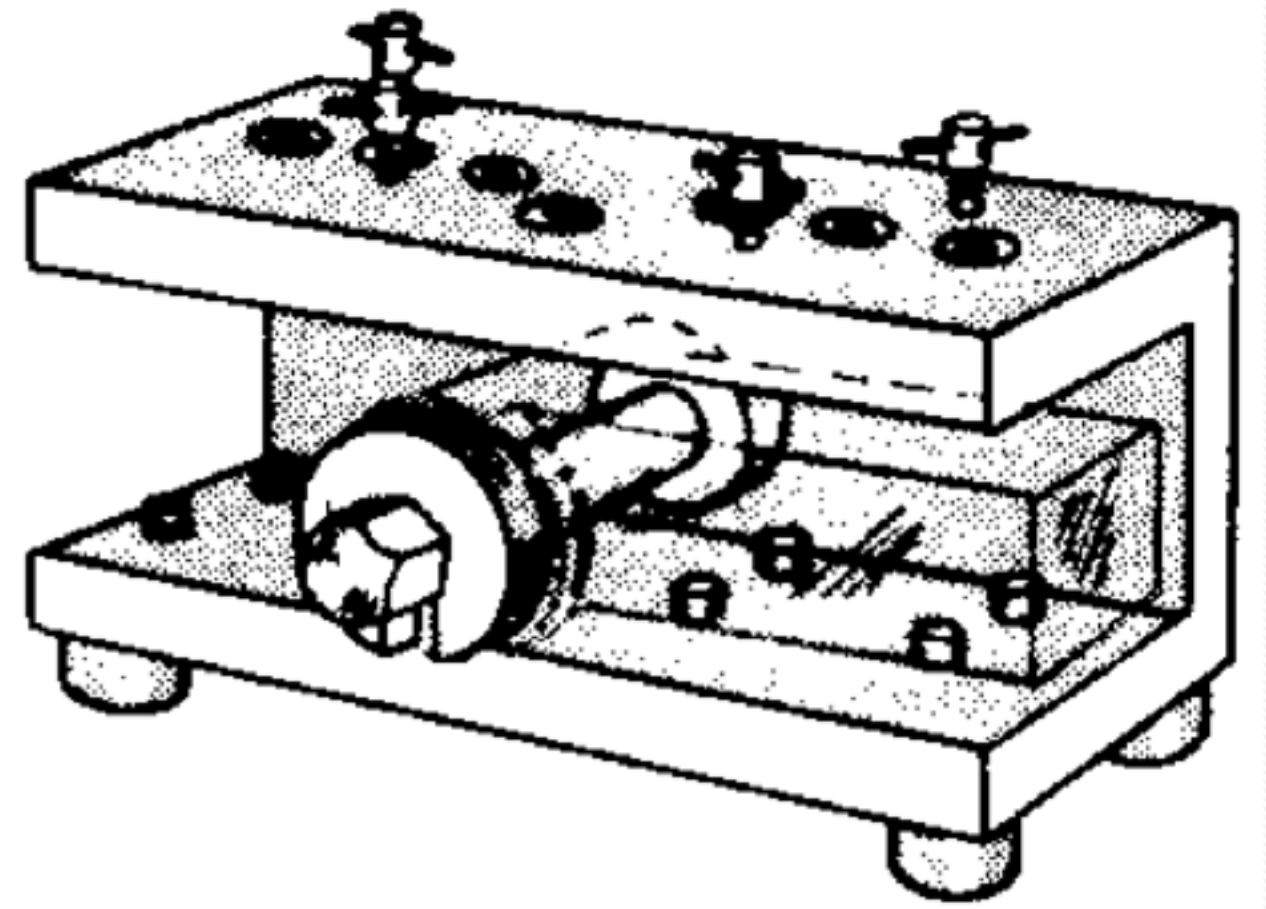
Drill jig with retractable wedge clamp



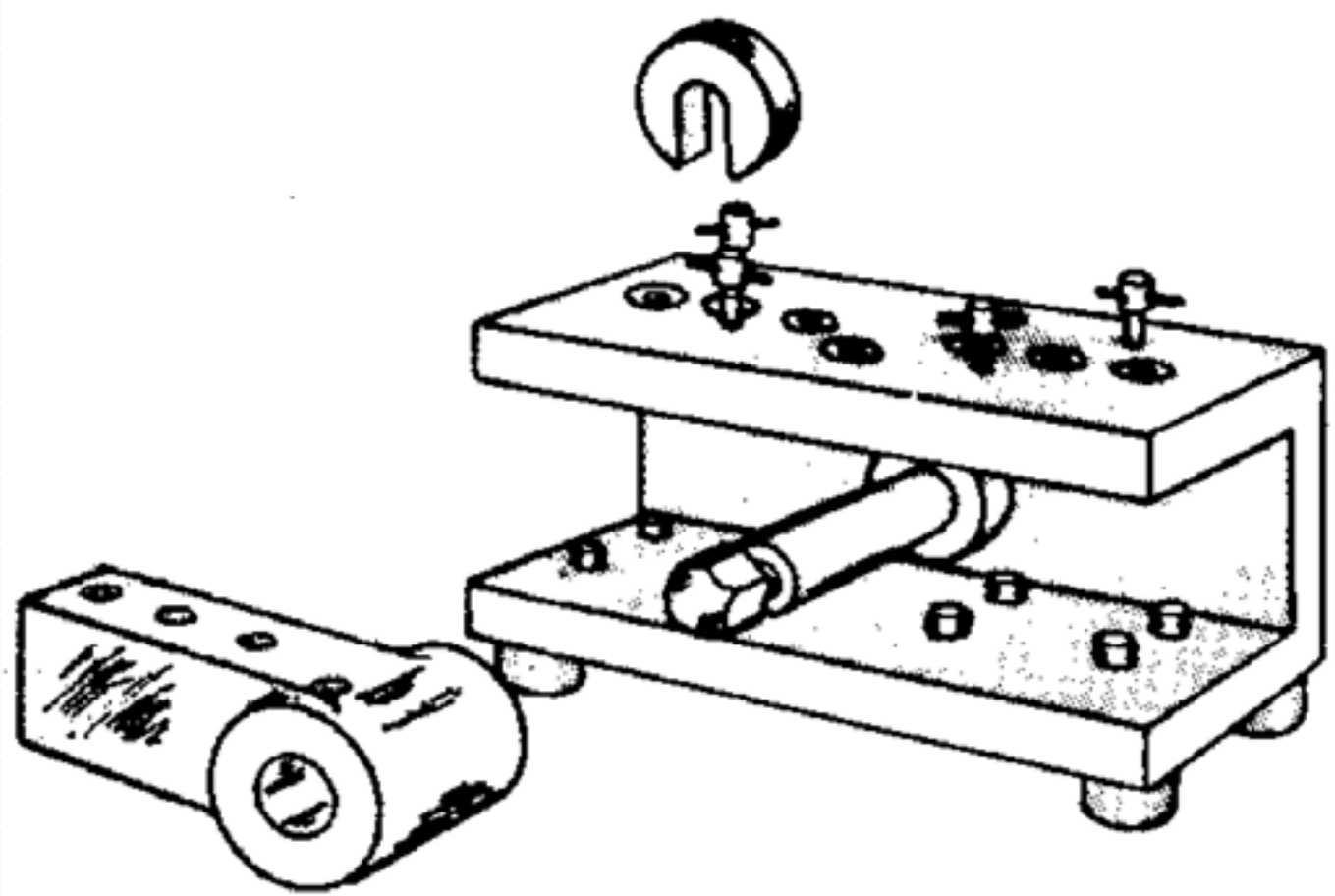
Drill jig with RH component



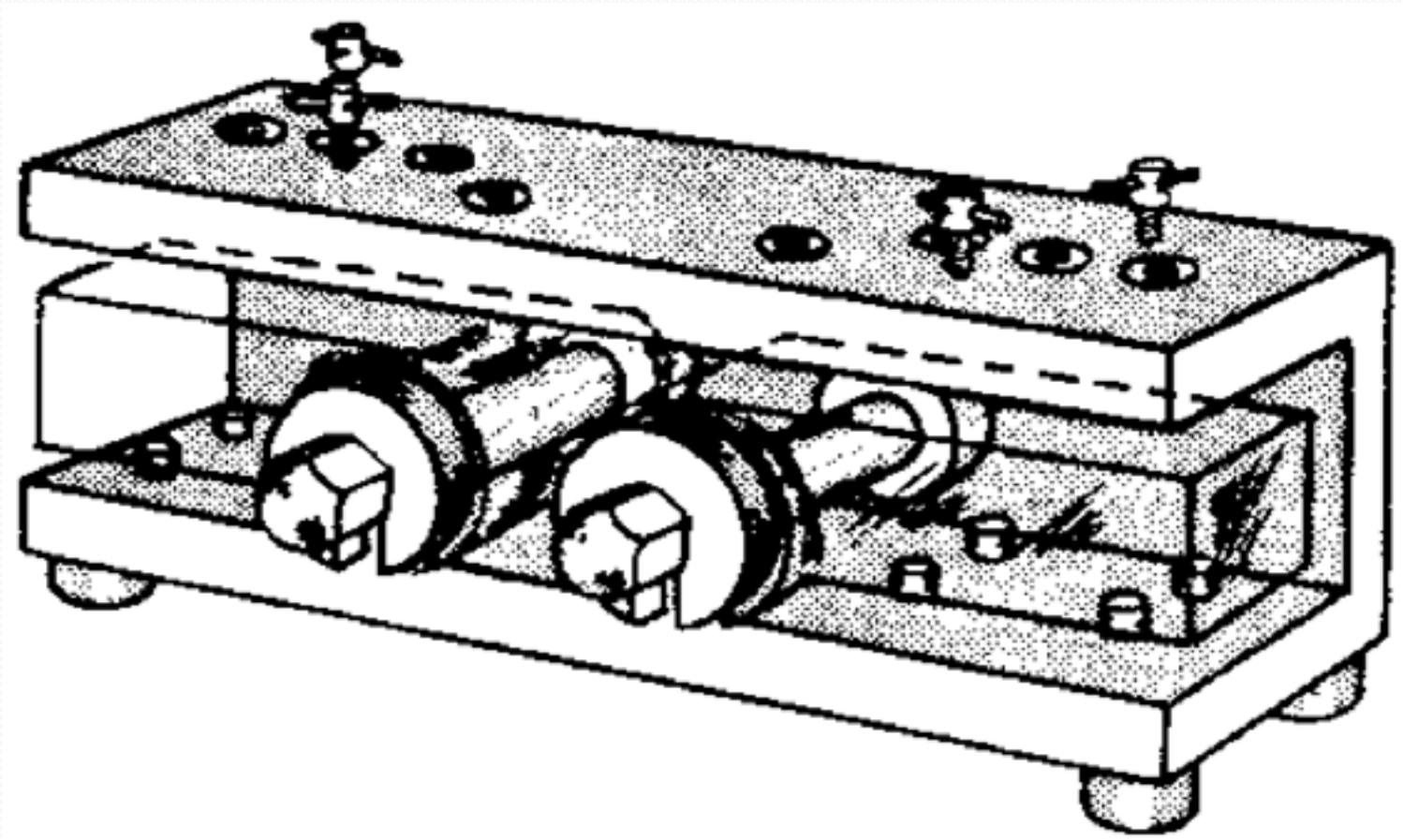
Drill jig with LH component



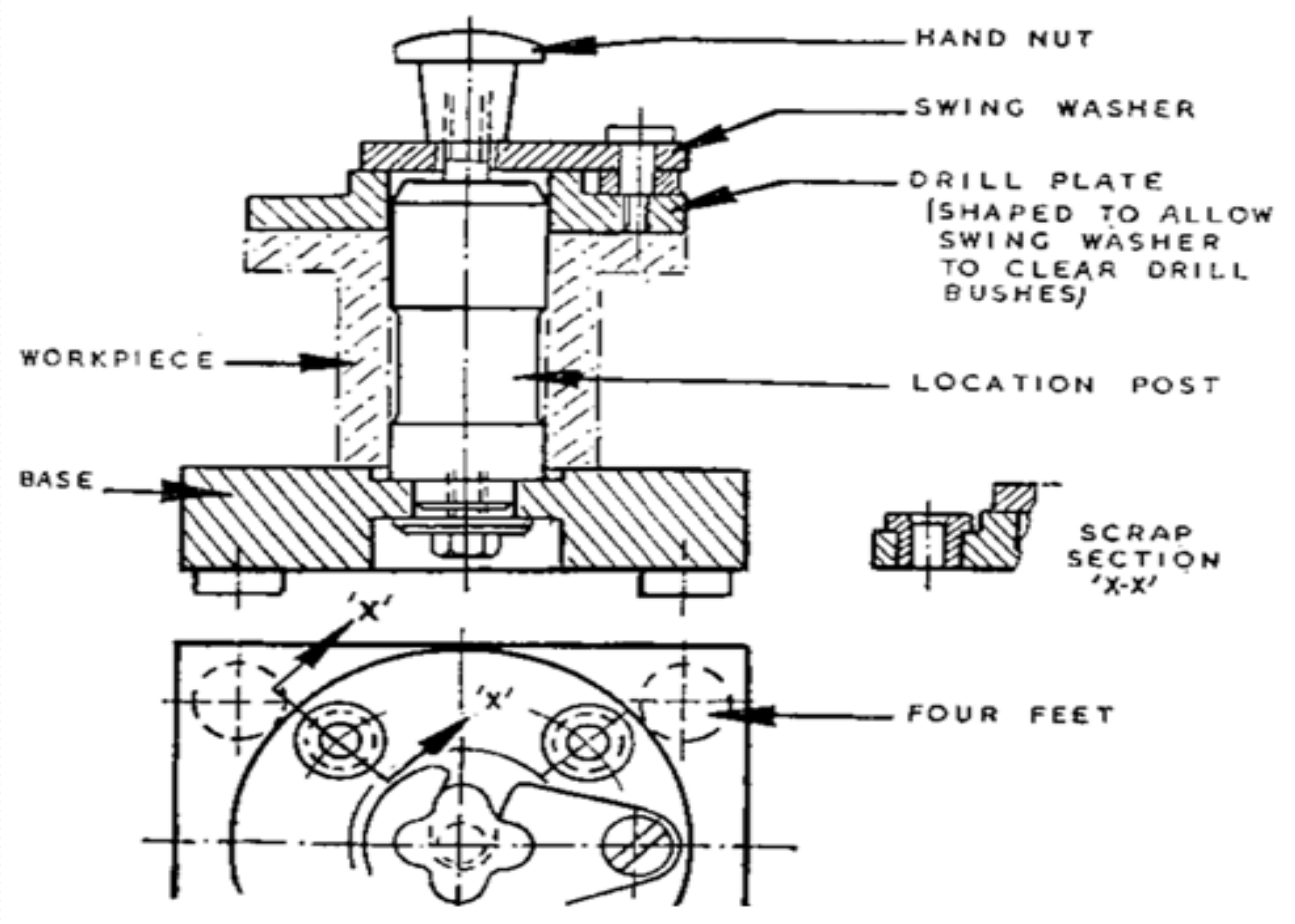
Drill jig with RH component unassembled



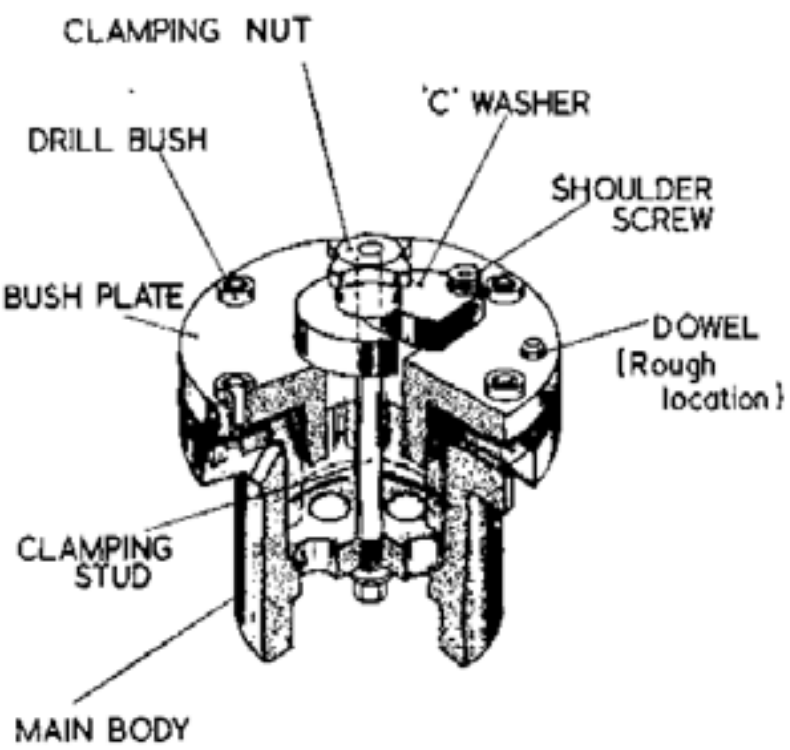
Drill jig with RH and LH components simultaneously

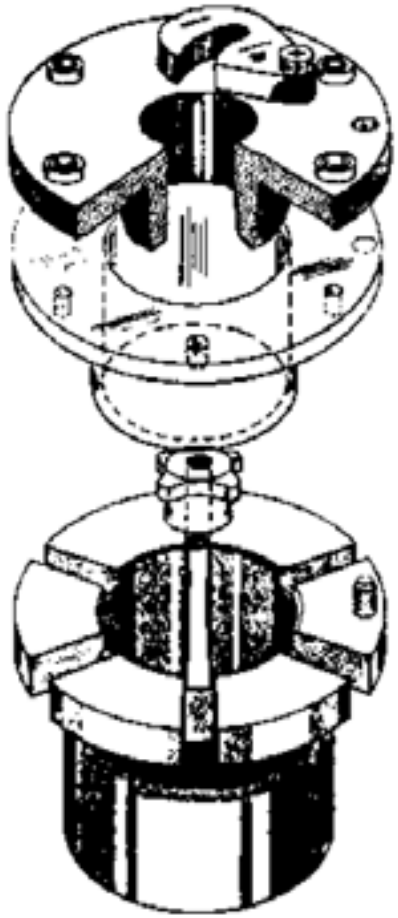


Post Jig


HAND NUT
SWING WASHER
DRILL PLATE
(SHAPED TO ALLOW SWING WASHER TO CLEAR DRILL BUSHES)
WORKPIECE
LOCATION POST
BASE
SCRAP SECTION 'X-X'
'X'
'X'
FOUR FEET

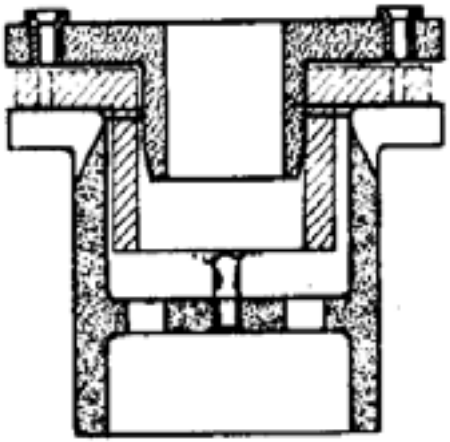
Pot drill jig





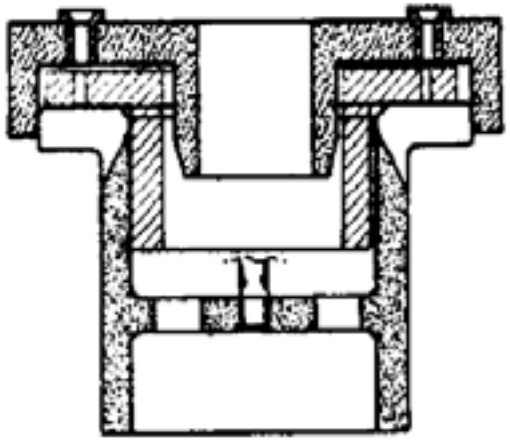
View showing clamping screw released, 'C' washer withdrawn, so that bush plate may be lifted off and component removed

Pot drill jig (contd.)



Condition (a)

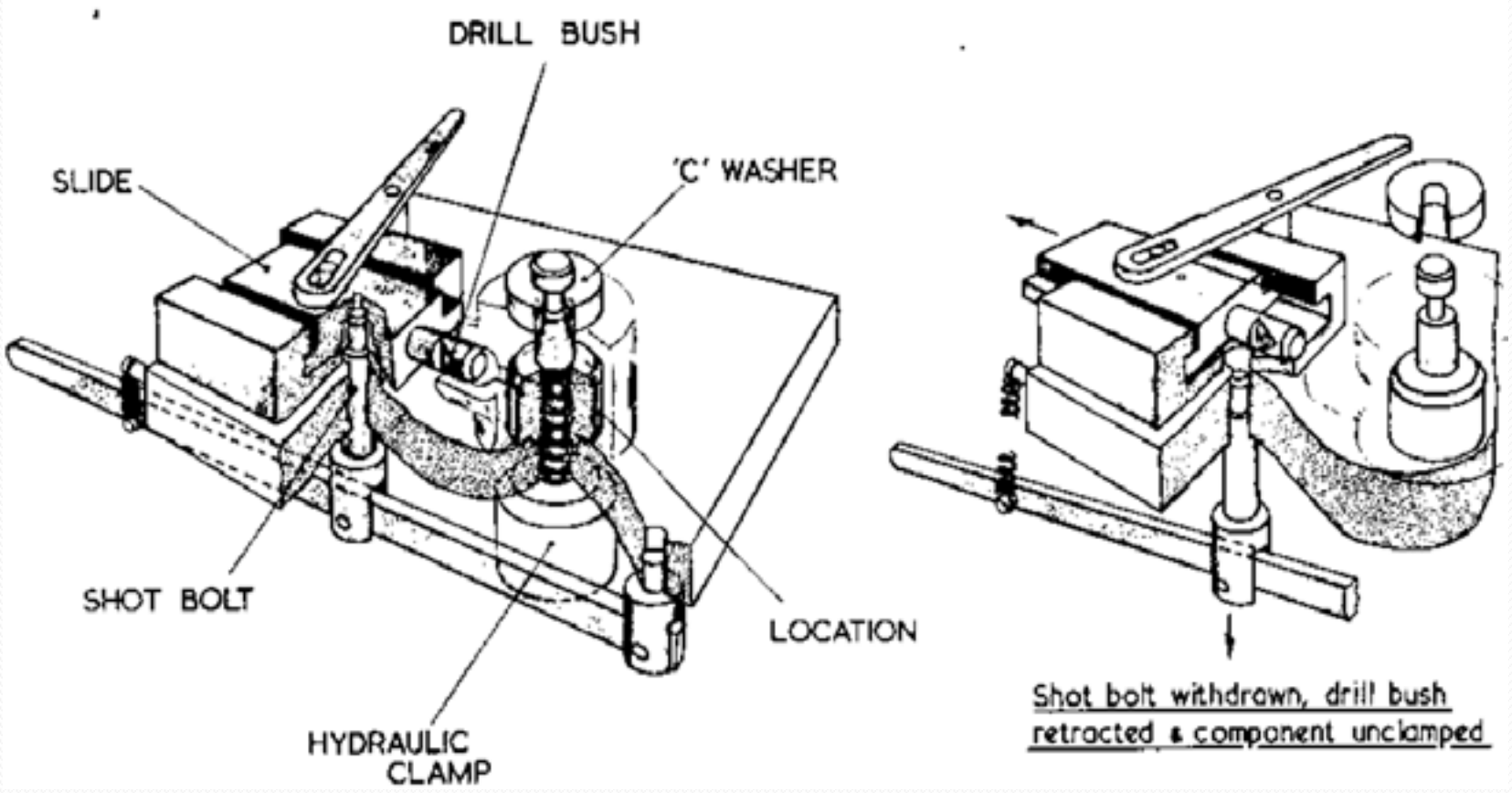
Holes drilled relative to component bore



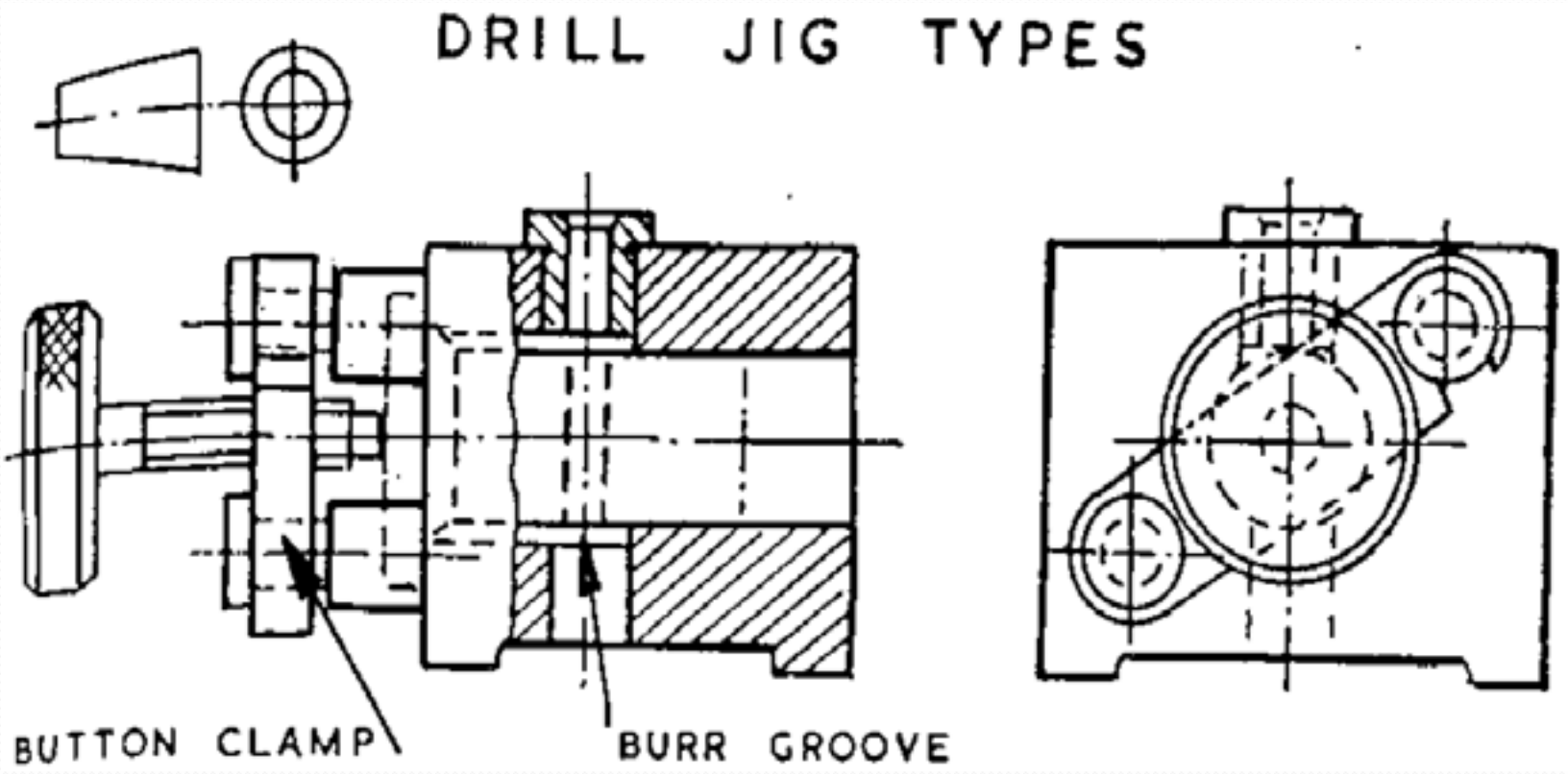
Condition (b)

Holes drilled relative to body O/D of component

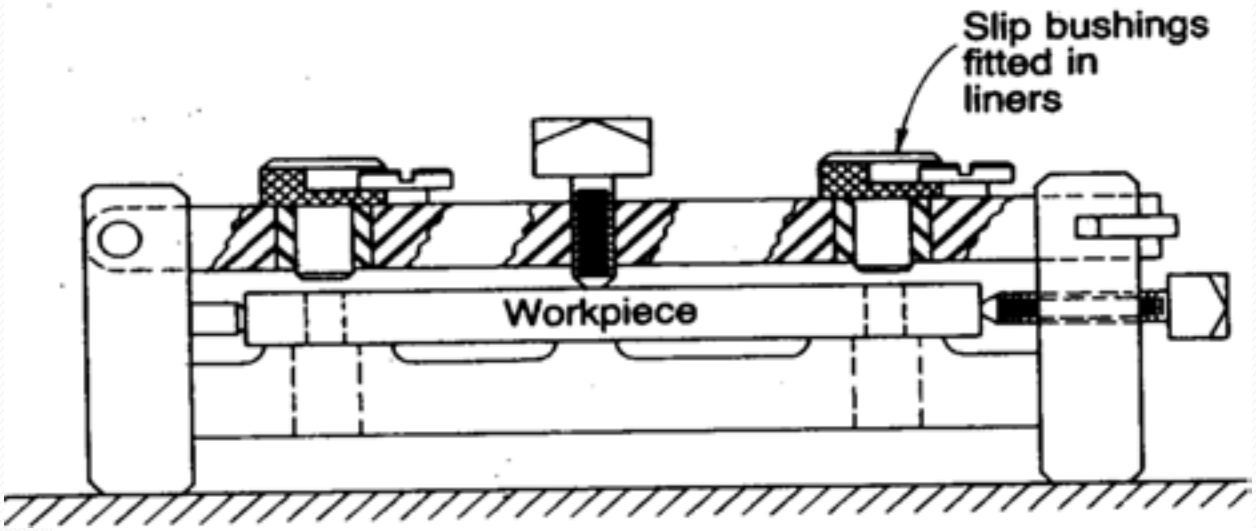
Drill jig with retractable drill bush

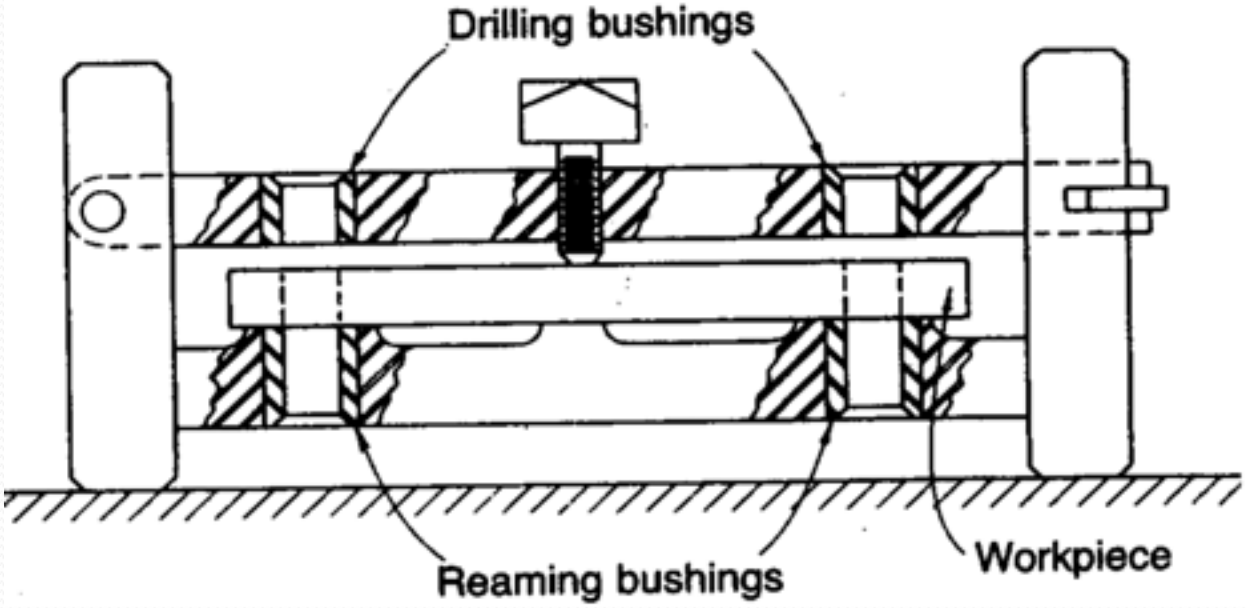


Solid Jig



Solid jig with workpiece





Jig design guidelines

- Drill jigs should be
  - Of light construction
  - Consistent with rigidity to facilitate handling
  - Rigidity to be maintained especially when jigs have to be turned over so that holes can be drilled from more than one side
- All unnecessary metal should be cored out of the jig body
- A jig which is not bolted to the machine table should be provided with feet, preferably four, opposite all surfaces containing guide bushings, so that it will 'rock' if not standing square on the table and so warn the operator

Jig design guidelines (contd.)

- Clearance holes or burr slots should be provided in the jig to allow for the burr formed when the drill breaks through the component and for swarf clearance, particularly from locating surfaces
- Make all component clamping devices as quick acting as possible
- Design the jig fool-proof by using foul pins and similar devices arranged in such a way that the component, tools or bushes can't be inserted except in the correct way

Jig design guidelines (contd.)

- Make some locating points adjustable when the component is a rough casting and may be out of alignment
- Locate clamps so that they will be in the best position to resist the pressure of the cutting tool when at work
- If possible, make all clamps integral parts of the jig and avoid the use of loose parts
- Avoid complicated clamping and locating arrangements which are liable to wear or need constant attention

Jig design guidelines (contd.)

- Place all clamps as nearly as possible opposite some bearing point of the component, to avoid springing the component, and in accessible positions
- All sharp edges should be removed from the various detail parts of the jig
- Provide handles or other devices wherever these will make the handling of the jig more convenient
- If possible, place all tool guide bushings inside the geometrical figure formed by connecting the points of location of the feet

Jig design guidelines (contd.)

- Make, if possible, all locating points visible to the operator when placing the component in position in the jig so that the component can be seen to be correctly located. The operator should also be able to have an unobstructed view of the clamps
- Before using the jig in the machine shop for commercial purposes, test all jigs as soon as they are made
- The location points, which are hardened if necessary, are established with considerations to machine operations, if any, to follow, and that any mating parts are located from the same datum surface

Jig design guidelines (contd.)

- Locating and clamping arrangements are designed to reduce idle time at a minimum by using simple clamps which are easy and quick to operate and also operate without damaging the component
- Springs should be used whenever possible to elevate the clamps clear of the component whilst being loaded or unloaded
- Clamps should be positioned above the points supporting the component, in order to avoid distortion and should be strong enough to hold the component without bending

Jig design guidelines (contd.)

- Generally clamps should not be relied upon for holding the work against the pressure exerted by the cutting tool
- Locating and supporting surfaces should, whenever possible, be renewable
  - Such surfaces should be of hard material
- The process of inserting and withdrawing the component from the jig should be as easy as possible
  - Ample space should be left between the jig body and the component for hand movements
  - Some means of ejection should exist to release the component if it sticks in the jig

Jig design guidelines (contd.)

- The design of the jig should be safe
  - Handles or levers should be large enough to clear adjacent parts so that pinched fingers are avoided
- If necessary, make provisions for the use of coolant
- Position locations at places where there is no flash or burr on the component
- If possible, eliminate spanners by the use of levers
  - If spanners have to be used, make one spanner fit all the clamp operating bolts and nuts
- Consideration should be given at the design stage to the use of standardized jig components

Power requirement for drilling

$$Torque,\ M = K\ A\ f^{0.8}\ d^{1.8}$$

$$Thrust,\ T = 2\ K\ B\ f^{0.8}\ d^{0.8} + K\ E\ d^{2}$$

- d = drill diameter, in
- K, A, B, E - Constants

Work-Material Constants for Calculating Torque and Thrust

Work Material	K
Steel, 200 Bhn	24,000
Steel, 300 Bhn	31,000
Steel, 400 Bhn	34,000
Most aluminum alloys	7,000
Most magnesium alloys	4,000
Most brasses	14,000
Leaded brass	7,000
Cast iron, 165 Bhn	15,000
Free-machining mild steel, resulfurized	18,000
Austenitic stainless steel (Type 316)	34,000

Power requirement for drilling (contd.)

Torque and Thrust Constants Based upon Ratios *c/d* or *w/d*

c/d	Approx. *w/d*	Torque constant *A*	Thrust constant *B*	Thrust constant *E*
0.03	0.025	1.000	1.100	0.001
0.05	0.045	1.005	1.140	0.003
0.08	0.070	1.015	1.200	0.006
0.10	0.085	1.020	1.235	0.010
0.13	0.110	1.040	1.270	0.017
0.15	0.130	1.080	1.310	0.022
0.18	0.155	1.085	1.355	0.030
0.20	0.175	1.105	1.380	0.040
0.25	0.220	1.155	1.445	0.065
0.30	0.260	1.235	1.500	0.090
0.35	0.300	1.310	1.575	0.120
0.40	0.350	1.395	1.620	0.160

(*Courtesy National Twist Drill, Div. of Regal-Beloit Corp.*)

* *c* = chisel edge length, in. (mm)
d = drill diameter, in. (mm)
w = web thickness, in. (mm)

Torque and Thrust Terms Based upon Feed

Feed, *f*, ipr	$f^{0.8}$	Feed, *f*, ipr	$f^{0.8}$
0.0005	0.0025	0.012	0.030
0.001	0.004	0.015	0.035
0.002	0.007	0.020	0.045
0.003	0.010	0.025	0.055
0.004	0.012	0.030	0.060
0.005	0.014	0.035	0.070
0.006	0.017	0.040	0.075
0.008	0.020	0.050	0.090
0.010	0.025		

References

- Fundamentals of tool design, fifth edition, Society of Manufacturing Engineers
- Engineering drawing and design, sixth edition, Jensen, Helsel and Short, McCgraw hill publications

Questions?