Drilling

Drilling

- **Drilling is the operation of producing circular hole in the work-piece by using a rotating cutter called DRILL.**

- **The machine used for drilling is called drilling machine.**

- **The drilling operation can also be accomplished in lathe, in which the drill is held in tailstock and the work is held by the chuck.**

- **The most common drill used is the twist drill.**

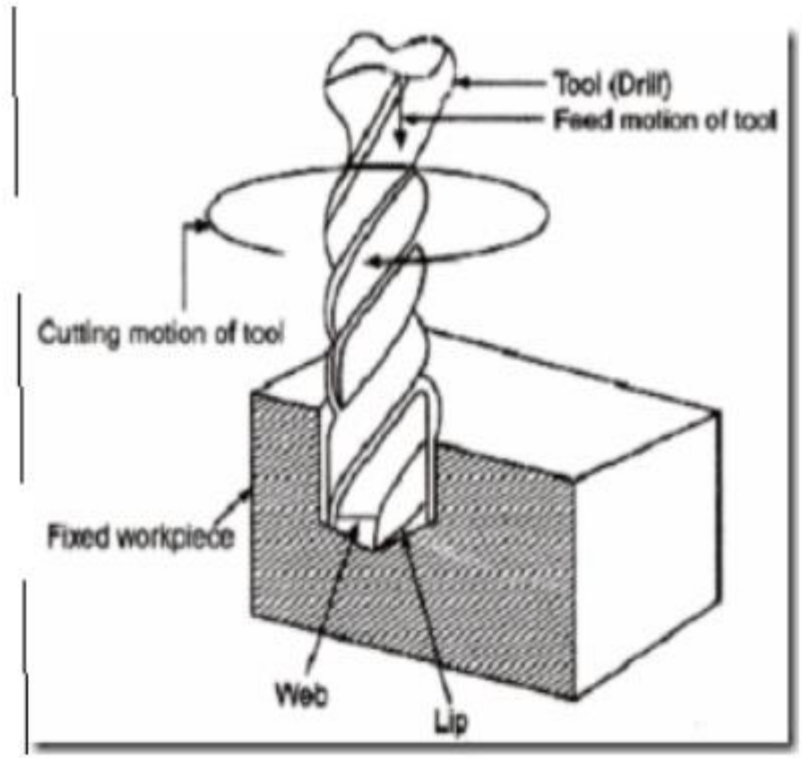
- **It is the simplest and accurate machine used in production shop.**

Drilling machine

- Drilling machine
  - Spindle
    - Turns drill to advance into work (hand or automatically)
  - Work table
    - Holds workpiece rigidly in place as hole drilled
  - Used primarily to produce holes in metal
  - Other operations: tapping, reaming, boring, counter boring, countersinking, spot-facing

Working principal of drilling machine

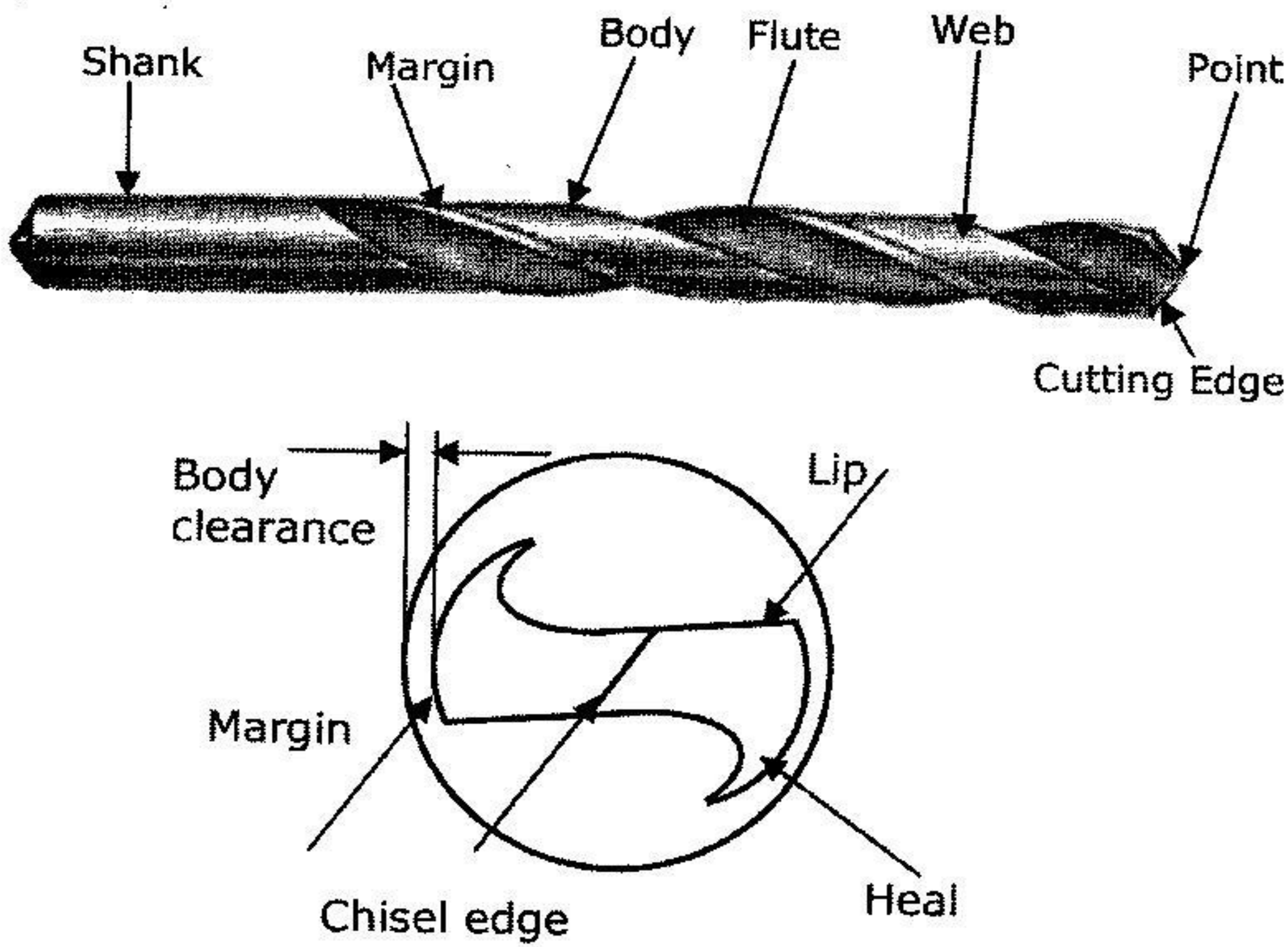
- The rotating edge of the drill exerts a large force on the workpiece and the hole is generated.
- The removal of metal in a drilling operation is by shearing and extrusion.



Specifications of drilling machine

- Size of drilling table.
- Largest bit the machine can held.
- Maximum size of the hole that can be drilled.
- Maximum size the work piece that can be held.
- Power of the motor, spindle speed or feed.

Tool Nomenclature



TOOL NOMENCLATURE

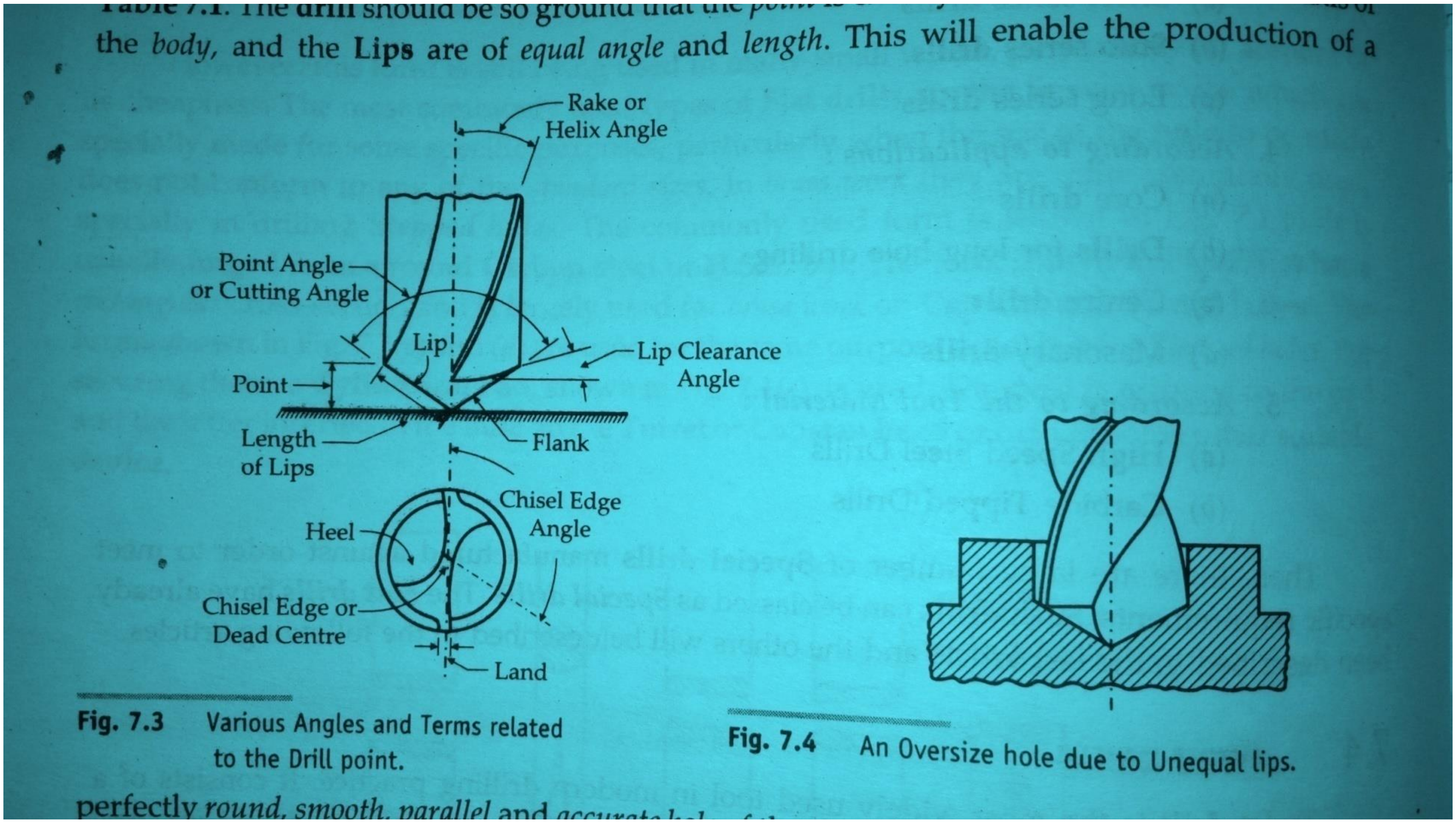

the *body*, and the **Lips** are of *equal angle* and *length*. This will enable the production of a

Fig. 7.3 Various Angles and Terms related to the Drill point.

Fig. 7.4 An Oversize hole due to Unequal lips.

perfectly *round, smooth, parallel* and

TOOL NOMENCLATURE

Table 7.1 Recommended Values of Principal Drill Angles

Material to be drilled	Included Cutting angle or Point angle	Lip clearance angle	Helix angle or Rake angle	Chisel edge angle
Aluminium (pure)	80° – 120°	8° – 12°	24° – 48°	120° – 135°
Cast iron (soft)	118°	8° – 12°	24° – 32°	120° – 135°
Cast iron (hard)	118°	8° – 12°	24° – 32°	120° – 135°
Brass	118°	8° – 15°	0° – 18°	120° – 135°
Copper	120° – 140°	8° – 15°	28° – 40°	120° – 135°
Steel	118°	8° – 12°	24° – 32°	120° – 135°
Stainless steel	120° – 140°	10° – 12°	24° – 32°	120° – 135°
Al. alloys	140°	8° – 12°	20° – 40°	120° – 135°
Plastics & Hard rubber	80°	8° – 12°	24° – 32°	120° – 135°
Pure nickel	118°	10° – 12°	24° – 32°	120° – 135°

Types of drilling machines

a) Based on construction:

Portable,

Sensitive or bench drilling machine

Radial,

up-right,

Gang,

Multi-spindle

Automatic

Turret

Deep hole

b)Based on Feed:

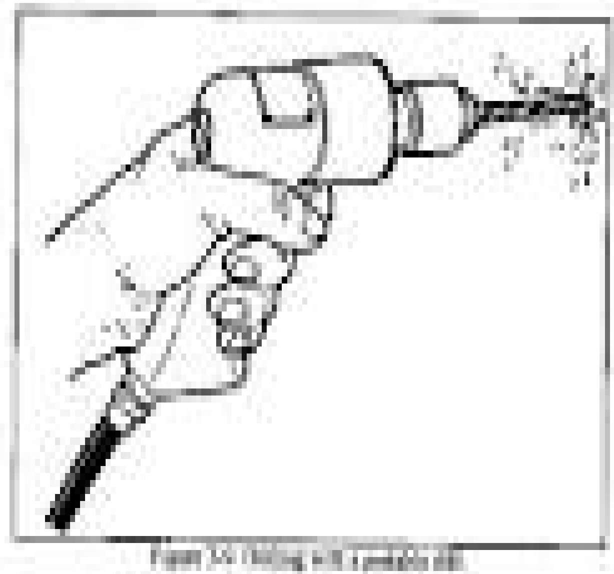
Hand and Power driven Portable drilling machine

Portable drilling machine

- It is a small light weight, compact and self contained unit that can drill holes upto 12.5 mm diameter.

- The machine is driven by a small electric motor operating at high speed.

- The machine is capable of drilling holes in the workpieces in any position.



Bench Drilling Machine

- These are light duty vehicles.
- Mounted on benches.
- To drill small diameter holes ,a twist drill is fitted in the drill chuck.
- This design is used to drill hole from 1.5mm to 15mm diameter.
- The controls are light and delicate speeds from 800 to 900 rpm are typical range.

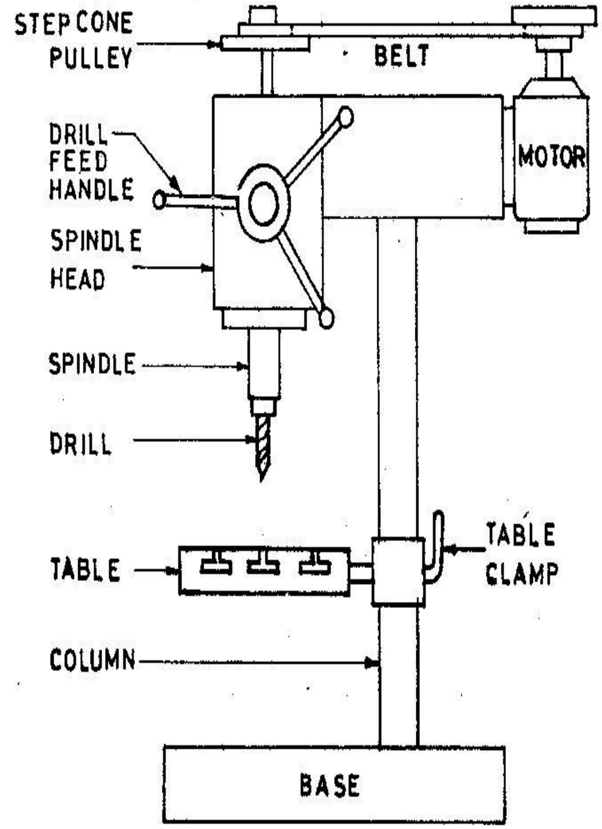
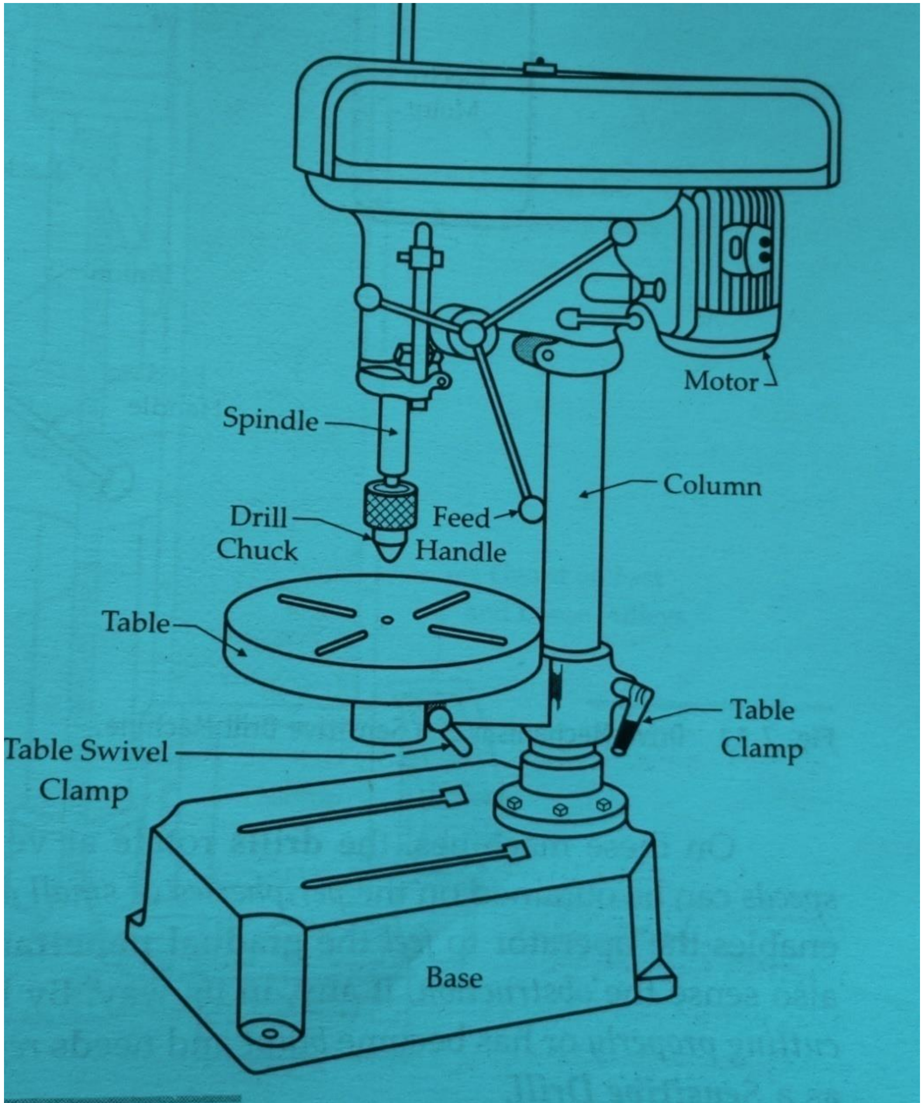


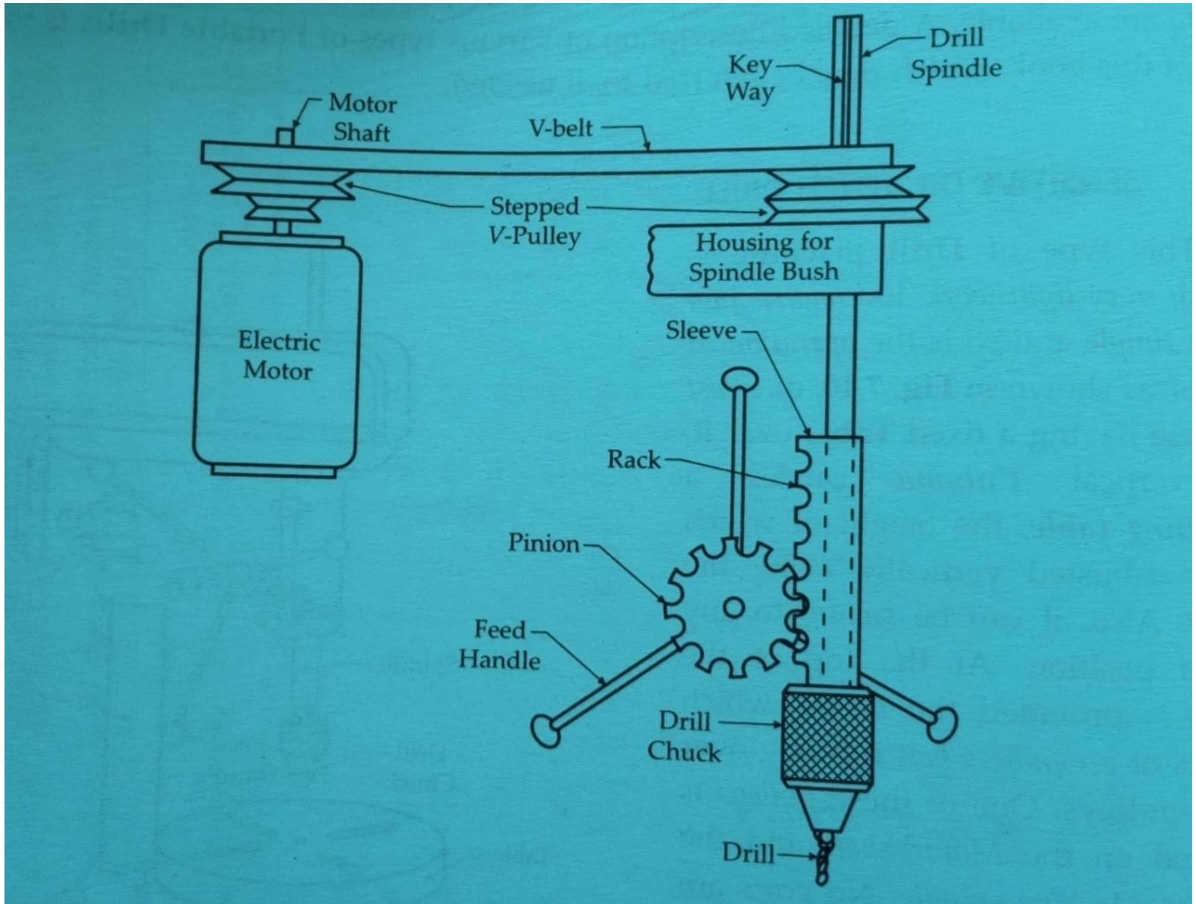
Fig.

Drilling Machine



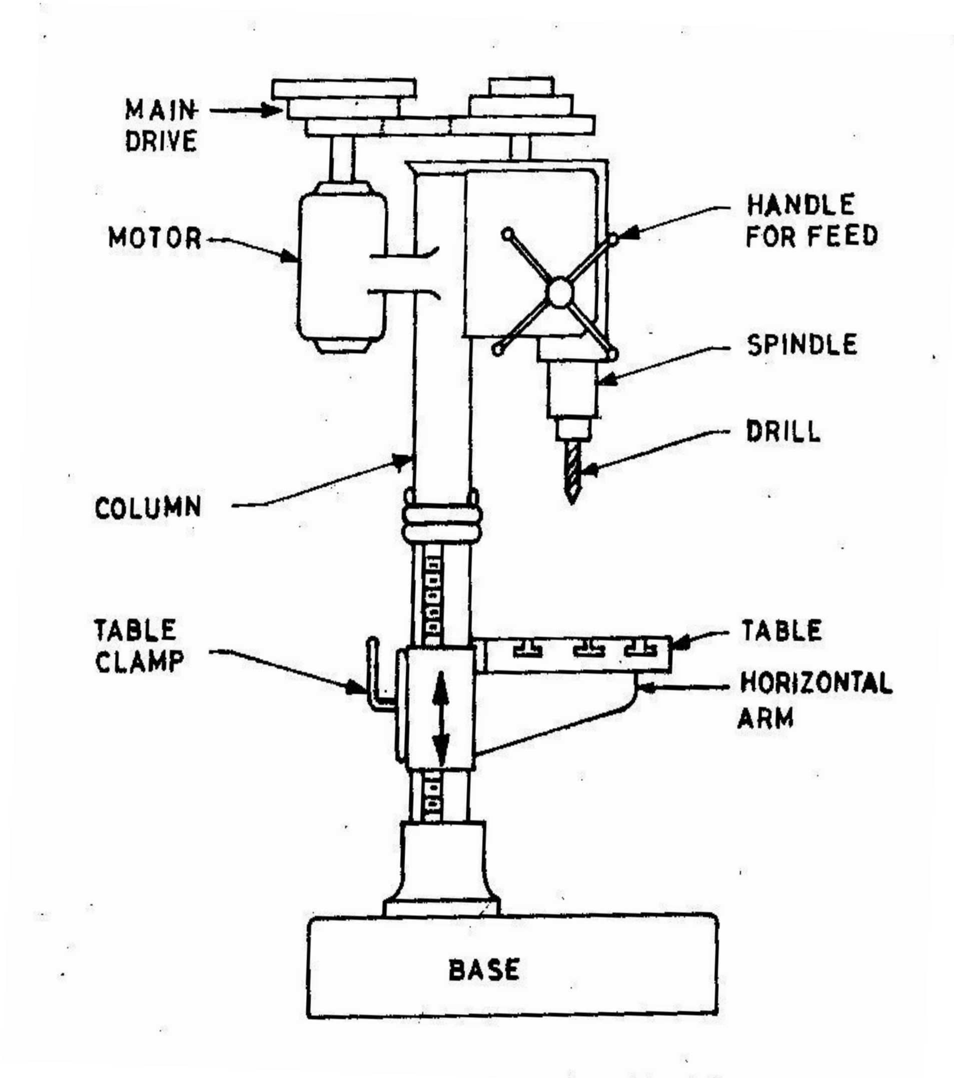
. 7.10 Sensitive or Bench Drill.

Drive Mechanism in DM



Drive Mechanism of a Sensitive Drill Machine.

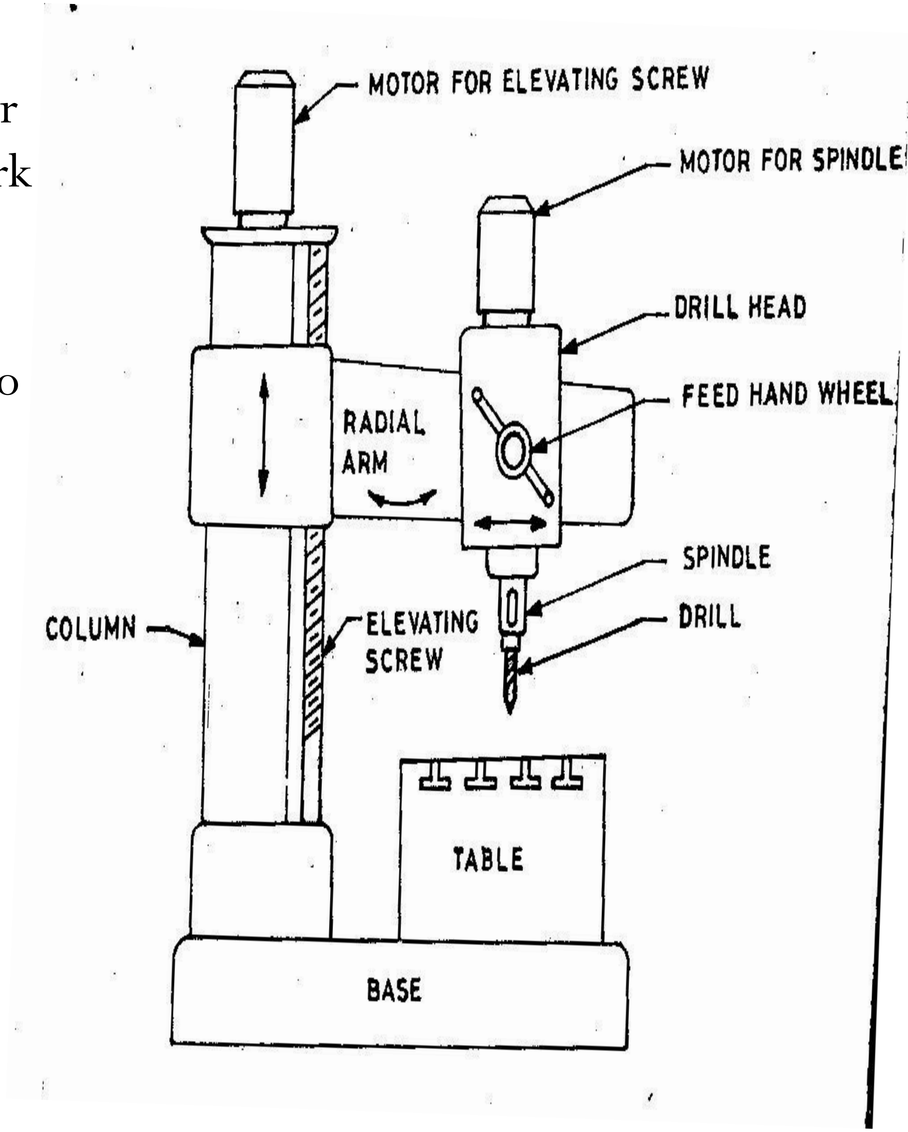
Up-Right Drilling Machine



- Similar to sensitive drills have power feed mechanism for rotating drills and are designed for heavier.
- It is used for heavier work.
- Drill holes upto 50mm
- Table can move vertically and radially

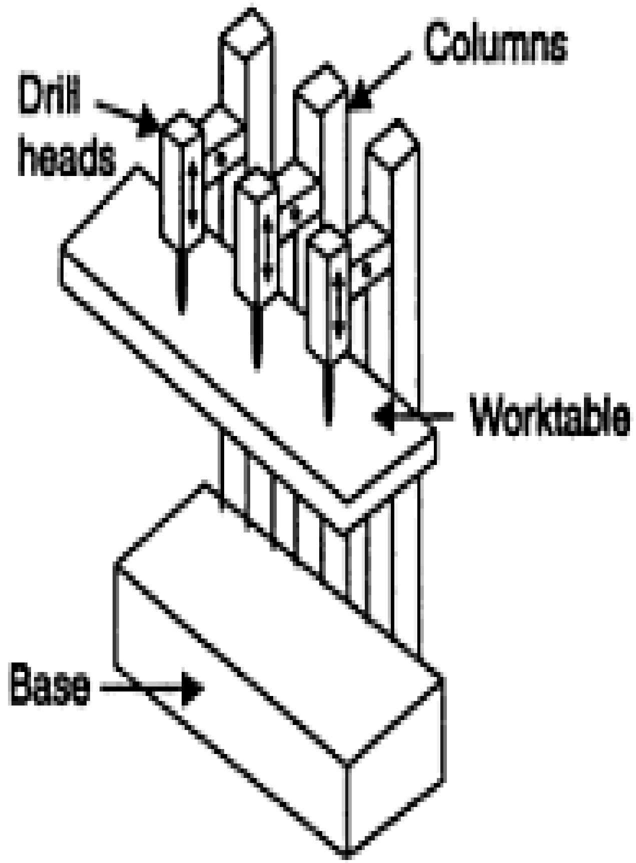
Radial Drilling Machine

- It the largest and most versatile used for drilling medium to large and heavy work pieces.
- It can be radially adjusted around the column in any position over the work to get different size and shapes of work.
- The movements may be either manual or power driven.
- The table is to be rotated through 360 deg.
- The wide rang of power are as well as sensitive and geared manual feeds.

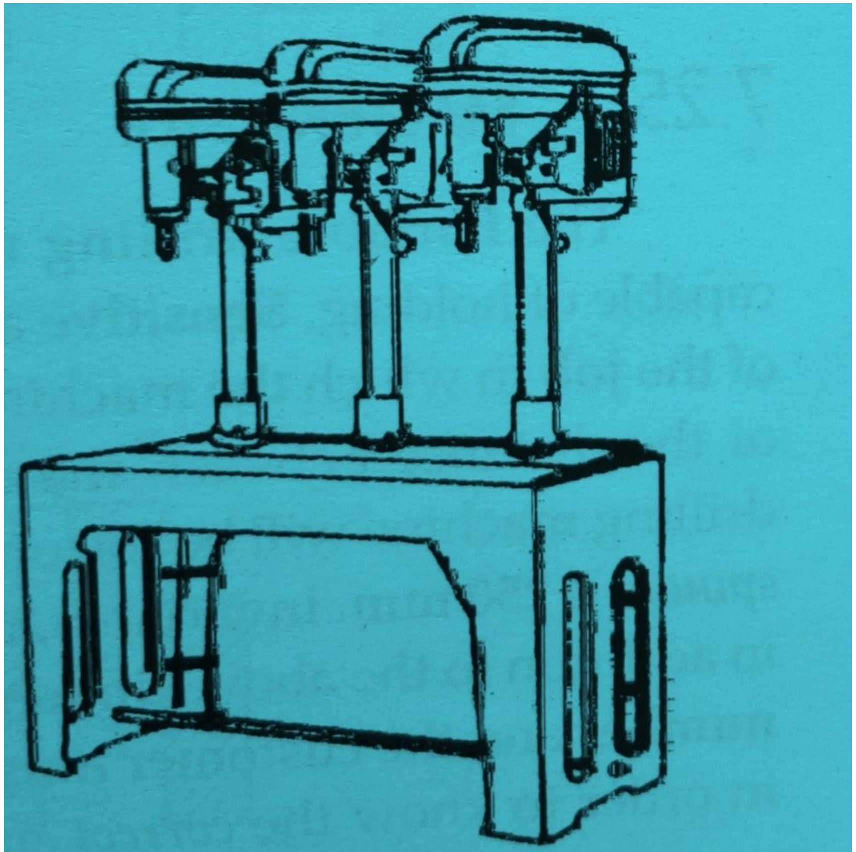


Gang drilling machine

- When drilling spindles are mounted on a single table, it is known as a gang drill.
- Each of these spindles can be independently set for different speed and depth of cut.
- Such machines are useful when number of holes of different sizes are to be drilled on the same work piece.
- Apart from drilling, a number of other machining operations like reaming counter boring, tapping etc can also be performed at a time on this machine.



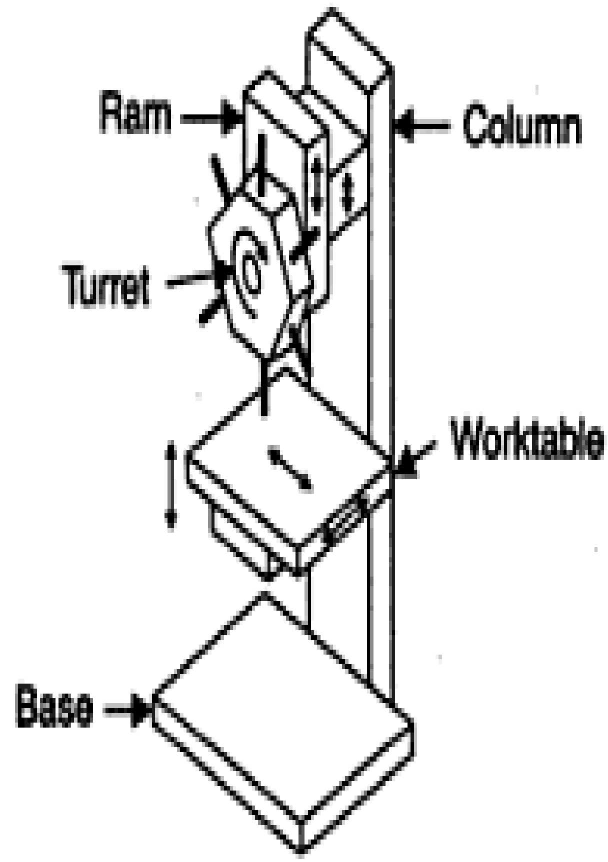
Gang Drilling Machine



g. 7.17 Gang Drilling Machine.

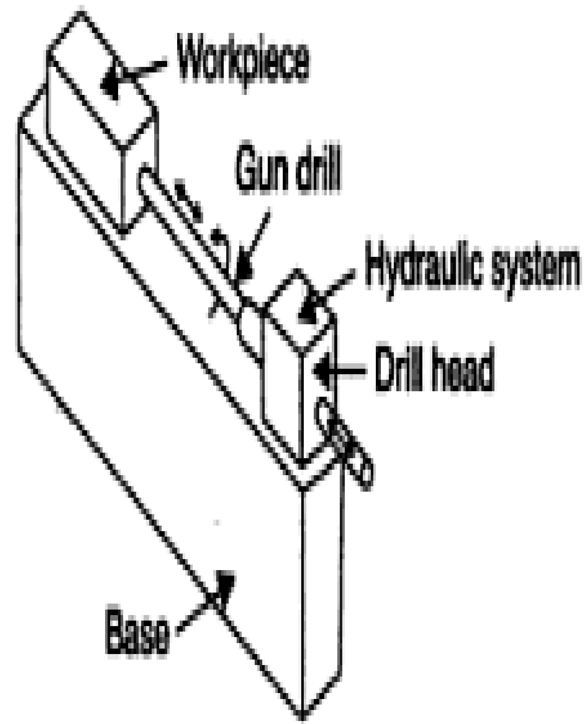
Turret Type Drilling Machine

- The stations are set up with a variety of tools numerical control is a also available.
- Two fixtures can be located side by on the workable table, thus permitting loading and unloading of one part while the other part is being machined this reduces the machine cycle.

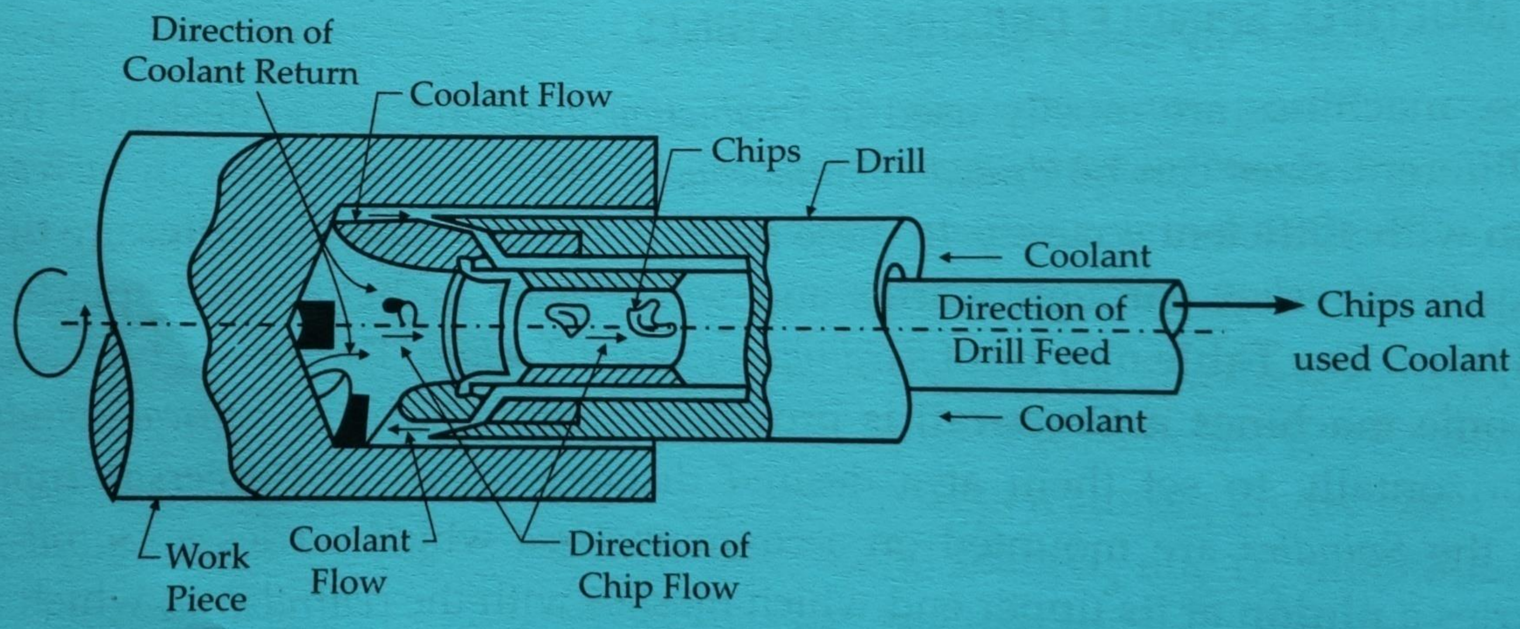


Deep hole drilling

- These machines are used for drilling holes whose depth exceed normal drill size. These machines are operated at high speed and low feed.
- These machines are either horizontal or vertical. The work or the drill may revolve. most machines are of horizontal construction using a center cut gun drill, which has a single cutting edge with a straight flute running througout its length.
- These machines are very useful for drilling deep holes in rifle travels, crankshafts.



Deep hole DM



Deep hole drilling on a Horizontal Machine (Enlarged sectional view of the Drilling Area).

Deep hole drilling machine

- Very deep holes of L/D ratio 6 to even 30, required for rifle barrels, long spindles, oil holes in shafts, bearings, connecting rods etc, are very difficult to make for slenderness of the drills and difficulties in cutting fluid application and chip removal.
- Such drilling cannot be done in ordinary drilling machines and

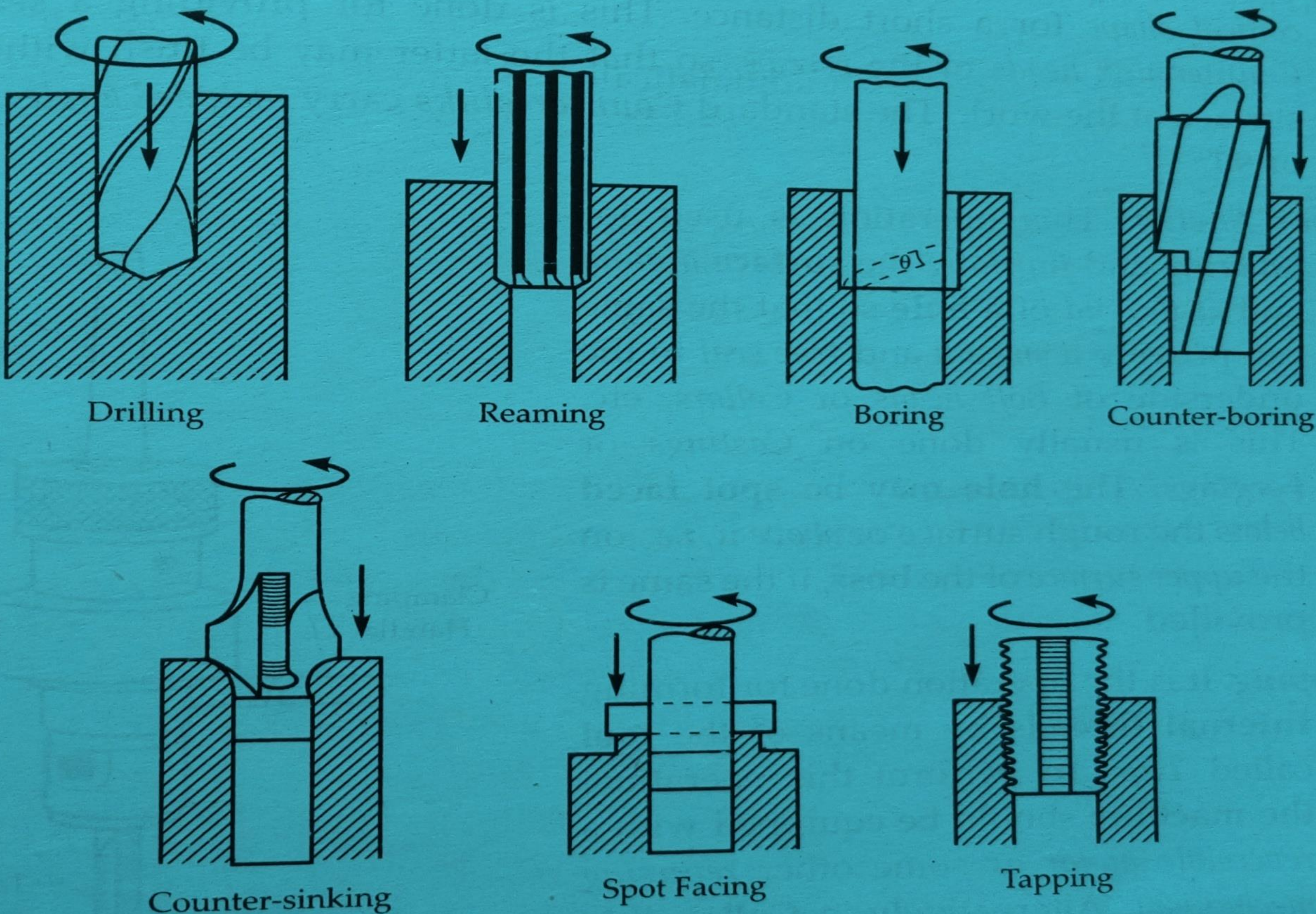
  bordinary drills.
- It needs machines like deep hole drilling machine such as gun drilling machines with horizontal axis which are provided with supports

DRILLING OPERATIONS…

- Operations that can be performed in a drilling machine are

  - Drilling
  - Reaming
  - Boring
  - Counter boring
  - Countersinking
  - Tapping and
  - Spot Facing

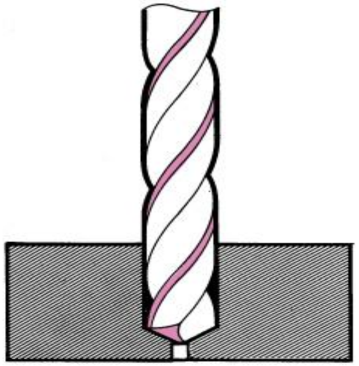
Drilling operations...



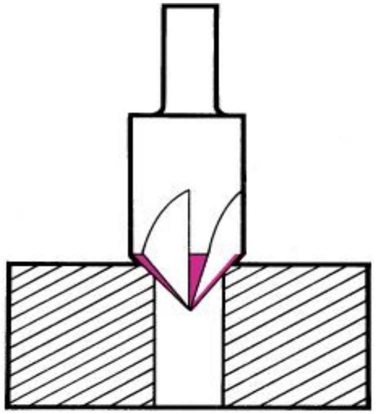
Operations done on a Drilling Machine.

Operations Performed

- Drilling
  - Operation of producing hole by removing metal from solid mass using twist drill

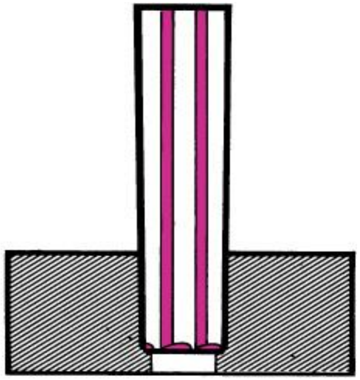


- Countersinking
  - Operation of producing tapered or cone-shaped enlargement to end of hole

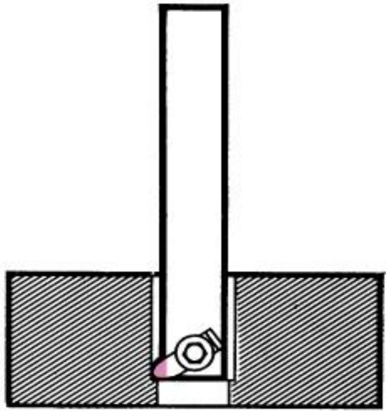


Operations Performed

- Reaming
  - Operation of sizing and producing smooth, round hole from previously drilled or bored hole

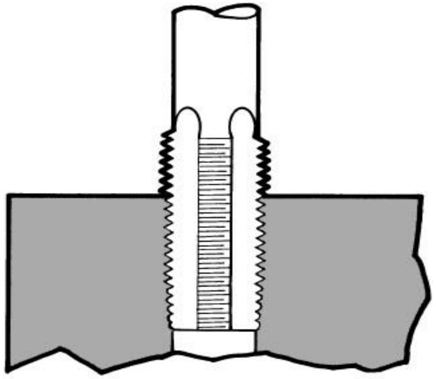


- Boring
  - Truing and enlarging hole by means of single-point cutting tool

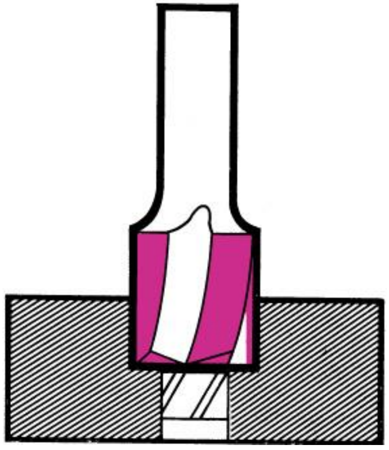


Operations Performed

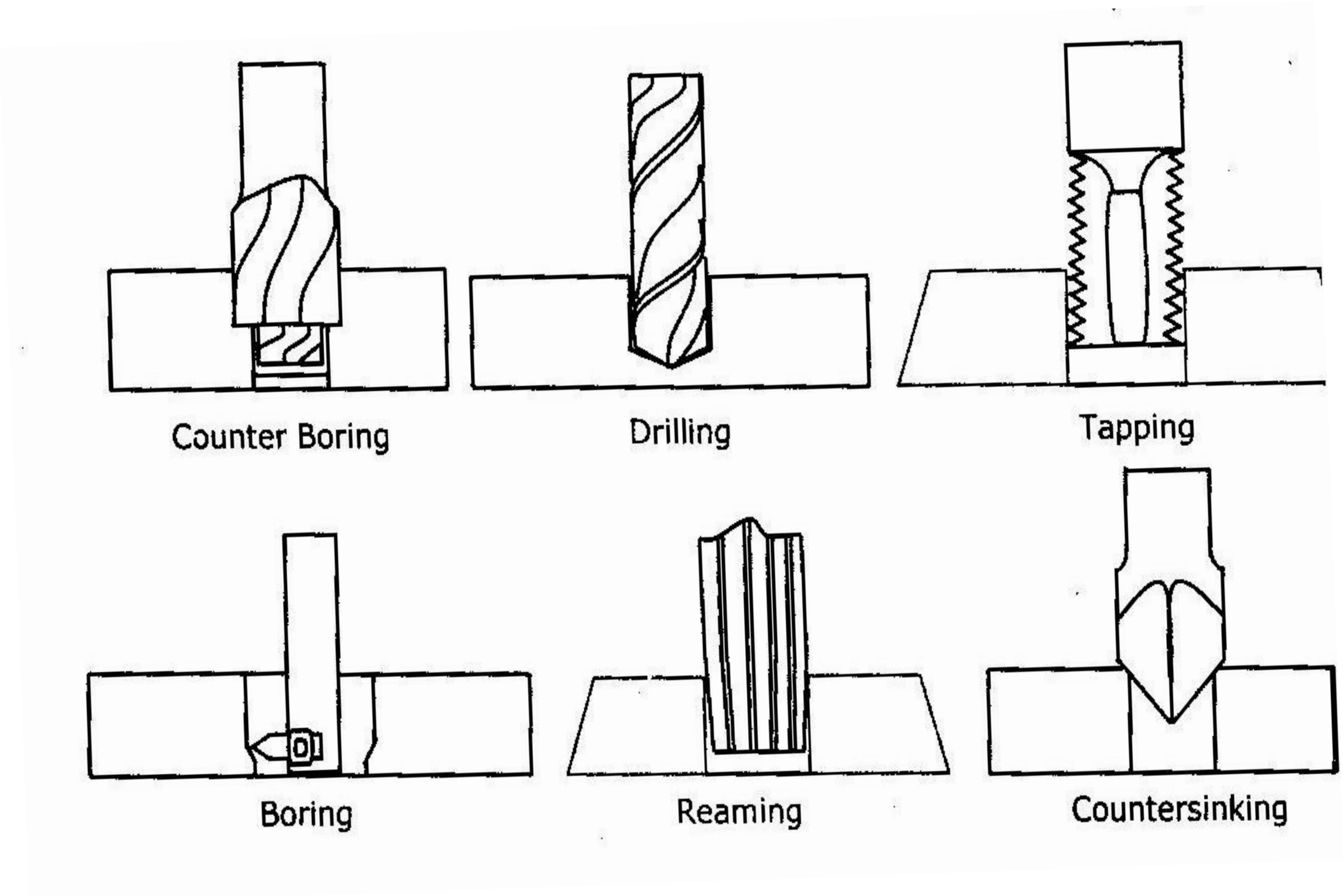
- Tapping
  - Cutting internal threads in hole with cutting tool called tap



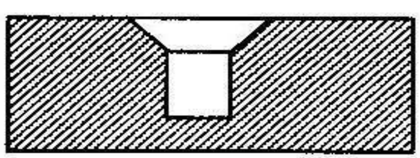
- Counterboring
  - Enlarging top of previously drilled hole to given depth to provide square shoulder for head of bolt or capscrew



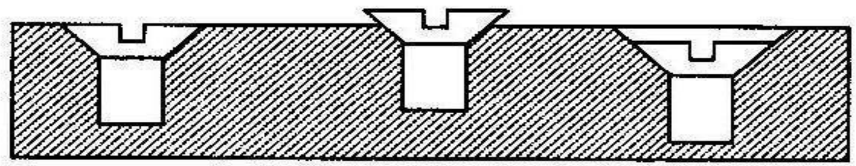
OPERATIONS IN DRILLING MACHINE



COUNTER BORE AND SPOT FACING

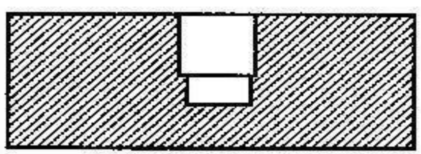


a

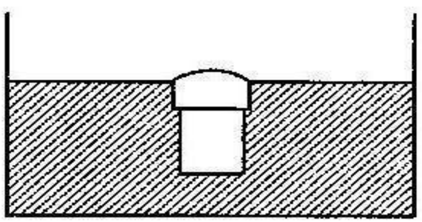


b

Countersunk hole



Counterbored hole



Spot faced hole

Types of cutters

Reamers :-

Multi tooth cutting tool

Accurate way of sizing and finishing the pre-existing hole.

Accuracy of ± 0.005mm can be achieved

Boring Tool:-

Single point cutting tool.

Boring tool is held in the boring bar which has the shank.

Accuracy of ± 0.005mm can be achieved.

TYPES OF CUTTERS

Countersinks :-

Special angled cone shaped enlargement at the end of the hole Cutting edges at the end of conical surface.

Cone angles of 60°, 82°, 90°, 100°, 110°, 120°

Counter Bore Tool:-

Special cutters uses a pilot to guide the cutting action .

Accommodates the heads of bolts.

TYPES OF CUTTERS

Combined Countersinks and central drill :-

Special drilling tool to start the hole accurately.

At the end it makes countersinks in the work piece.

Gun drill :-

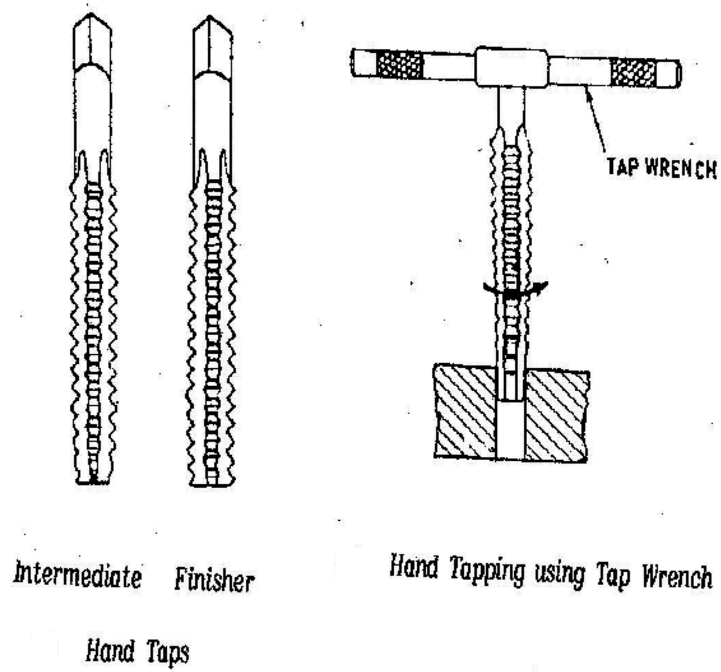
Machining of lengthy holes with less feed rates.

To overcome the heating and short life of the normal drill tool

TYPES OF CUTTERS

Tapping:-

- For cutting internal thread
- Multi cutting edge tool.
- Tapping is performed either by hand or by machine.
- Minor dia of the thread is drilled and then tapping is done.



Parameters Definitions

- Cutting Speed (v):-

  It's the peripheral speed of the drill

  $v = \Pi * D * N$ where

  D = dia of the drill in m

  N = Speed of rotation in rpm

Feed Rate (f):-

It's the movement of drill along the axis (rpm)

Depth of Cut (d):-

The distance from the machined surface to the drill axis

$d = D / 2$

Material Removal Rate:-

It's the volume of material removed by the drill per unit time

$$MRR = (\Pi D^2 / 4) * f * N \ \ mm^3 / min$$

Machining Time (T) :-

It depends upon the length (l) of the hole to be drilled , to the Speed (N) and feed (f) of the drill

$$t = L / f N \ min$$

In *Drilling operation*, the Machining Time is given by

$$T = \frac{L}{N \times f} \text{ min}$$

where N = rpm of drill

L = Length of axial travel of drill in mm

f = feed per rev. in mm

T = machining time in min

Now $L = l + a$ (See **Fig. 7.24**)

where l = depth or thickness of workpiece

a = approach of drill = 0.3d

and d = diameter of drill

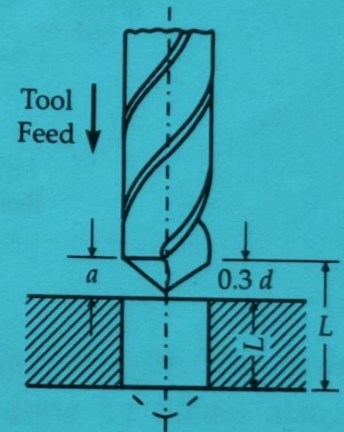


Fig. 7.24

Example 7.3 *Calculate the Machining Time for drilling 4 holes of* ***16 mm dia****. each on a flange from the following data. Flange thickness =* ***30 mm*** *; Cutting speed =* ***22 mpm****, Feed =* ***0.2 mm/rev****.*

Solution. $N = \frac{\text{Cutting speed} \times 1000}{3.14 \times d} = \frac{22 \times 1000}{3.14 \times 16} = \mathbf{438 \text{ r.p.m.}}$

For one hole ; $T = \frac{L}{N \times f} = \frac{30 + 0.3 \times 16}{438 \times 0.2} = \frac{\mathbf{34.8}}{\mathbf{87.6}}$ **min**

$\therefore$ For 4 holes, $T = \frac{4 \times 34.8}{87.6} = \mathbf{1.47 \text{ min.}}$

Approximate Energy Requirements in Cutting Operations (at drive motor, corrected for 80% efficiency; multiply by 1.25 for dull tools).

	Specific energy	
Material	$W \cdot s/mm^3$	$hp \cdot min/in.^3$
Aluminum alloys	0.4–1.1	0.15–0.4
Cast irons	1.6–5.5	0.6–2.0
Copper alloys	1.4–3.3	0.5–1.2
High-temperature alloys	3.3–8.5	1.2–3.1
Magnesium alloys	0.4–0.6	0.15–0.2
Nickel alloys	4.9–6.8	1.8–2.5
Refractory alloys	3.8–9.6	1.1–3.5
Stainless steels	3.0–5.2	1.1–1.9
Steels	2.7–9.3	1.0–3.4
Titanium alloys	3.0–4.1	1.1–1.5

Drilling Problems# 1

A 0.75-in-diameter drill is being used on a drill press operating at 300 rpm. If the feed is 0.005 in./rev, what is the material removal rate? What is the MRR if the drill diameter is tripled?

Drilling Problems# 2

A hole is being drilled in a block of magnesium alloy with a 15-mm drill at a feed of 0.1 mm/rev. The spindle is running at 500 rpm. Calculate the material removal rate, and estimate the torque on the drill.

Drilling Problems# 3

- A drilling operation is to be performed with a 12.7 mm diameter twist drill in a steel work part. The hole is a blind hole at a depth of 60 mm and the point angle is 118°. The cutting speed is 25 m/min and the feed is 0.30 mm/rev. Determine (a) the cutting time to complete the drilling operation, and (b) metal removal rate during the operation, after the drill bit reaches full diameter.

Drilling Problems# 4

- A two-spindle drill simultaneously drills a ½ in hole and a ¾ in hole through a work piece that is 1.0 inch thick. Both drills are twist drills with point angles of 118°. Cutting speed for the material is 230 ft/min. The rotational speed of each spindle can be set individually. The feed rate for both holes must be set to the same value because the 2 spindles lower at the same rate. The feed rate is set so the total metal removal rate does not exceed 1.50 in3/min. Determine (a) the maximum feed rate (in/min) that can be used, (b) the individual feeds (in/rev) that result for each hole, and (c) the time required to drill the holes.

Drilling Problems# 5

A NC drill press is to perform a series of through-hole drilling operations on a 1.75 in thick aluminum plate that is a component in a heat exchanger. Each hole is 3/4 in diameter. There are 100 holes in all, arranged in a 10 by 10 matrix pattern, and the distance between adjacent hole centers (along the square) = 1.5 in. The cutting speed = 300 ft/min, the penetration feed (*z*-direction) = 0.015 in/rev, and the traverse rate between holes (*x-y* plane) = 15.0 in/min. Assume that *x-y* moves are made at a distance of 0.50 in above the work surface, and that this distance must be included in the penetration feed rate for each hole. Also, the rate at which the drill is retracted from each hole is twice the penetration feed rate. The drill has a point angle = 100°. Determine the time required from the beginning of the first hole to the completion of the last hole, assuming the most efficient drilling sequence will be used to accomplish the job.

Drilling Problems# 6

- A gundrilling operation is used to drill a 9/64-in diameter hole to a certain depth. It takes 4.5 minutes to perform the drilling operation using high pressure fluid delivery of coolant to the drill point. The current spindle speed = 4000 rev/min, and feed = 0.0017 in/rev. In order to improve the surface finish in the hole, it has been decided to increase the speed by 20% and decrease the feed by 25%. How long will it take to perform the operation at the new cutting conditions?

Drilling Problems# 7

- In a drilling operation, a 0.5-in. drill bit is being used in a low-carbon steel work piece. The hole is a blind hole which will then be tapped to a depth of 1 in. The drilling operation takes place with a feed of 0.010 in./rev and a spindle speed of 700 rpm. Estimate the time required to drill the hole prior to tapping.

- In this problem we are going to deal a situation where one have to decide some parameters. The specifications are the choice of the design engineer.