# Drills

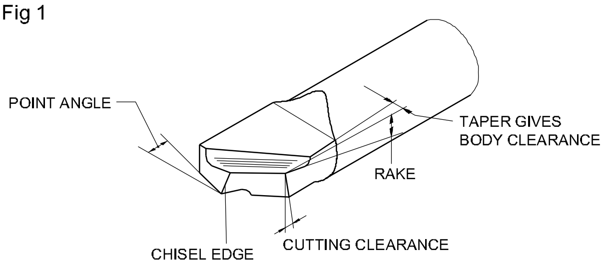
**Objectives:** At the end of this lesson you shall be able to
- **state drilling**
- **state the necessity of drilling**
- **name the types of drills used**
- **identify the parts of a twist drill.**

**Drilling:** Drilling is the production of cylindrical holes of definite diameters in workpieces by using a multi-point cutting tool called a 'drill'. It is the first operation done internally for any further operation.

### Types of drills and their specific uses

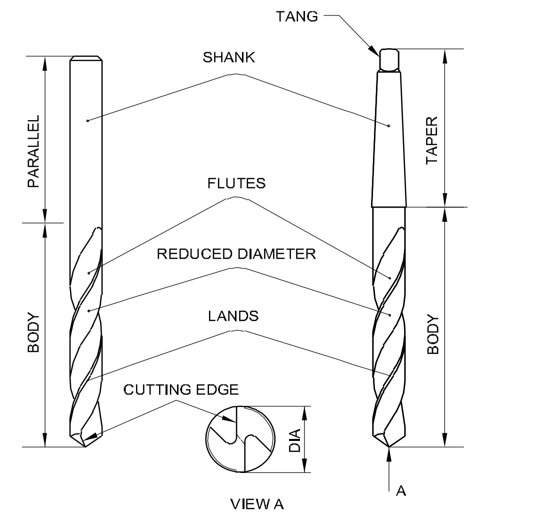
**Flat drill** (Fig 1) **:** The earliest form of drill was the flat drill which is easy to operate,besides being inexpensive to produce. But it is difficult to hold during operation,and the chip removal is poor. Its operating efficiency is very low.

Fig 1




**Twist drill :** Almost all drilling operation is done using a twist drill. It is called a twist drill as it has two or more spiral or helical flutes formed along its length. The two basic types of twist drills are, parallel shank and taper shank. Parallel shank twist drills are available below 13mm size (Fig 2).

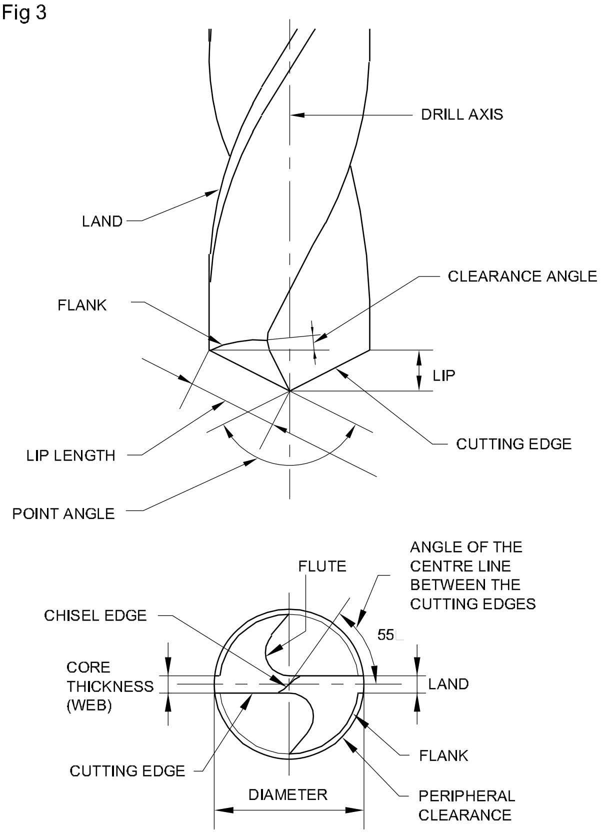
Fig 2




**Parts of a twist drill :** Drills are made out of high speed steel. The spiral flutes are machined at an angle of 27 1/2° to its axis.

The flutes provide a correct cutting angle which provides an escape path for the chips. It carries the coolant to the cutting edge during drilling. (Fig 3)

Fig 3




The portions left between the flutes are called 'lands'. The size of a drill is detemined and governed by the diameter over the lands.

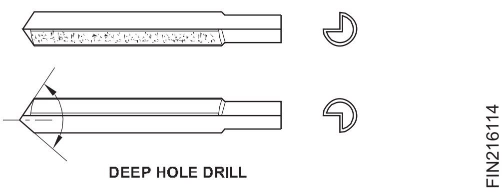
The point angle is the cutting angle, and for general purpose work, it is 118°. The clearance serves the purpose of clearing the back of the lip from fouling with the work. It is mostly 8°.

### Deep hole drills

Deep hole drilling is done by using a type of drill known as 'D' bit (Fig 4)

| |
|---|
| **Drills are made of high speed steel.** |

Fig 4

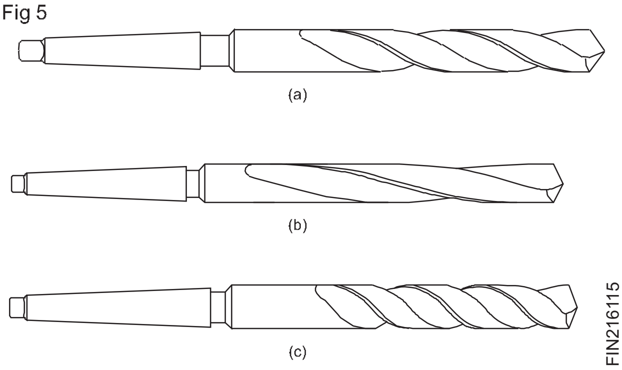



Drills are manufactured with varying helix angles for drilling different materials. General purpose drills have a standard helix angle of 27 1/2°. They are used on mild steel and cast iron. (Fig 5a)

A slow helix drill is used on materials like brass, gun metal, phosphor-bronze and plastics. (Fig 5b)

A quick helix drill is used for copper, aluminium and other soft metals (Fig 5c)

Fig 5



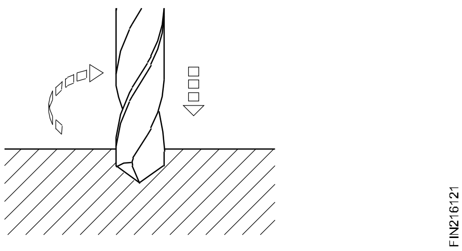

**A quick helix drill should never be used on brass as it will 'dig in' and the workpiece may be thrown from the machine table.**

## Drill (Parts and functions)

**Objectives:** At the end of this lesson you shall be able to
- **state the functions of drills**
- **identify the parts of a drill**
- **state the functions of each part of a drill.**

Drilling is a process of making holes on workpieces.The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate into the material. (Fig 1)

Fig 1




**Parts of a Drill** (Fig 2)

The various parts of a drill can be identified from figure 2.

**Point**

The cone shaped end which does the cutting is called the point. It consists of a dead centre, lips or cutting edges, and a heel.

**Shank**

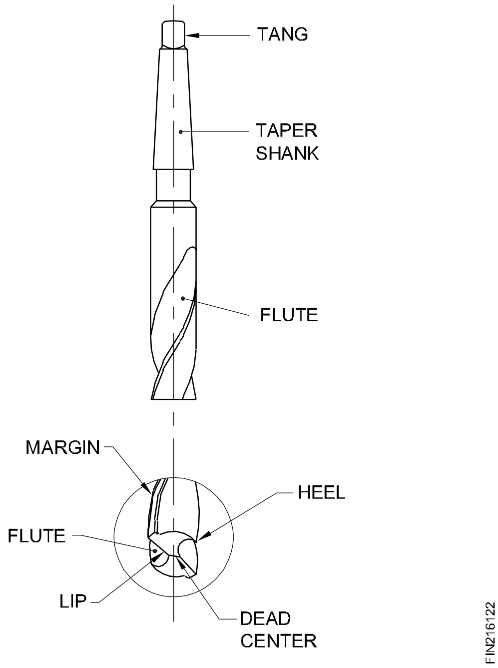
This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Taper shank, used for larger diameter drills, and straight shank, used for smaller diameter drills. (Fig 3)

**Tang**

This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Fig 2




**Body**

The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

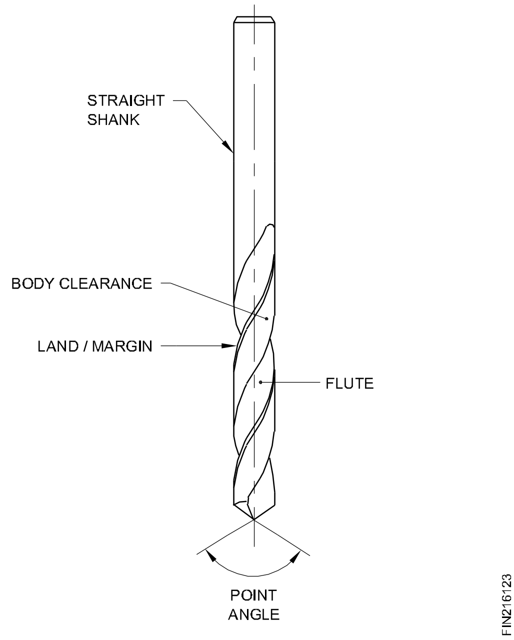
**Flutes** (Fig 3)

Flutes are the spiral grooves which run to the length of the drill. The flutes help

- To form the cutting edges
- To curl the chips and allow these to come out
- The coolant to flow to the cutting edge.

**Land/Margin** (Fig 3)

Fig 3




The land/margin is the narrow strip which extends to the entire length of the flutes.

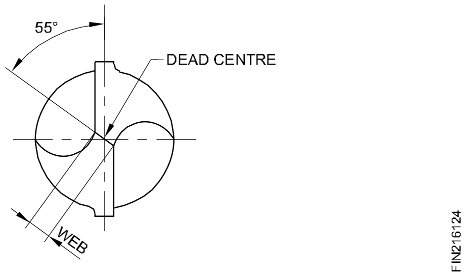
The diameter of the drill is measured across the land/ margin.

**Body clearance** (Fig 3)

Body clearance is the part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

**Web** (Fig 4)

Fig 4




Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.

— — — — — —

# Drill angles

**Objectives:** At the end of this lesson you shall be able to
- **identify the various angles of a twist drill**
- **state the functions of each angle**
- **list the types of helix for drills as per ISI**
- **distinguish the features of different types of drills**
- **designate drills as per ISI recommendations.**

Like all cutting tools the drills are provided with certain angles for efficiency in drilling.

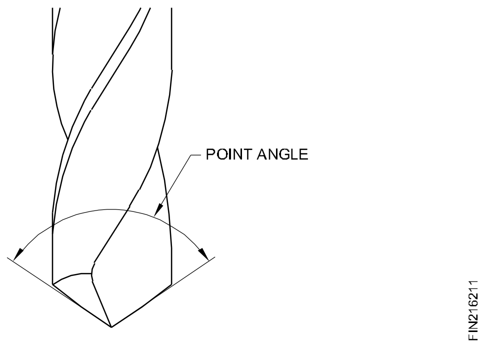
**Drill angles**

They are different angles for different purposes. They are listed below.

Point angle, helix angle, rake angle, clearance angle and chisel edge angle.

**Point angle/ cutting angle** (Fig 1)

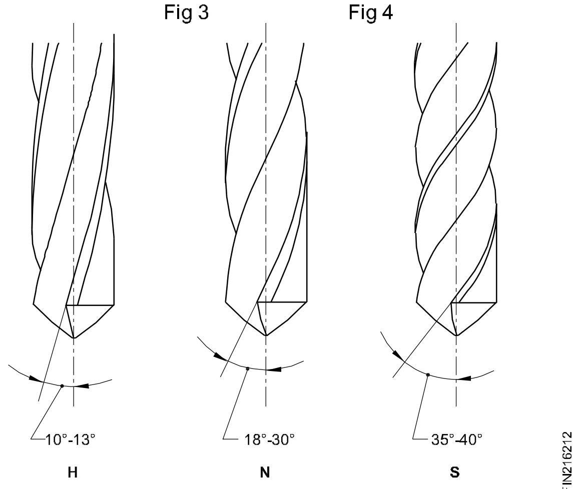
Fig 1




The point angle of a general purpose (standard) drill is 118°. This is the angle between the cutting edges (lips). The angle varies according to the hardness of the material to be drilled. (Fig 1)

**Helix angle** (Figs 2,3 and 4)

Fig 2 Fig 3 Fig 4




Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of the twist drill.

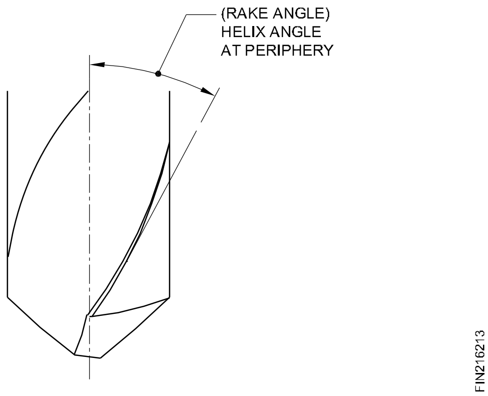
The helix angles vary according to the material being drilled. According to indian standards, three types of drills are used for drilling various materials.

- Type N - For normal low carbon steel.
- Type H - For hard and tenaceous materials.
- Types S - For soft and tough materials.

The type of drill used for general purpose drilling work is type N.

**Rake angle** (Fig 5)

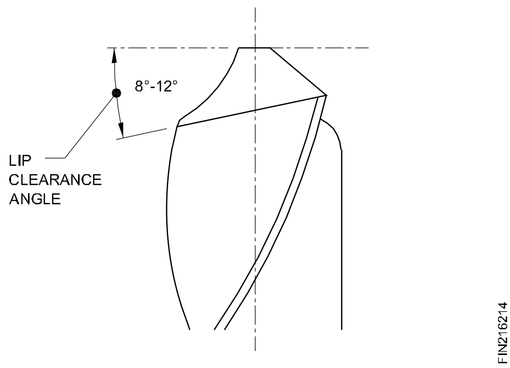
Fig 3




Rake angle is the angle of flute (helix angle).

**Clearance angle** (Fig 6)

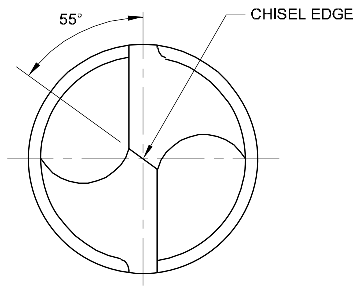
Fig 4



The clearance angle is meant to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much, the cutting edges will be weak, and if it is too small, the drill will not cut.

**Chisel edge angle/web angle** (Fig 7)

Fig 5




FIN216215

This is the angle between the chisel edge and the cutting lip.

**Designation of drills**

Twist drills are designated by the

- Diameter
- Tool type
- Material

**Example**

A twist drill of 9.50 mm dia. of tool type 'H' for right hand cutting and made from HSS is designated as:

Twist drill 9.50 - H - IS5101 - HS

where H = tool type

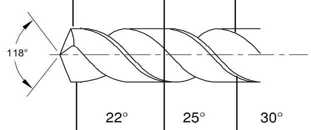
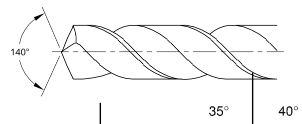
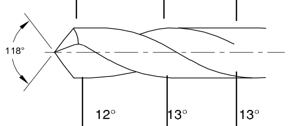
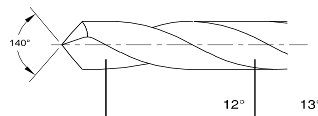
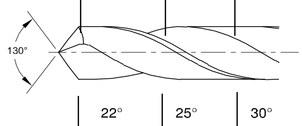
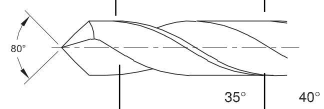
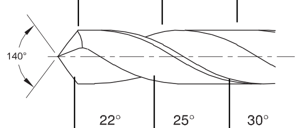
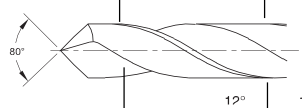
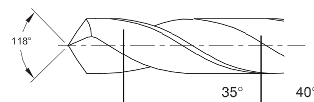
IS5101 = IS Number

HS = tool material

9.5 = diameter of the drill.

If the tool type is not indicated in the designation, it should be taken as type 'N' tool.

**DRILLS FOR DIFFERENT MATERIALS**

| **Recommended drills** | | | | | |
|---|---|---|---|---|---|
| **Material to be drilled** | **Point angle** | **Helix angle** d=3.2-5 5-10 10- | **Material to be drilled** | **Point angle** | **Helix angle** d=3.5-5 5- |
| Steel and cast steel up to 70 kgf/mm² strength<br>Gray cast iron<br>Malleable cast iron<br>Brass<br>German silver, nickel. | |  | Copper (up to 30 mm drill diameter)<br>Al-alloys,forming curly chips<br>Celluloid | |  |
| Brass, CuZn 40 | |  | Austenitic steels<br>Magnesium alloys | |  |
| Steel and cast steel 70...120 Kgf/mm² | |  | Moulded plastics (with thickness s>d) | |  |
| Stainless steel;<br>Copper (drill diameter more than 30 mm)<br>Al-alloy, forming short broken chips | |  | Moulded plastics, with thickness s<d<br>Laminated plastics, hard rubber (ebonite)<br>marble, slate, coal | |  |
| | | | Zinc alloys | |  |

— — — — — —

# Drilling - Cutting speed, feed and r.p.m , drill holding devices

**Objectives:** At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and rpm**
- **determine r.p.m/spindle speed**
- **select r.p.m for drill sizes from the tables.**

For a drill to give a satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled,and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the Table 1. Based on the cutting speed recommended, the r.p.m, at which a drill has to be driven is determined.

**TABLE 1**

**Recommendad cutting speeds**

| Materials being drilled (HSS Tool) | |
|---|---|
| Aluminium | 70 - 100 |
| Brass | 35 - 50 |
| Bronze(phosphor) | 20 - 35 |
| Cast iron (grey) | 25 - 40 |
| Copper | 35 - 45 |
| Steel (medium carbon/mild steel) | 20 - 30 |
| Steel (alloy, high tensile) | 5 - 8 |
| Thermosetting plastic (low speed due to abrasive properties) | 20 - 30 |

**Cutting speed calculation**

Cutting speed (V) $= \frac{\pi \times d \times n}{1000}$ m/min

$$r.p.m.(n) = \frac{V x 1000}{d x \pi}$$

n - r.p.m.

v - Cutting speed in m/min.

d - diameter of the drill in mm.

$\pi$ = 3.14

**Examples**

Calculate the r.p.m for a high speed steel drill ∅ 24 to cut mild steel.

The cutting speed for mild steel is taken as 30 m/min from the table.

$$n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ r.p.m}$$

It is always preferable to set the spindle speed to the nearest available lower range.

The r.p.m. will differ according to the diameter of the drills. The cutting speed being the same, larger diameter drills will have lesser r.p.m and smaller diameter drills will have higher r.p.m.

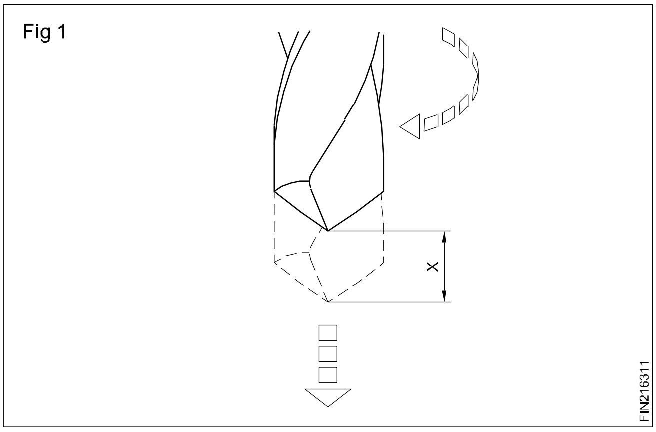
The recommended cutting speeds are achieved only by actual experiment.

# Feed in drilling

**Objectives:** At the end of this lesson you shall be able to
- **state what is meant by feed**
- **state the factors that contribute to an efficient feed rate.**

Feed is the distance (X) a drill advances into the work in one complete rotation. (Fig 1)

Feed is expressed in hundredths of a millimeter.




Example - 0.040mm/ rev

The rate of feed is dependant up on a number of factors.

- The finish required
- Type of drill (drill material)
- Material to be drilled

Factors like rigidity of the machine, holding of the work-piece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table gives the feed rate which is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

TABLE 1

| **Drill diameter** (mm) H.S.S | **Rate of feed** (mm/rev) |
|---|---|
| 1.0 - 2.5 | 0.040 - 0.060 |
| 2.6 - 4.5 | 0.050 - 0.100 |
| 4.6 - 6.0 | 0. 075 - 0.150 |
| 6.1 - 9.0 | 0.100 - 0.200 |
| 9.1 - 12.0 | 0.150 - 0.250 |
| 12.1 - 15.0 | 0.200 - 0.300 |
| 15.1 - 18.0 | 0.230 - 0.330 |
| 18.1 - 21.0 | 0.260 - 0.360 |
| 21.1 - 25.0 | 0.280 - 0.380 |

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

**For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.**

## Drill-holding devices

**Objectives:** At the end of this lesson you shall be able to
- **name the different types of drill-holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes on materials, the drills are to be held accurately and rigidly on the machines.

The common drill-holding devices are drill chucks, sleeves and sockets.

**Drill chucks:** Straight shank drills are held in drill chucks. (Fig 1A) For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

The drill chucks are held on the machine spindle by means of an arbor (Fig 1B) fitted on the drill chuck.

**Taper sleeves and sockets (Fig 2):** Taper shank drills have a Morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedging action. Due to this reason Morse tapers are called self-holding tapers.

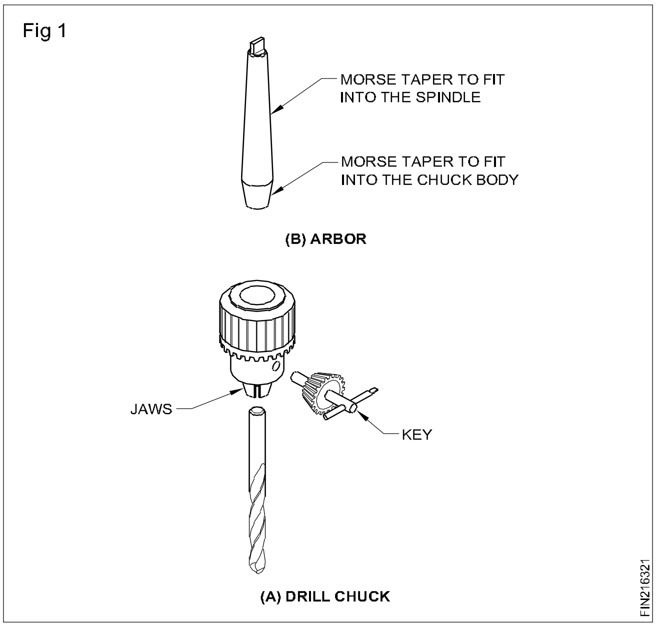
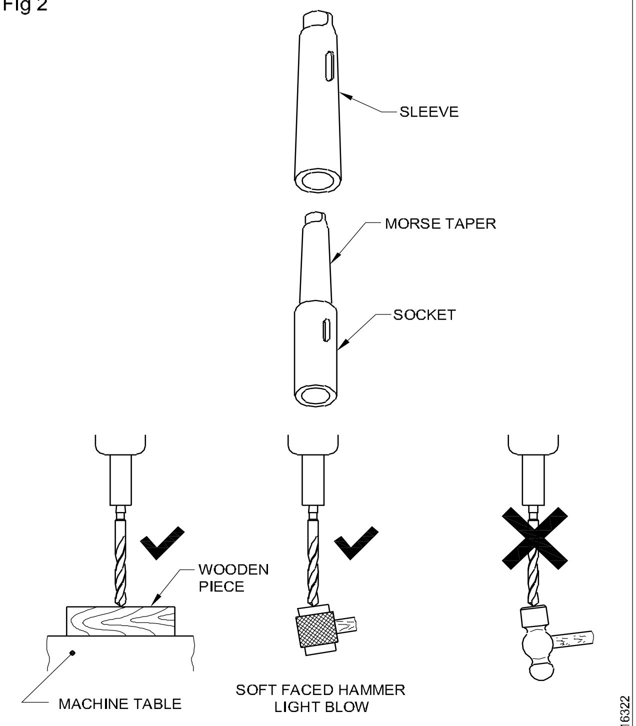


Fig 2




FIXING DRILLS ON SPINDLE

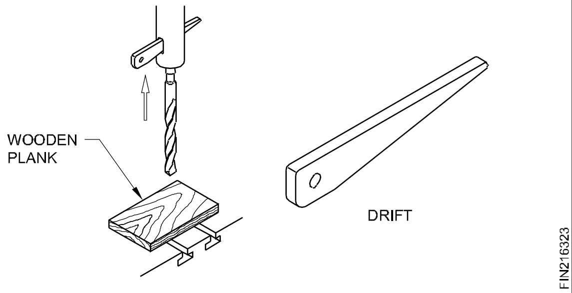
The drills are provided with five different sizes of Morse tapers, and are numbered from MT 1 to MT 5.

In order to make up the difference in sizes between the shanks of the drills and the bore of machine spindles, sleeves of different sizes are used. When the drill taper shank is bigger than the machine spindle, taper sockets are used. (Fig 2)

While fixing the drill in a socket or sleeve, the tang portion should align in the slot. This will facilitate the removal of the drill or sleeve from the machine spindle.

Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

Fig 3




While removing the drill from the sockets/sleeves don't allow it to fall on the table or jobs.

**Drill chucks are made from special alloy steel**

**Drill sleeves are made from case hardened steel**

— — — — — —