Introduction

When one mechanical member rests on another and there is relative motion between them, they constitute a bearing. However, bearings are generally regarded as separate elements, which are inserted between the two mechanical members, and which permit controlled relative motion between them.

A bearing has ONE main function:—
To lessen the friction between the two members.

All rotating parts of machinery are supported by a type of bearing. Generally speaking, bearings may be broadly classified into TWO main groups:

(A) Plain bearings.

(B) Rolling contact bearings (anti-friction bearings).

(A) **PLAIN BEARINGS** (Also known as JOURNAL bearings, SLEEVE bearings or BUSHES).

In this type of bearing there is a sliding contact between the shaft and the bearing. Plain bearings offer the simplest and most economical means of supporting shafts. They have no moving parts and are usually nothing more than one piece of metal enclosing a shaft.

NOTE: A plain bearing can be split. e.g., the "big end" bearing of a con-rod.

(a) Journal Bearings (Bushes)
Refer to Fig. 1.

![Diagram of Journal Bearing](image)

FIG. 1

This type of bearing is intended to resist radial loading, i.e., loading which is perpendicular to the axis of the shaft. The word 'journal' refers to the supporting portion of the shaft.
In the simplest form of journal bearing there is no bush. The journal revolves in a hole in the main member. This is acceptable in certain cases e.g. a shaft with only occasional use, hand operated shafts etc. Alternatively the shaft may be the stationary member.

(b) Thrust Bearings
Refer to Fig. 2.

This type of bearing is used to resist thrust or axial loading, i.e., loading which is along the axis of the shaft.

A plain thrust bearing may be in the form of a collar, washer or a series of washers, and usually bears against a collar which is an integral part of the shaft.

(c) Flanged Bearings
Refer to Fig. 3.

This type of bearing is used when there is a combination of both radial and thrust loading. It is therefore a combination of both the journal and thrust bearings and as its name suggests, resembles a bush with a flange attached.
Plain bearings are generally made from a metal that has good wearing qualities. Metals most commonly used for this purpose are phosphor-bronze, brass, gunmetal and cast iron.

NOTE: Plain bearings are also manufactured from 'teflon', which as well as having good wearing qualities, has the distinct advantage that it can be operated at much higher speeds than the metallic bushes - in the region of 6000 R.P.M.

Other non-metallic bearing materials are nylon and ferobestos.

The shaft should have a smooth finish and should be harder than the bearing material. The smoother and harder the shaft, the better the operating performance.

For practical reasons, the length of the bearing should be between one and two times the shaft diameter, and the outside diameter approximately 25% larger than the shaft diameter.
Refer to Fig. 4.

Plain bearings are a commercial item and are readily obtainable in a large combination of diameters and lengths.

NOTE: Always refer to manufacturer's catalogues when selecting a plain bearing and choose a stock item if possible.

Lubrication of Plain Bearings

(1) Self-lubrication.

A majority of the plain bearings used today are the self-lubricating type, i.e., the bearing is made of porous material and is impregnated with oil or some other suitable lubricant, which automatically lubricates the bearing surfaces during operation. This type of bearing is a great asset where regular lubrication is difficult or sometimes impossible to supply.

(2) External lubrication

An external supply of lubricant is fed to the bearing by various means. It is used:-

(a) for bearings which are not self-lubricating e.g., phosphor bronze, brass or gunmetal. Oil or grease can be used.

(b) as a supplementary lubrication for self-lubricating bearings, in order to give longer life and better performance.

Oil only should be used.
Lubrication Methods

Refer to Fig. 5, page 7.5, for examples of lubrication methods applicable to rotating shafts and rotating housings.

When lubrication is supplied to a bush it is desirable to have either:

(1) A flat on the shaft (in the case of stationary shafts). The flat (say 1.5 mm deep) should be slightly shorter in length than the bush and on the non-pressure side.

or (2) A network of suitable grooves in the bush. Longitudinal grooves generally stop short of the ends of the bush.

In the case of reciprocating motion there should be sufficient oil or grease grooves to ensure lubrication to all parts of the journal.

Advantages of Plain Bearings

(1) Initial cost is lower in most cases.

(2) Less radial space required than for rolling contact bearings.

(3) Better suited to overload and shock conditions.

(4) Quieter operation than rolling contact bearings, especially after wear has taken place.

(5) Less difficulty with fatigue.

(6) Less easily injured by foreign matter.

Disadvantages of Plain Bearings

(1) Limited to relatively low speeds (metallic types).

(2) Require constant supervision for lubrication. (Not self-lubricating types.)

(3) Relatively high rate of wear.

(B) ROLLING CONTACT BEARINGS. (Ball, Roller and Needle bearings)

These are sometimes called antifriction bearings because with this type of bearing, friction has been reduced to a minimum. Rolling contact bearings may be classified into three main groups:

(1) those capable of taking radial loads only

(2) those capable of taking thrust loads only

(3) those capable of taking a combination of both radial and thrust loads.

(1) Radial loads only
   Cylindrical roller bearings
   Needle bearings
FIG. 5
(2) Thrust loads only
- Thrust ball bearings
  - Angular contact thrust ball bearings

(3) Radial and thrust loads
- Deep groove ball bearings
- Self aligning ball and roller bearings
- Angular contact ball bearings
- Spherical roller bearings, double row
- Spherical roller bearings, single row
- Tapered roller bearings
- Spherical roller thrust bearings

Most rolling contact bearings consist of the following components:

(a) an inner ring (inner race)
(b) an outer ring (outer race)
(c) a set of rolling elements
(d) a 'cage' (separator)

The cage separates the rolling elements and spaces them evenly around the periphery of the inner race.
Refer to Fig. 6.

![Diagram of bearing components](FIG. 6)

Discussion will be confined to the following main types of antifriction bearings.

(1) Single row deep groove ball bearings.

Refer to Fig. 7(a).

Owing to the groove depth, ball size and high degree of conformity between balls and grooves, this bearing can deal with considerable axial load in addition to radial load.

![Diagram of deep groove ball bearing](FIG. 7(a))
(2) **Self-aligning ball bearings.**

Refer to Fig. 7(b).

The self-aligning ball bearing has two rows of balls with a common sphered track in the outer ring. This form of track gives the bearing its self-aligning property and permits automatic adjustment to minor angular displacements to the shaft due to mounting errors. It also prevents the bearing from exerting even the slightest bending influence on the shaft. This bearing will take small axial loads.

Used where bending is a significant feature of the shaft design or accurate mounting is difficult. Examples: Shafts with overhung loads, line shafting.

(3) **Self-aligning roller bearings.**

Refer to Fig. 7(c).

As for self-aligning ball bearings except that spherical rollers replace the balls. Will take heavy axial loads.

(4) **Single thrust ball bearings.**

Refer to Fig. 7(d).

The single thrust ball bearing has one row of balls between two washers. Deals exclusively with axial loads acting in one direction.

(5) **Adapter bearings.**

Refer to Figs. 7(e) and (f).

These are normal self-aligning ball or roller bearings fitted with a tapered split sleeve (adapter sleeve), lock washer and nut. After the assembly is placed in position on a shaft the lock washer is tightened. This forces the bearing up the adapter sleeve taper and clamps the bearing assembly in position.

Shaft tolerance does not have to be close. This type of bearing is ideal for bright rolled mild steel shafting.
(6) **Cylindrical roller bearings.**

Refer to Fig. 7(g) for a few of the many different variations of this type of bearing.

![Diagram of cylindrical roller bearings](image)

The rollers of the cylindrical roller bearing are guided by flanges on one of the bearing rings, the other ring usually having no flanges. This design has the merit of permitting relative axial displacement of shaft and bearing housing within certain limits. Bearings with a flange on the other ring as well can locate the shaft axially, provided that the axial load is not great. Dismantling is easy, even when both bearing rings have a tight fit. This bearing is suitable for comparatively heavy radial loads and for use at high speeds.

![Fig. 7(g)](image)

(7) **Single row angular contact ball bearings.**

Refer to Fig. 7(h).

![Diagram of single row angular contact ball bearings](image)

In the single row angular contact ball bearing the ball tracks are so disposed that a line through the ball contact points forms an acute angle with the bearing axis. This feature makes the bearing particularly suitable for heavy axial loads. A bearing of this type must always be adjusted towards another bearing capable of dealing with axial forces in the opposite direction. It cannot be separated into its component parts except by the use of force.

This is a more specialised bearing. The assemblies can be "normal" or in certain cases in machine design "preloaded".

![Fig. 7(h)](image)

(8) **Tapered roller bearings.**

Refer to Fig. 7(i).

![Diagram of tapered roller bearings](image)

![Fig. 7(i)](image)
Since the axes of its rollers and tracks form an angle with the shaft axis, the tapered roller bearing is especially suitable for carrying radial and axial forces acting simultaneously. In cases where the axial forces are very considerable, a series of bearings with a steep taper angle is available. Whichever design is used, the bearing must always be adjusted towards another bearing capable of dealing with axial forces acting in the opposite direction. The taper roller bearing is a separable type; its inner ring with rollers and its outer ring are mounted separately.

(9) Transmission housings.
Refer to Figs. 7(j), (k) and (l).

These are a few of the very wide range of split and solid housings (generally of C.I.) available fitted with adapter bearings.

Bearing Assemblies (for bearings shown in Fig. 7(a), (b), and (c), pages 7.6 and 7.7).

When designing bearing assemblies ensure that the bearings cannot be pre-loaded i.e., loaded with forces that are not design loads. Pre-loads can be caused by differential thermal expansion of the shaft and housings or by imperfections in the manufacture of these parts. (Deliberately pre-loaded bearing assemblies are a highly specialised form of design which is only discussed briefly in this book in the section on single row angular contact ball bearings, pages 7.8 and 7.14.)

Two assembly conditions arise for consideration:
(a) rotating shaft.  
(b) rotating housing.

There are two basic methods of designing a bearing assembly to avoid pre-loading:
(1) The floating bearing method.
(2) The fixed bearings method.

Firstly it must be understood that whichever ring of the bearing rotates, has the tighter fit: the inner ring for a rotating shaft or the outer ring for a rotating housing. This is of importance where method (1) is used. In this method one bearing is fixed on the shaft and in the housing; the second bearing, the non-locating bearing, has only one ring, the one having the tighter fit, axially located, the other ring must be free to move axially in relation to the shaft or housing.

Where the bearings are arranged so that axial location of the shaft is given by each bearing in one direction only, method (2), it is sufficient for the rings to be located at one side only. This arrangement is mainly used for short shafts, with either rotating shaft or rotating housing.

(1) Refer to Fig. 8, page 7.10.

This shows the floating bearing method which is generally used for a rotating
The bearing at one end is fixed in position on the shaft and in the housing. At the opposite end the bearing is fixed only on the shaft, the outer race having the ability to "float" axially, thus avoiding any likelihood of pre-loading the bearing assembly.

FIG. 8

(2) Refer to Fig. 9, page 7.11.

This shows an alternative bearing assembly which requires a little more care with machining if pre-loading is to be avoided. Typically in this method the parts are made and assembled with the exception that one spacer or the spigot on one cover is left unmachined in length. This part is omitted from the preliminary assembly.

The required length is measured from the partial assembly and then the appropriate part is completed. In actual fact the complete assembly is given approximately 0.05 mm axial float.

Bearing assemblies for bearings shown in Fig. 7(g), (h) and (i), page 7.8.

(1) Cylindrical roller bearings.

Typical bearing mounting No. 1, refer to Fig. 10.

The shaft shown in this example is the rotating member so the inner rings of the bearings are an interference fit. The outer rings are normally made a transition fit, but a tighter fit may be used if necessary. The shaft is located axially in both directions by the four ribbed roller bearing (these ribs are known alternatively as lips or flanges). It is suitable for heavy radial loading and can also accommodate light, intermittent or reversing, axial loads provided the speed is not high. Limited axial expansion can be accommodated as there is no danger of the two bearings being nipped together axially. The ribs of the locating bearing are backed-up by deep abutments to minimise shear stresses being set up in the ribs.

FIG. 10

It is important that these deep abutments are flat and square with the axis of rotation, otherwise the ribs could become distorted resulting in premature failure of the bearing.  (Cont. on page 7.12.)
Fig. 9 shows a typical rope sheave assembly. As it is sometimes customary to arrange several sheaves on a common shaft, the sheaves and bearings should be as compact as possible to give the least pulley block width. Also, in these situations one grease fill lasts for several years.
7.12

Typical bearing mounting No. 2, refer to Fig. 11.

The above arrangement is one where an abutment can be provided only on one side of a roller bearing outer ring and the roller bearing with double ribbed inner ring, single ribbed outer ring is particularly advantageous. If an outer ring should attempt to move axially then positive restraint is provided in one direction by the abutment and in the other by the rollers. The outer rings are mounted offset to prevent the rollers binding on the ring ribs. Again, the ribs are backed-up by deep abutments to prevent shear stresses being set up in the ribs. It is important that these deep abutments are flat and square with the axis of rotation, otherwise the ribs could become distorted.

As the inner rings rotate they must be made interference fits on the shaft. Normally, the outer rings are interference fits when not clamped endwise as is the case in this arrangement.

(2) Single row angular contact ball bearings.

Typical bearing mounting No. 1, refer to Fig. 12.

This is the common method of arranging angular contact bearings when the shaft is the rotating component. They will take axial loads in either direction in addition to carrying radial loads. The open sides of the outer rings face one another and, consequently, the lines joining the points of contact between the balls and the raceways of each bearing converge towards one another as they approach the shaft.

To remove unwanted play from the two bearings and to ensure that the balls are maintained in the correct running position, adjustment is carried out through the outer ring of one bearing by means of shims. The outer rings must be sliding fits in the housings and the inner rings are interference fits on the shaft. A rotating shaft usually runs at a higher temperature than its stationary housing and, as this causes expansion of the shaft relative to the housing, a small end movement should remain in the arrangement after adjustment. If this point is ignored the two bearings would become nipped together as a result of relative expansion. Because of the expansion problem this arrangement is only used when the distance between the bearings is short.

Typical bearing mounting No. 2, refer to Fig. 13, page 7.13.

The bearings in this arrangement face the opposite way to those in Mounting (1); the lines of contact between the balls and their raceways diverge as they
7.13

FIG. 13

approach the shaft and give a more rigid mounting than the previous application for moment loading.

Adjustment is carried out through one of the inner rings which must, therefore, be a sliding fit on the shaft. Consequently, this arrangement should only be used with a stationary shaft.

A small end movement should normally be left after adjustment to allow for any possible thermal expansion. The bearing centres are very short and rigidity is the primary requirement. The bearings can be axially pre-loaded providing due care is taken to avoid any overload condition. (Pre-loaded bearings are discussed on page 7.14).

To facilitate assembly of the inner ring of the inner bearing, the length of shaft between the bearings should be reduced marginally in diameter.

Typical bearing mounting No. 3, refer to Fig. 14.

FIG. 14

This is a variation of the arrangement shown in Fig. 12. It is also a favoured method for use with a rotating shaft.

The outer rings would be sliding fits in the housing and the inner rings interference fits on the shaft. The shaft should be reduced marginally in diameter for almost the full length of the spacer. This facilitates assembly of the inner ring of the inner bearing. (A small length of seating should be left for each end of the spacer.) Relief should be machined in the housing also, when this would facilitate bearing assembly.
Preload. This is an initial predetermined internal thrust (axial) load imposed on the bearings to provide both radial and axial rigidity. This is accomplished in various ways depending on the type of application. There are several methods of obtaining the necessary amount of preload. The most important are:

- shims.
- spacers.
- springs.
- manual adjustment.

Normally, the preload should not exceed from one-fifth to one-third of the rated capacity of the bearing, and preferably only slightly above the minimum for satisfactory work.

Preloading is a specialised type of assembly and it is preferable to consult the Bearing Company in individual cases.

![Fig. 15(a)](image)

Preload may be adjusted by the cover shims or spacer length.

![Fig. 15(b)](image)

Preload may be adjusted by varying either of the spacer lengths.

![Fig. 15(c)](image)

Preload can be varied by nut adjustment.

(3) Tapered roller bearings

On account of the tapered construction of a Tapered Roller Bearing, an applied radial load sets up a thrust reaction which must be resisted by another bearing. Hence it is not generally practicable to mount Tapered Roller Bearings singly, they must be used in pairs.

There are two fundamental methods of using such a pair of bearings:
The indirect mounting, in which the small ends of the rollers point inwards, Fig. 16(a).

![Indirect and Direct Mounting Diagrams]

The direct mounting, in which the small ends of the rollers point outwards, Fig. 16(b).

**Indirect mounting**

Indirect mounting of Tapered Roller Bearings is usual when space is limited, and it is essential to have the greatest stability of mounting possible, e.g., wheels, etc., mounted on stationary shafts. The spacing of bearing centres should be at least 10 per cent, and preferably 15 per cent to 20 per cent of the diameter of the wheel they carry.

**Direct mounting**

Direct mounting is used for applications where ample bearing spread can be obtained and where it is desirable to make adjustment by the cups, such as in a high speed application, where the cone must be a press fit upon the shaft.

The increased stability of the indirect over the direct mounting may be better understood from Figs. 17(a) and (b), where, in the direct mounting, the lines of resultant force normal to the cone raceways cut the common axis of the bearings a distance $B_1$ apart. In the indirect mounting the corresponding distance $B_2$ is seen to be much greater, although the distance between the bearings $A$ is the same in each case.
A typical Tapered Roller Bearing mounting is shown in Fig. 18.

There are many factors affecting the choice and mounting of Tapered Roller bearings. They are a specialised type of bearing and it is advisable in individual problems to seek the help of the manufacturer. Complete books are devoted to instruction on the use of Tapered Roller Bearings.

Footstep bearing

Refer to Fig. 19.

This is a bearing arrangement which takes the vertical and horizontal loads at the base of a vertical shaft.
Selecting a rolling contact bearing

Machine designers have a large variety of bearing types and sizes at their disposal from which to make a choice. Each of these types have characteristics which make it best for a certain application. Although selection can become a complicated problem the following list could serve as a general guide for most applications:

(1) Generally, ball bearings are less expensive in the smaller sizes where lighter loads are involved, while roller bearings are less expensive in the larger sizes where heavier loads are involved.

(2) Roller bearings are more satisfactory under shock or impact loading than ball bearings.

(3) To accommodate any misalignment between shaft and housing, a 'self-aligning' type of bearing should be used. Self-aligning bearings are necessary where bending deflection is a significant feature of the shaft design.

(4) Single row thrust ball bearings should be subjected only to pure thrust loads only and the shaft speed should be moderately low. To accommodate thrust loading at high shaft speeds, it is better to use a bearing that will take a combination of both types of loads.

(5) Self-aligning ball bearings and cylindrical roller bearings have the lowest friction.

(6) Some bearings (e.g. single row deep groove ball bearings) are available with built-in seals so that the bearings can be pre-lubricated and thus operate for much longer periods of time without requiring attention. They can be purchased as single or double sealed or shielded. High speed should be avoided to prevent generation of excessive heat and subsequent melting of the grease.

Lubrication of rolling contact bearings

Lubricants are used in bearings for two main reasons:

(1) to reduce friction between the surfaces in contact

(2) to act as coolants and hence help to dissipate any heat which may be generated in the bearing

Lubricants also help to prevent corrosion of the bearing and they act as a barrier against the entry of foreign matter into the bearing.

The bearings may be:

(a) lubricated during usage by providing lubricant continuously or inter-mittently

(b) pre-lubricated, so that no additional lubricant has to be provided during a set usage of the bearing

Conventional types of lubricants can be generally classified into three groups:

(1) Oils.

(2) Greases.

(3) Solid-film lubricants.
Oils

The most important aspect to consider when selecting an oil to lubricate a bearing is the viscosity of the oil, i.e., the ability of the oil to flow and withstand loading over a range of temperatures.

The following types of oil lubrication can be employed according to the bearing set-up and requirements:-

(1) **Intermittent oiling** - usually carried out by hand, the oil reaching the bearing through an access hole.

(2) **Drop feed** - oil is released from a reservoir at a predetermined rate through some type of variable valve.

(3) **Oil bath** - this is a satisfactory method for low and medium speeds. The static level of the oil should not be higher than the centre of the lowest rolling element of the bearing being lubricated (if possible), otherwise overheating of the bearing may result.

(4) **Oil splash** - the system predominantly used in gearboxes, when the same lubricant is suitable for both gears and bearings. Care should be taken that the "splash" is sufficient to adequately lubricate but not heavy enough to flood the bearing.

(5) **Circulation** - the system used to lubricate heavy duty bearings. A pump is used to circulate the oil and so ensure a positive supply. Care should be taken to ensure that the oil flows freely and does not become "captive" in any part of the system.

(6) **Oil mist** - used for bearings which are operating continuously at high speeds. The oil is metered, atomized by compressed air, mixed with filtered air and supplied to the bearings under pressure. It is most important to "wet" the bearings when using this type of lubrication, i.e., commence lubrication of the bearings before the machinery is put into operation.

**Advantages of oil lubrication**

(1) Easier to drain and refill, which is important if lubricating intervals are close together.

(2) Oil used to lubricate bearings might also be usable in other parts of the machine.

(3) More effective than grease in dissipating heat from the bearing and its housing.

(4) Can be used over a greater range of speeds than grease.

(5) Readily feeds into all parts of the bearing.

(6) Helps to carry away foreign matter which may have entered the bearing.

**GREASES**

Greases are mostly mineral oils which have been thickened by the addition of some kind of metallic soap. Grease is usually applied in either of the following ways:
(1) **Intermittent greasing** - grease is pumped into the bearing at regular intervals using a conveniently placed nipple and grease gun. Care should be taken not to "over lubricate".

(2) **Prepacking** - the bearings are prepacked in grease so that they will last for a predetermined time without needing maintenance.

Some of the advantages of "prepacking" are:-

(i) grease might be harmful to other parts of the machinery.

(ii) space limitations might eliminate the use of a grease filled housing.

(iii) some housings cannot be kept free of contaminating material.

(iv) lubrication could be dangerous or even impossible to perform.

(v) lubrication could be overlooked.

**NOTE:** In either of the grease lubrication methods mentioned above there is no danger with very slow speed bearings in packing them fully with grease. It is with medium and high speed applications where this should be avoided because of the danger of overheating. In these cases the available space should be no more than one third filled with grease.

**Advantages of Grease Lubrication**

(1) Does not flow as readily as oil so it is easily contained in a housing.

(2) Leak-proof systems are not necessary.

(3) Less maintenance is required.

(4) Has better sealing qualities than oil and therefore helps to keep foreign matter out of the bearing.

**Solid-film Lubricants**

These are a relatively modern means of lubricating bearings. They are usually applied as a dry powder and have the advantages that they offer greater resistance to penetration by "rough" surfaces and they shear more easily than the conventional types of lubricants. (An advantage when starting machinery.)

Stringent requirements involving cost, load capacity, temperature resistance, operating environment, corrosiveness, abrasiveness etc. limit the selection of solid-film lubricants to a few types.

The types most commonly used are:-

graphite, molybdenum disulphide ("molybond"), tungsten disulphide, nylon (low loads only)

**Advantages of rolling contact bearings**

(1) Starting friction is low, (good for intermittent use and low starting temperatures).

(2) Loads can be inclined at almost any angle.
(3) Thrust components can be carried.
(4) Maintenance costs are relatively low.
(5) Bearings are easily replaced when worn.
(6) Less axial space required than for plain bearings.

Disadvantages of rolling contact bearings

(1) More expensive than plain bearings in most cases.
(2) Failure of one rolling element means failure of the complete bearing.
(3) More critical tolerancing required for both shaft and housing.

Sealing of rolling contact bearing assemblies

There are two main reasons for sealing bearing assemblies:

(1) To keep out dirt, grit, water, chemicals and any other foreign matter.
(2) To keep in the lubricant or alternatively to let excess lubricant (generally grease) escape. Allowing the excess grease to escape prevents the generation of pressure build-up and excessive heat.

Types of seals.

(1) Rubbing seals.
(2) Non-rubbing seals.
(3) Combination seals.

(1) Rubbing seals.

The two common types would be:

(a) felt
and (b) leather and synthetic rubber.

a). Felt seals must be used in combination either with sheet metal pressings, Fig. 20(a) or a deep machined taper sided groove, which the felt must fit snuggly and completely fill. These grooves are indicated in their typical form in the housings shown in Fig. 7(j), (k) and (l), page 7.9. Felt seals are only used for grease lubrication.

b). Most leather and synthetic seals are of a proprietary make. Although commonly known as "oil seals" they can be used for either oil or grease applications. They are available as complete assemblies in a metal pressing, with the seal backed up by a spring. Fig. 20(b) shows a typical oil seal. The spring maintains adequate contact force; the seal can follow the non-uniform rotational movement of the shaft to some degree. Fig. 9, page 7.11 shows a simple practical application. The seals can be fitted either way depending on the type of duty required.

Reversed assembly is sometimes used to allow excess grease to escape where
there is the likelihood of over-filling of the housing with grease.

A considerable variety of oil seal designs are available. These can be seen in the various manufacturer's catalogues.

Sometimes two seals are used, one facing in each direction. The space between the seals in this case should be filled with grease.

(2) Non-rubbing seals.

Annular grooves would be the most common type.

Other types are less commonly used, such as labyrinths and flingers.

Annular grooves are shown as an alternative application in Fig. 9, page 7.11. Three grooves are an ideal number to use where space is available. When these grooves are used with grease, the grooves pack hard with grease and make a close seal.

Groove size is generally about 1.5 to 3 mm square. Some designers prefer grooves that taper in towards the top. Shaft clearance where shaft bending is not a major problem should be about 0.8 mm on diameter for shafts up to 50 mm diameter. For larger shafts, diametral clearances of 1.3 mm have been successfully used.

(3) Combination seals.

These become rather specialised.

They are used sometimes in extremely dirty conditions. Various combinations are adopted by designers and the utilisation of the rubbing and non-rubbing principles in conjunction proves very effective.

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DESIGN OF BEARINGS

Plain Bearings

Glossary of Terms

N = speed of rotation in r.p.m.

p = bearing pressure on projected area, MPa

W = load supported by bearing, N

Q = reaction opposing W, N

L = bearing length, mm

d = diameter of journal, mm

r = radius of journal, mm