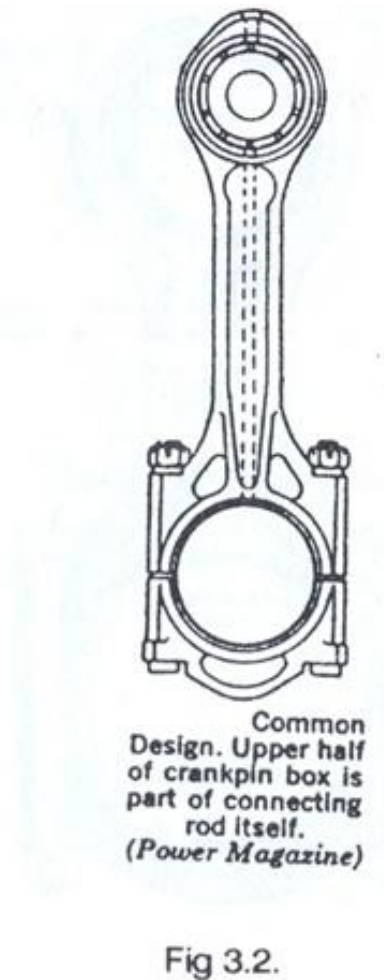
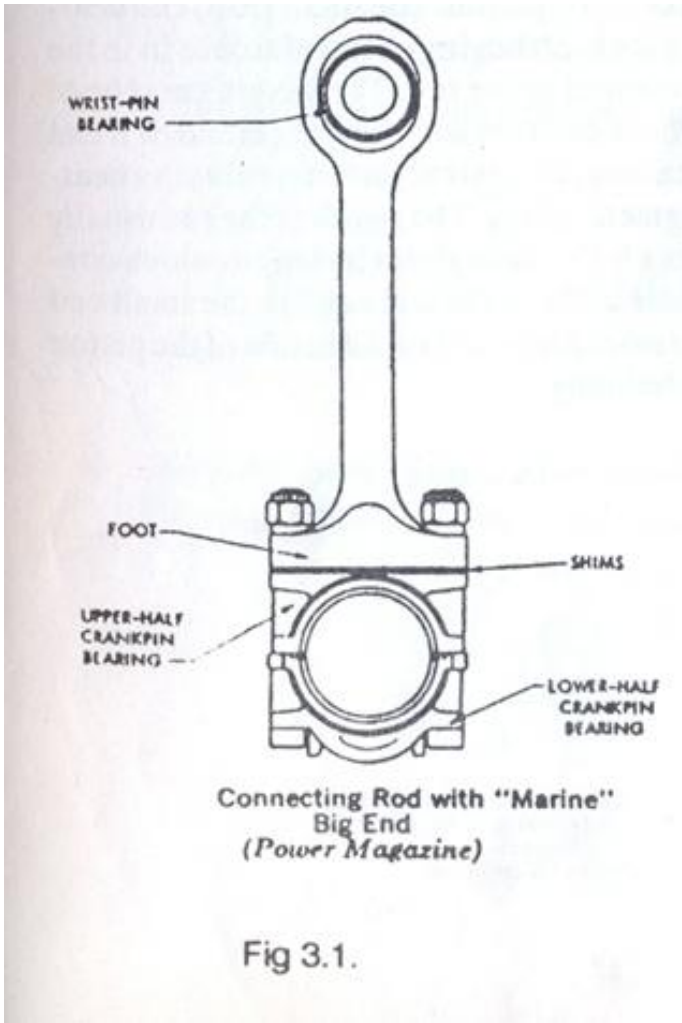


CONNECTING RODS



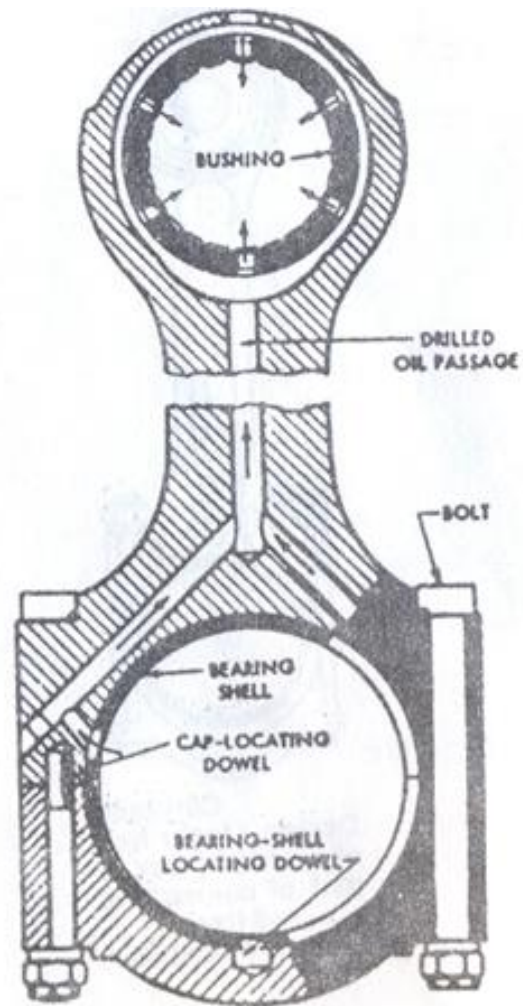
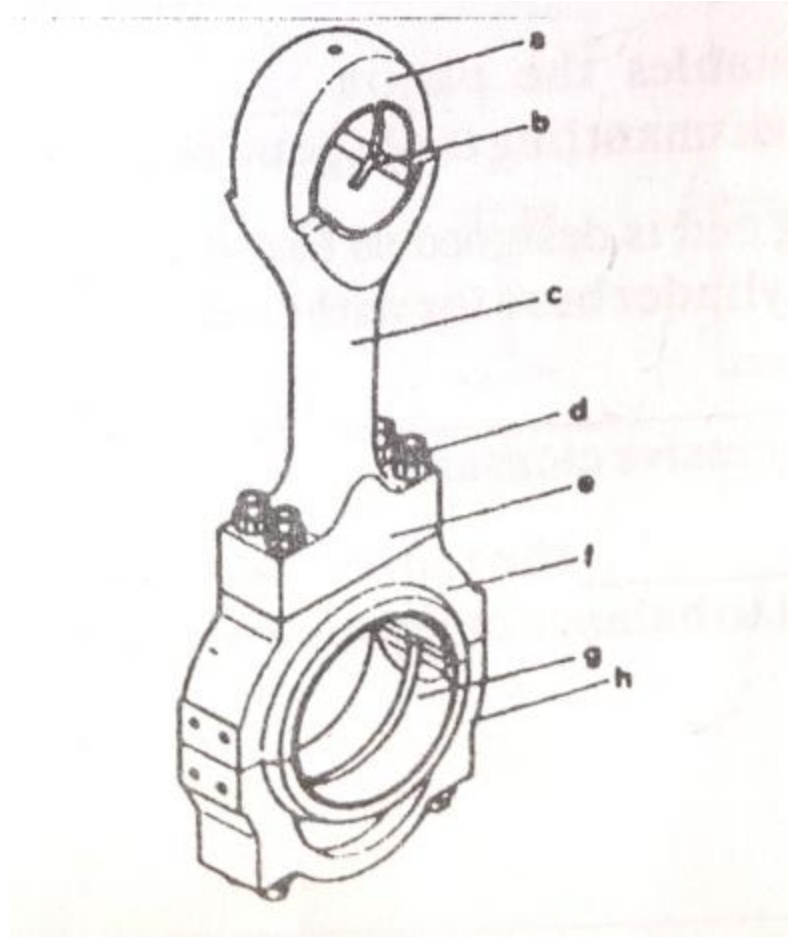


Fig.3.3



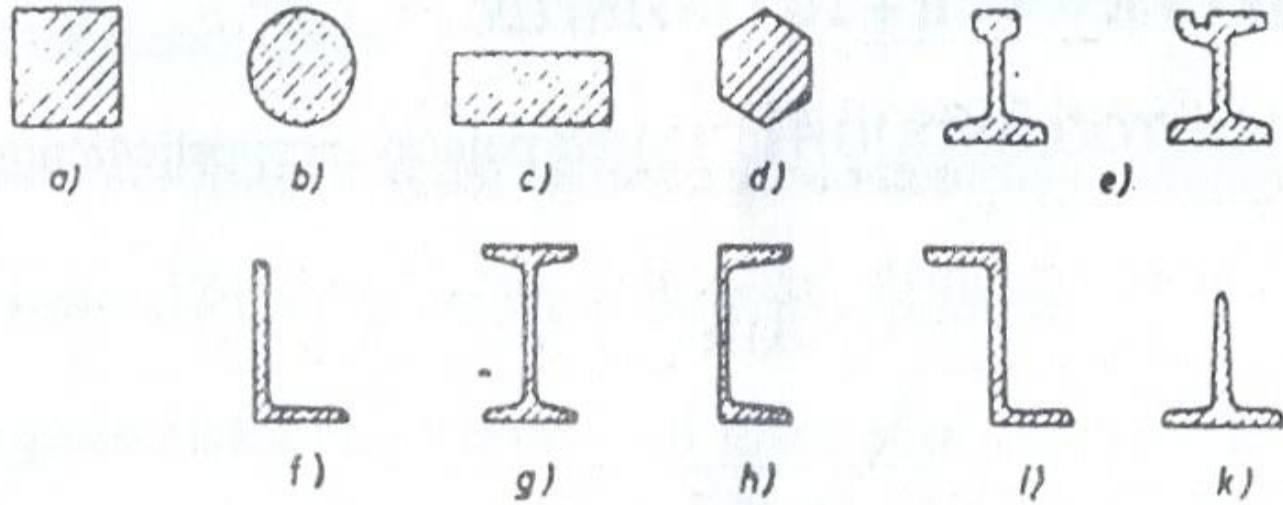
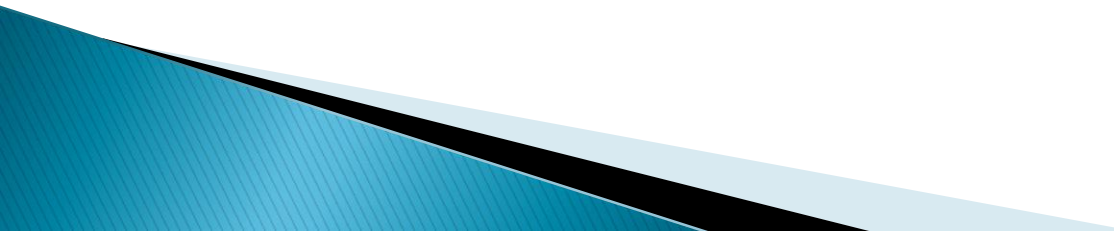
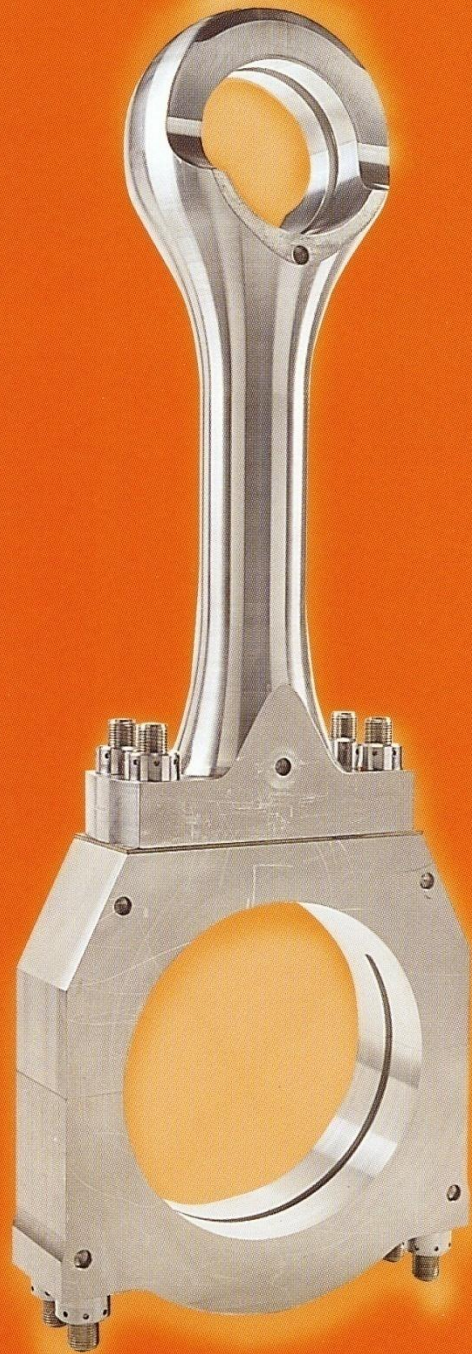


Fig.3.5



The connecting rod does this important task of converting reciprocating motion of the piston into rotary motion of the crankshaft. It consists of an upper forked section which fits on the crosshead bearings while the lower part fits on the crankpin bearing.





Complete the sentences below

- ▶ *The connecting rod does the important task of*
- ▶ *It consists of an upper forked section which fits on while the lower part fits on*

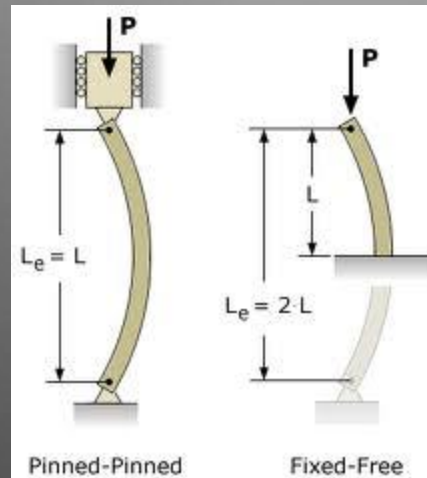
With this sort of arrangement there is heavy **axial loading** on the connecting rod which *reaches its peak* at the top dead center because the gas pressure and the inertial forces add to increase the overall force. Other abnormal working conditions such as **piston seizure** and momentary *increase in peak pressure* can also result in *severe increase in stress* on the con-rod and it could fail due to **buckling** due to these forces.

Buckle: to bend or cause to bend out of shape, esp. as a result of pressure or heat

Buckling: deformacija, izvijanje, (lima, stupa itd. pod tlakom)

Buckling:

Bending of a sheet, plate, or column supporting a compressive load



Supply the missing terms

With this sort of arrangement there is heavy _____ on the connecting rod which reaches its peak at the _____ because the gas pressure and the inertial forces add to increase the overall force. Other abnormal working conditions such as _____ and momentary increase in peak pressure can also result in severe increase in stress on the con-rod and it could fail due to _____ due to these forces.

Buckling: Bending of a sheet, plate, or column supporting a compressive load.

Construction of Con-Rod

Normally connecting rods are forge-manufactured and the material used is typically mild and medium **carbon steel**. The ends where the rod is connected to the X-head or crankpin have bearings which are made of **white metal** working surface and **shims** (thing packings) are used to make the necessary adjustments. There are four **bolts** at each connection point which help for assembly and removal of the connecting rod, and are *tightened* to their required torque using **hydraulic jack**.

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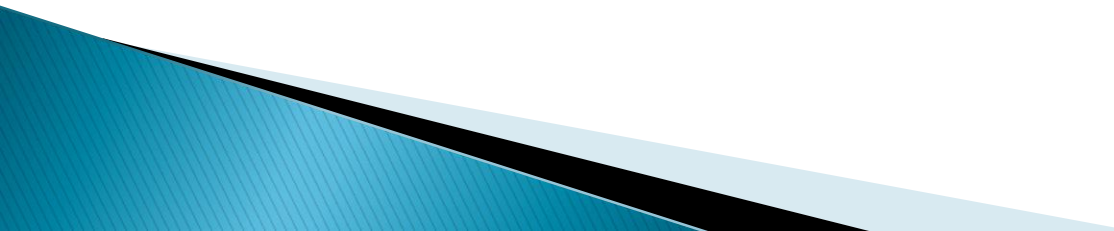
- ▶ In case of auxiliary marine diesel engines which are 4-stroke engines, the con-rod is constructed by **drop forging** and the material used is normally **alloy steel** and the **alloy metals** being nickel, chromium and molybdenum. The bottom end connecting bolts of 4 stroke engines often fail due to severe forces acting on them and this failure in turn can cause various **structural damages** in the engine in turn. Hence it is very necessary to tighten these bolts properly and keep *checking for their tightness*, lest one has to pay a heavy price for this minor negligence later on.

Fill in the prepositions

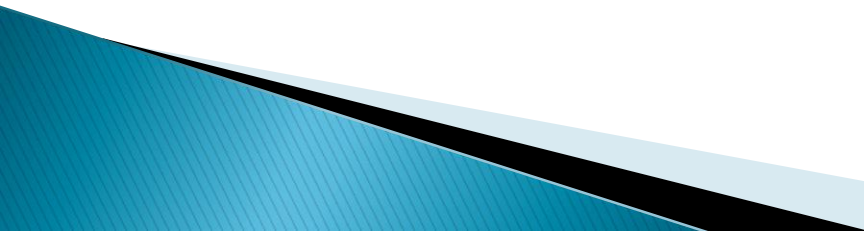
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Function

The **connecting rod** *connects the crankshaft directly to the piston* or, as in some other designs, *to the crosshead*. It is a running component connecting the crankshaft to the piston (in trunk piston engines) or to the crosshead (in crosshead engines). It has both linear (reciprocating, up-and-down) & rotational (rotary) motion.

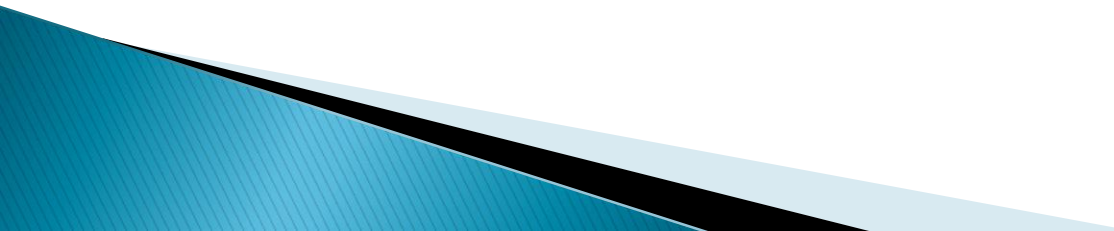


Function

- ▶ *The connecting rod connects the crankshaft directly or, as in some other designs, to*
 - ▶ *It connects the crankshaft to the piston (in _____ piston engines) or to the crosshead (in _____ engines).*
 - ▶ *It has two motions: _____ (reciprocating, up-and-down) & _____ motion.*
- 

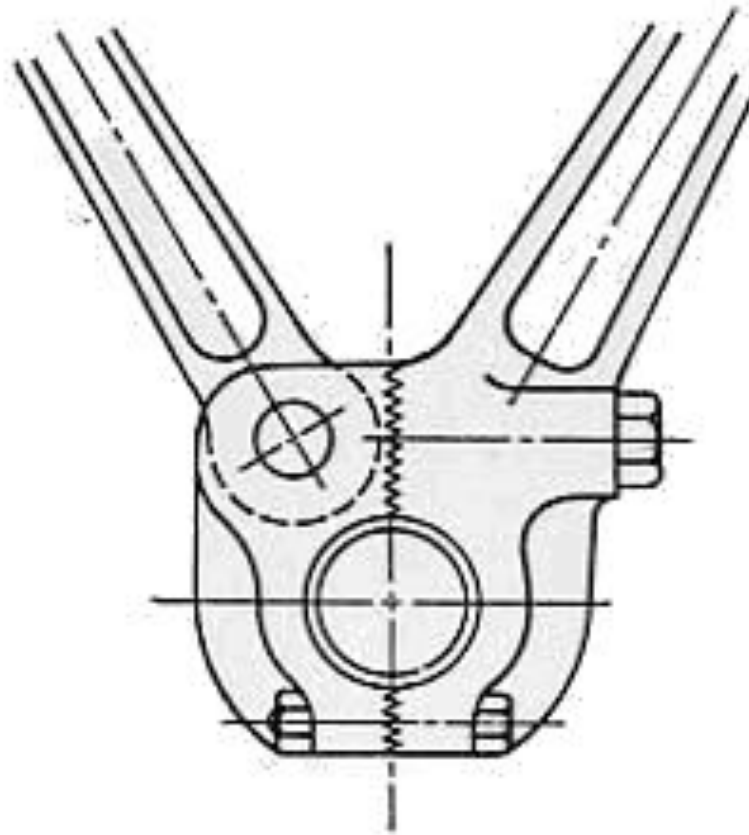
- ▶ *The primary function of the connecting rod is to transmit, either directly or indirectly.*
- ▶ *Its secondary function is to, which demands for a quite a large _____ passage*

TYPES

- ▶ Marine type: The large end bearing is separate from rod the rod which has a palm end (T-shaped end)
 - ▶ Fixed centre design: The upper half of the crankpin box makes part of of the connecting rod.
Alternative design: Connecting rod with obliquely split large end.
 - ▶ Fork and blade type: Vee engine connecting rods.
 - ▶ Articular type: Vee engine connecting rods
- 

TYPES

- ▶ _____: The large end bearing is separate from rod the rod which has a palm end (T-shaped end)
- ▶ _____: The upper half of the crankpin box makes part of of the connecting rod. Alternative design: Connecting rod with obliquely split large end.
- ▶ _____type: Vee engine connecting rods.
- ▶ _____ type: Vee engine connecting rods



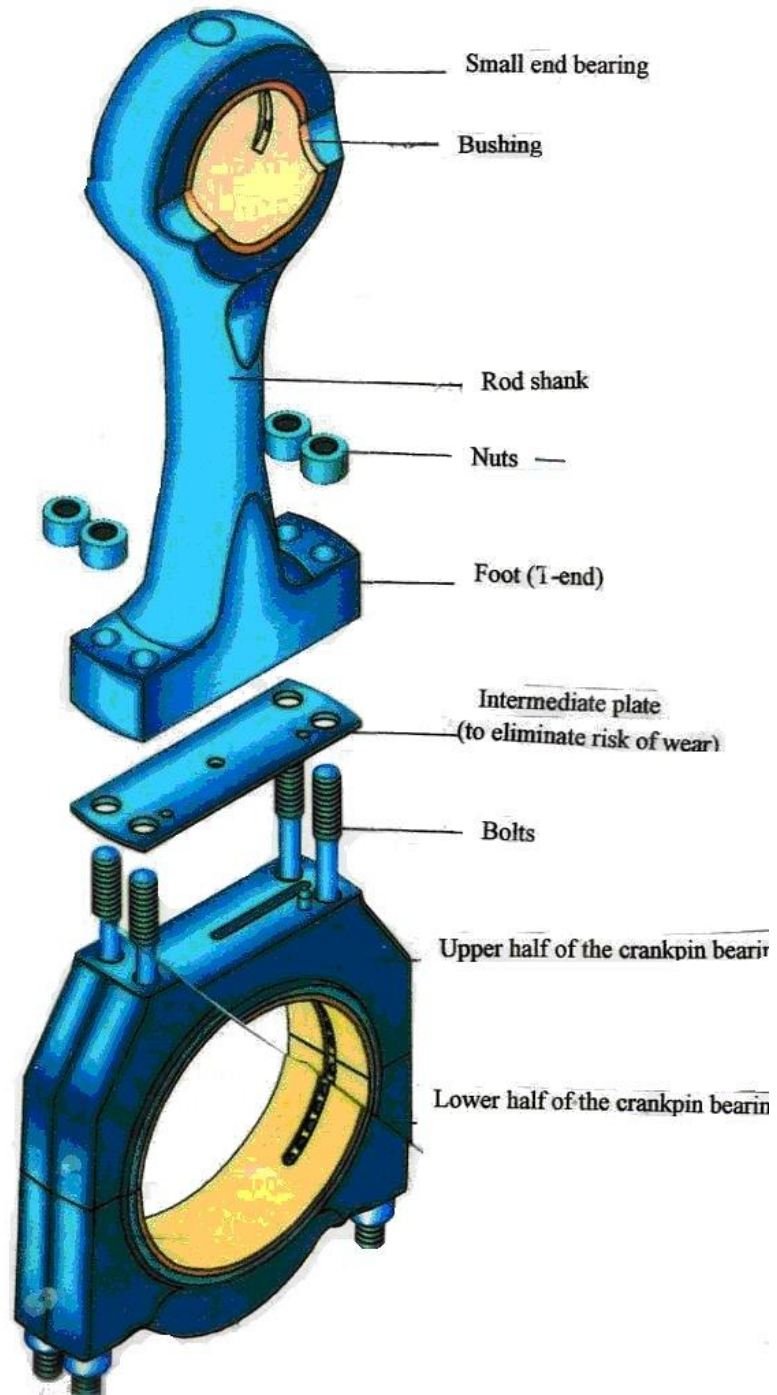
**Vee engine connecting rod
-articulated type**

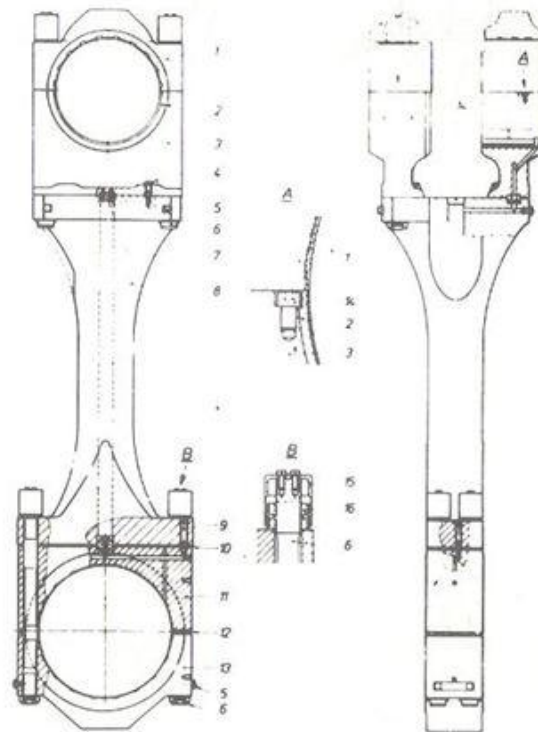
Elements and parts

1. Crankpin end → Bottom end bearing, lower end bearing, big end bearing, crankpin bearing, or large end bearing.
 - Attachment point for the crankpin, carrying a bearing.
 - It consists of two half removable shells (marine type) held together by bolts and nuts. The shells have a lining of bearing metal, white metal or Babbitt (copper–lead or tin–aluminium+thin flashing of lead or indium to provide for an anticorrosion layer).
 - Bearing housing contains cooling oil grooves.
 - Between the foot and the box (bearing housing) there are shims (distance pieces, compression shims, compression plates) for adjustment of cylinder compression.

Elements & parts

1. *Crankpin end* → *Bottom end bearing, lower end bearing, big end bearing, crankpin bearing, or large end bearing.*
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 - *Bearing housing contains cooling oil _____.*
 - *Between the foot and the box (bearing housing) there are _____ (distance pieces, compression shims, compression plates) for _____ of cylinder compression.*





1. Crosshead bearing cover
3. Bearing lower part
5. Locking screw
7. Centering Pin
9. Fixing bolt
11. Upper bearing
13. Lower half of bearing
15. Locking sleeve
2. Bearing shell
4. Fixing bolt
6. Top end bolt.
8. Connecting Rod
10. Compression plate
12. Shim for adjusting vertical clearance
14. Stop screw
16. Nut to connecting rod bolt.

Elements & parts

2. Rod shank

It is also called the body and may *take up* different forms. It has drilling throughout its length.

3. Gudgeon pin end → Upper end bearing, top end bearing, or small end bearing, wristpin bearing.

- Upper end bearing is a bushing having an interference fit (nip) in the eye bored in the rod.
- The eye is a single piece bearing (bush, bushing) pressed into sleeve.

Elements & Parts

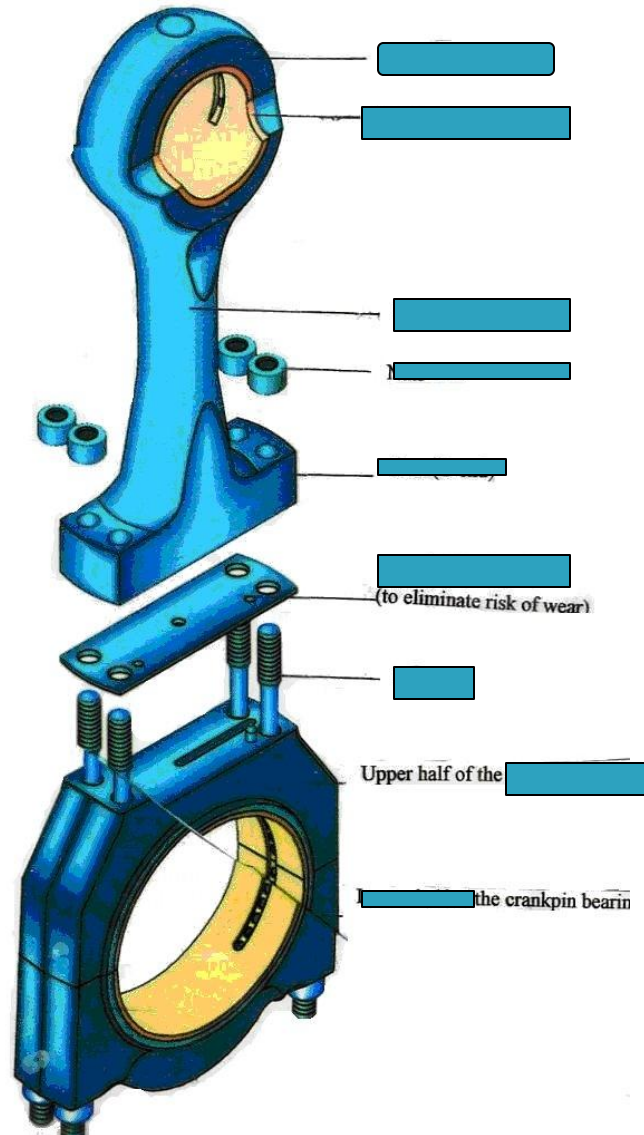
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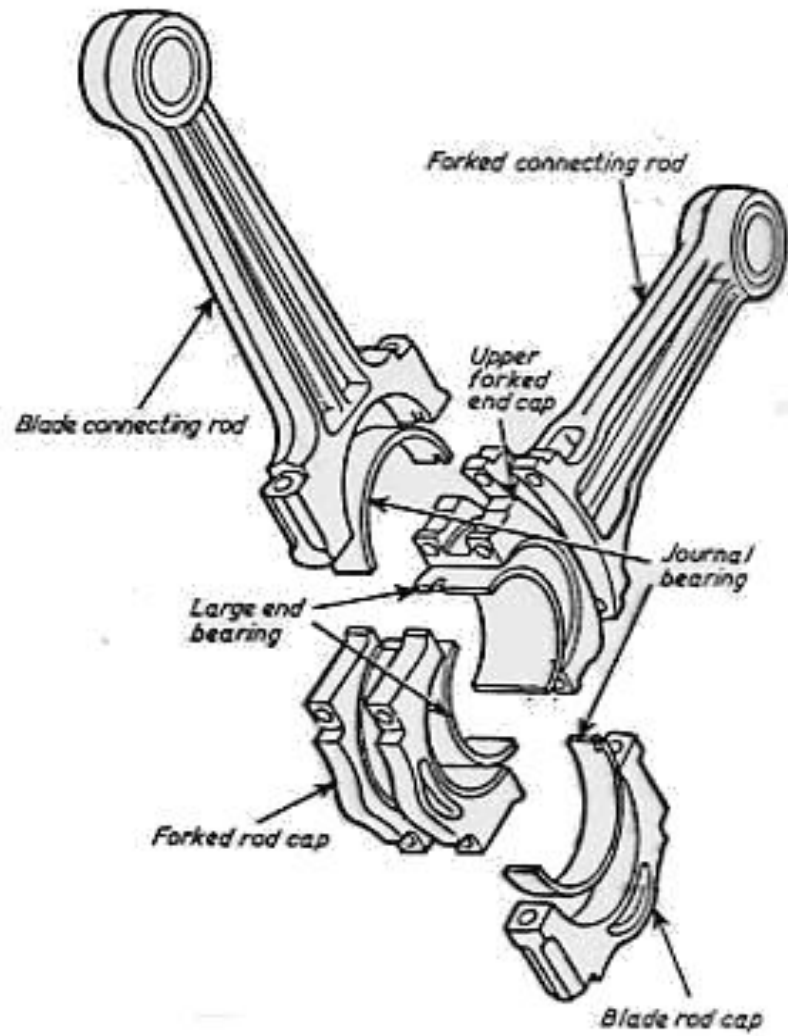
- Upper end bearing is a _____ having an interference fit (nip) in the eye bored in the rod.*
- The eye is a single piece bearing (bush, bushing) _____ into sleeve.*

Supply the terms for the parts of the connecting rod



Describe the location and function of the following:

- Gudgeon pin
- Rod shank
- Small end
- Large end
- journal



Vee engine connecting rod
-fork and blade type

STRESSES

1. Axial forces → resulting from gas pressure and inertia of piston assembly modified by the side thrust arrising in consequence of the connecting rod crank angle.

▶ The maximum axial load is compressive (at TDC).

- Tensile stresses occur after firing, due to piston inertia.
- Bending stresses also occur after firing.

2. Transverse forces → known as whip, are caused by inertia effects of the rod mass.

Fortunately, axial & transverse forces do not occur at the same time.

STRESSES

1. Axial forces → _____ from gas pressure and inertia of piston _____ assembly modified by the side thrust _____ in consequence of the connecting rod crank angle.

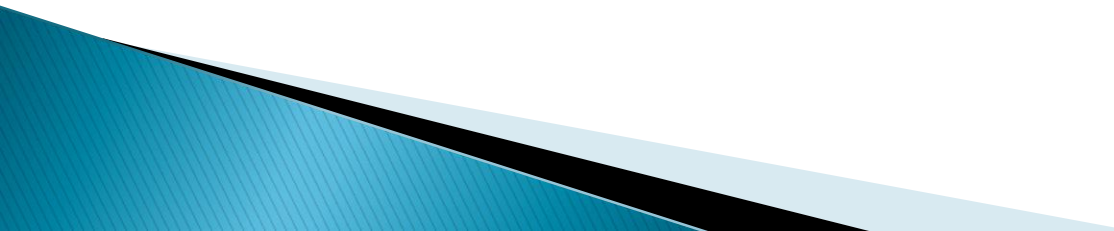
▶ The maximum axial _____ is compressive (at TDC).

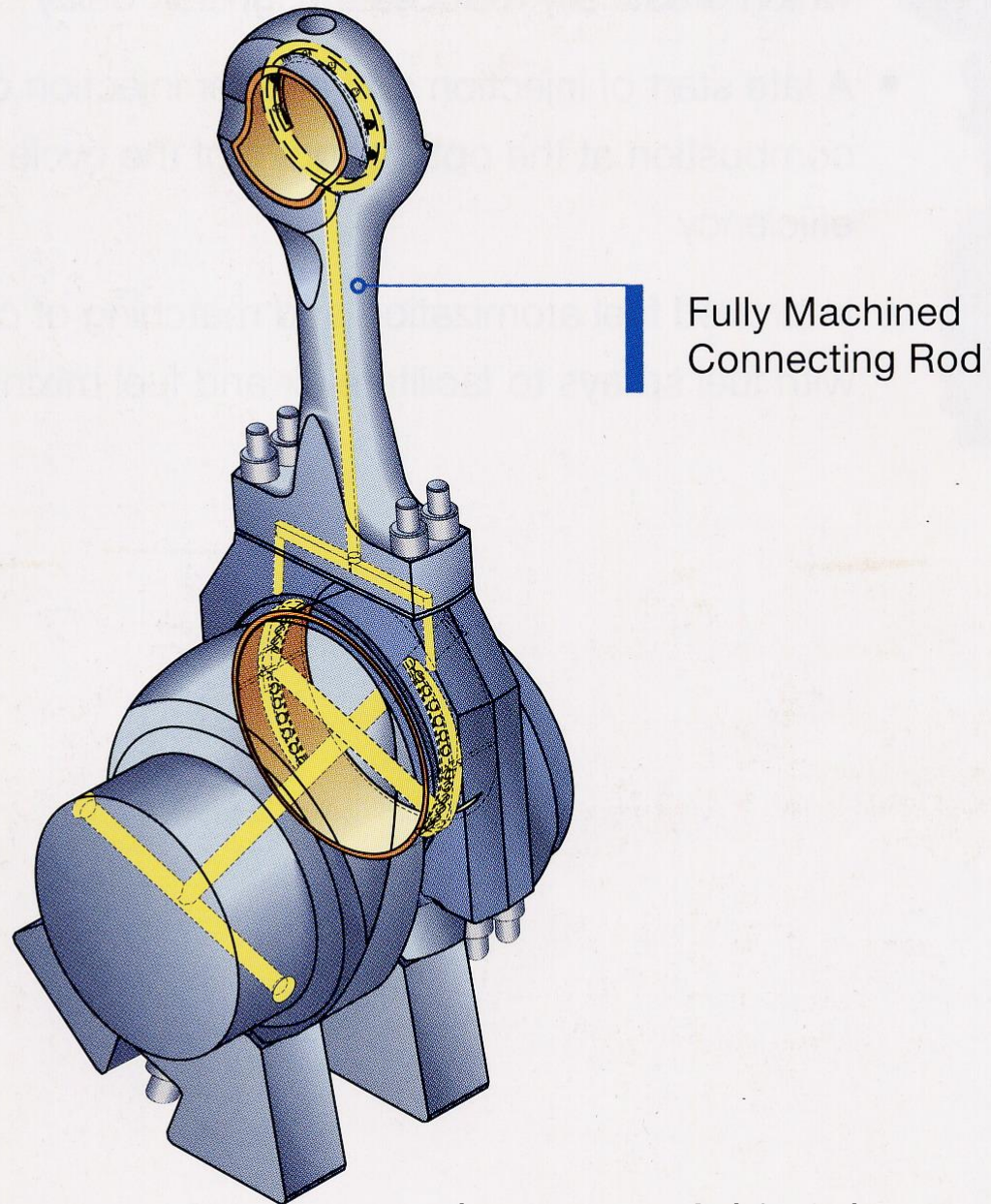
- T_____ stresses occur after firing, due to piston inertia.
- B_____ stresses also occur after firing.

2. Transverse forces → known as _____, are caused by _____ effects of the rod mass.

Fortunately, axial & transverse forces do not occur

LUBRICATION

- ▶ Lubrication is carried out through the shank bore (drilling) in running throughout the shank length. It conducts oil from the big end to the small end for lubrication and to the inside of piston for its cooling.
- 



to shape, cut, or remove (excess material) from (a workpiece) using a machine tool

LUBRICATION

- ▶ *Lubrication is carried out through the(drilling) and the shank*
- ▶ *It conducts oil from the to the for lubrication and to the inside of for its cooling.*

Prediction

- ▶ In essence, the connecting rod is a *straight bar* with a _____ at each end, whose purpose is *to transmit the piston _____ to the crankshaft*. The connecting rod must be strong, yet must not be too heavy because of inertia forces, especially in _____ speed engines. Articulated rods are made of _____ pieces.

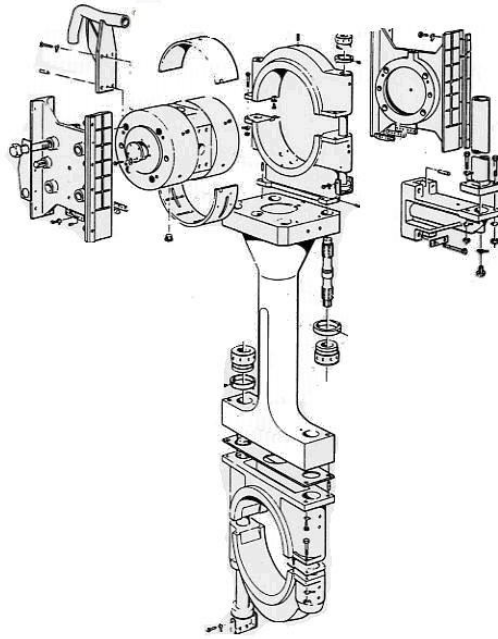
Check on your prediction

- ▶ *In essence, it is straight bar with a bearing at each end, whose purpose is to transmit the piston thrust to the crankshaft. The connecting rod must be strong, yet must not be too heavy because of inertia forces, especially in high speed engines. Articulated rods are made of two pieces.*

- ▶ The rod is usually *forged* from alloy steel, frequently with an “I” or “channel” section to give its greatest stiffness for its weight. Connecting rod large ends are basically either of “*marine*” type or *fixed centre design*. These two basic designs are shown in Fig. 3.1 and 3.2.

- ▶ The rod is usually *forged* from alloy _____, frequently with an “I” or “channel” section to give its greatest stiffness for its weight.
- ▶ Connecting rod large ends are basically either of “_____” type or _____*design*.
- ▶ These two basic designs are _____ in Fig. 3.1 and 3.2.

BURMEISTER AND WAIN ENGINES



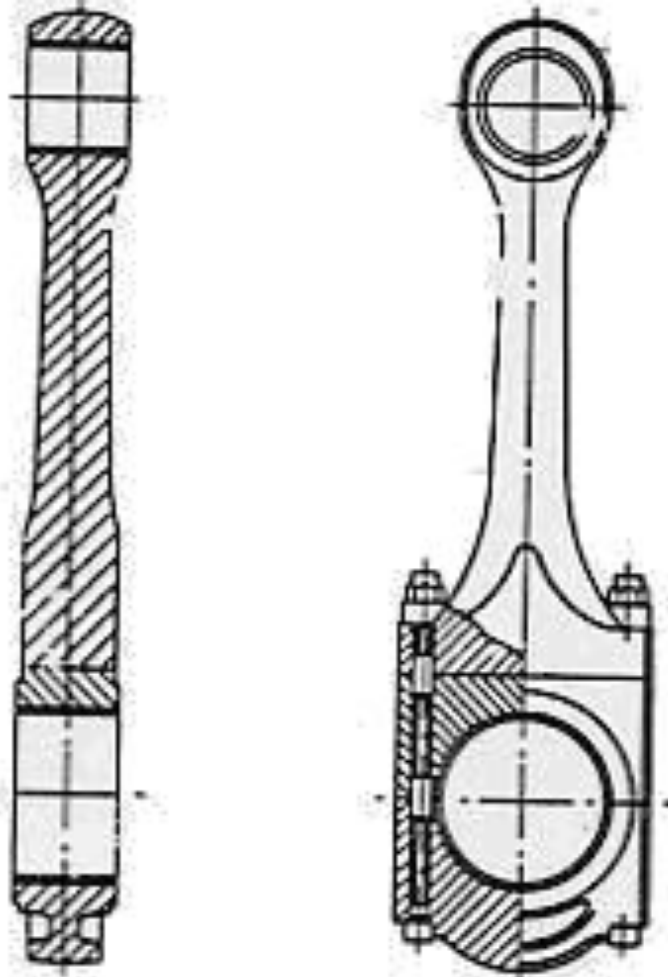
CONNECTING ROD & CROSSHEAD

Marine type rod

- ▶ In the **marine type design** (Fig.1) the rod **large end**, called “*crankpin end*”, consists of a separate bearing housing (or box) divided in two parts, bolted to a foot on the rod *shank*. A **distance piece**, known as compression plate or *shim*, is interposed between the foot and the box to permit the piston to be moved nearer to or farther from the cylinder head *at top dead centre*. Its thickness is chosen so as to ensure correct compression ratio.

Marine type rod

- ▶ *In the marine type design (Fig.1) the rod large end, called “crankpin end”, consists of a divided in two parts, bolted to a foot on the rod shank.*
- ▶ *A distance piece, known as or shim, is interposed between the and the box to the piston to be moved nearer to or farther from the cylinder head at*
- ▶ *Its thickness is chosen so as to ensure correct compression*



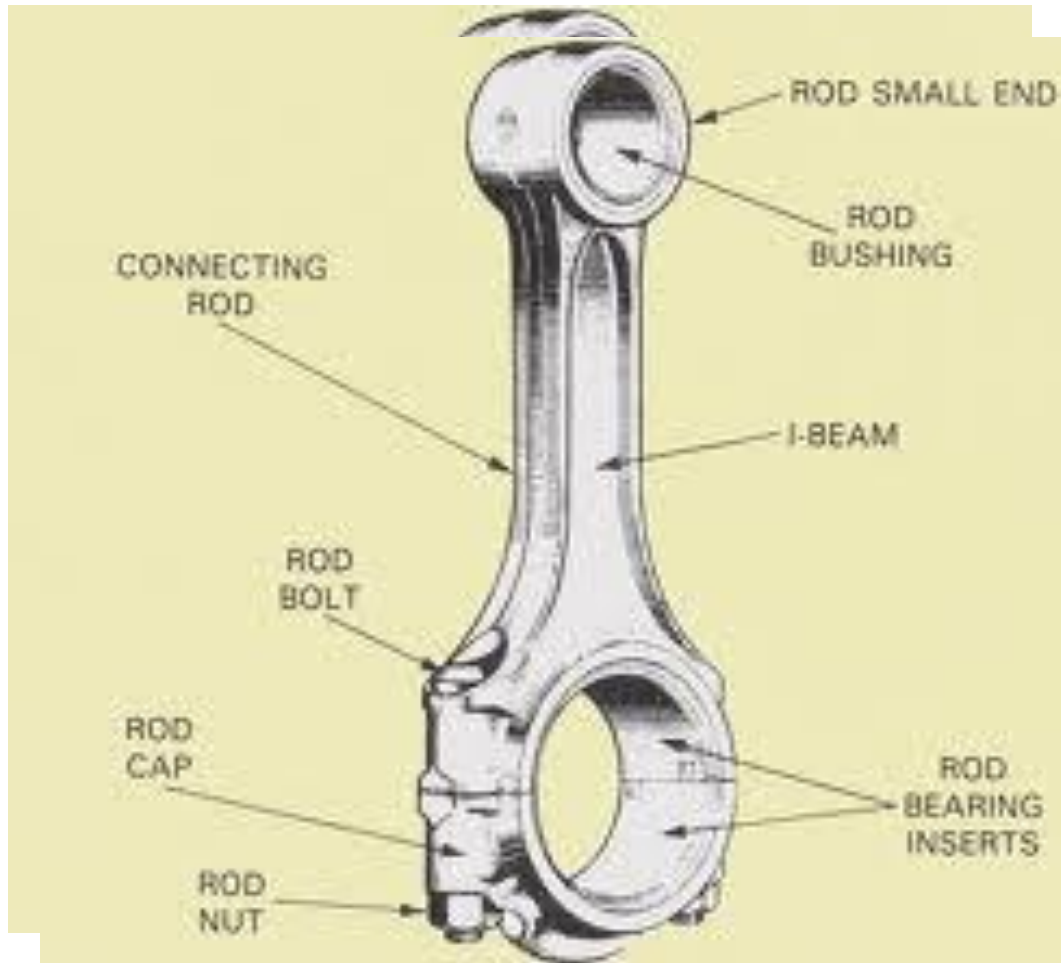
Marine type connecting rod

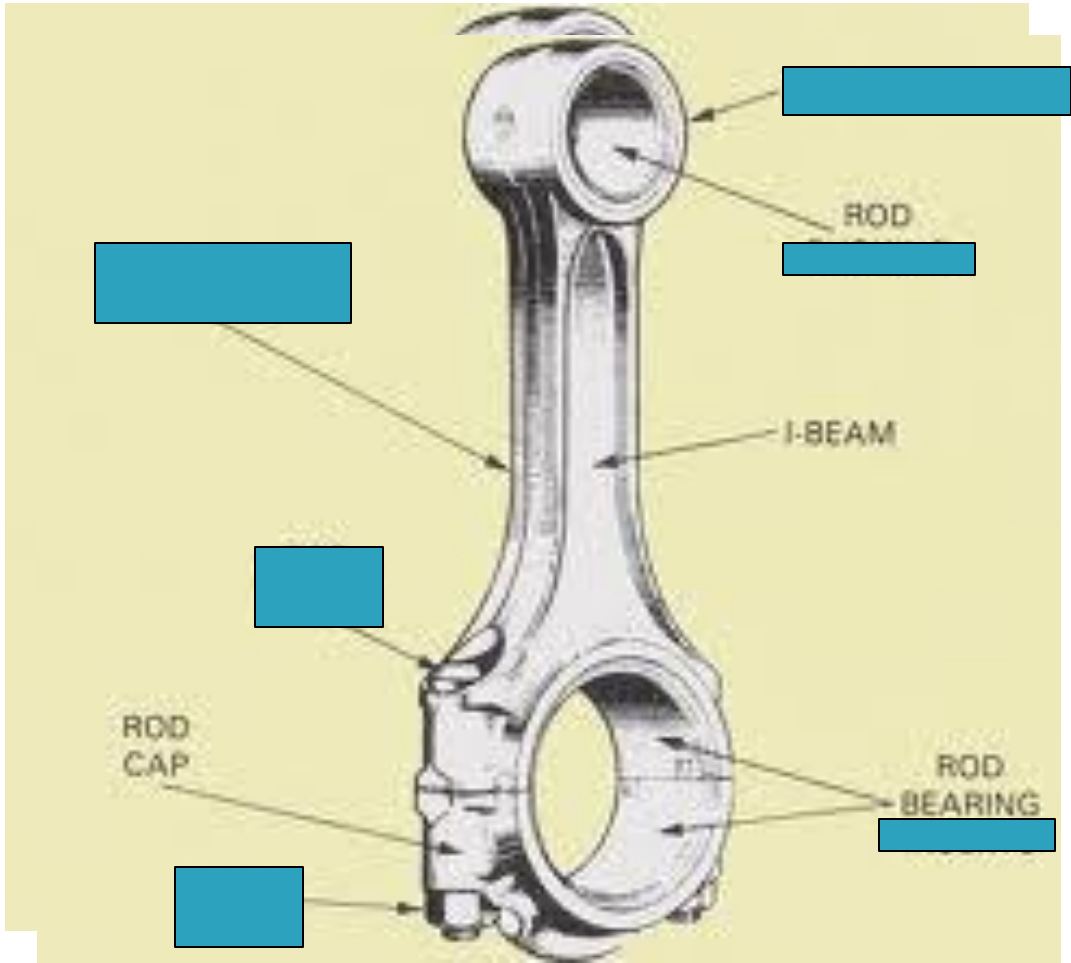
Fixed centre rod

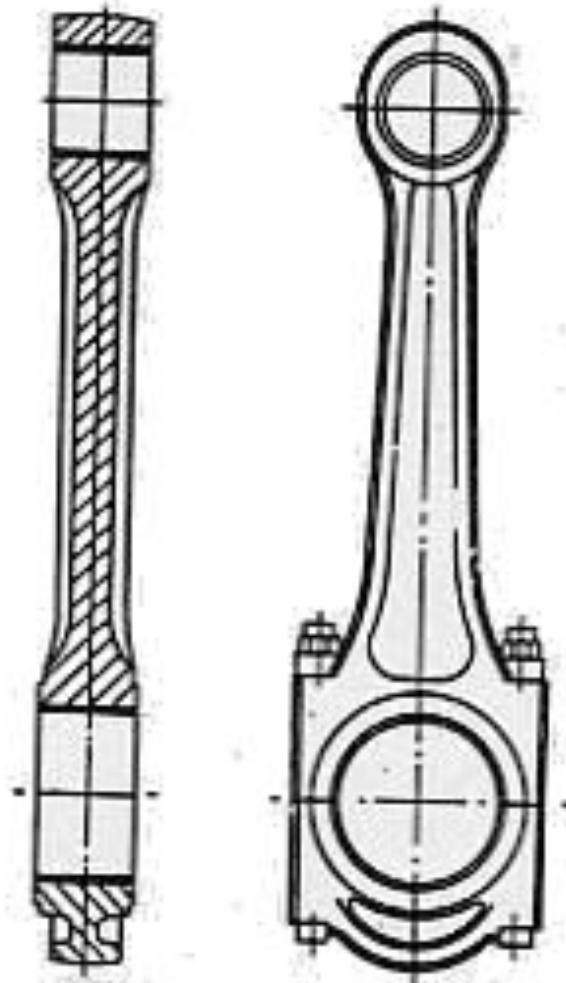
- ▶ The simpler construction of the **fixed centre rod** (Fig.2) does not have this adjustment and relies on *accuracy* to ensure correct clearances. With a few exceptions medium speed diesel engines have **trunk pistons** with the result that pistons and connecting rods have to be fitted together before being assembled into the cylinder. The methods of **assembly** and **overhaul** tend to influence the design of the large end.

Fixed centre rod

- ▶ *The simpler construction of the fixed centre rod (Fig.2) does not have this adjustment and relies on accuracy to*
- ▶ *With a few exceptions medium speed diesel engines have trunk pistons with the result that pistons and connecting rods have to be fitted together*
- ▶ *The methods of _____ and _____ tend to influence the design of the large end.*







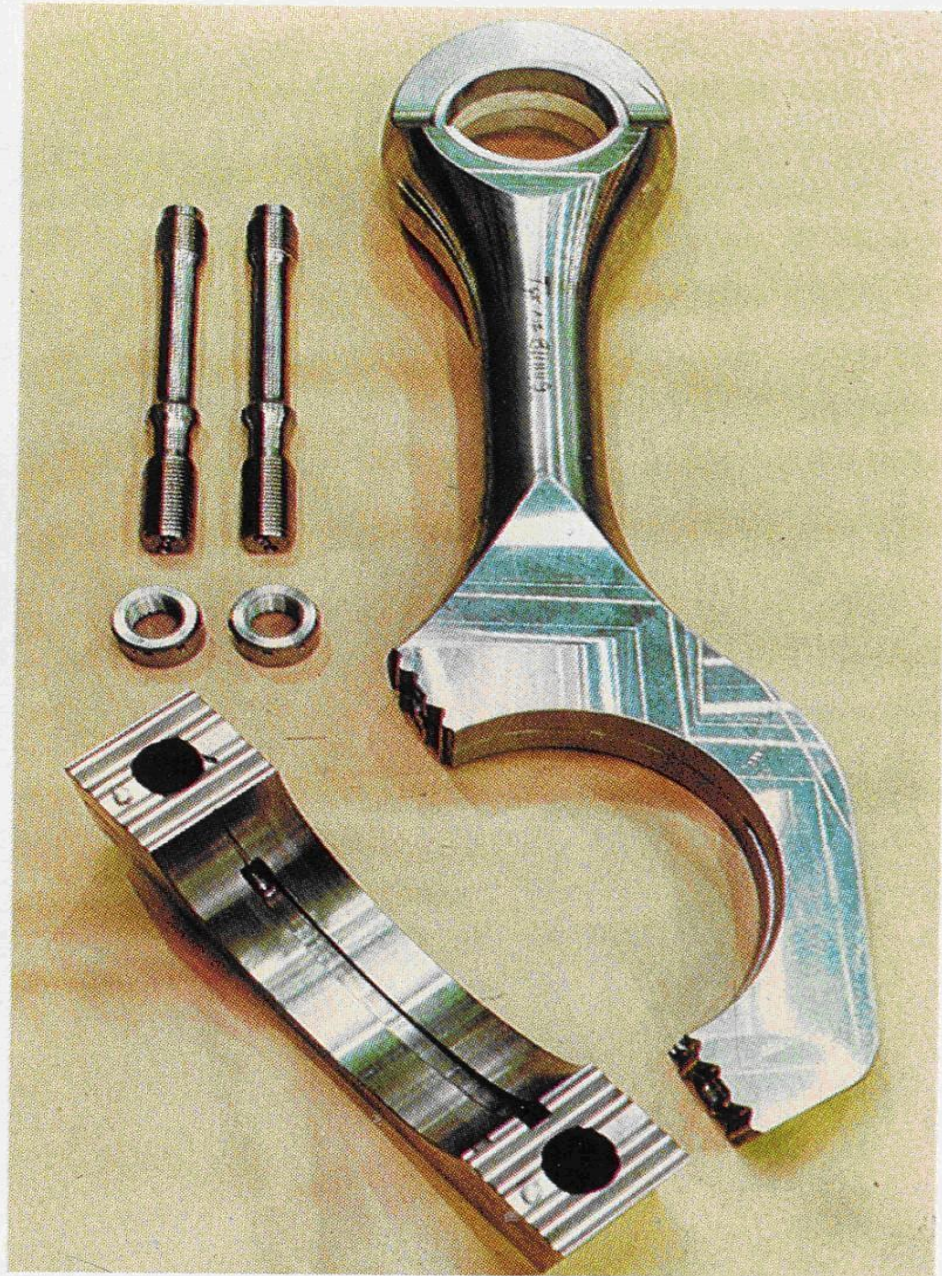
Fixed centre connecting rod

Rod withdrawal

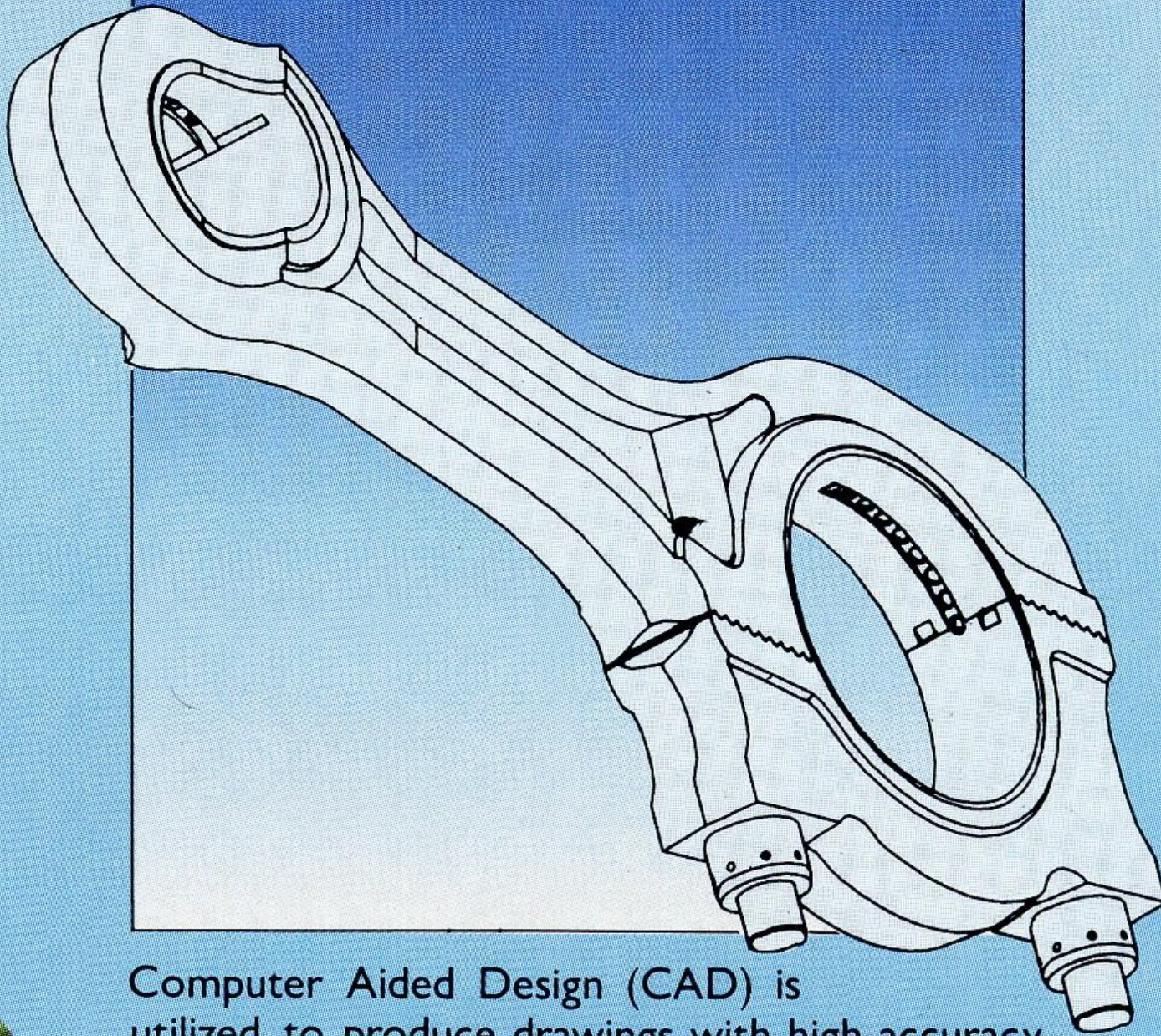
- ▶ For one or two types of engine, the piston and rod *can be withdrawn downwards* from the cylinder into the crankcase and then out through the crankcase door. However, this design tends to result in a high engine so that the piston and rod is more usually withdrawn upwards. This means that in case of engines having cylinders blocks, the rod has to be small enough to pass through the bore of the cylinder.

Withdrawal

- ▶ *For one or two types of engine, the piston and rod can be withdrawn _____ from the cylinder into the crankcase and then out*
- ▶ *However, this design tends to result in so that the piston and rod is more usually withdrawn _____.*
- ▶ *This means that in case of engines having cylinders blocks, the rod has to be small enough*



The connecting rod is fully machined.



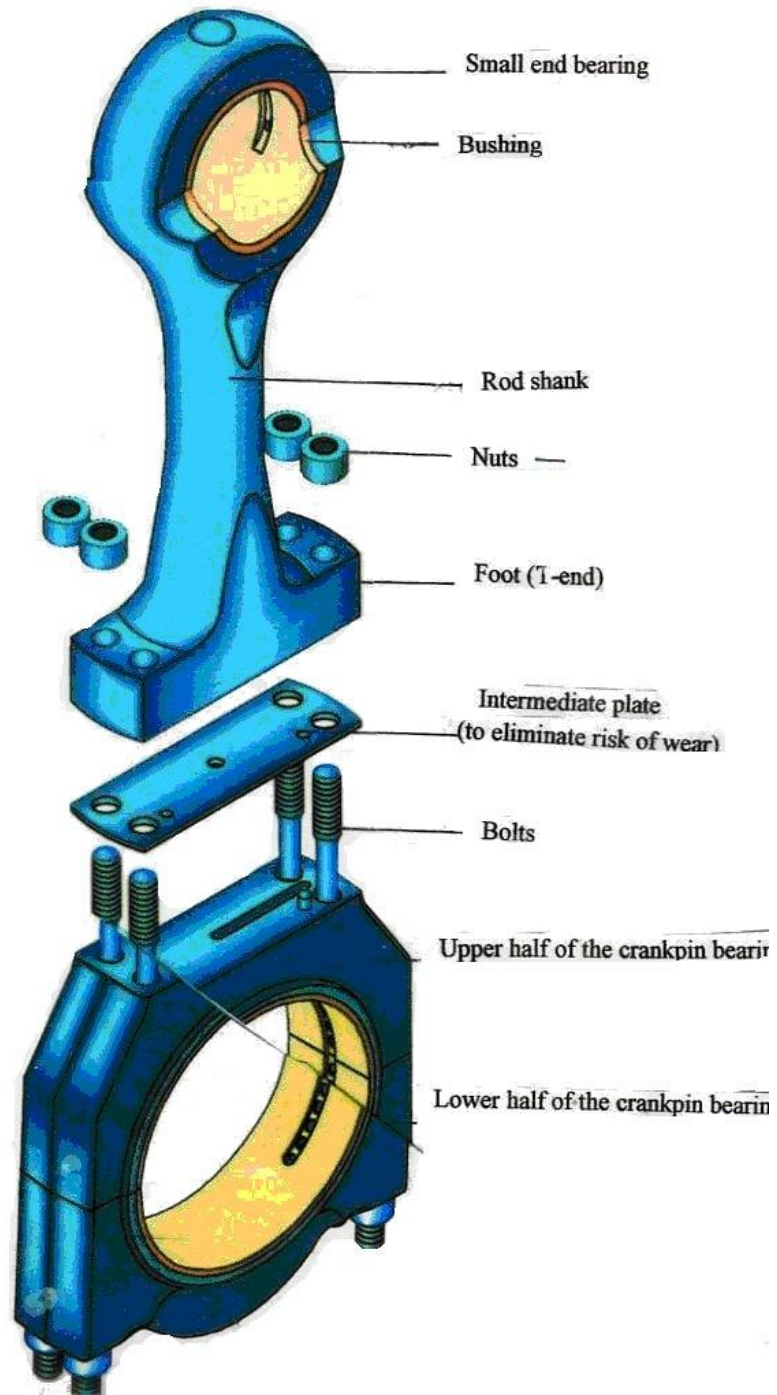
Computer Aided Design (CAD) is utilized to produce drawings with high accuracy.

Large end bearing

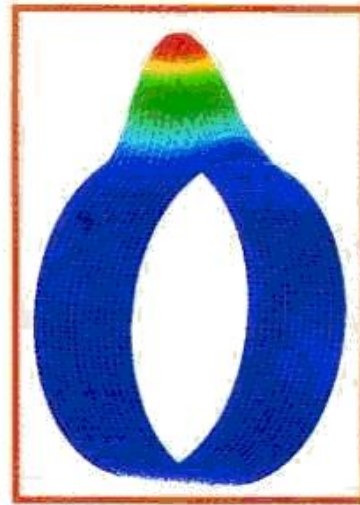
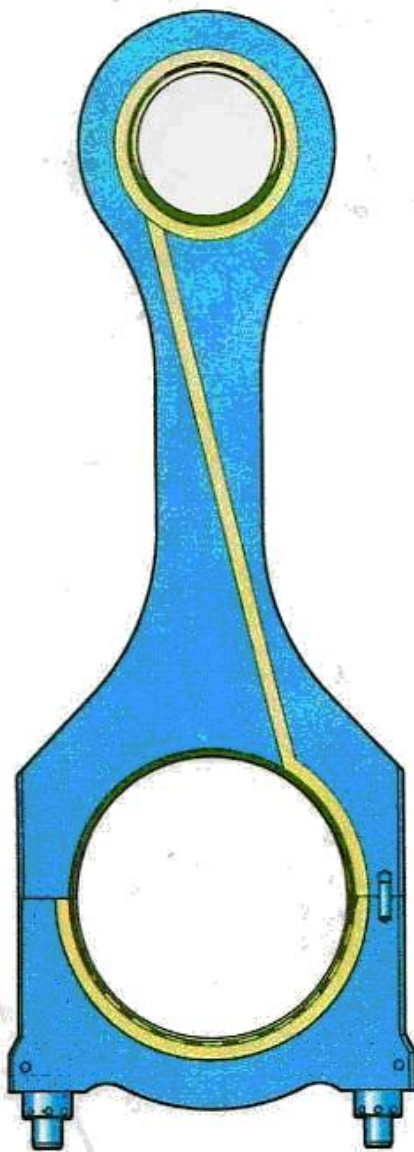
- ▶ The design of the **large end bearing** is similar to that of the main bearing. The steel *shells*, of relatively thin wall section, have a *lining* of bearing metal, white metal, copper–lead or tin–aluminium, and a thin *flashing* of lead or indium to provide an anti–corrosion layer. In the bearing housing there are **grooves** through which oil passes to cool the piston.

Large end bearing

- ▶ *The design of the large end bearing is similar to that of the _____ bearing.*
- ▶ *The steel shells, of relatively thin wall section, have a _____ of bearing metal, white metal, copper-lead or tin-aluminium, and a thin _____ of lead or indium to provide an anti-corrosion _____.*
- ▶ *In the bearing housing there are _____ through which oil passes to cool the _____.*

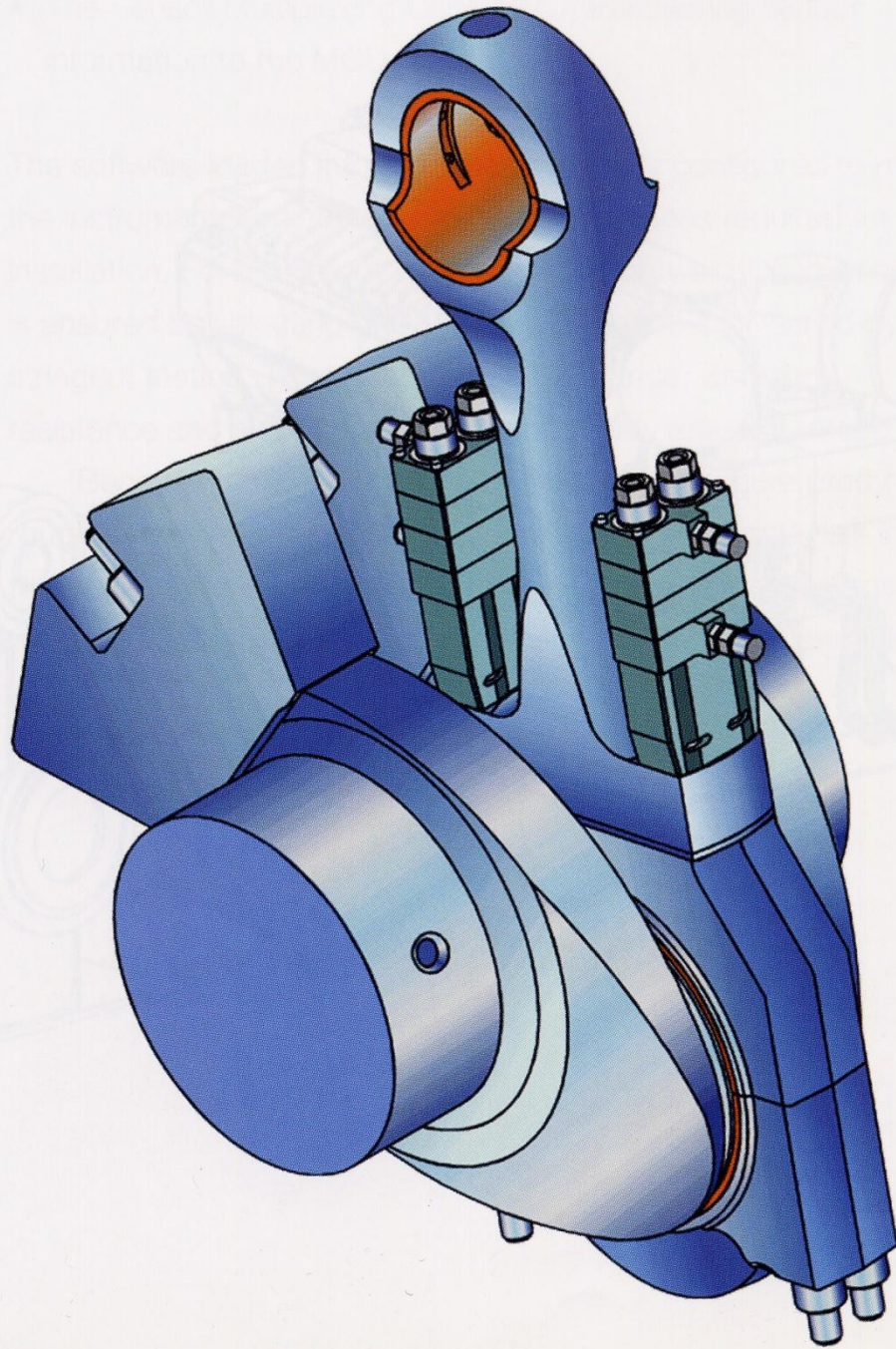


- ▶ The **small (top) end bearing** is a *bush* having an *interference fit* in the eye bored in the rod. The **bushing** may be of bronze or other hard bearing metal or it can be a composite structure of steel with a bearing metal lining. The **shank** of the rod usually has a bore throughout its length which conducts oil from the large end to the small end for lubrication and to the inside of the piston for cooling.



Oil film pressure distribution caused by forces in big end bearing for Wärtsila 64

A bore drilled in latest Wärtsila 64 engines



QUESTIONS AND DISCUSSION

1. What is the function of the connecting rod? What does it consist of?
2. What are the forces (stresses) acting on the connecting rod of a single acting engine?
3. State the difference between the “connecting rod “ and “piston rod”.
4. When are the pistons and connecting rods fitted together?
5. Describe the two ways of removing the connecting rod from the cylinder.
6. What is the requirement for the connecting rods in the engines having cylinder blocks?
7. What are the main parts of a bearing?
8. What are the bearing shells made of?
9. What is a joint between the large and the small end bearings?
10. When is the engine fitted with a crosshead?
11. How are the large end and small end bearings lubricated?

Test

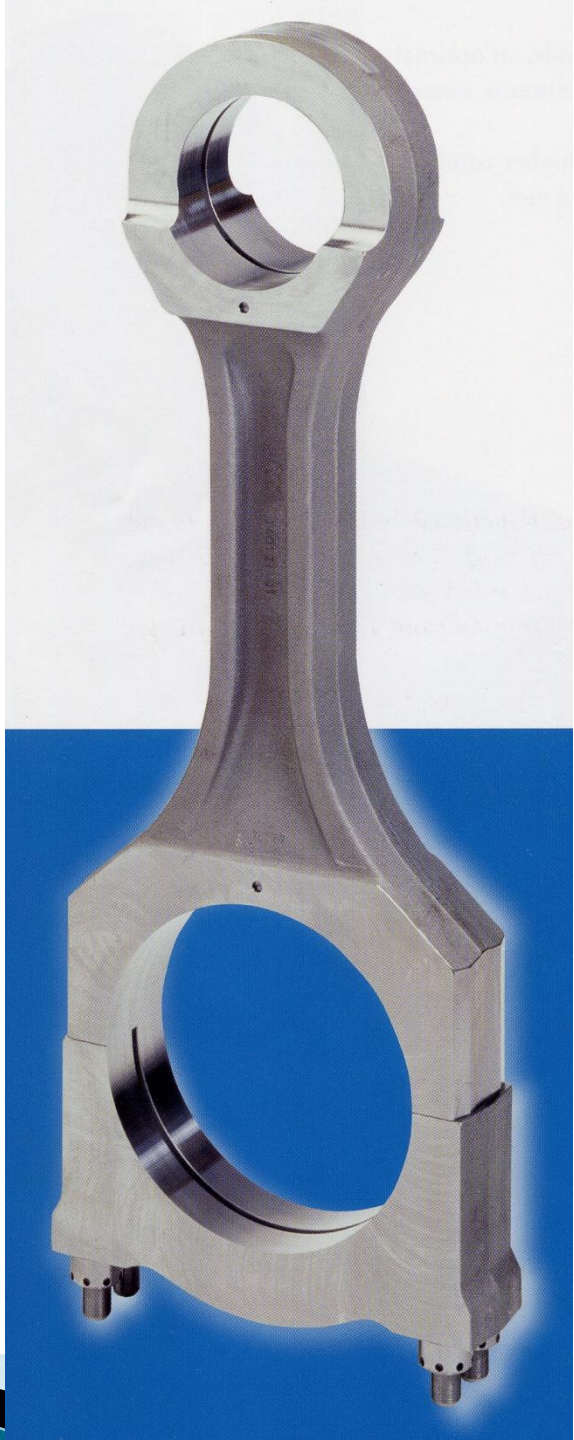
- ▶ **CRANKSHAFT, MAIN BEARINGS AND SHAFT ALIGNMENT**

- ▶ The crankshaft, which converts the _____ motion of the piston to rotating motion, must resist the _____ stresses caused by the connecting rod _____ when the piston is at top centre.
- ▶ Then the maximum gas pressure acts straight down on the _____ and tends to bend the shaft between the adjacent _____. The crankshaft must also _____ the torsional forces produced by the change of speed.
- ▶ Medium speed engines have crankshaft usually solid _____ , i.e. made from a single piece, while slow speed engine crankshafts are mostly of semi-built design with crankpins and _____ forged or cast in one piece and shrunk on to the _____. The type of steel used, which is carbon or alloy steel containing nickel, chromium and molybdenum, is chosen for its strength, resistance to _____ and hardness of bearing surface.

- ▶ The cranks of a multi-throw shaft are set at appropriate angles giving a “firing order” for the engine. The firing order is chosen primarily to obtain a smooth torque and the best mechanical balance. However, main bearings loads, exhaust arrangements suitable for turbocharging and torsional vibration may also be taken into account. Although the crankshaft appears to be robust, they rely on the main bearings to develop their full strength.
- ▶ When a crankshaft has to be handled outside the engine, it should be carefully supported to avoid high bending moments on it by its own weight. In the engine it is essential to ensure that the bearings carrying it are in good alignment, as bearing misalignment will cause the crankshaft to bend and eventually break it.
- ▶ The main bearing shells are made of steel with a lining of bearing metal which can be white metal, copper-lead or aluminium-tin alloy. A thin flash of lead or indium is often added to provide a layer giving protection against corrosion. The shells are held in position and shape by seatings of the bedplate or frame. To ensure efficient and reliable operation the crankshaft should be checked periodically for alignment by measuring the deflection of the webs.

LESSON THREE

CONNECTING RODS

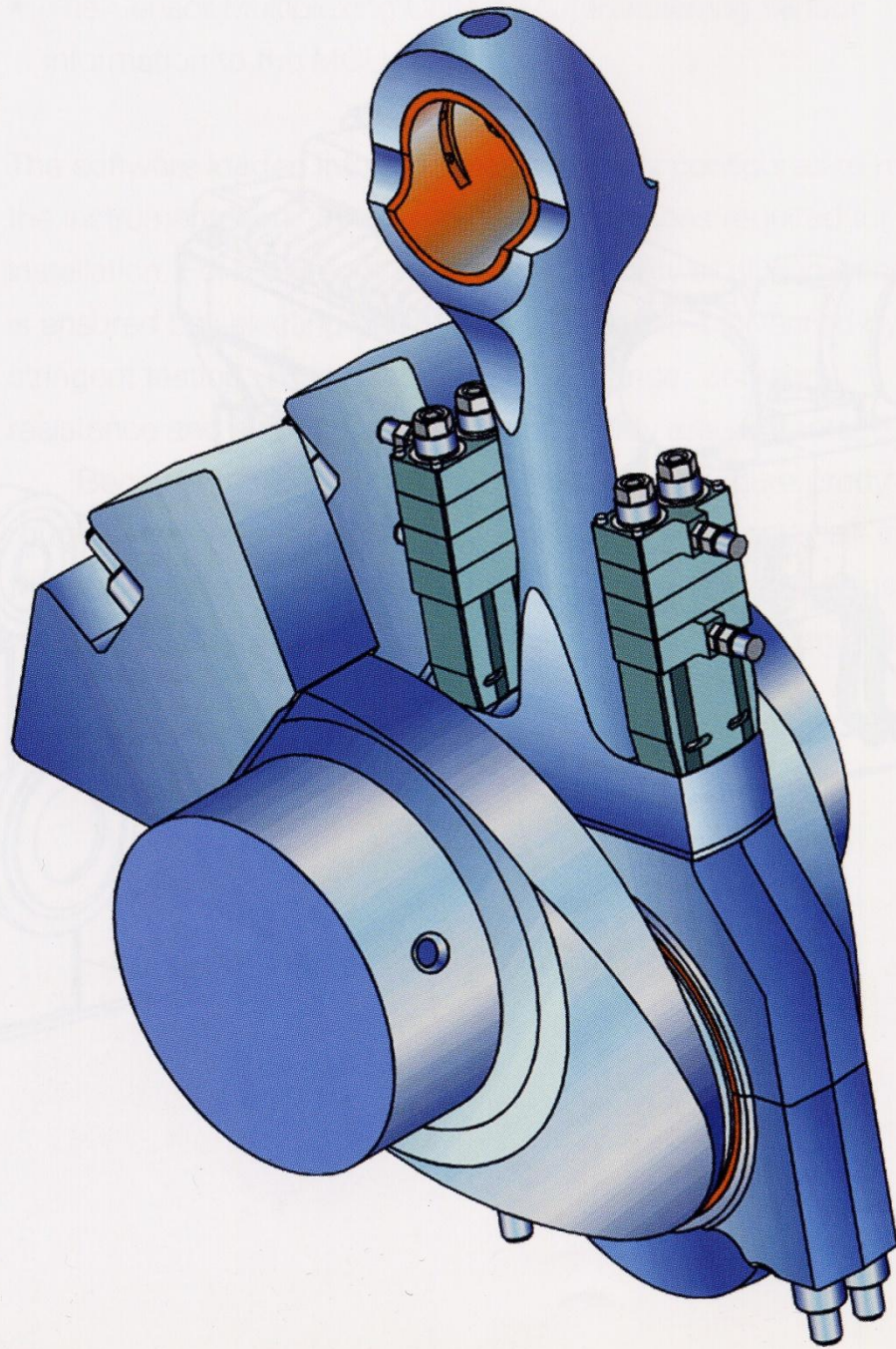




1. DEFINITION *

A running component connecting the crankshaft to the piston (in **trunk piston engines**) or to the crosshead (in **crosshead engines**).

It has both **linear** (**reciprocating, up-and-down**) & **rotational** (**rotary**) motion.

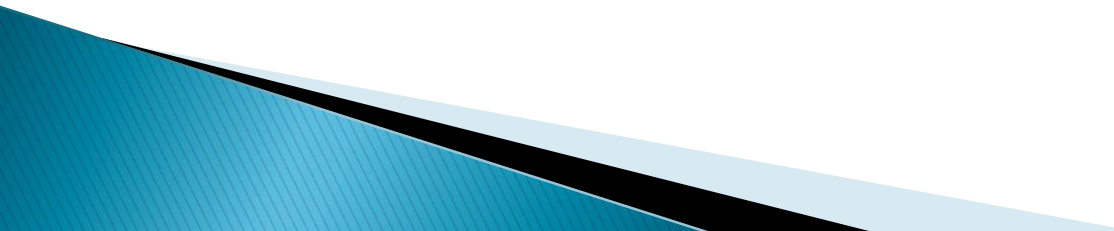


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2. FUNCTION



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2. FUNCTION

- **Primary function**: to transmit the push (pressure, thrust) of the piston to the crankshaft, either directly or indirectly.

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- **Primary function**: to transmit the push (pressure, thrust) of the piston to the crankshaft, either directly or indirectly.
- **Secondary function**: (in most designs) to convey cooling oil to the pistons which demands for a quite a large diameter **passage**

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3. TYPES *

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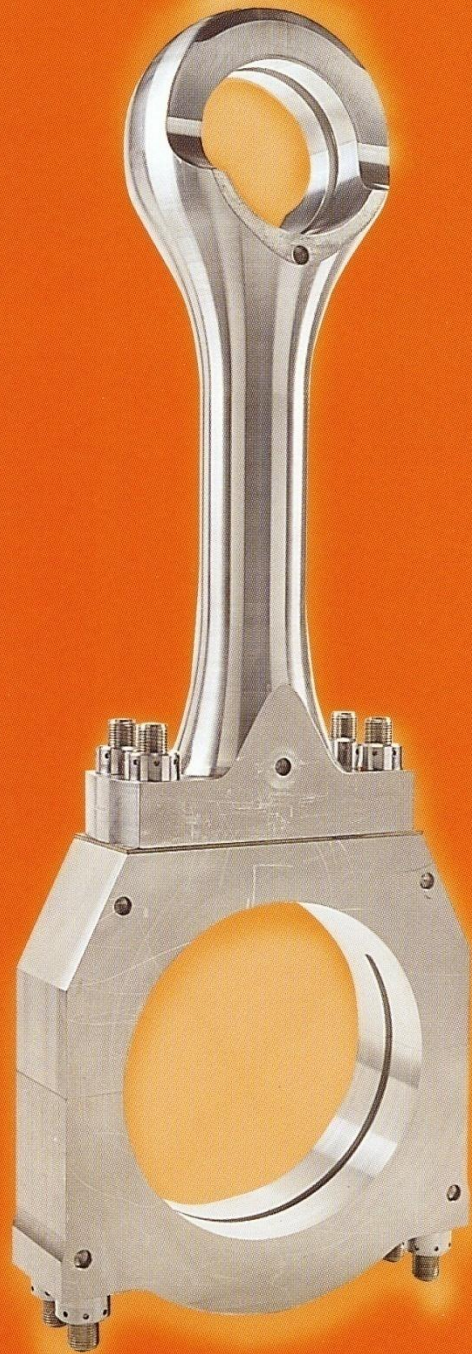
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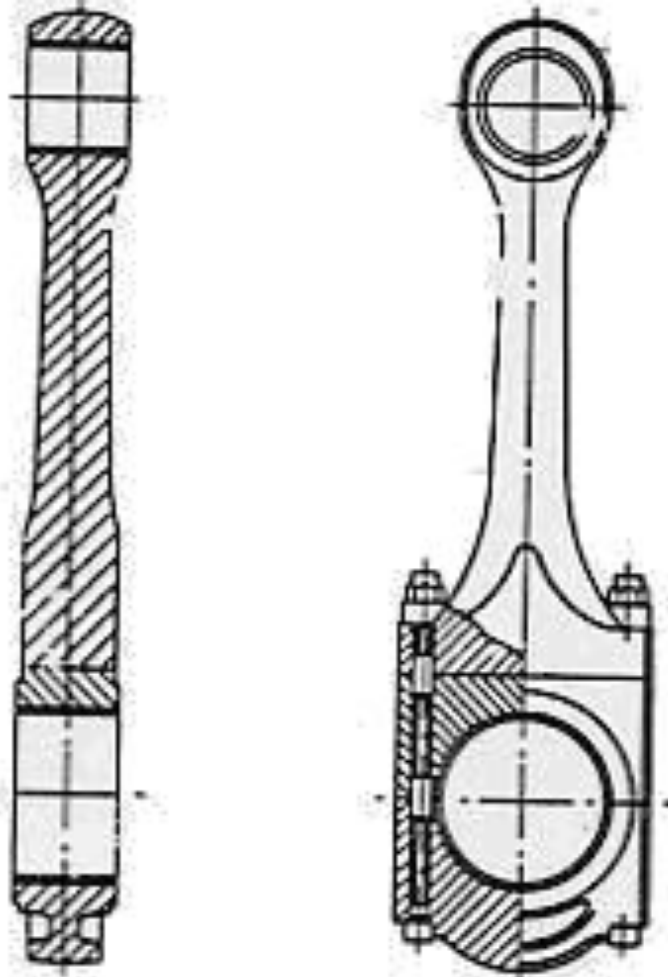
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3. TYPES *

- **Marine type**: The large end bearing is separate from rod the rod which has a **palm end** (**T-shaped end**)





Marine type connecting rod

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A running component connecting the crankshaft to the piston (in **trunk piston engines**) or to the crosshead (in **crosshead engines**).

It has both **linear** (**reciprocating, up-and-down**) & **rotational** (**rotary**) motion.

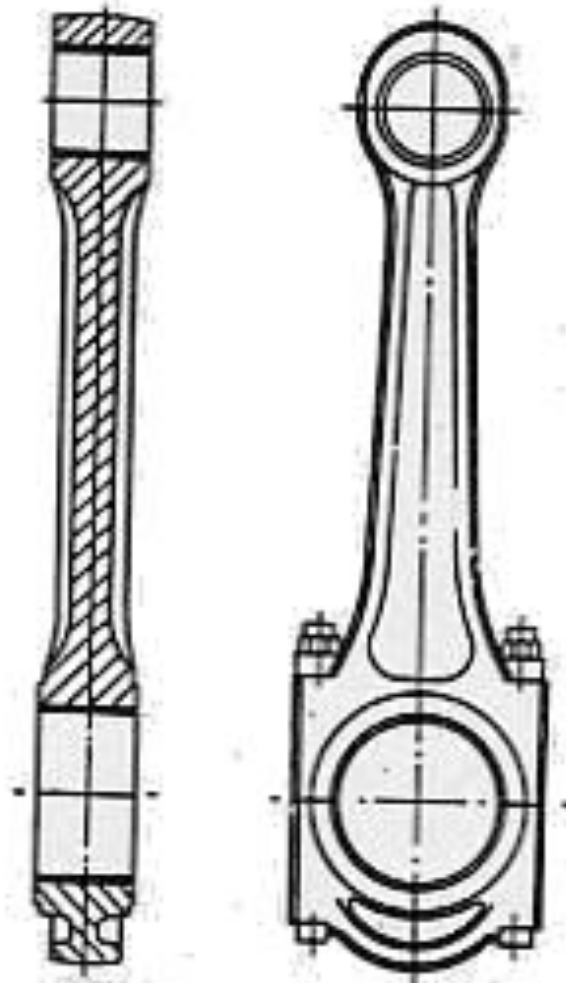
2. FUNCTION

- **Primary function**: to transmit the push (pressure, thrust) of the piston to the crankshaft, either directly or indirectly.
- **Secondary function**: (in most designs) to convey cooling oil to the pistons which demands for a quite a large diameter **passage**

3. TYPES *

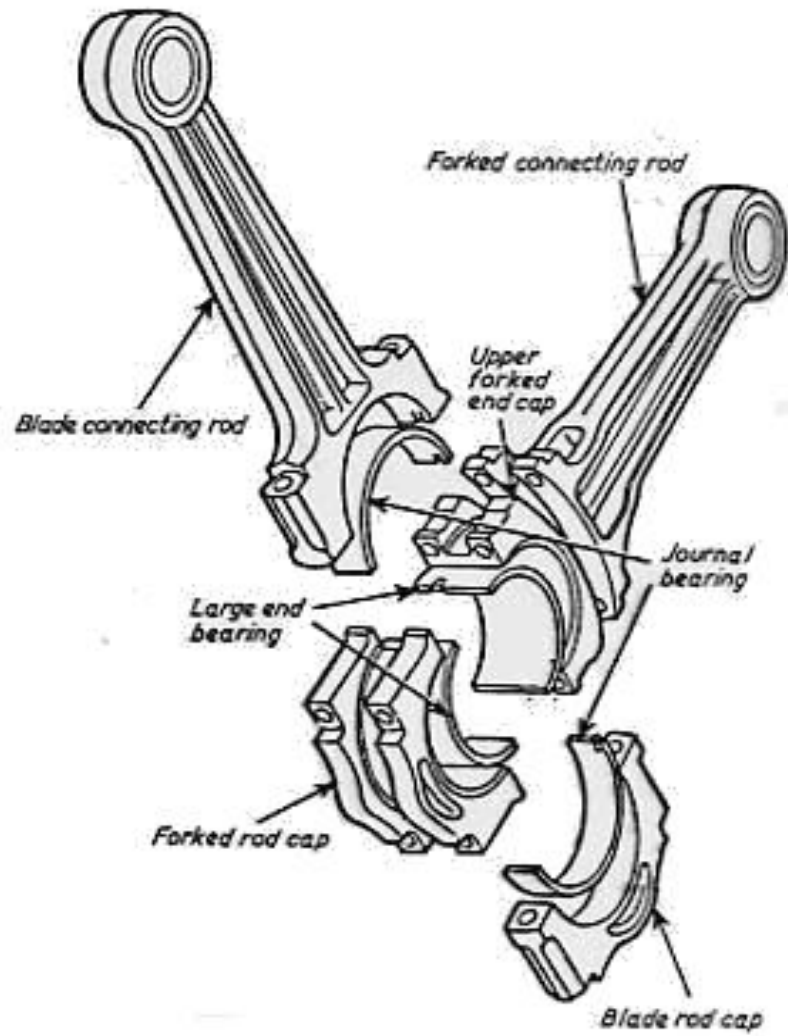
- **Marine type**: The large end bearing is separate from rod the rod which has a **palm end** (**T-shaped end**)
- **Fixed centre design**: The upper half of the **crankpin box** makes part of of the connecting rod./ Alternative design: Connecting rod with **obliquely split large end**.



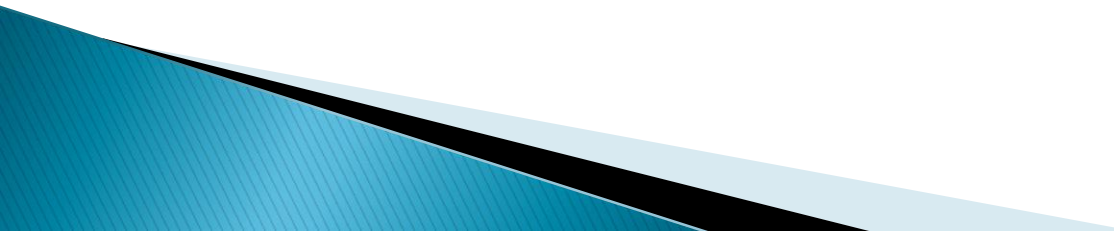


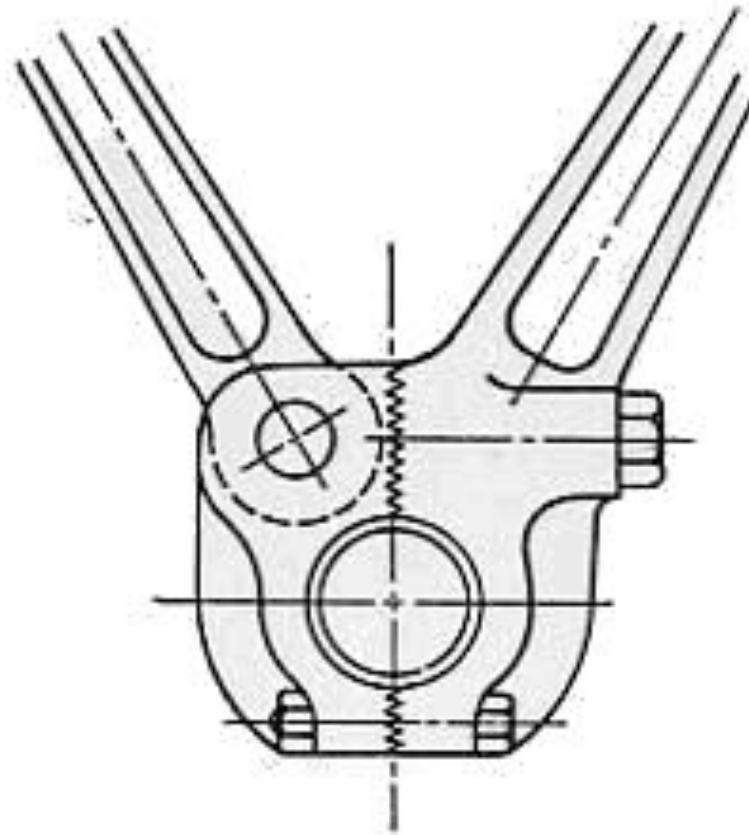
Fixed centre connecting rod

➤ **Fork and blade type:** Vee engine connecting rods.



Vee engine connecting rod
-fork and blade type

- **Fork and blade type:** Vee engine connecting rods.
 - **Articular type:** Vee engine connecting rods
- 



**Vee engine connecting rod
-articulated type**

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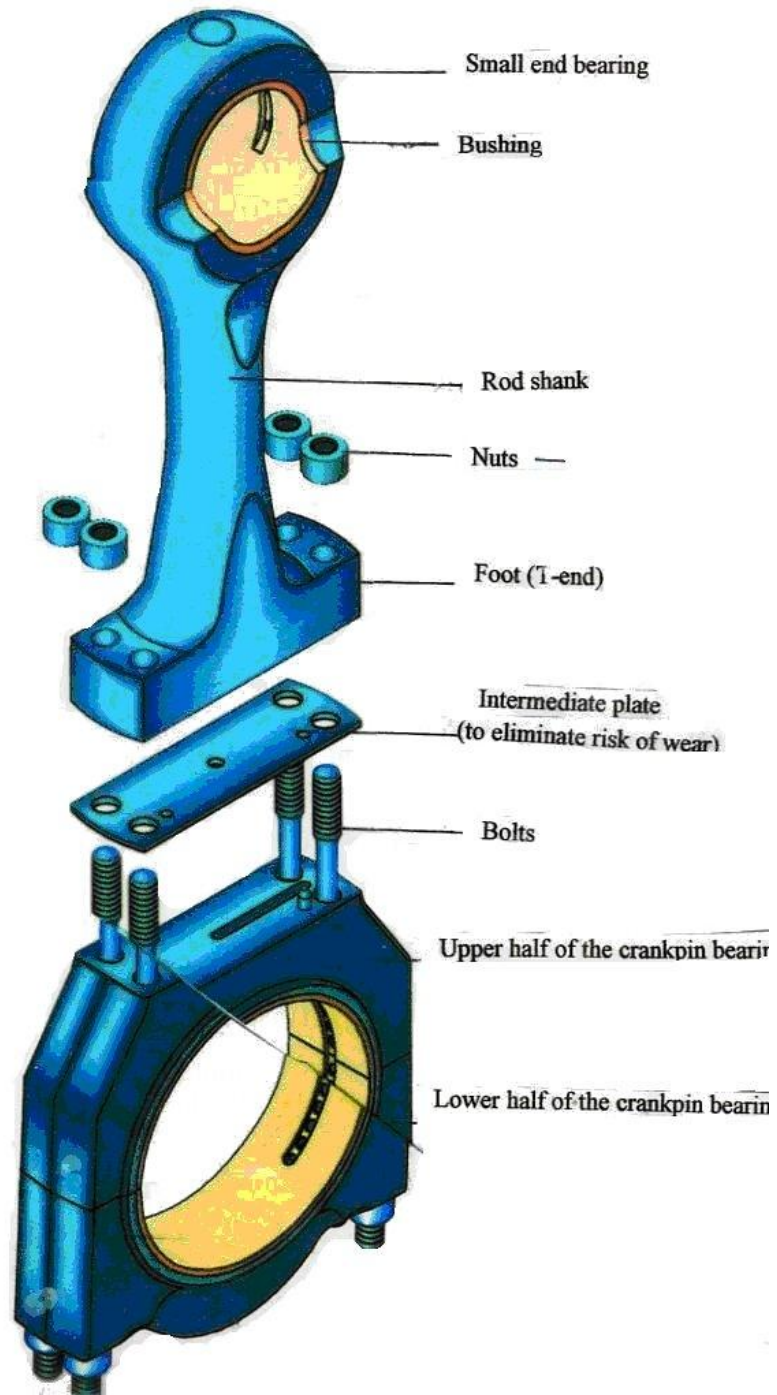
4. ELEMENTS

4.1 Crankpin end →

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➤ It consists of **two half removable shells** (marine type) held together by bolts and nuts. The shells have a lining of **bearing metal, white metal or Babbitt** (**copper-lead** or **tin-aluminium+thin flashing of lead or indium** to provide for an **anticorrosion layer**.

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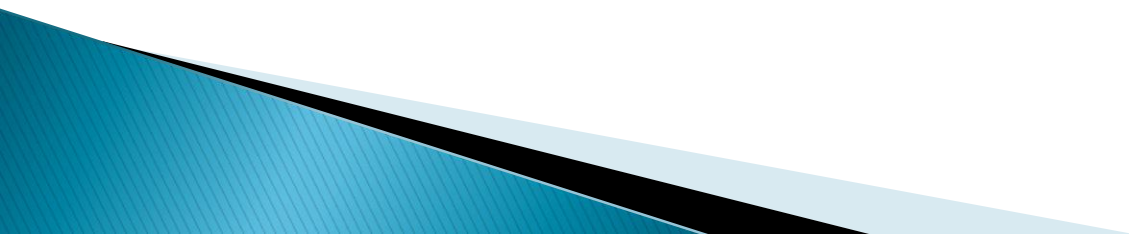
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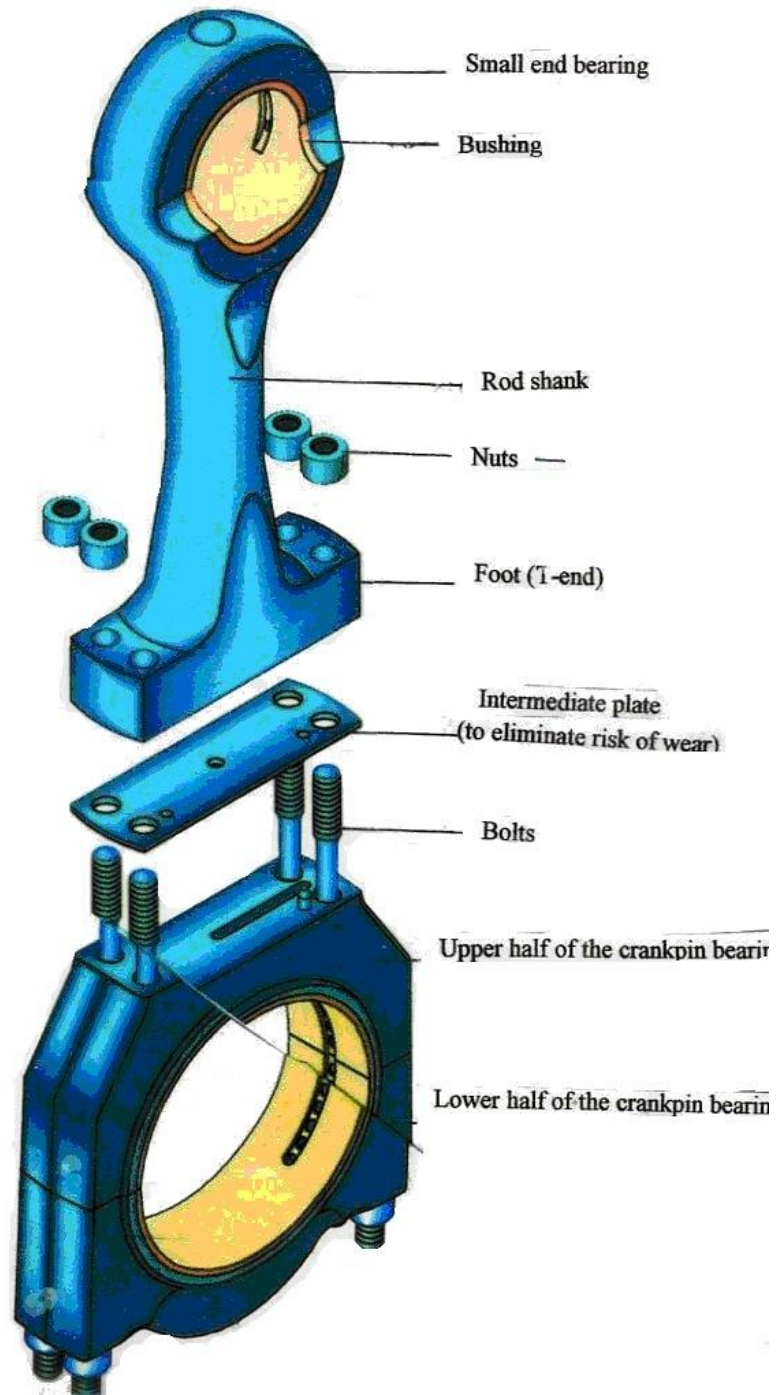
➤ Between the **foot** and the **box** (**bearing housing**) there are **shims** (**distance pieces, compression shims, compression plates**) for adjustment of cylinder compression.

4.2 Rod shank



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It is also called the body and may take up different forms. It has a drilling throughout its length.



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4.3 Gudgeon pin end →

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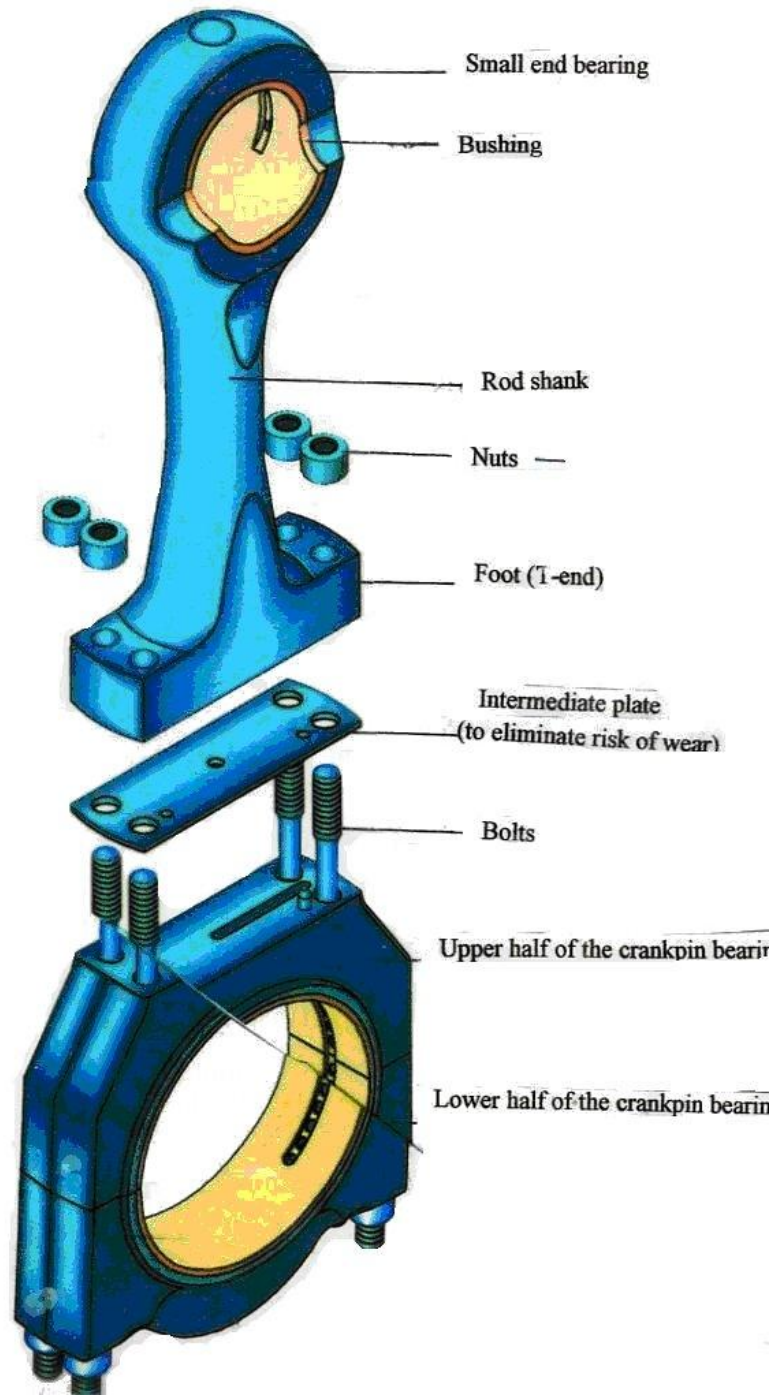
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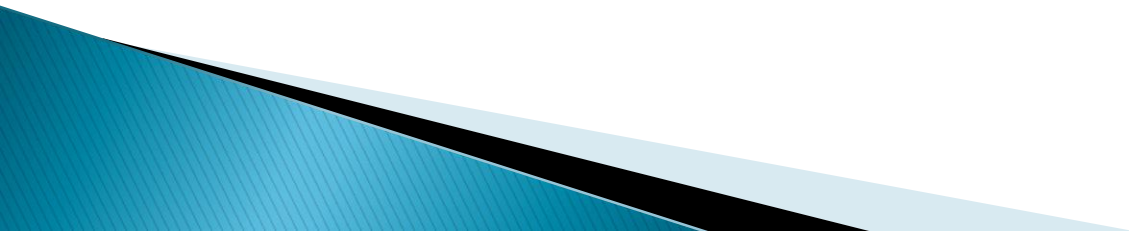
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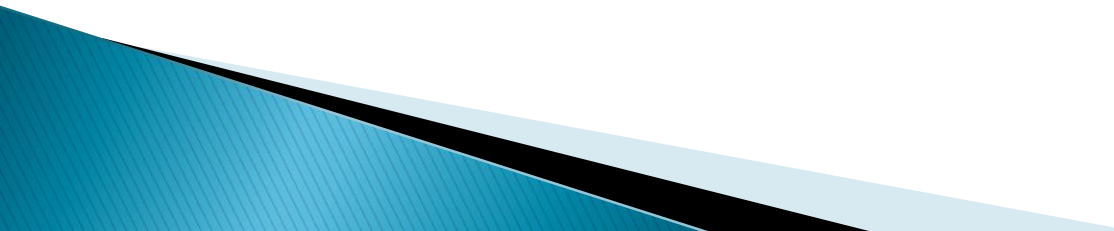
- Upper end bearing is a **bushing** having **an interference fit (nip)** in **the eye bored** in the rod.
- The eye is a single piece bearing (**bush, bushing**) **pressed** into **sleeve**.
- The bushing is of **bronze** or of **cast steel & centrifugally cast bearing metal**.

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5.1 Axial forces →



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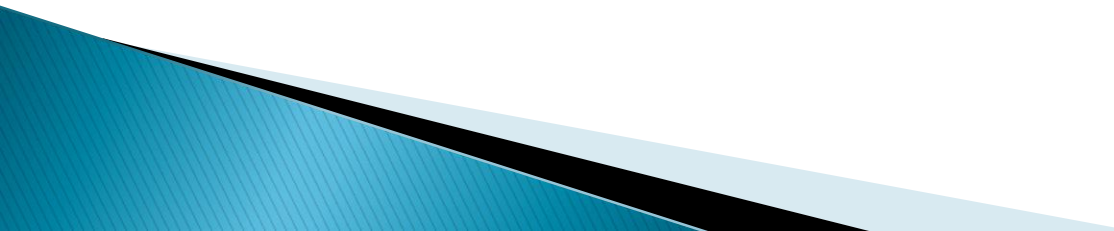
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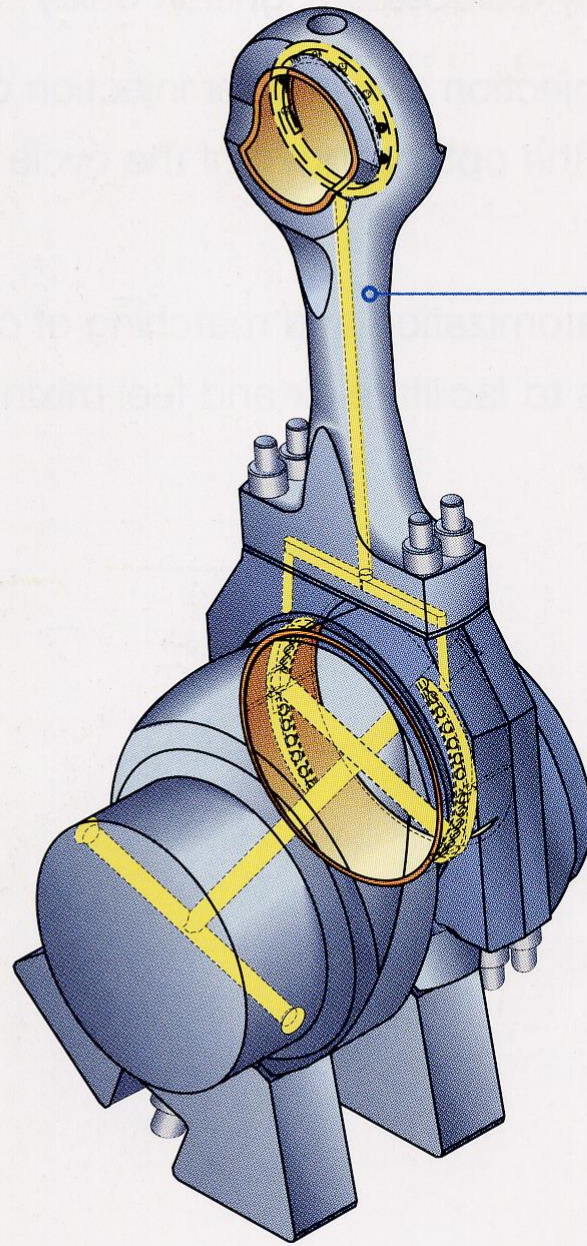
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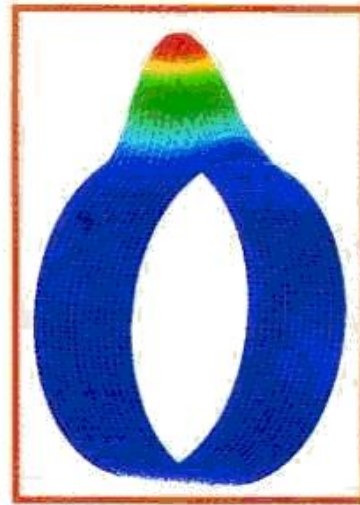
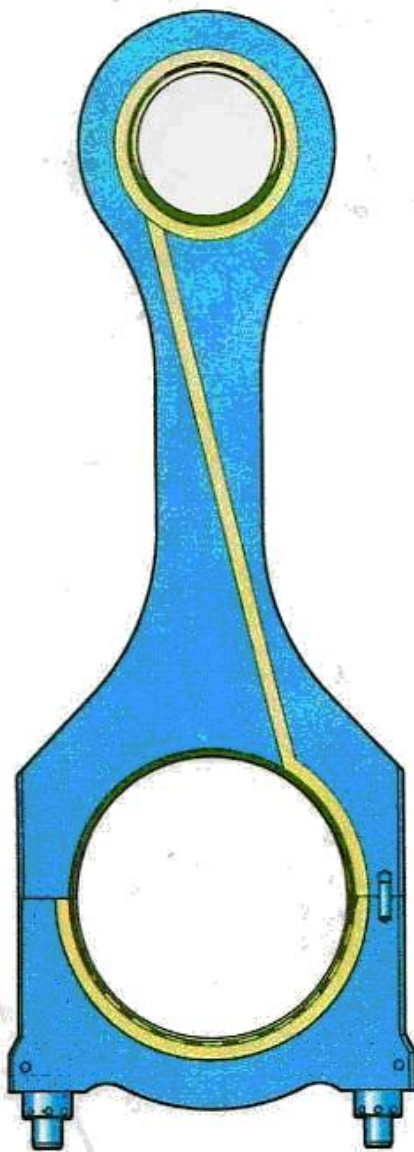
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6. LUBRICATION

It is carried out through the **shank bore** (**drilling**) **in running** throughout the shank length. It **conducts** oil from the big end to the small end for **lubrication** and to the inside of piston for its **cooling**.



Fully Machined
Connecting Rod



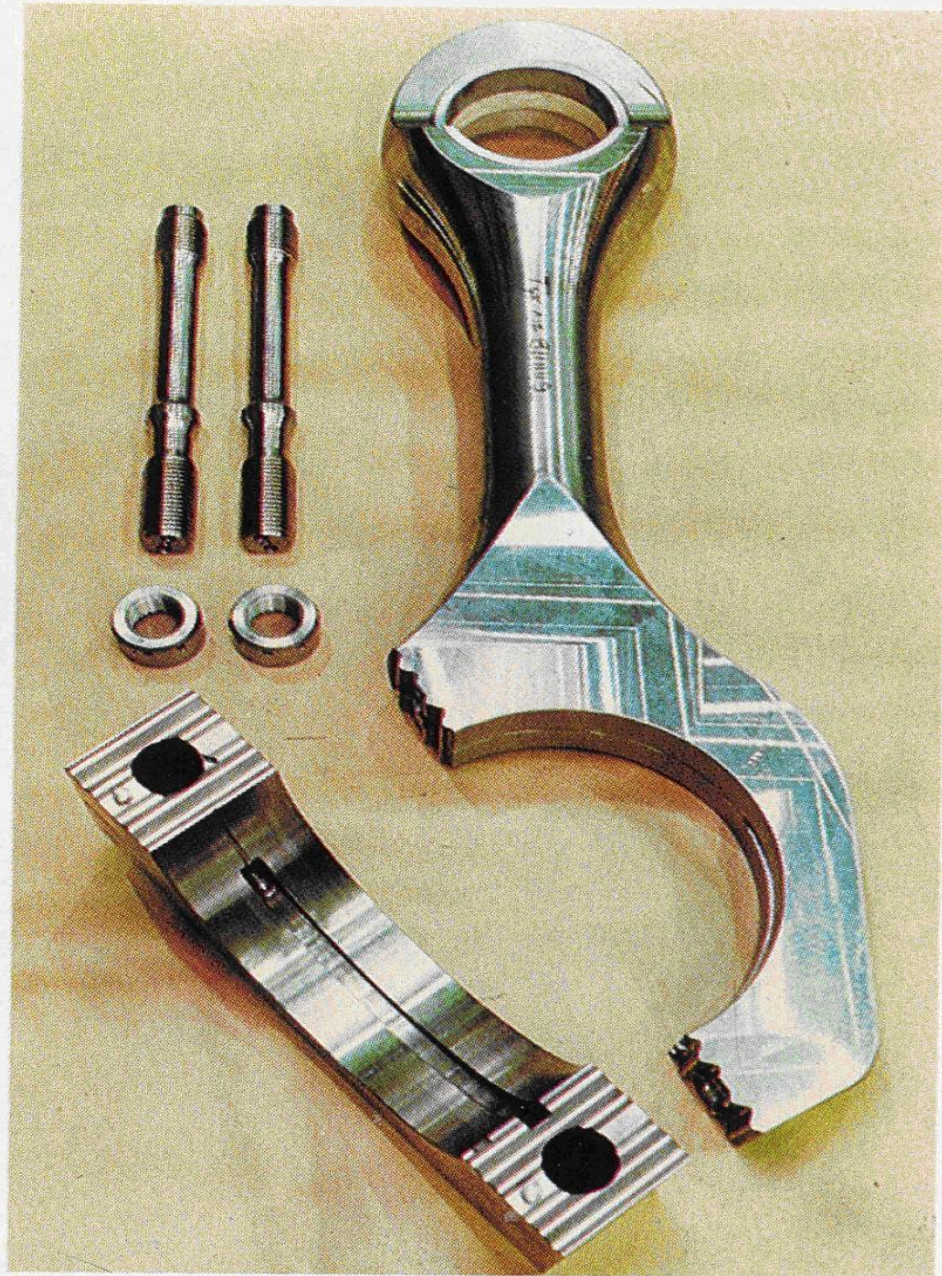
Oil film pressure distribution caused by forces in big end bearing for Wärtsila 64

A bore drilled in latest Wärtsila 64 engines

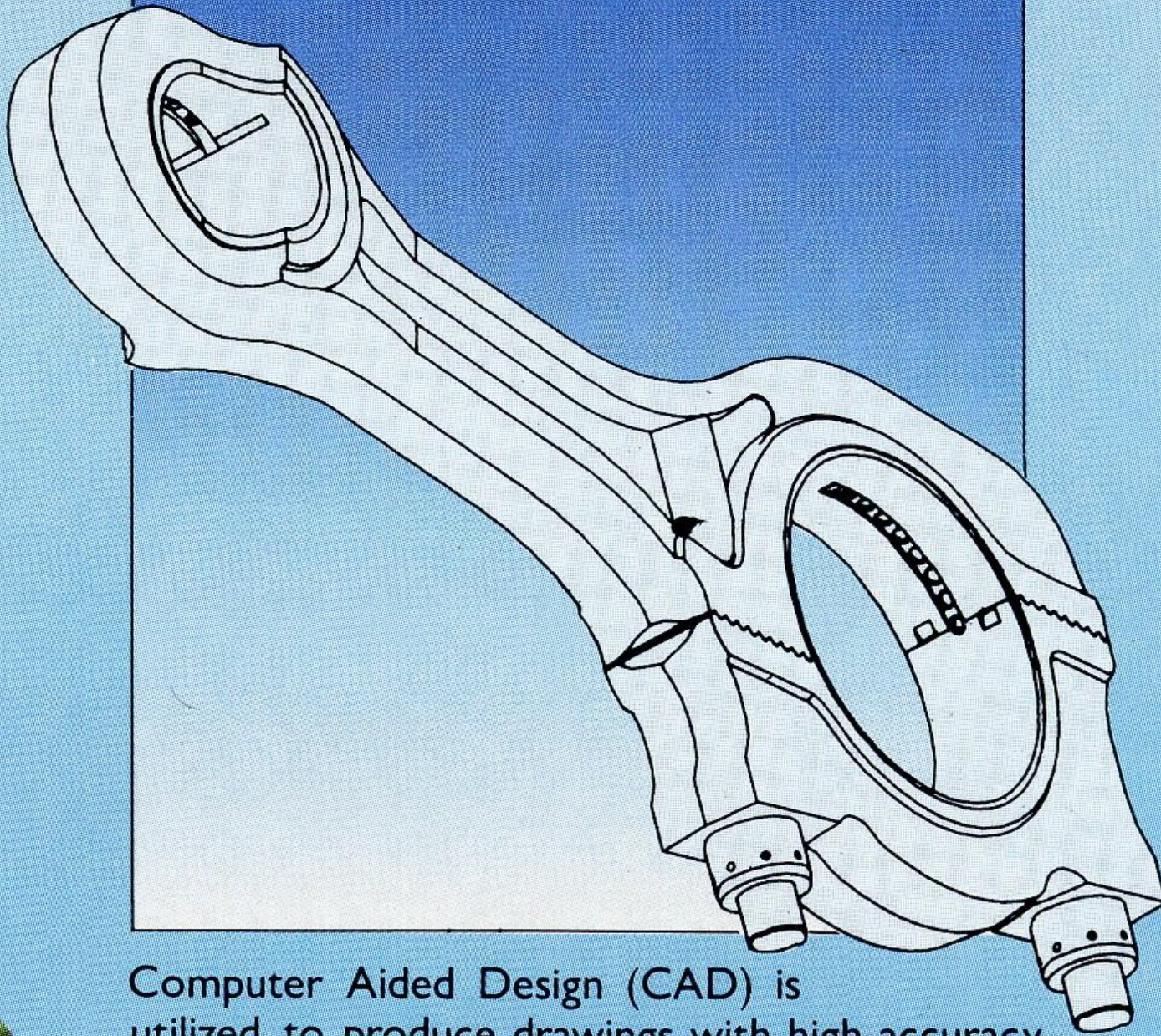
7. WITHDRAWAL

(Pulling out, removal)

In most designs through the **upper end**. In few designs the piston and The connecting rod are withdrawn **downwards**.



The connecting rod is fully machined.



Computer Aided Design (CAD) is utilized to produce drawings with high accuracy.