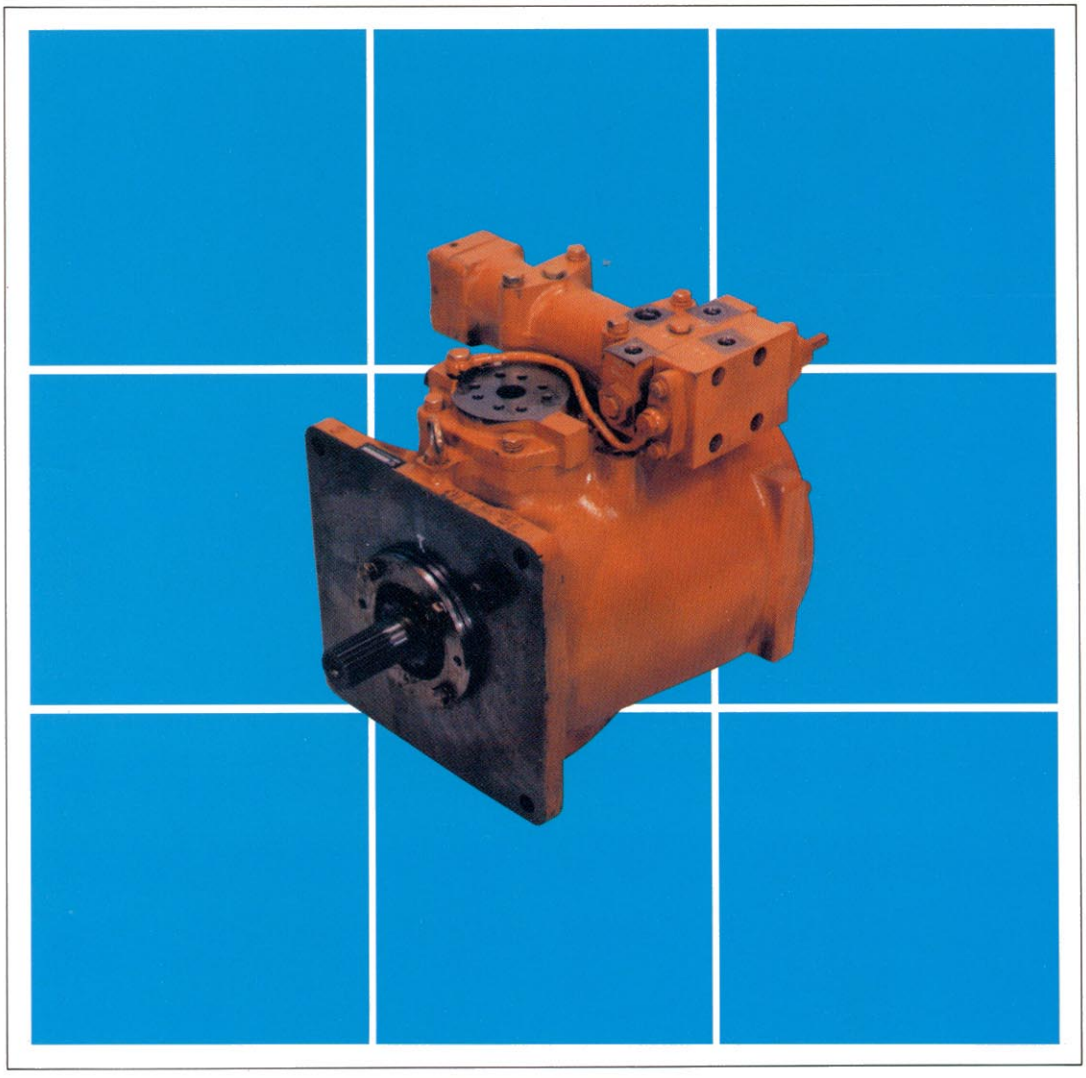
FORM : SEBG4120-01

SHOP MANUAL

GUIDANCE FOR REUSABLE PARTS

PISTON PUMPS and MOTORS



GUIDANCE FOR REUSABLE PARTS

KOMATSU

INDEX

INTRODUCTION

This Guidance for Reusable Parts provides basic knowledge and explanation of the causes of damage needed when disassembling, assembling or repairing piston pumps and motors (PPM).

It includes photographs of various types of damage so that judgement can be made visually as to whether a part can be used again or not.

This Guidance for Reusable Parts is designed so that it can be used by a wide range of people in the repair and maintenance of piston pumps and motors. We hope that it will be used to make suitable judgement about reuse or replacement of parts to reduce repair costs and to improve machine availability.

Note: This publication is intended for guidance only and KOMATSU LTD. hereby expressly denies and excludes any representation, warranty or implied warranty for the reuse of piston pumps and motors.

TYPE OF HYDRAULIC PUMPS

Hydraulic pump	**Rotating type**	Gear pump Vane pump Screw pump
	Double acting type	Axial piston pump (bent axis type, swash plate type) Radial piston pump Reciprocating piston pump

★ Hydraulic pumps are categorized according to their form into fixed displacement pumps and variable displacement

Specifications of hydraulic pumps

The main specifications used to describe hydraulic pumps are as follows.

1. Displacement volume (per rotation) Unit : cc/rev
   This shows the displacement for one revolution of the hydraulic pump.

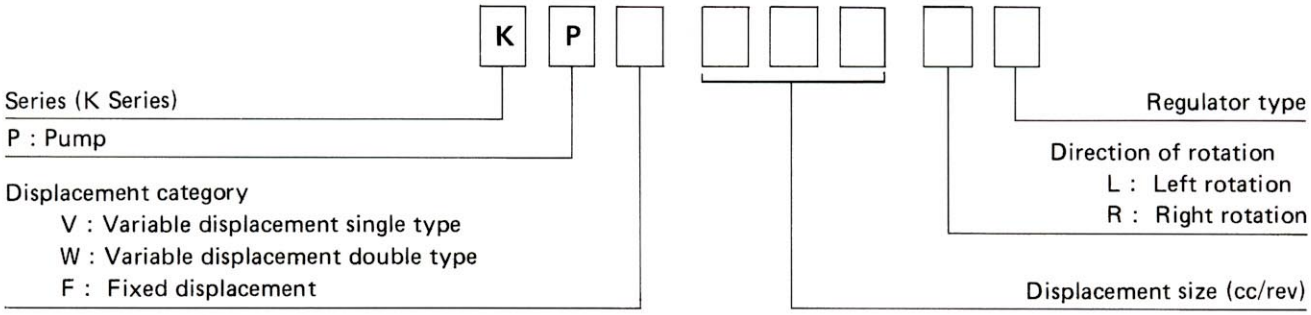
2. Delivery (per minute) Unit : litre/min
   This shows the amount of oil delivered in one minute when the hydraulic pump is rotating at the specified speed.

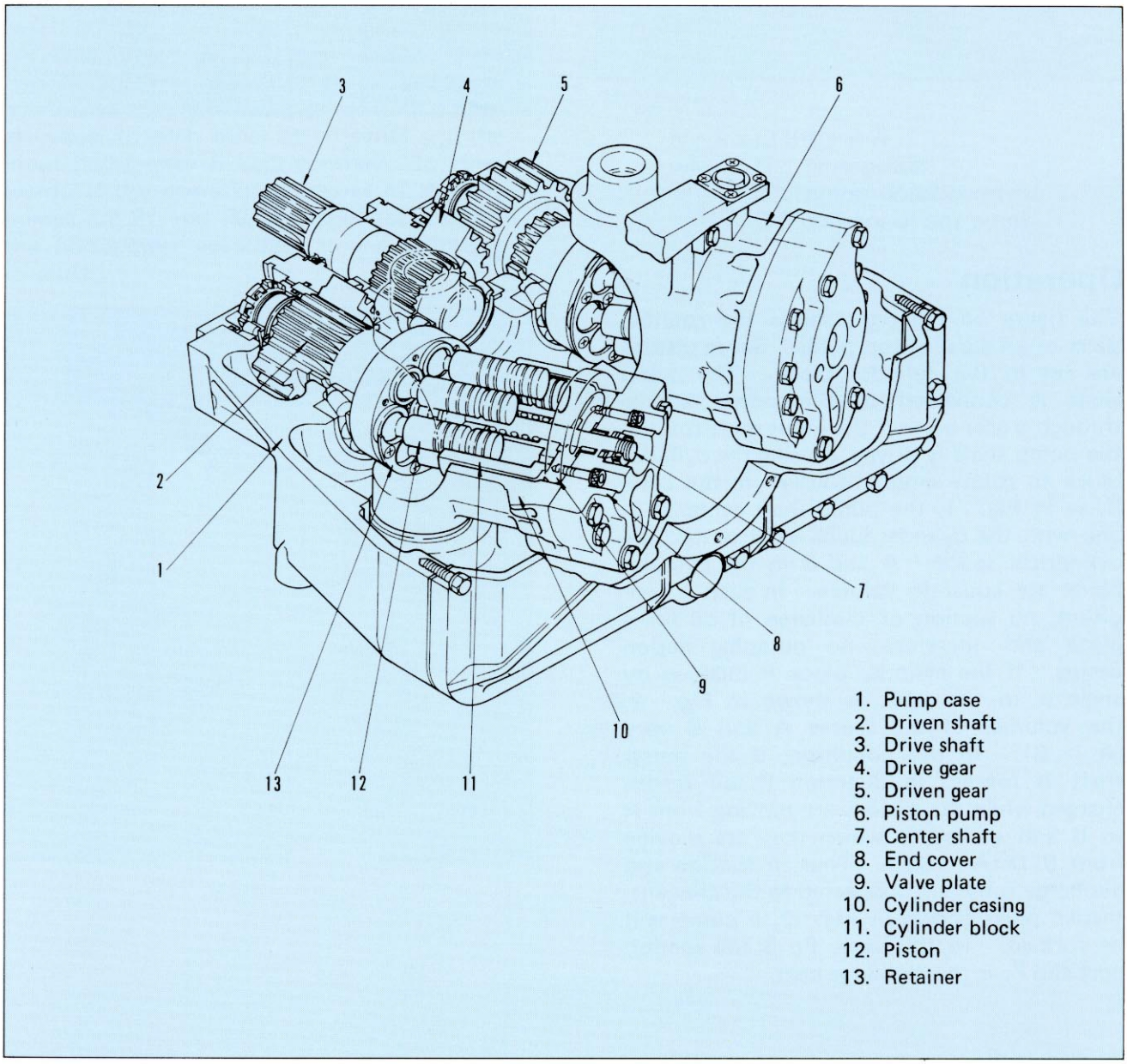
3. Max. speed Unit : rpm
   This shows the maximum permissible speed of the hydraulic pump.

4. Rated pressure Unit : kg/cm^2
   This shows the maximum pressure at which the hydraulic pump can be used continuously for a fixed time.

5. Peak pressure (momentary maximum pressure) Unit : kg/cm^2
   This shows the maximum momentary pressure which is generated when a load is applied to the hydraulic pump.

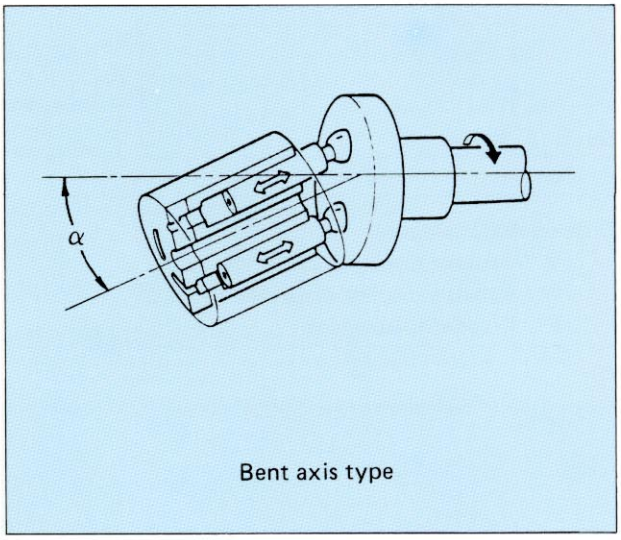
Piston pump (bent axis type)





Function

The motive force transmitted to the main shaft is transmitted to the drive shaft, and the rotation and torque are converted into hydraulic energy. Pressurized oil is then delivered corresponding to the load. Because of the movement of the servo piston, the angle of the piston pump in the axial direction (α = bent axis angle) is changed, so the delivery volume is changed freely.



Bent axis type

Operation

The figure on the right shows the rotating parts of an axial piston pump. Seven pistons are set in the cylinder block. The pump shaft is connected to the power source through a gear box. If the input shaft rotates, the pump shaft is driven, causing the cylinder block to rotate simultaneously. In this case, if, as in Fig. 1, the pump shaft center is in line with the cylinder block axial center, the cylindrical spaces A and B in the cylinder block are equal in volume. In such a condition, no suction or discharge of oil takes place and therefore, no pumping action occurs. If the cylinder block is inclined by angle α to the shaft as shown in Fig. 2, the volumes of the spaces A and B vary (A $>$ B). In this condition, if the pump shaft is rotated in direction P, oil is discharged while the pistons are moving from A to B and sucked in which they are moving from B to A (180°). Thus, if suction and discharge tubes are connected to the crescent-shaped ports shown in Fig. 2, a pump will be formed. In this case, Pb is the suction port and Pc is the discharge port.

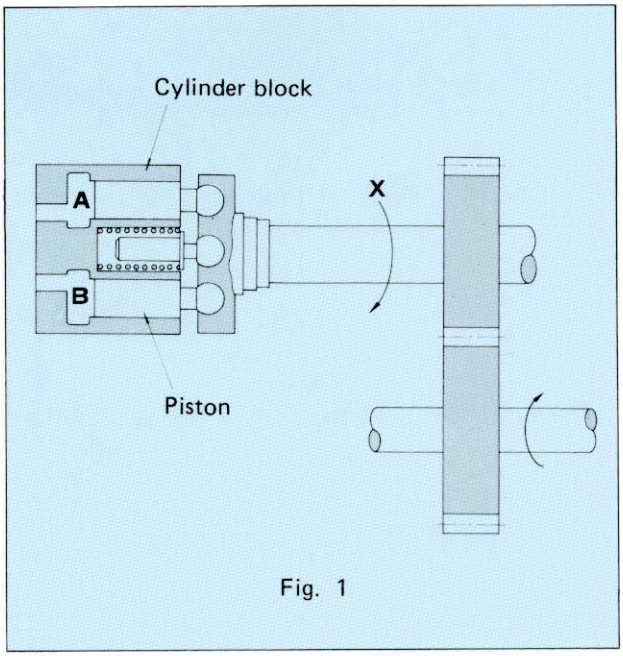


Fig. 1

As mentioned above, if angle α is 0°, neither discharge nor suction takes place. If a difference in volume occurs between spaces A and B, suction and discharge of oil takes place. The flow rate q per rotation increases as the value of (A-B) increases (that is, as a angle α becomes larger). This axial piston pump is designed so that the maximum value of angle α is 25°

The KPW pump is designed specially as a hydraulic power source for construction machines. Two variable capacity axial pumps (bent axis type) are installed in one casing together with the drive shaft gear. These are then driven by one input shaft. These two pumps are controlled by a special regulator, so that the flow rates of both pumps are equal to each other at all times and the input horsepower is kept constant. In other words, if the operating pressures of the two pumps are P1 and P2, the regulator controls the horsepower according to the following formula.

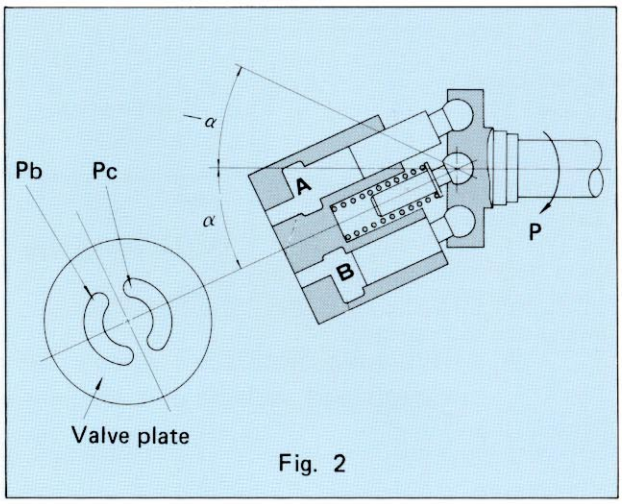


Fig. 2

$N = k \times Q\ (P1 + P\ 2)$

where N : horsepower
k : proportional constant
Q : delivery of one pump

TYPE OF HYDRAULIC MOTORS

Hydraulic motor	**Rotating type**	Gear motor Vane motor Screw motor
	Double acting type	Axial piston motor (bent axis type, swash plate type) Radial piston motor

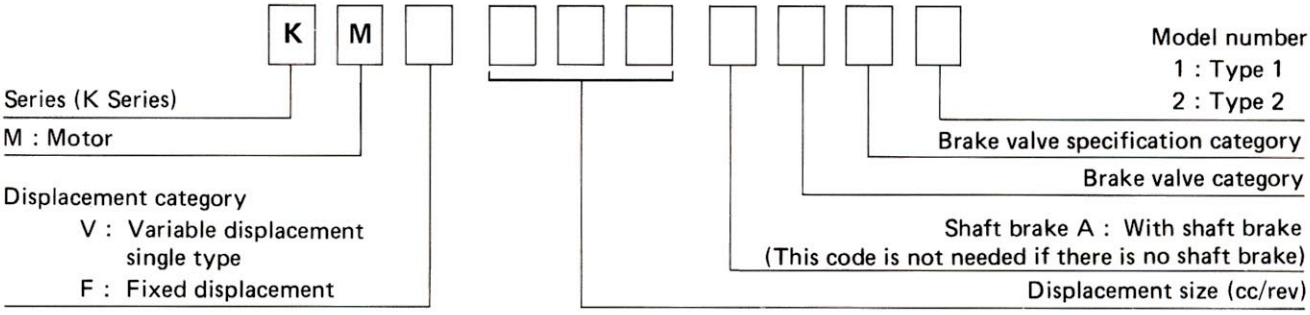
★ Hydraulic motors are categorized according to their form into fixed displacement motors and variable displacement motors.

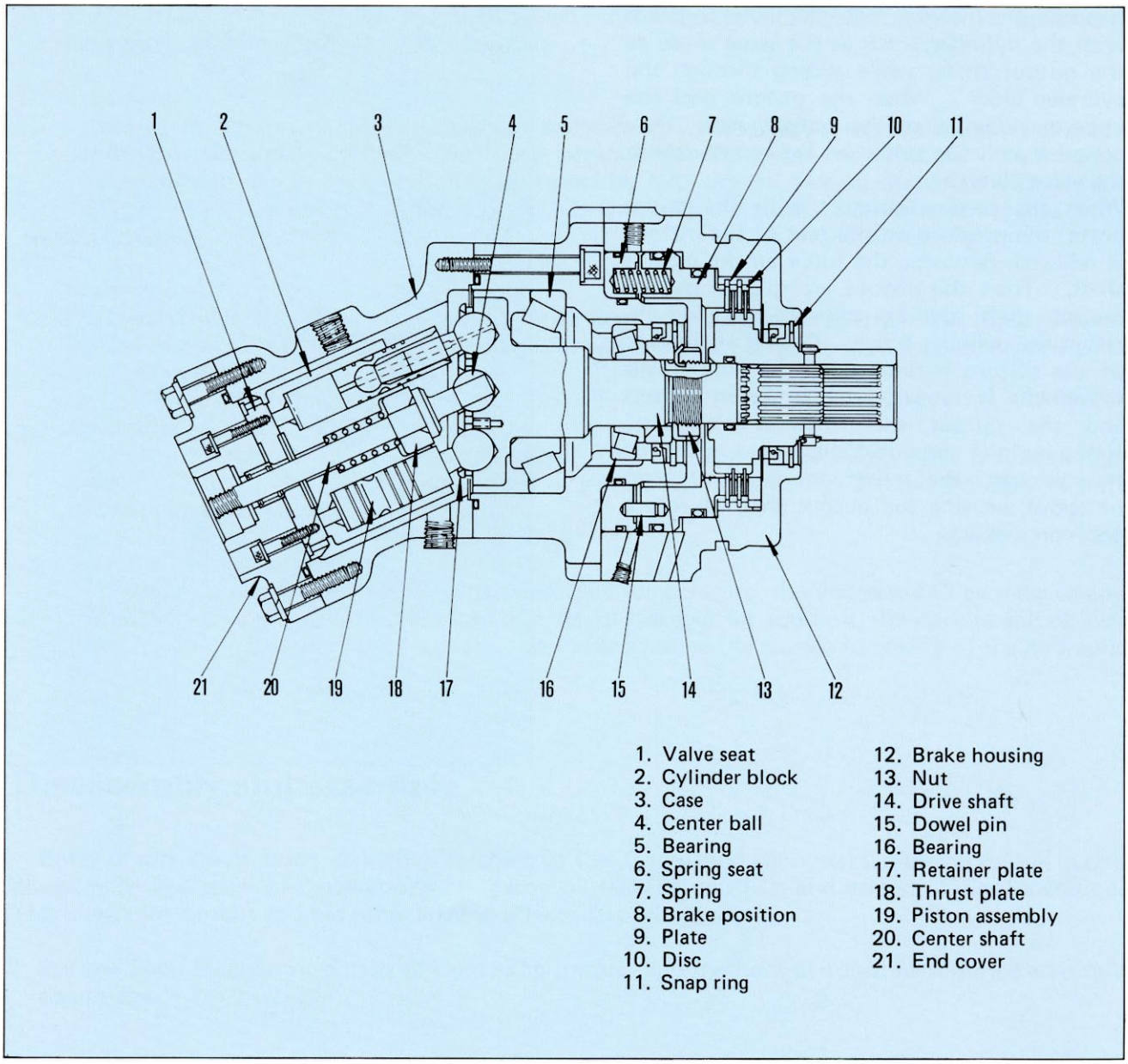
Specifications of hydraulic motors

The main specifications used to describe hydraulic motors are as follows.

1. Theoretical displacement Unit : cc/rev
   This shows the theoretical flow needed to rotate the hydraulic motor one turn. It corresponds to the theoretical delivery (per rotation) of the hydraulic pump.
2. Max. speed Unit : rpm
   This shows the maximum permissible speed of the hydraulic motor.
3. Rated pressure (normal continuous pressure) Unit : kg/cm^2
   This shows the maximum pressure at which the hydraulic motor can be used continuously for a specified time.
4. Rated torque Unit : kgm
   This shows the torque generated by the hydraulic motor at rated pressure.

Piston motor (bent axis type)





1. Valve seat
2. Cylinder block
3. Case
4. Center ball
5. Bearing
6. Spring seat
7. Spring
8. Brake position
9. Plate
10. Disc
11. Snap ring
12. Brake housing
13. Nut
14. Drive shaft
15. Dowel pin
16. Bearing
17. Retainer plate
18. Thrust plate
19. Piston assembly
20. Center shaft
21. End cover

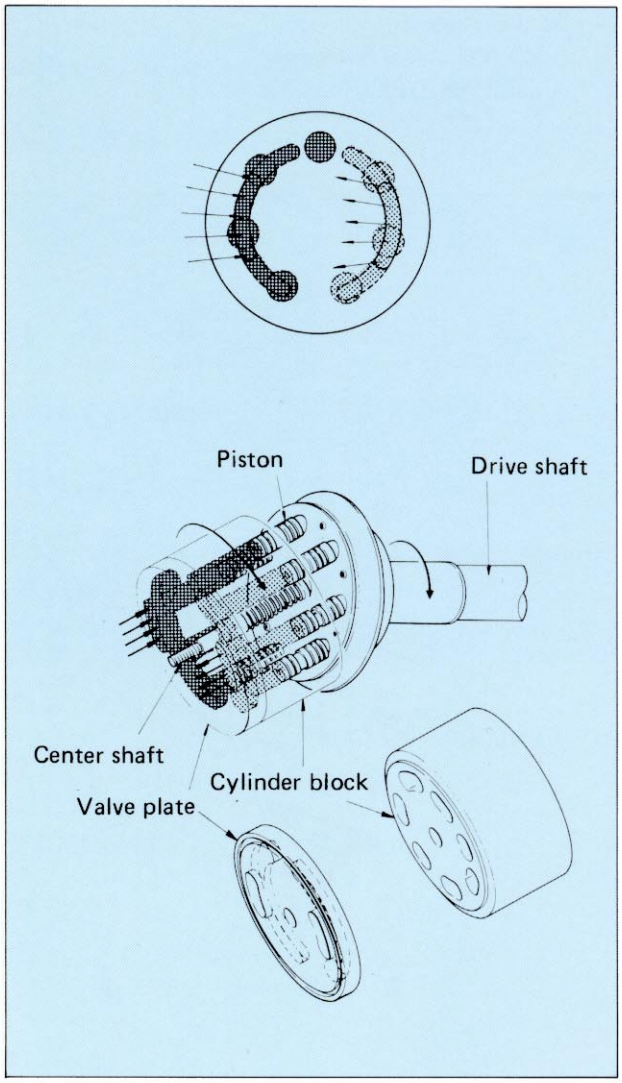
Function

The piston motor converts the pressurized oil (fluid energy) sent by the hydraulic pump into motive force (mechanical energy).

Operation

In the drawing on the right, when oil flows into the valve plate ports on the left and out of the ports on the right, the oil pressure is applied to the rear sides of the pistons connected to the left hand ports, causing the output shaft to rotate clockwise. When this happens, the pistons rotate clockwise together with the cylinder block at the same speed as the output shaft, while sliding through the cylinder block. When the pistons pass the uppermost point of the output shaft, they connect with the ports on the outlet side in the valve plate.

When the pistons connect with the outlet ports, the pressure on the rear of the pistons is relieved, removing the force on the output shaft. Then the pistons are rotated by the output shaft and are allowed to slide through the cylinder block. The oil at the rear of the pistons is drained to the tank. This movement is repeated by all seven pistons and the output shaft rotates clockwise. If the oil inlet and outlet ports are used in the reverse way, the movement is the reverse of above, causing the output shaft to rotate counterclockwise.



MAIN CAUSES OF DAMAGE

About 70% of damage to hydraulic equipment is caused by problems in maintenance and in the selection of hydraulic oil. Therefore, to prevent damage, and to use the machine efficiently, it is important to give careful consideration to the selection of hydraulic oil and to the way of handling the machine.

Hydraulic oil

Hydraulic oil is an important element because it acts as the medium to transmit pressure. It also plays an important role as a coolant and lubricant for sliding parts.

As the hydraulic oil is used, it becomes contaminated by the entry of dirt of water, so the condition of the oil is generally checked by the following four items : discoloration, water content, viscosity, and acidity (alkalinity). Of these, the items which most frequently lead to damage of the equipment are water and contaminants causing discoloration.

1) **Discoloration**

Hard particles (contaminants), such as particles of worn metal, sand or dirt, cause wear or scuffing of the sliding surface. They also advance the change to acidity of the hydraulic oil.

Generally speaking, discoloration is expressed by NAS grade. The oil should be within grade 10; it must be changed if it is above grade 12. Grade 11 and grade 12 can often be reused if the oil is cleaned.

2) **Water content**

If water gets into the hydraulic oil, the oil does not lubricate properly. This leads to wear, seizure and rusting of parts. The standard for water content is within 0.2%; above this level, the oil must be changed or cleaned.

3) **Cavitation**

If air gets into the oil, it creates bubbles. When these bubbles burst, there is sudden high pressure at that point, which causes noise or vibration. In particular, around the delivery port of the pump, this causes damage by erosion.

4) **Rise in oil temperature**

If the oil is allowed to rise above the specified temperature, the viscosity will be reduced and the delivery amount will drop because of internal leakage. In addition, the oil film will be lost, thereby causing wear and seizure, and it will also advance the change to acidity of the hydraulic oil.

Disassembly and assembly

Entry of dirt, dents, burrs, scratches, catching of the O-ring, and abnormal tightening torque during disassembly and assembly operations can cause oil leakage, scuffing and seizure during operation. This lowers the output and has other adverse effects on performance.

★ See the Shop Manual for details of tightening torques and methods of adjustment during assembly operations.

JUDGEMENT ABOUT DAMAGE

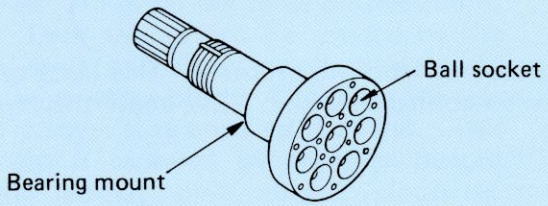
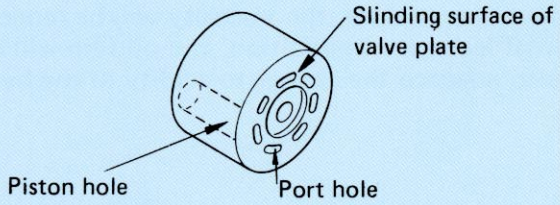
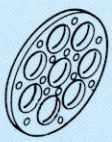
The piston pump and motor are the heart of the hydraulic equipment. If there is wear, scuffing, dents, or seizure of the piston pump or motor, the performance of the hydraulic equipment will drop and other problems will occur. Therefore, it is important to exercise extreme care when making judgements about the reuse of parts.

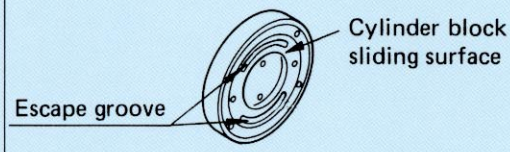
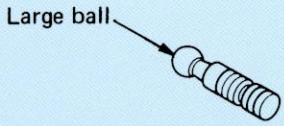
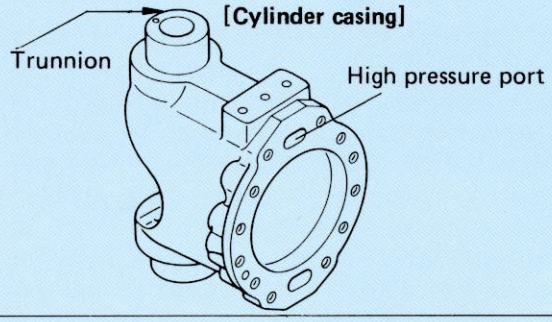
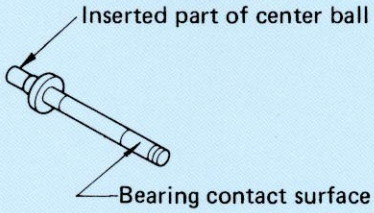
When making judgements about the reuse of parts, it is important to consider daily maintenance and operating conditions to find out exactly why that kind of damage was caused. In this Guidance Manual, there are photographs of damage ranked A, B or C. These photographs should be used together with the know-how derived from experience to make judgements about reuse of the part.

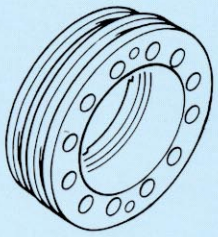
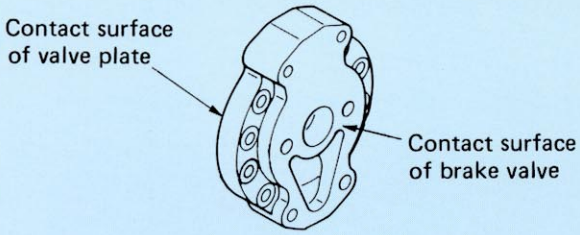
Check points when judging parts

To make accurate judgement on damaged parts, it is necessary to wash and clean the parts first and then to pay careful attention to the following check points.

If there is any malfunction or drop in the performance of a piston pump or motor, check the discoloration of the hydraulic oil and use the results as reference when looking for the cause of the problem.

Part Name	Check point
[Drive shaft] 	• Scratches or seizure of ball socket • Wear of spline • Wear or seizure of bearing mount
[Cylinder block] 	• Scratches, seizure, or wear of valve plate sliding surface • Seizure or wear inside piston hole • Scratches, erosion-corrosion around port hole
[Retainer] 	• Scratches, dents, or deformation around hole • Bending

Part Name	Check point
[Valve plate] 	• Scratches, seizure, cracking, or discoloration of cylinder block sliding surface • Errosion-corrosion around escape groove
[Piston] 	• Wear, scratches, or seizure inside or outside piston • Scratches or wear of large ball
[Cylinder casing] 	• Cracking around high pressure port and root of trunnion • Wear or deformation of trunnion
[Center shaft] 	• Wear or deformation of inserted part of center ball • Wear or seizure of bearing contact surface • Bending in axial direction
[Center ball] 	• Scratches, dents, or deformation of ball surface • Wear, discoloration, or seizure of end face of hole

Part Name	Check point
[Brake piston] 	• Scratches, or cracking of outside circumference
[End cover] 	• Scratches on contact surface of valve plate • Cracking around port hole • Scratches or rust on brake valve contact surface
[Bearing]	• For details, see "Guidance for Reusable Parts", Bearing Section.
[Brake disc, plate]	• For details, see "Guidance for Reusable Parts", Disc, Plate Section.

LEVEL OF DAMAGE AND JUDGEMENT ON REUSE

The level of damage for piston pumps and motors is categorized into three stages : A, B, C. Judgement about reuse of parts is made according to these categories.

Category	Leverl of damage	Action
A	This category indicates slight or minor damage which creates no problem for the performance of the machine. There is no risk of this damage causing secondary damage.	Can be used as it is
B	This category indicates medium damage which at present is no problem to the performance of the machine, but there is a risk of secondary damage, so replacement is preferable if the part is used for· heavy duty work.	Repair and reuse
C	This category indicates serious or critical damage, or that the part has reached the end of its life. If this part is used it may break and cause serious damage, so it must be replaced.;	Can not be reused

Damage to parts does not simply consist of one type of damage; it often consists of several types of damage occurring together. In such cases, take the most dangerous form of damage as a guide when making judgement, and always take the overall safety of the machine into consideration.

If the level of damage is ranked between category A and category B as shown in the photographs, the damage should be ranked at the more dangerous category, that is, category B.

This judgement frequently depends on the user's needs (does the part still have the demanded residual life ?), so it is impossible to make an unconditional judgement. However, it is necessary to consider what kind of operation it will be used in, what level of capacity it must display, what length of time it will be used and if it can be used continuously.

Therefore, judgement on the harmful effects or danger of the damage must be based on experience, so when ranking the damage, use the photographs as reference.

Judgement standards for reuse

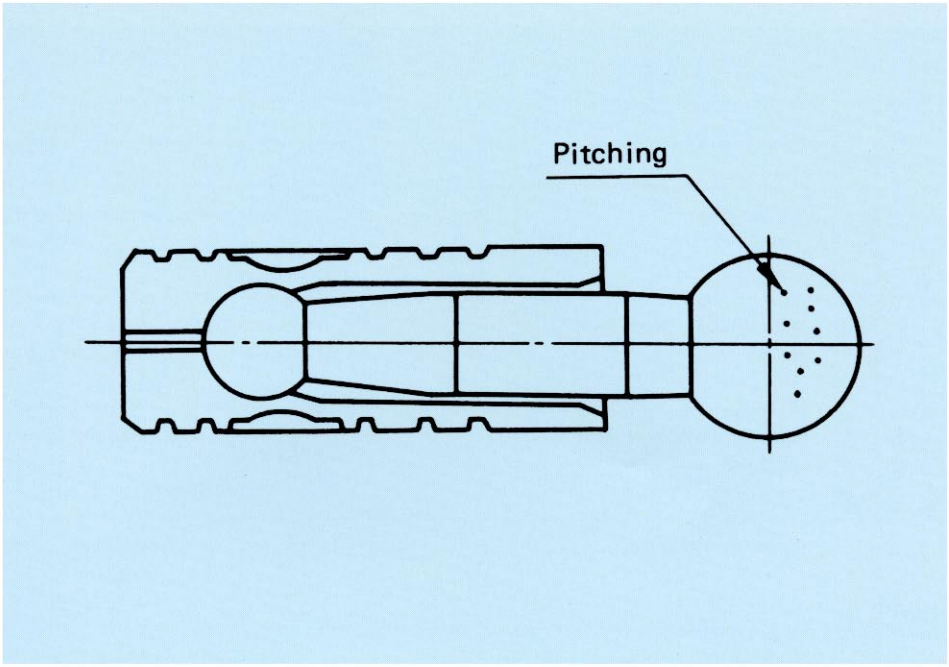
Part Name	Location of damage		Category		
			A	B	C
Drive and driven shaft	1	Ball socket	No scratches, seizure, or discoloration	–	Shows scratches, discoloration or seizure
	2	Spline	Wear of tooth face within 0.5 mm	–	Wear of tooth face over 0.5 mm
	3	Shaft bearing mount	No seizure or wear	–	· Shows seizure or wear · Clearance is made when shaft bearing is reassembled
Cylinder block	1	Valve plate sliding surface	No scratches, seizure, or wear	Lap again if fingernails catch in the scratch	· Scratch remains even after lapping · Shows extreme seizure and wear
	2	Inside surface of piston bore	No seizure or wear When piston is inserted it moves smoothly to the bottom of the bore	–	· Shows seizure or wear · Piston does not go in.
	3	Area around port hole	No scratches or erosion-corrosion	Erosion-corrosion does not deform the shape of the port Lap scratches again	Shows scratches and erosion-corrosion
Valve plate	1	Cylinder block sliding surface	No scratches, seizure, cracking, or discoloration	Reuse possible if metal deposits of cylinder block metal are removed after lapping	· There are scratches joining the ports · There are cracks
	2	Escape groove	No erosion-corrosion	Reuse possible if damage is removed by lapping	Shows erosion-corrosion
Piston	1	Outside circumference of piston	· No wear, scratches, seizure, or cracking · Moves smoothly when inserted in piston bore of cylinder block	–	· Shows scratches, seizure, or cracking Piston does not go into piston bore · Shows wear * If more than one of the PPM set is damaged or broken, replace the whole piston assembly.
	2	Large ball	· No scratches or wear · Moves smoothly when inserted in ball socket of drive shaft	–	Shows scratches or wear

Part Name	Location of damage		Category		
			A	B	C
Retainer	1	Bending	No bending	Bending within 0.3 mm	Bending more than 0.3 mm
	2	Hole	No scratches, dents or deformation	Scratches and dents can be easily removed with sand-paper	• Hole is deformed • Shows scratches or dents
Center shaft	1	Insertion part of center ball	No deformation or wear	–	Shows deformation or wear
	2	Bearing contact surface	No wear or seizure	–	Shoes wear or seizure
	3	Bending	No bending		Bending more than 0.05 mm
Center ball	1	Ball surface	• No scratches, dents, or deformation • Moves smoothly when inserted in ball socket of drive shaft	Scratches and dents can be easily removed with sand-paper	Shows deformation or deep scratches and dents
	2	End face of hole	No wear, seizure, or dis-coloration	–	Shows wear, seizure, or dis-coloration
Brake piston	1	Outside circum-ference	No scratches or cracks	–	Shows scratches or cracks
End cover	1	Valve plate contact surface	No scratches	Reuse possible if scratches are removed by lapping	All damage except A and B
	2	Cracking	No cracking	–	All damage except A
	3	Brake valve contact surface	No scratches or rust	Scratches can be easily removed with sandpaper (#600~#1200) or oilstone	All damage except A and B
Cylinder casing	1	Cracking	No cracking Around high pressure port and trunnion root	–	All damage except A
	2	Trunnion	No wear or deformation	–	All damage except A

EXAMPLES OF DAMAGE

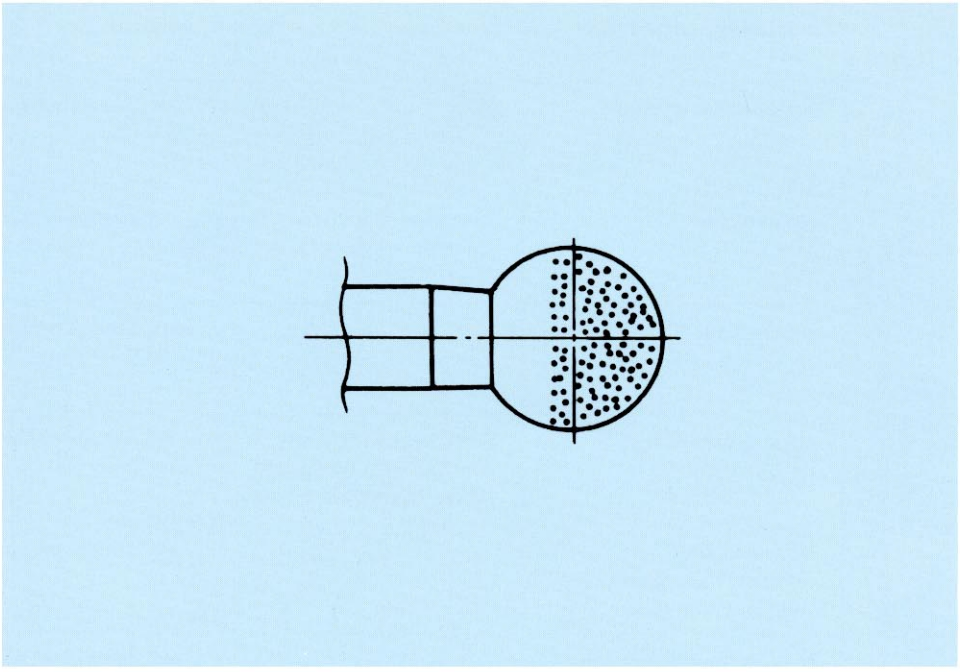
Large ball of piston

1



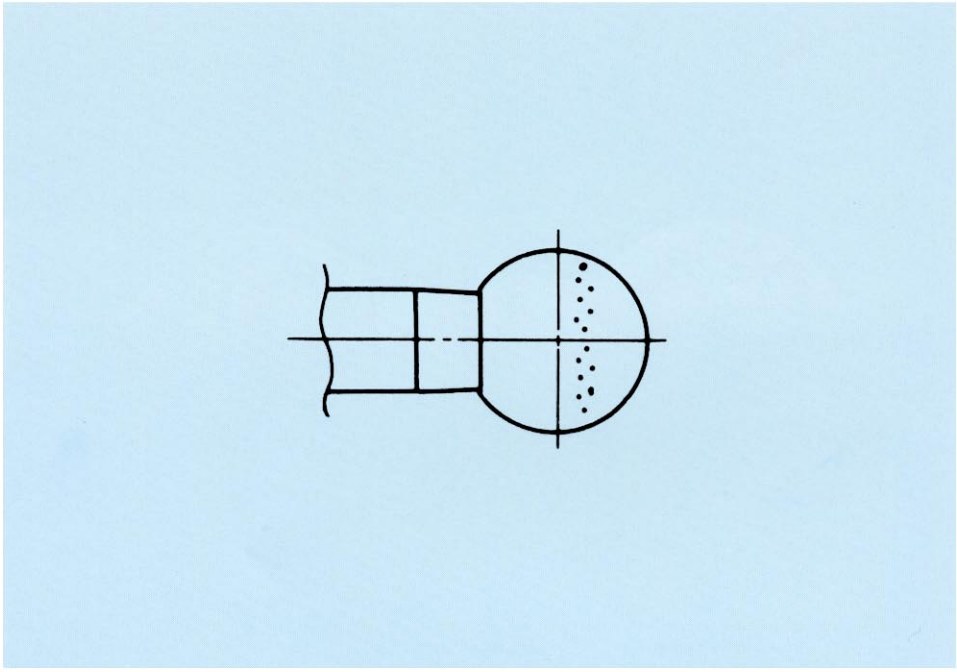
Category : A
Condition : Pitting has occurred in places
Cause : Shock caused by hydraulic vibration (pulsation)

2



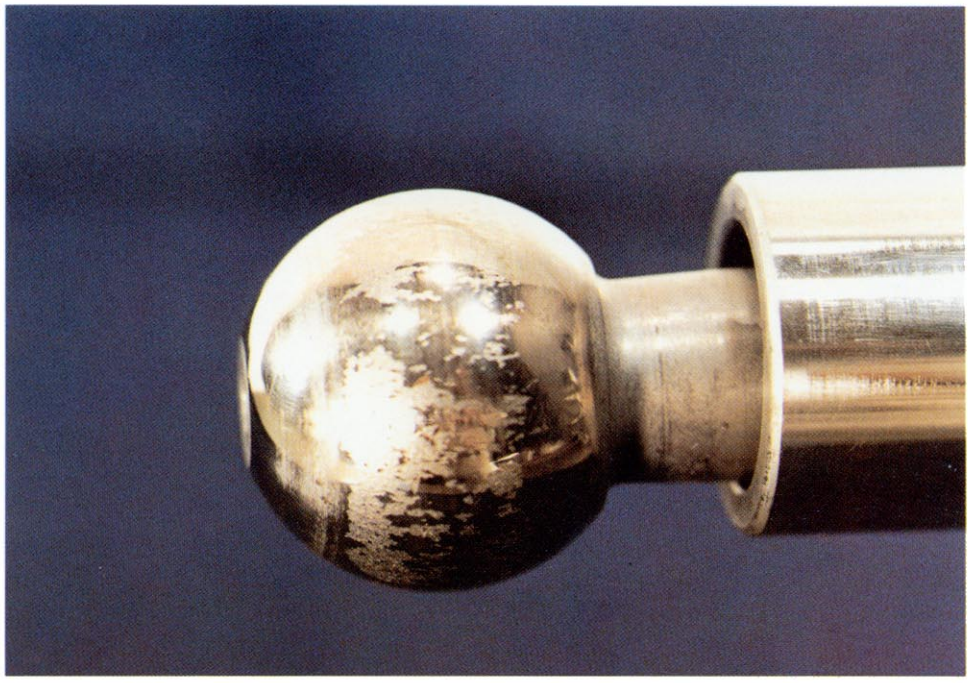
Category : C
Condition : The face is completely pitted, surface roughness and sphericality defective
Cause : Shock caused by hydraulic vibration (pulsation)

3



Category : C
Condition : Pitting has occurred in a band
Cause : Shock caused by hydraulic vibration (pulsation)

4

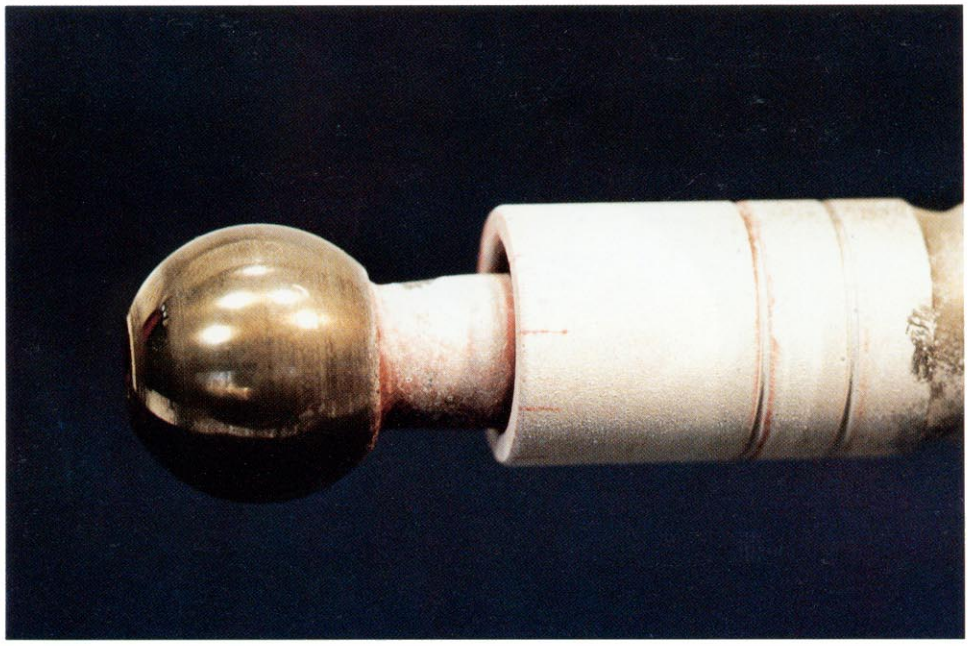


Category : C
Condition : Pitting has occurred in a band.
Cause : Shock caused by hydraulic vibration (pulsation)

5

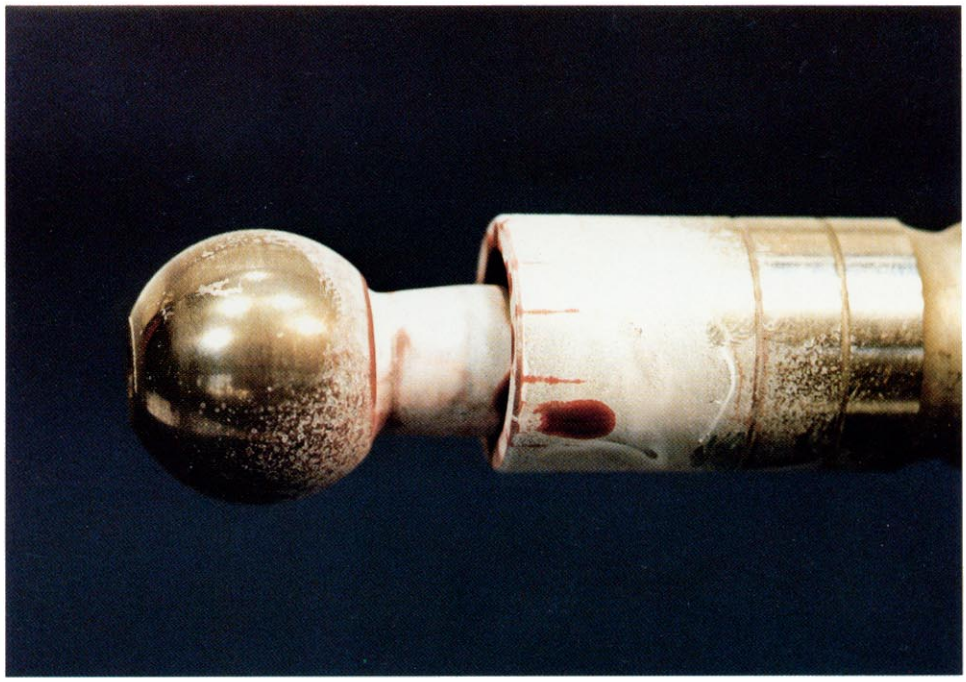
Category : C
Condition : Cracks found in end of piston
Cause : Excessive load acted on part due to abnormal pressure vibration

6



Category : C
Condition : Cracks found in end of piston
Cause : Excessive load acted on part due to abnormal pressure vibration

7

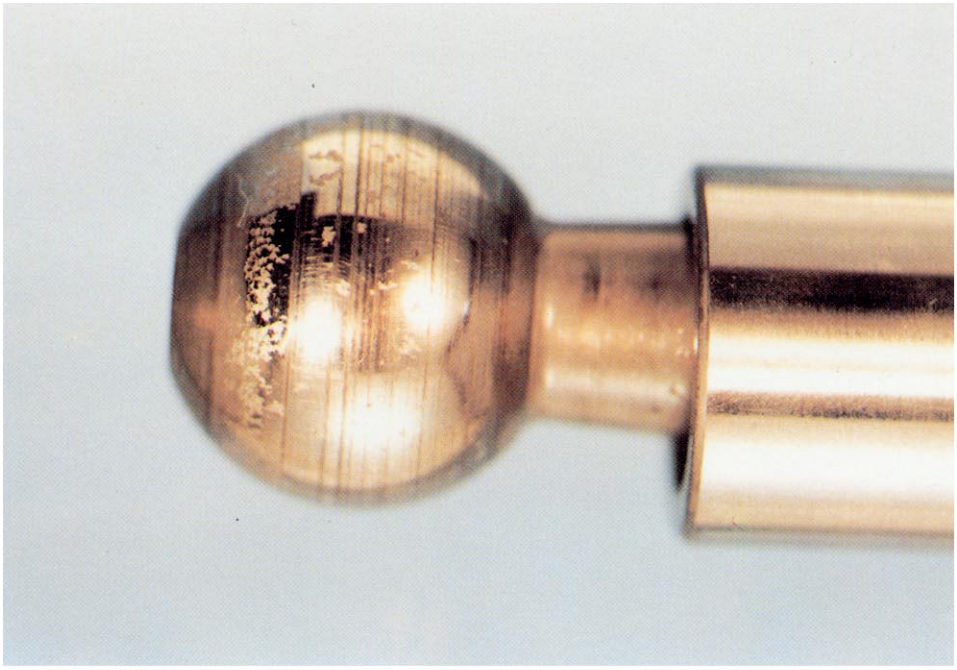


Category : C
Condition : Cracks found in end of piston
Cause : Excessive load acted on part due to abnormal pressure vibration

8

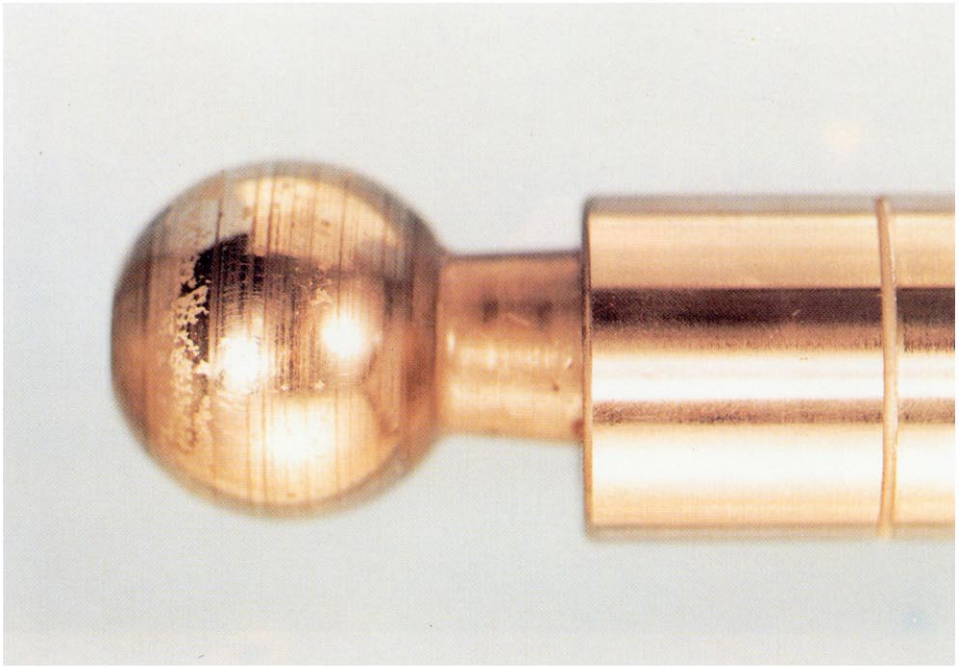
Category : C
Condition : Cracks found in end of piston
Cause : Excessive load acted on part due to abnormal pressure vibration

9



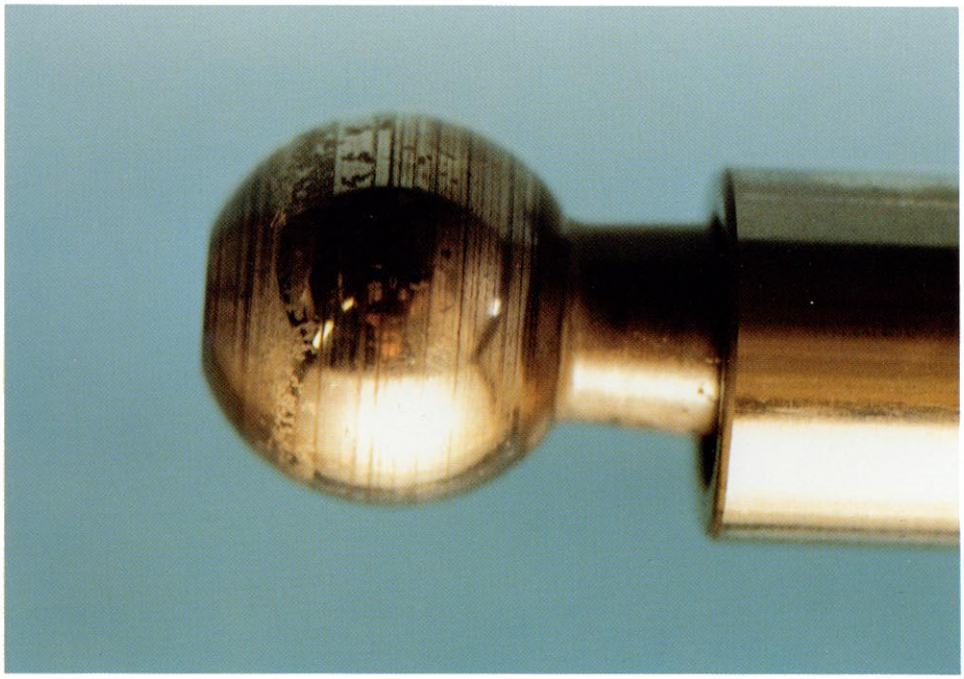
Category : C
Condition : Pitting found in large ball of piston
Cause : Shock caused by hydraulic vibration (pulsation)

10



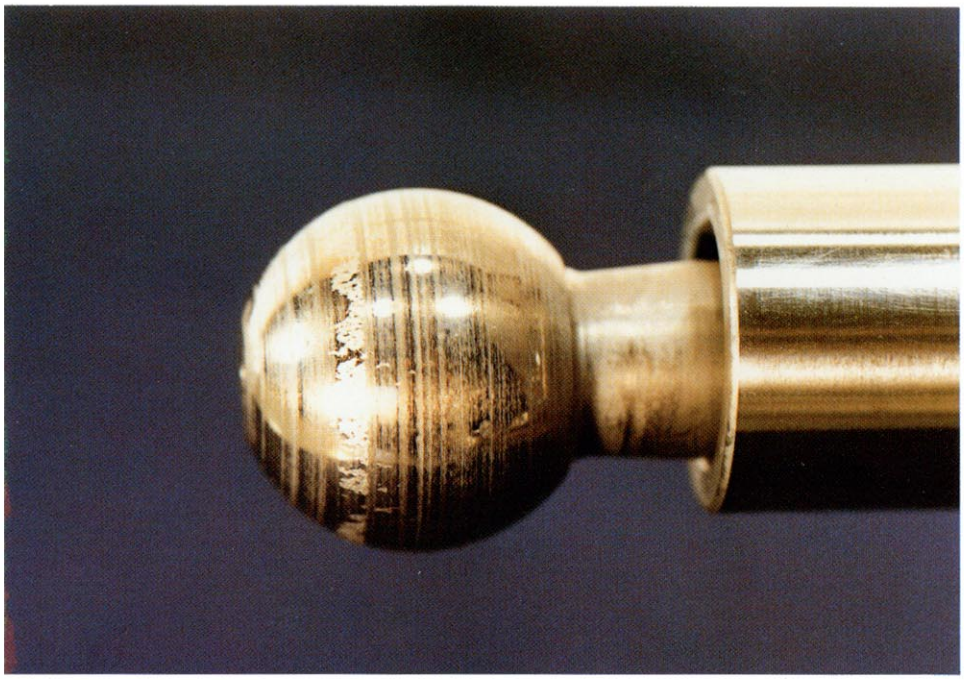
Category : C
Condition : Pitting found in large ball of piston
Cause : Shock caused by hydraulic vibration (pulsation)

11



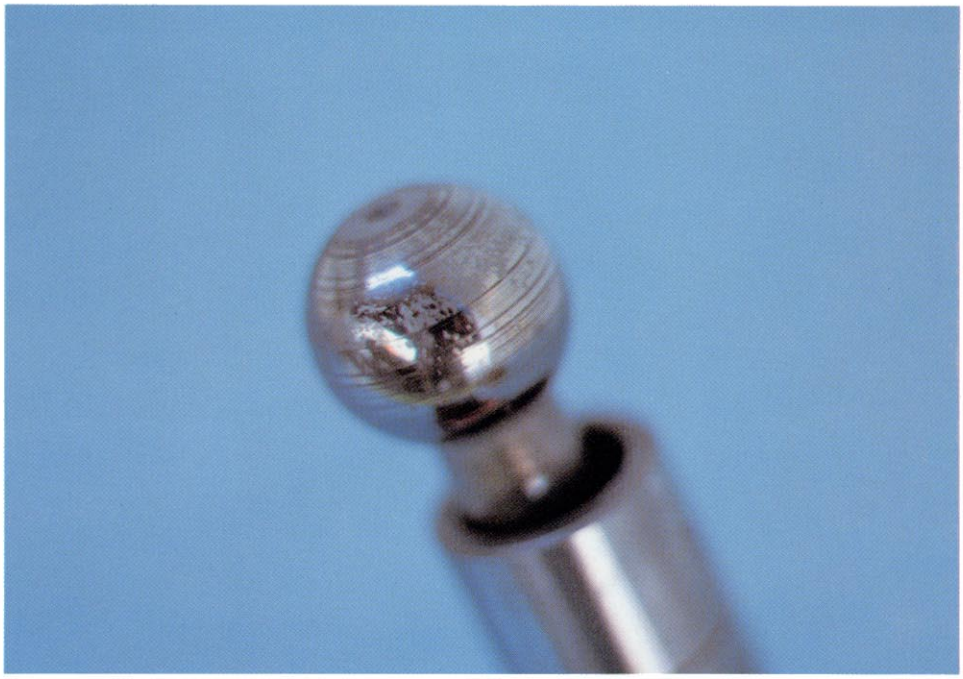
Category : C
Condition : Pitting found in large ball of piston
Cause : Shock caused by hydraulic vibration (pulsation)

12



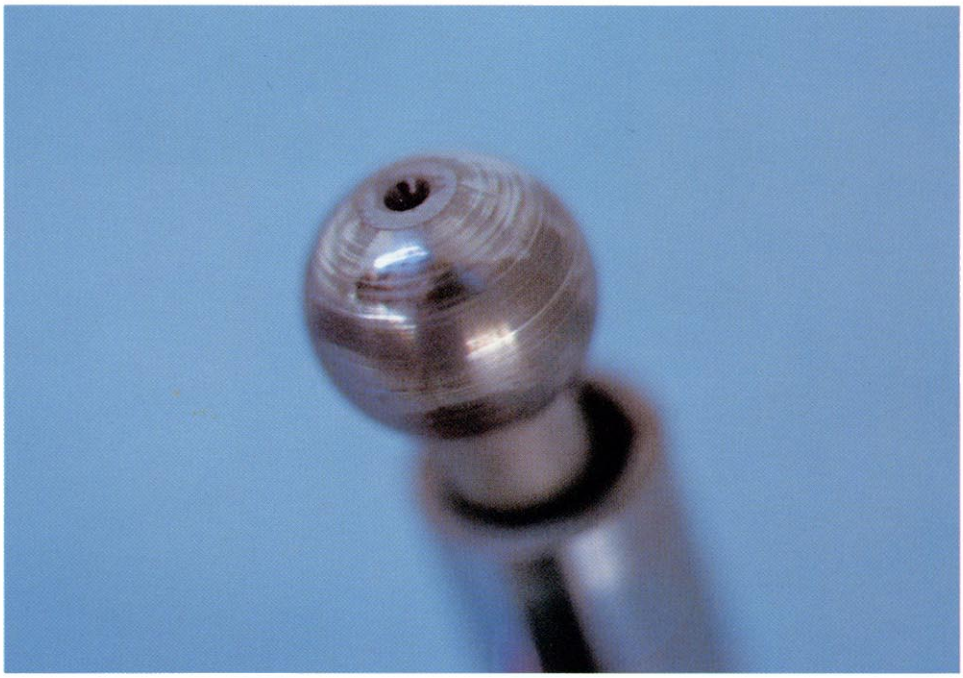
Category : C
Condition : Pitting found in large ball of piston
Cause : Shock caused by hydraulic vibration (pulsation)

13



Category : C
Condition : Pitting found in large ball of piston
Cause : Shock caused by hydraulic vibration (pulsation)

14



Category : A
Condition : No pitting found in large ball of piston
Cause :

Center shaft

15

Category : C

Condition : Wear caused by contact with spring found at middle of center shaft

Cause : Wear at contact point caused by contact with spring (replace spring at the same time)

16

Category : A

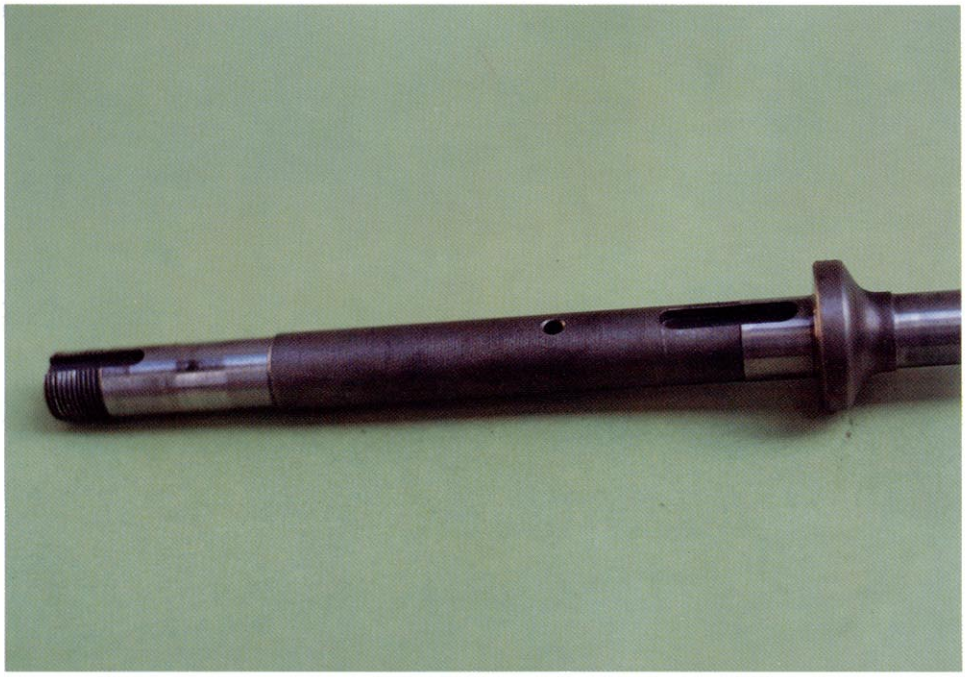
Condition : Bearing contact surface in good condition, slight wear caused by contact with spring

Cause :

17

Category : A
Condition : Bearing contact surface in good condition
Cause :

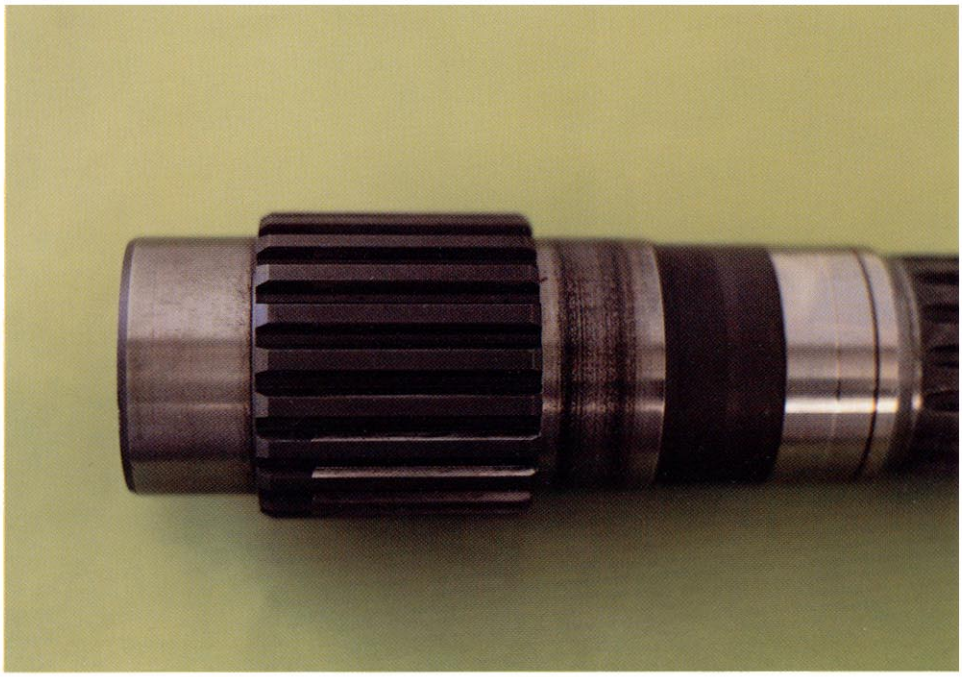
18



Category : A
Condition : Bearing contact surface in good condition
Cause :

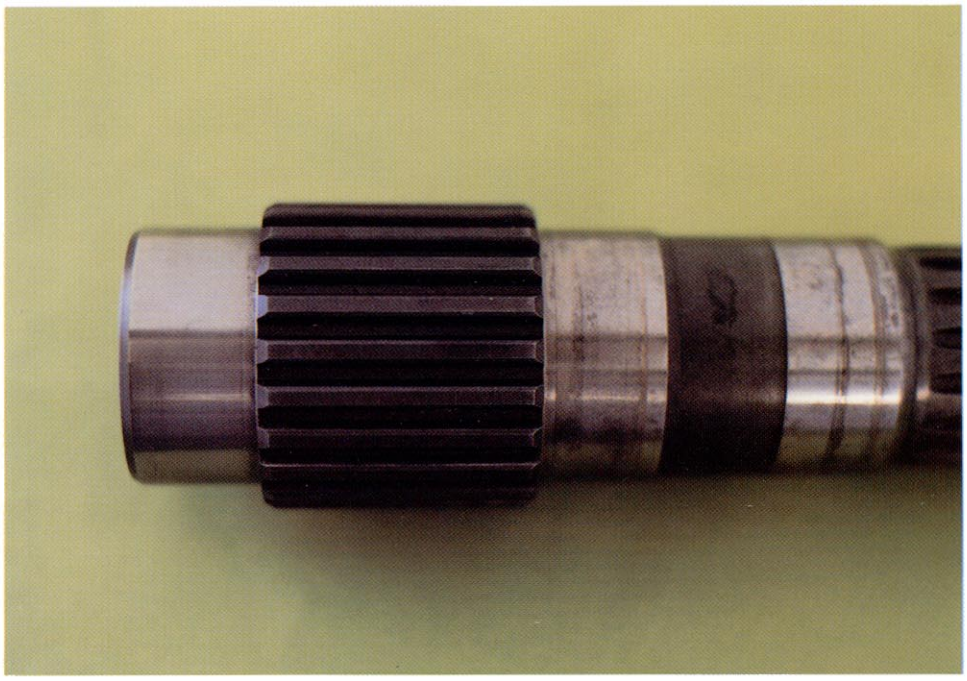
Drive and driven shaft

19



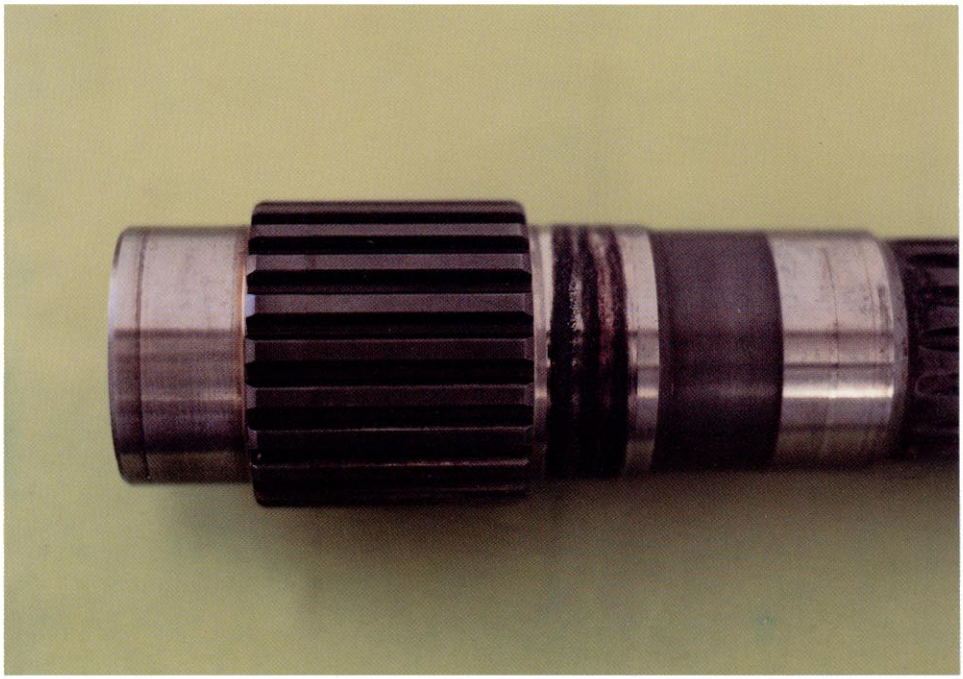
Category : C
Condition : Seizure of bearing mount
Cause : Damage caused by dirt caught in bearing assembled at part concerned

20



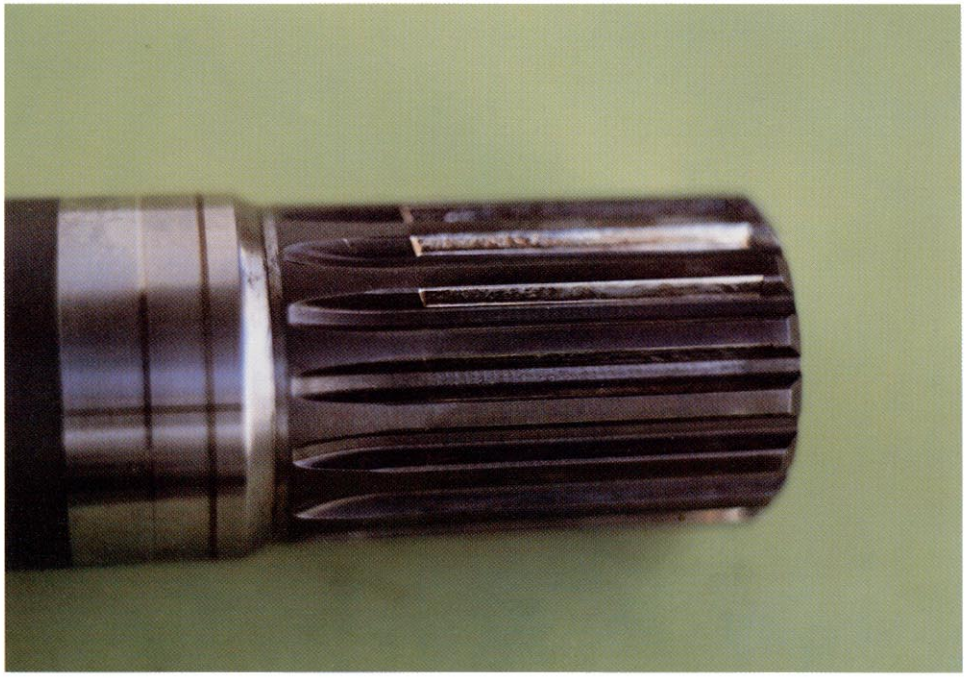
Category : A
Condition : Bearing mount and spline (gear mount) in good condition
Cause :

21



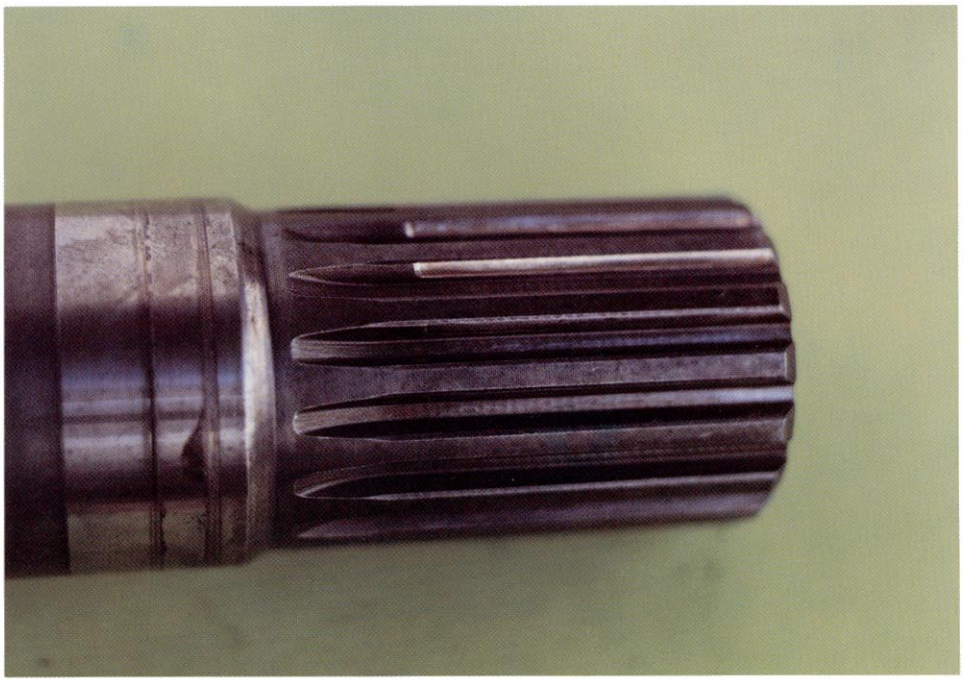
Category : A (Depth of wear to spline teeth surface within 0.5 mm)
Condition : Bearing mount contact good
Cause :

22



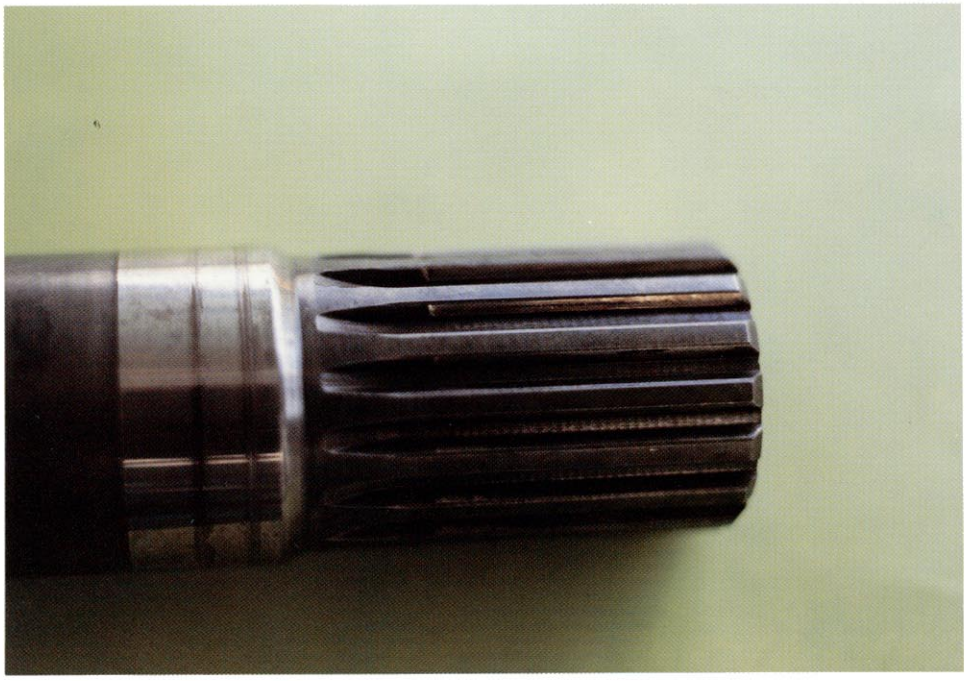
Category : B (Depth of wear to spline teeth surface within 0.5 mm)
Condition : Contact damage to seal; possible to correct with sandpaper
Cause : Contact of seal lip due to long operation

23



Category : A (Depth of wear to spline teeth surface within 0.5 mm)
Condition : Wear of spline
Cause : Wear caused by defective lubrication of spline

24

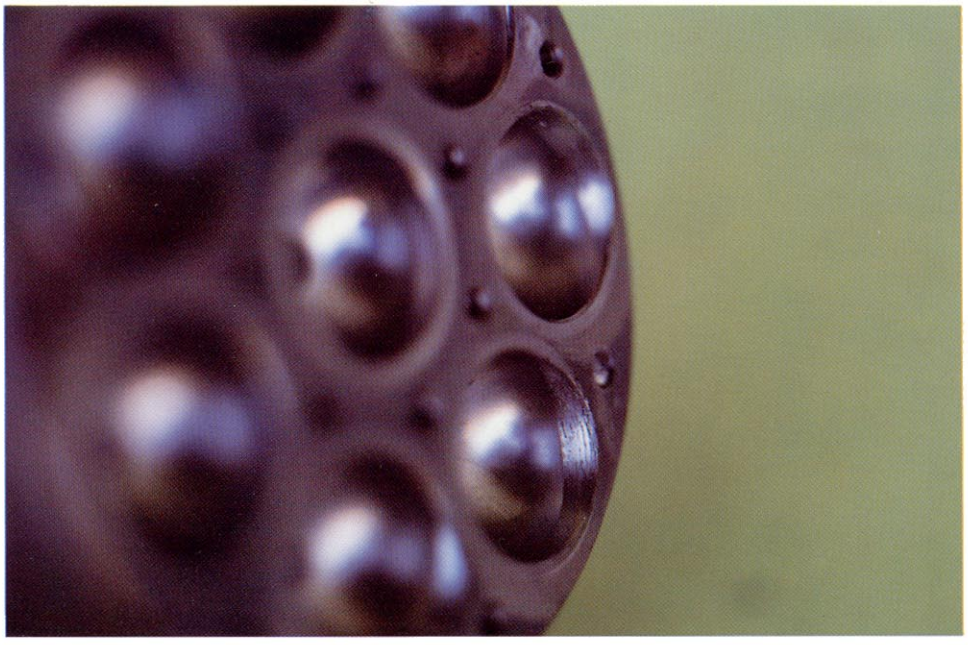


Category : A (Depth of wear of spline teeth surface within 0.5 mm)
Condition : Wear of spline
Cause : Wear caused by defective lubrication of spline

25

Category : C
Condition : Wear at corners of ball socket
Cause : Excessive load acted on piston assembled at part concerned

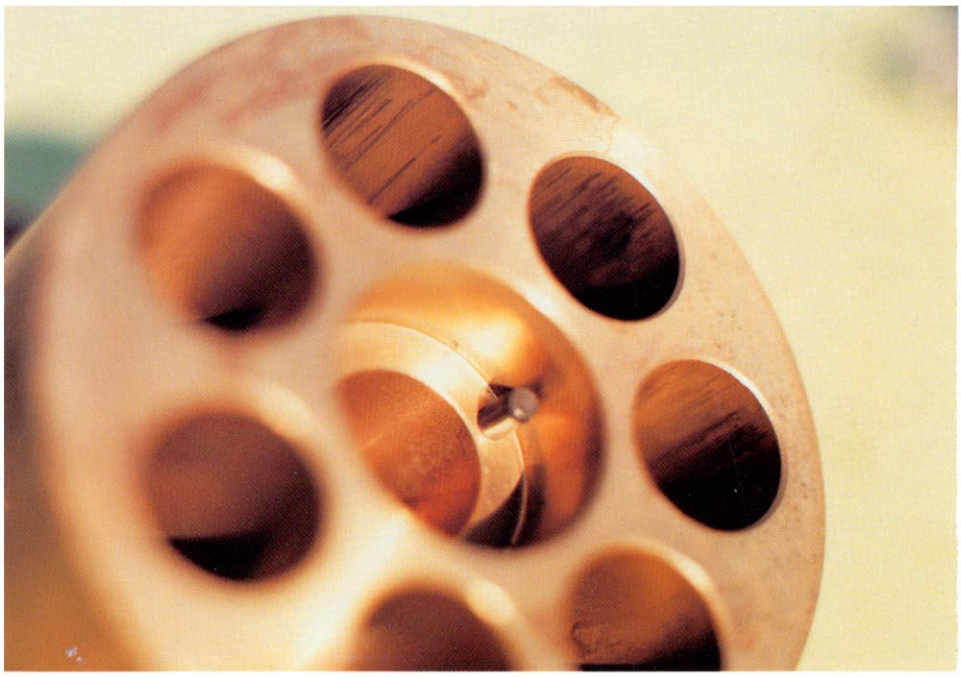
26



Category : C
Condition : Wear at corners of ball socket
Cause : Excessive load acted on piston assembled at part concerned

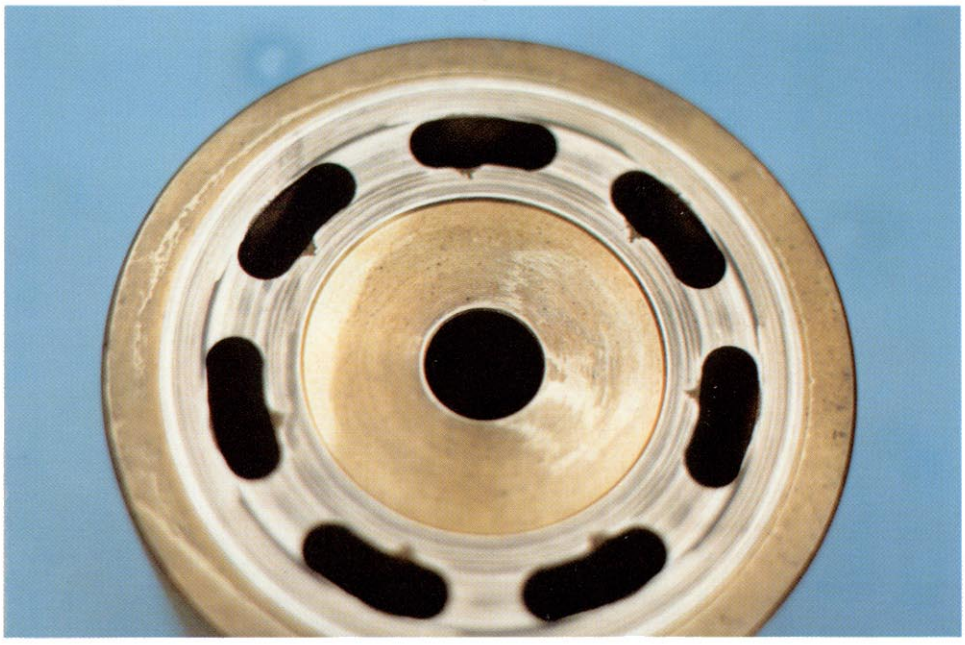
Cylinder block

27



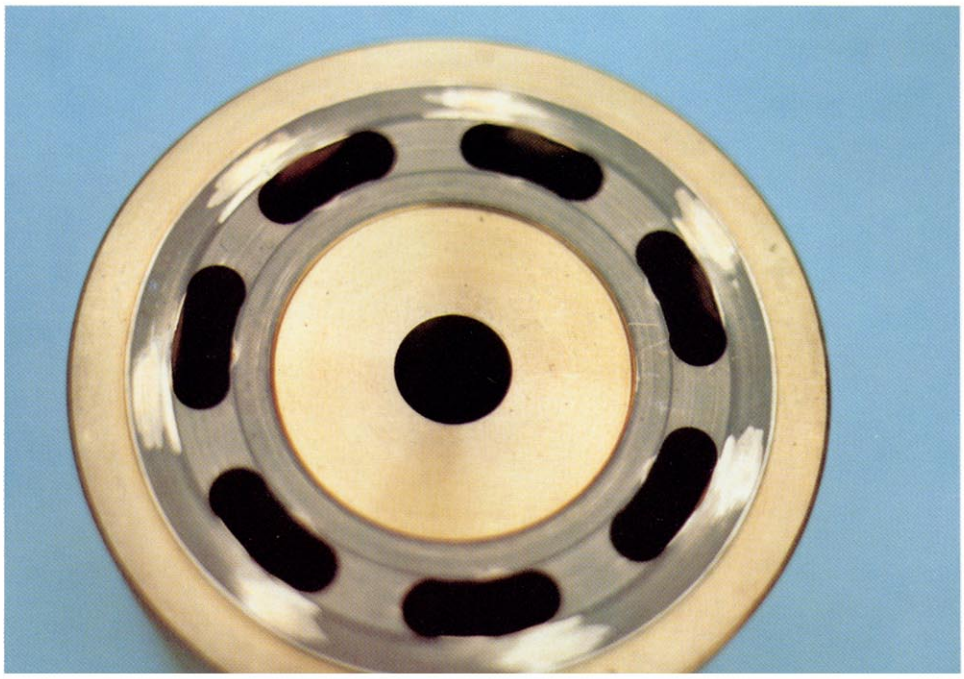
Category : A (If fingernails can catch in scratch = Category C)
Condition : Scratches inside piston bore caused by dirt or dust
Cause : Entry of dirt or dust

28



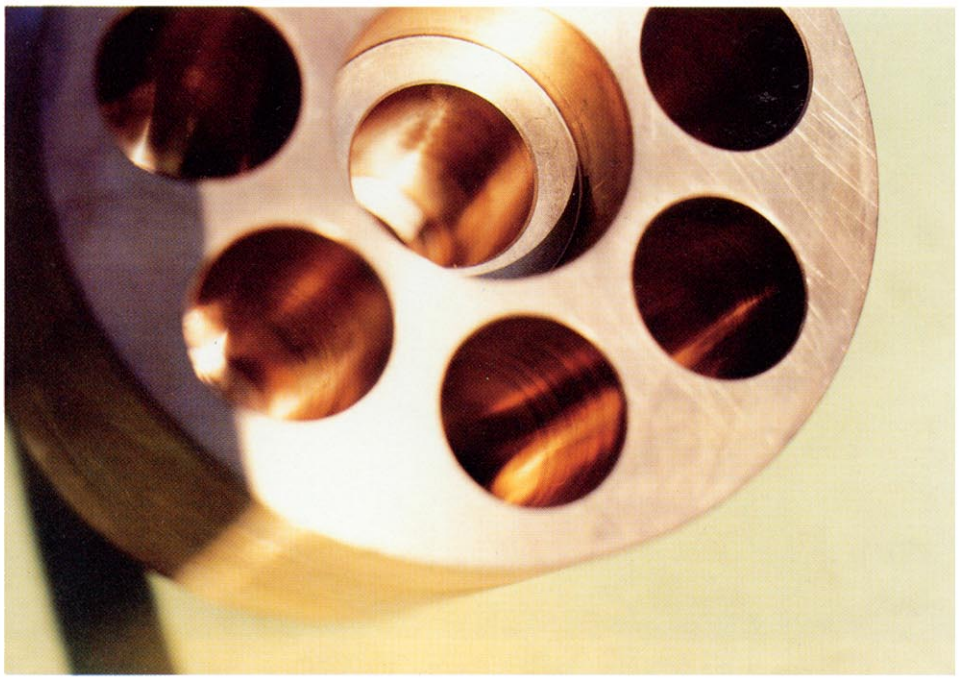
Category : B
Condition : Erosion-corrosion around port hole
Cause : Erosion-corrosion caused by cavitation

29



Category : B
Condition : Strong contact in places on sliding surface
Cause : Abnormal pressure vibration or slight cavitation

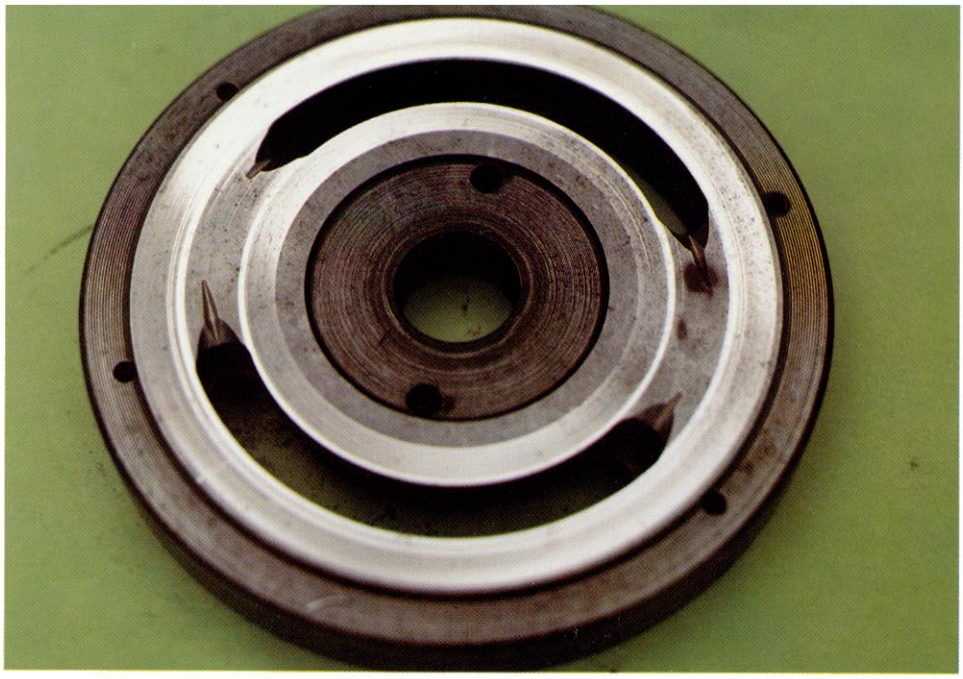
30



Category : A
Condition : Slight scratches inside piston bore caused by dirt or dust
Cause : Entry of dirt or dust

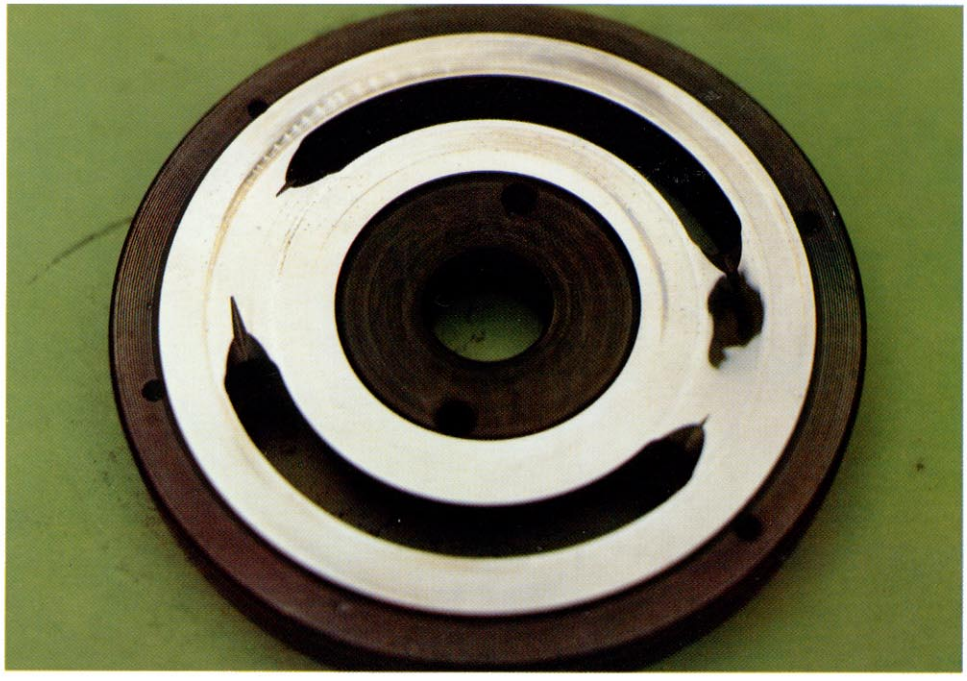
Valve plate

31



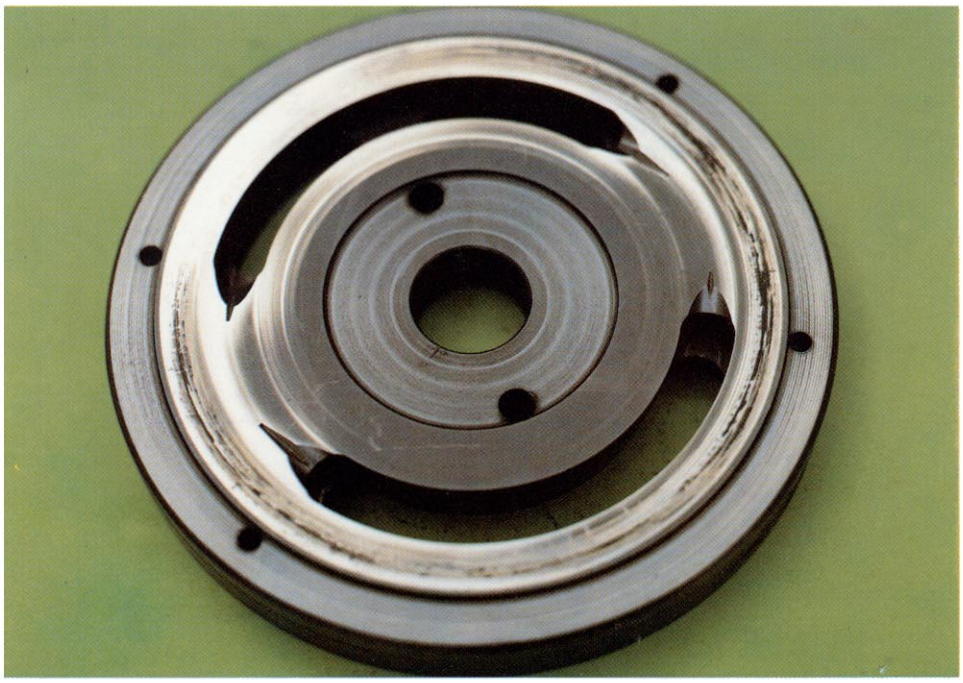
Category : B (Erosion-corrosion removed by lapping)
Condition : Erosion-corrosion in escape groove
Cause : Erosion-corrosion caused by slight cavitation

32



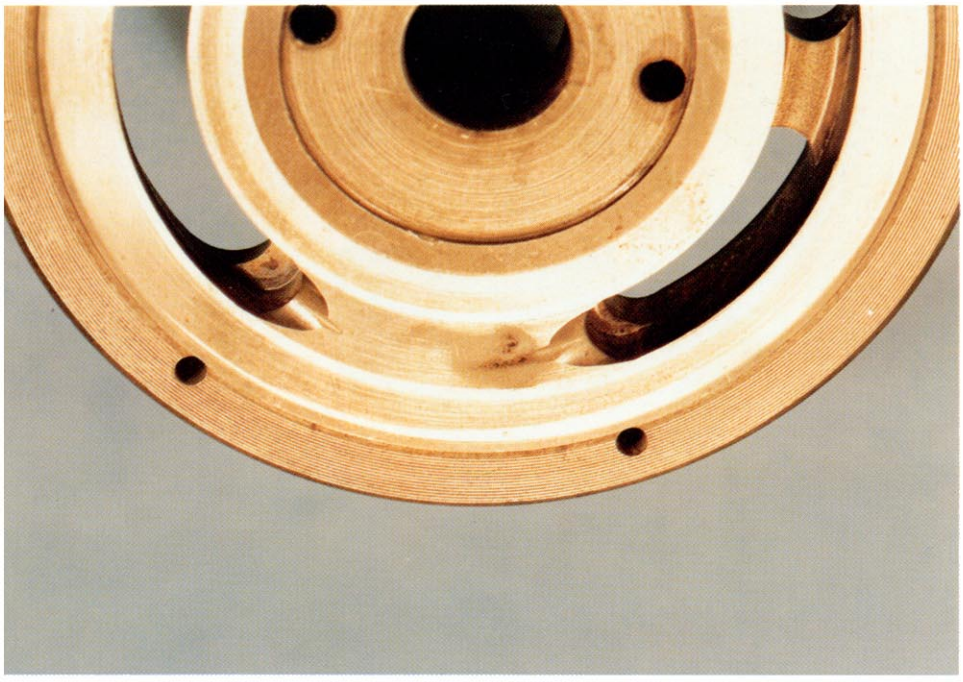
Category : C
Condition : Erosion-corrosion in escape groove, slight seizure around port hole
Cause : Erosion-corrosion caused by slight cavitation, lack of lubrication

33



Category : C
Condition : Seizure around port hole
Cause : Lack of lubrication caused by cavitation or aeration

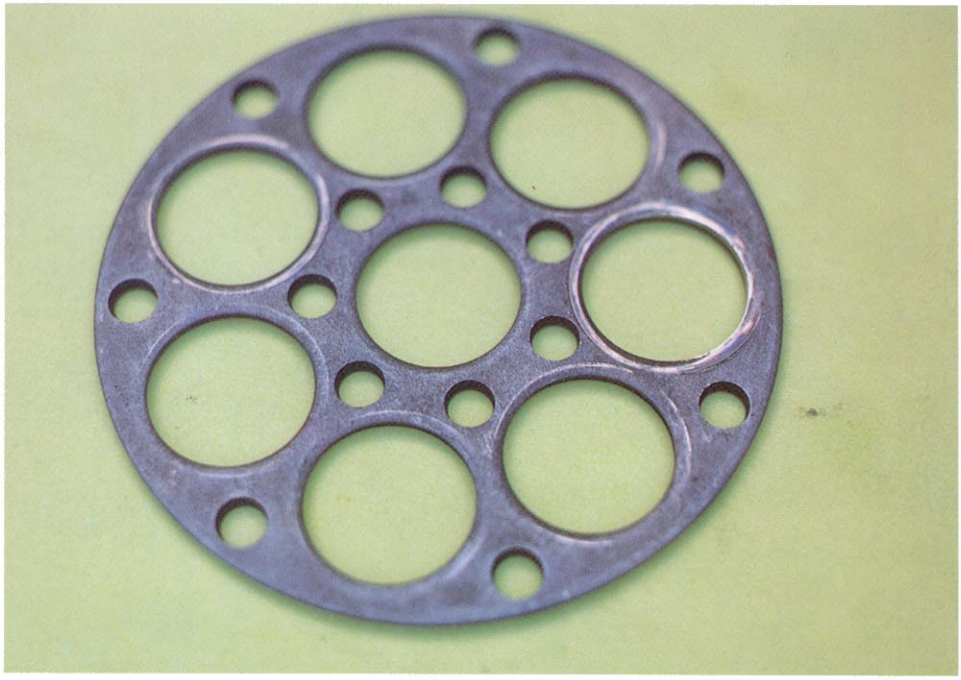
34



Category : C
Condition : Erosion-corrosion in escape groove
Cause : Erosion-corrosion caused by cavitation

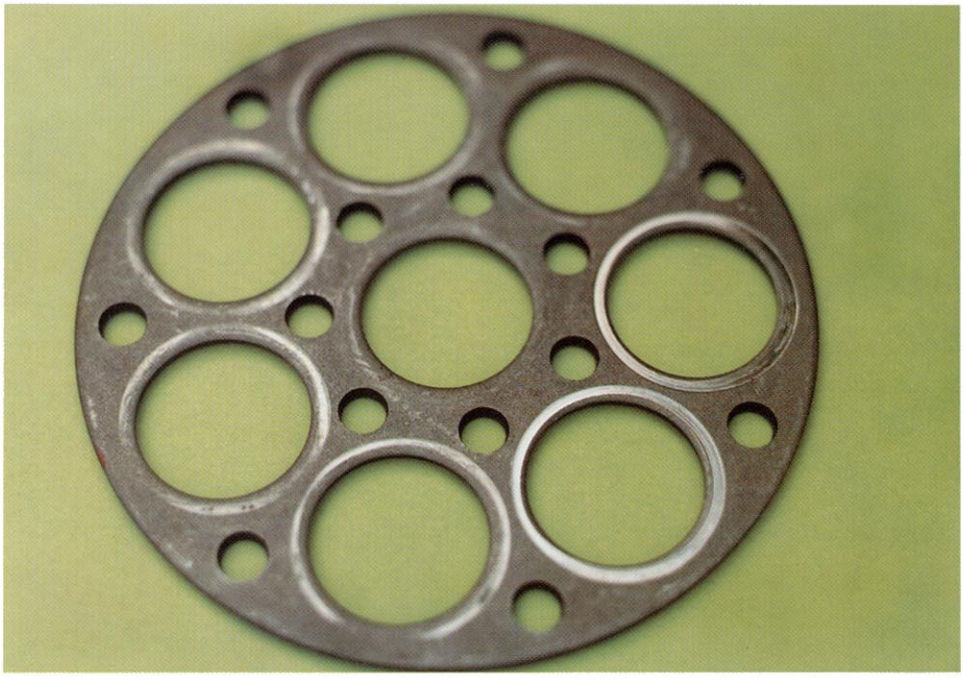
Retainer

35



Category : B
Condition : Strong contact at piston bore
Cause : Excessive load acted on piston assembled at part concerned

36



Category : B
Condition : Strong contact at piston bore
Cause : Excessive load acted on piston assembled at part concerned

Center ball

37

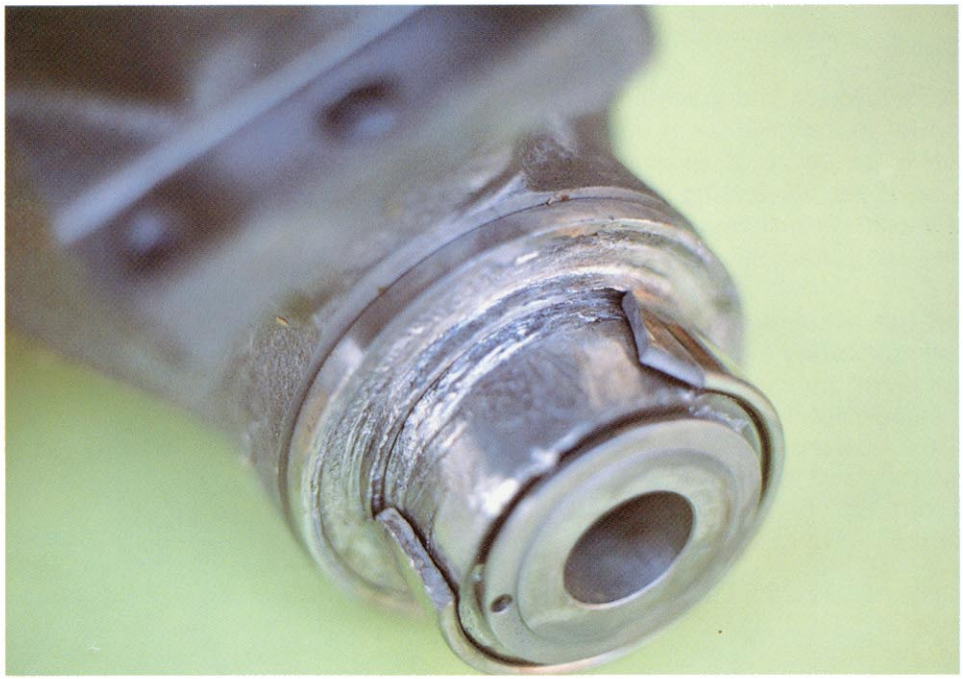
Category : B
Condition : Strong contact in places on ball surface
Cause : Shock caused by abnormal pressure vibration

38

Category : C
Condition : Pitting on ball surface
Cause : Shock caused by abnormal pressure vibration

Casing

39



Category : C
Condition : Damage to bearing mount
Cause : Damage to bearing caused by cavitation or aeration

PREVENTIVE MAINTENANCE

To prevent failures in the machine before they occur, and to allow the machine to demonstration its function 100% it is necessary always to know the condition of the machine, in particular to be aware of abnormal noise, particles of worn metal in the lubricating oil, and the level of the lubricating oil. In addition, by carrying out maintenance correctly as listed in the operation manual, most damage can be prevented, but be particulary sure to have the user carry out the following points properly.

- Always use genuine Komatsu lubricating oil, keep to the prescribed change intervals, and use lubricating oil to correspond with changes in the ambient temperature.
- Always warm up the engine thoroughly. Avoid as far as possible applying sudden excessive loads, accelerating suddenly or stopping suddenly.
- When the operator feels there is some abnormality, he should stop using the machine immediately and look for the cause.
- Carry out oil analysis periodically, and make every effort to prevent failure in the machine.

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