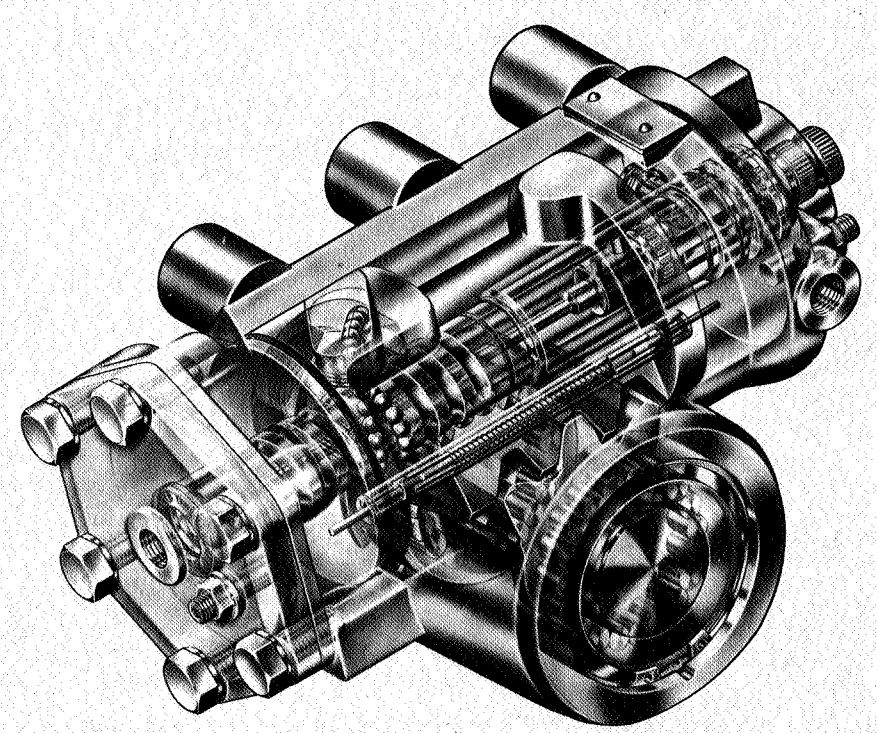
ZF–Servocom

Single and dual–circuit designs

Repair Instructions



ZAHNRADFABRIK FRIEDRICHSHAFEN AG

STEERING SYSTEMS DIVISION

Graf–von–Soden–Straße 5–9

D–7070 Schwäbisch Gmünd

Federal Republic of Germany

Telephone	(07171) 31–0	Telex	7248801
Telefax	(07171) 31–4396	Telex Customer Serv.	7248825

G 8090 R – KTS 5/91 e

ZF-Servocom

RepairInstructions

List of Contents

I. Dismantling

Caution!

Attention must be paid to absolute cleanliness when dismantling, storing parts and assembling in order to ensure that the complete steering system functions safely. Under no circumstances may force be used. The resultant damage can lead to partial or complete failure of the steering function whilst driving.

The Pitman arm is to be removed with a suitable puller device (see tool .20.). Removing the Pitman arm by driving a wedge between the housing and the Pitman arm or with hammer blows is basically to be avoided, since this can cause damage within the steering gear.

The numbers listed in brackets e.g. (53) refer to the numbers in the exploded view and the replacement parts list.

1. Removing cylinder cover

1.1 Clamp the steering in the assembly vice .1. or between soft jaws in a conventional vice. Check if the center marking is incorporated on the steering spindle. If necessary mark position of the center marking on the dust cap (53) to the serrations of the end of the steering shaft - without use of impact tool. Remove dust cap. Unscrew hexagon bolts (127) (Illustration 1).

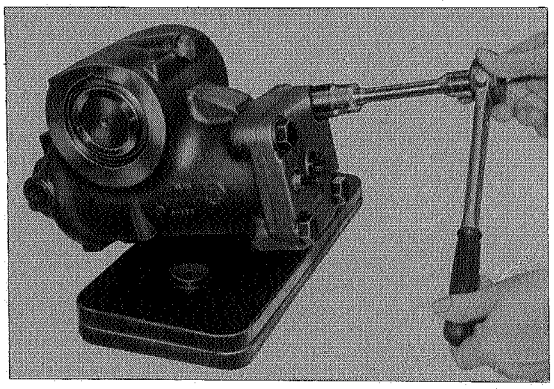


Fig. 1

1.2 Raise the cylinder cover (125) by turning the segment shaft by means of the Pitman arm (Illustration 2).

Caution!

Only turn the cylinder cap cover when the piston has returned in the direction of the housing base (damage to the valve plunger of the hydraulic steering-lock limiter).

Remove needle cage (120) and washer (121) from the cylinder cover. Remove sealing ring (123) and O-ring (122).

For steering designs with long R dimension

The cylinder cover (125) is formed as a steering housing and contains shaft sealing ring (8), washer (9) and needle cage (10).

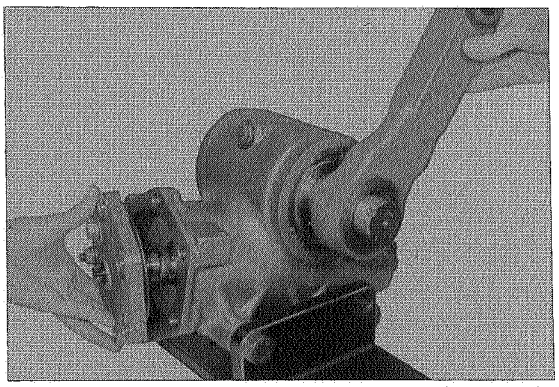


Fig. 2

1.3 For dual-circuit steering designs 8096

Remove steering valve circuit II

Unscrew bolts (204). Raise valve housing (203) (Illustration 3). Remove control bush (174), bearing ring (201) and ball cage (200).

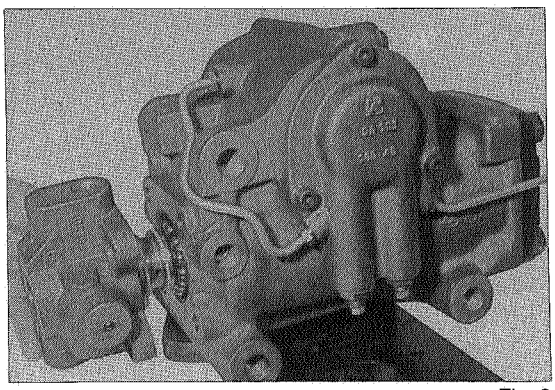


Fig. 3

1.4 Removing hydraulic steering-lock limiter

Slacken hexagon nuts (38) and unscrew the steering-lock limiter valves (36). Remove bolts (223). Remove housing cover (221) (Illustration 4).

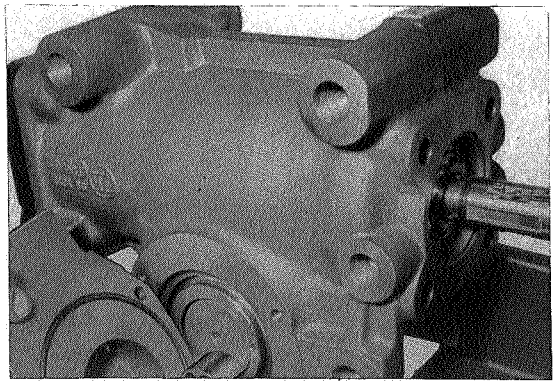


Fig. 4

2. Removing piston

Drive the complete piston/worm assembly out of the housing by turning the segment shaft whilst supported, by means of a temporarily raised Pitman arm (Illustration 5).

Caution!

Do not damage the valve plungers of the steering-lock limiter valves when handling the pistons (see para. 3.3).

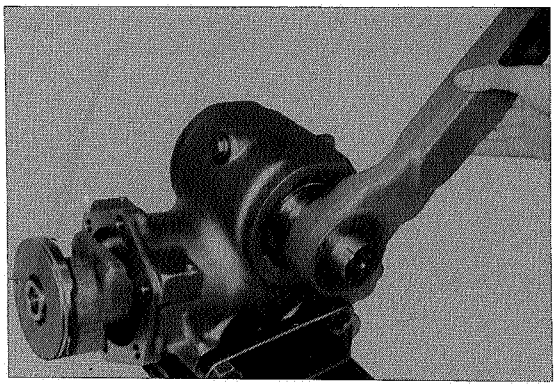


Fig. 5

3. Dismantling piston

3.1 Remove plug (112) with shims (113.1), and depending on the steering design bolts (113.2) or gasket (113) and recirculating ball tube halves (111) from the piston. Thread out the set of balls (110) by turning the worm (Illustration 6).

Remove sealing parts (116, 117, 118 and 119) from the piston.

3.2 Remove snap ring (155) (Illustration 7). Pull sliding tube (156) from the worm (161). Take out the two covers (163) and the cylinder pin (162) in order to avoid losing them, for example in the washing equipment.

Remove sealing parts (158, 159 and 164) from the radial grooves in the worm.

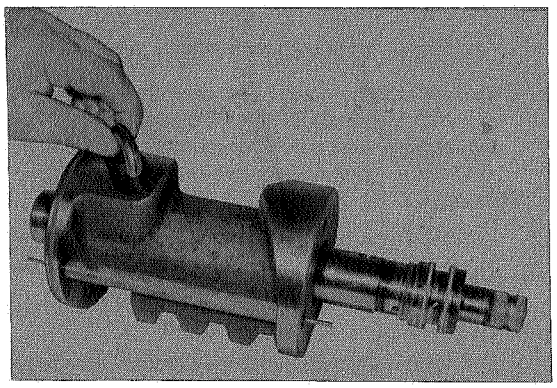


Fig. 6

Note:

The valve body consisting of a valve slide, the worm with torsion bar formed as a control bush is adjusted to the hydraulic center on special test equipment and then drilled in the same position and fixed with two pins. The setting is carried out very accurately and even removing one of these pins can cause change to the setting of the hydraulic center. We therefore urgently recommend that the valve body should not be dismantled. The complete assembly should be exchanged if a defect is detected.

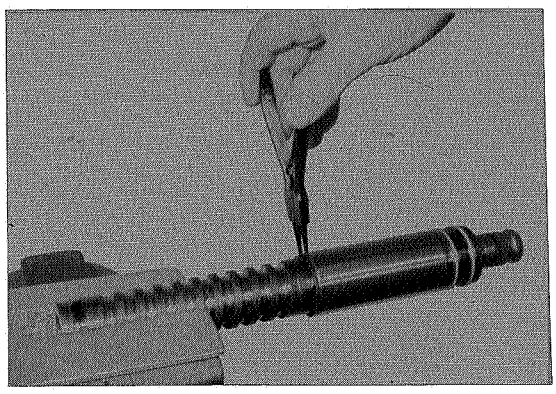


Fig. 7

3.3 Renewing steering-lock limiter valves

The removal and installation of the steering-lock limiter valves from the piston requires a specialist, especially when peening over the new valves with the specified peening over force. Exceeding the permitted peening over force can lead to the flanging being squeezed off and thus cause the valve to drift whilst driving. The firm seating and thus the sealing is not guaranteed when the peening over force is too low. Since the function of the steering and thereby the safety in operation of the complete vehicle depends on the careful execution of this work, we have prepared separate instructions for this with the use of special tools. The removal should only be undertaken when leakage or mechanical damage or sticking occurs.

4. Removing segment shaft

Note:

Removal of the segment shaft, without having to perform a later adjustment of the free from play engagement, is possible when none of the following parts - piston (100), segment shaft (80) or housing cover (4) have to be renewed and there is no play between the piston and the segment shaft. Such a removal can be advantageous, e.g. for changing the sealing parts. After removing the circlips (7) the housing covers (4) can be taken out without the peened locking features. The housing covers must then be assembled to the same side of the housing again and in the same position to the peening groove, but without any change to the peening itself. Prior removal of the piston is not required.

4.1 Remove dust cap (51) and plug (52). Remove circlips (7) on both sides of the housing covers (4) (Illustration 8).

Take out retaining segments (14) depending on steering design.

Shift the housing covers with the tool .5. slightly inwards (position and press on the respective front faces of the segment shaft) so that any burrs on the circlip of the housing can be removed with a scraper. Mark the housing covers left/right for possible reassembly without readjusting.

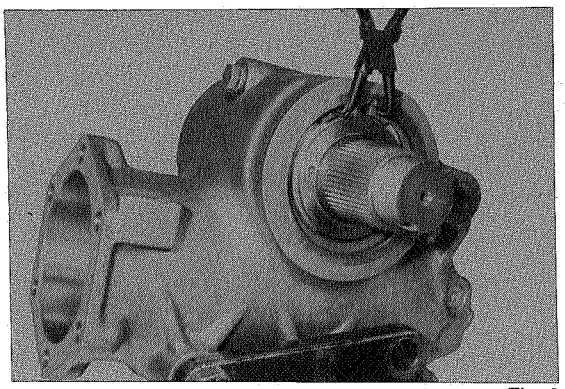


Fig. 8

4.2 Pull out housing covers with tool .2. (Illustration 9). The extractor spindle should not be placed in the centerings of the segment shaft, since this can cause the housing covers to tilt as a result of eccentricity (place thrust pad in between).

The largest possible claws are to be selected on the tool in order to avoid the extractor edges fracturing.

Pull support rings (6) and seals (5) out of the grooves.

Note:

The rollers of the roller bearings of the two housing covers (4) are sorted by the manufacturer into a particular tolerance group. Therefore the rollers of the two housing covers must not be mixed up.

A complete housing cover exchange can be carried out, e.g. from left to right, if this is necessary according to Section IV., para. 3.2.

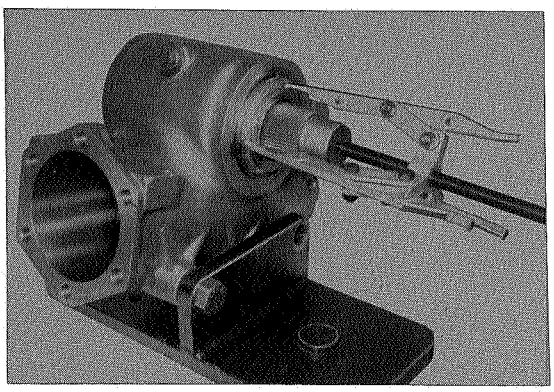


Fig. 9

4.3 Strip washers (3) off the segment shaft. Remove segment shaft from the housing (Illustration 10). Mark or note right/left design and Pitman arm side for subsequent reassembly in the housing.

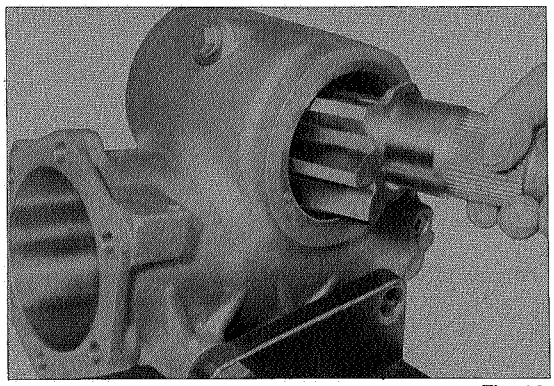


Fig. 10

5. Dismantling housing

5.1 Remove needle cage (10) and washer (9) from the housing. Remove shaft seal (8).

5.2 Rotate valve insert (22) - pressure limiting valve out of the housing (Illustration 11).

On steering designs with replenishing valve remove bolt (30) and replenishing valve (32).

Note:

The valve insert (22) - pressure limiting valve cannot be stripped down. The complete valve must be replaced in the event of wear or pressure deviation.

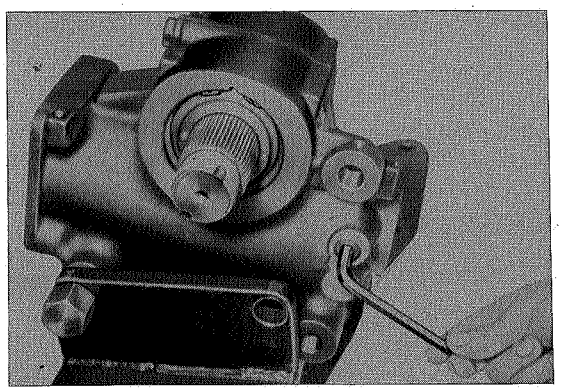


Fig. 11

6. Steering designs with flange mounted angular gear

Note:

The pair of mating bevel wheels, consisting of the bevel wheel (306) and bevel wheel (331) are provided in sets and therefore must be replaced together. The bevel wheel located on the steering spindle must not be pressed off for the purpose of changing the ball bearing, since if the bevel wheels are pressed off twice the firm seating of the serration cannot be guaranteed.

6.1 Mark or note location of the angular gear for steering. To do this rotate the steering spindle until its marking and the marking on the dust cap align with the marking on the angular gear (Illustration 12).

Remove bolt (352) and remove angular gear from the steering. Strip off shims (33).

Strip dust cap (314) from the end of the steering spindle (306). Loosen slotted nut (313) and rotate adjusting screw (312) from the housing. Remove O-ring (308).

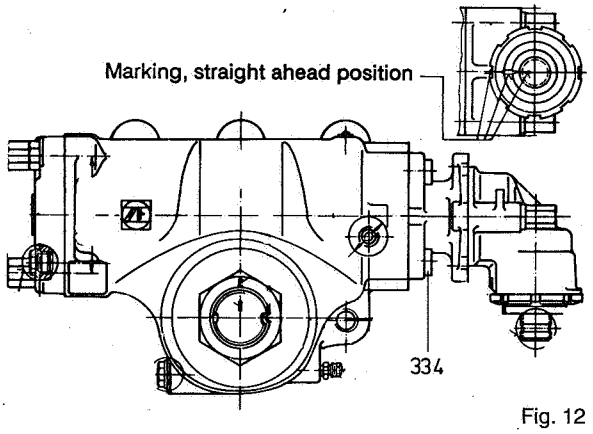


Fig. 12

6.2 Pull bevel wheel (306) with ball bearing out of the housing. Only remove the needle bush (302) if damage on the trunnion of the bevel wheel assembly is detected. Use tool .14. and .15. for removal. Mark position of intermediate flange (335) in relation to the housing. Slacken bolt (334) and remove the intermediate flange from the steering unit (Illustration 13).

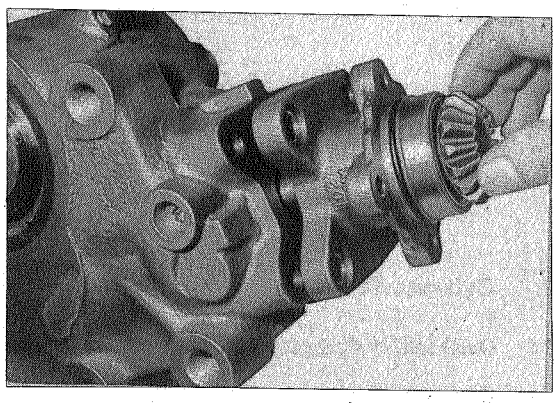


Fig. 13

6.3 Remove bevel wheel (331) (Illustration 14). Remove ball bearing from the intermediate flange.

On steering designs up to 4/88

Remove circlip (342) and ball bearing (343). Remove recessed hood washer (348) from intermediate flange.

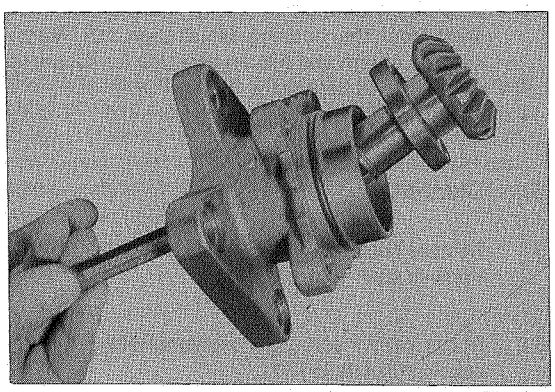


Fig. 14

II. Checking the steering parts

Note:

Wash all parts thoroughly in a cleaning fluid. Sealing rings and other rubber parts must not come into contact with chlorinated hydrocarbons due to danger of swelling, but must be cleaned in a water soluble industrial cleaner, as for example Henkel P^3 products or other soap products.

Check all parts for wear, corrosion, pressure damage, cracks and other defects in order to be able to decide whether the parts can be used again. New parts should be used in accordance with the spare parts list, relating to the particular type of steering, see identification plate, e.g. 8090 955 103.

Note in particular:
The test requires expertise and conscientiousness. The fitter must decide on his own initiative, whether the parts have to be changed.

The following must be checked amongst others:

1. Housing

1.1 Cylinder bore. Level slight scores due to elimination of high-spots (lobes) e.g. by means of a lock washer.

1.2 Circlip recesses. Eliminate any high-spots in order to avoid traces of scratches when assembling the housing covers (sealing).

1.3 Running surfaces of the head of the worm

1.4 Thread

1.5 Outer seat of shaft seal on residual rubber

1.6 Housing end face in the area of the axial needle bearing for the worm for bowing as a result of previous effects of force resulting from an accident. Place measuring rule on the machined flat surface for the dust cap (53). Replace housing in the event of visible bowing.

2. Cylinder cover

2.1 Outer seat of shaft sealing ring for residual rubber.

2.2 Flat side of the cover in the area of the axial needle bearing for the worm for bowing as a result of previous force effects due to an accident. Place the rule on the machined facing for the return connection. Replace cylinder cover in the event of visible bowing.

2.3 On steering designs with long R dimension:
Running surfaces of the worm head

3. Pistons

3.1 Outside diameter of piston

3.2 Steering limiting valve for leakage, loose seat, damage (even slight external mechanical damage, e.g. pressure points from multi-purpose pliers on the thin walled valve stem, can cause the valve to stick).

3.3 Teeth for wear (crack-testing longitudinally and laterally, with a suitable test method, is for example magnetic flux).
Caution! Scrap parts with cracks.

4. Worm

4.1 Recirculating ball thread. Piston and worm must be replaced together if damage or wear is detected. Friction value in the center area of the thread at least 5 Ncm.

4.2 Serrations on the valve slide

4.3 Running surfaces of the needle bearing and the shaft sealing ring. Impressions on the front side of the running surfaces of the needle bearing (10 and 120) can be the result of previous effects of force due to accidents. In such a case check the housing or cylinder cover for bowing in the area of the relevant needle bearing (see 1.6 and 2.2).

4.4 Crack-testing (crack-testing, longitudinally and laterally, with a suitable method, is for example magnetic flux. The jet of fluid must be directed so that the valve body is not moistened, so that small iron particles do not enter the control grooves).
Caution! Scrap parts with cracks.

5. Segment shaft

5.1 Tooth segment

5.2 Serration

5.3 Running surfaces of the sealing rings

5.4 Running surfaces of the roller bearings

5.5 Crack-testing, longitudinally and laterally (for example magnetic flux is a suitable test method). **Caution!** Scrap parts with cracks.

5.6 Housing cover (peen over points). Outside diameter for longitudinal scores (sealing).

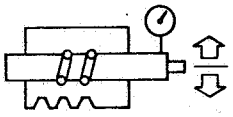
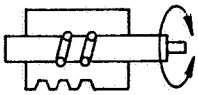
5.7 Only check radial deviation (bowing) of the segment shaft if roller bearing impressions e.g. on the front face of the worm have been detected as the result of previous effects of force. To do this lift up the segment shaft between points and measure the maximum permitted radial run out on the Pitman arm side roller bearing running surfaces, next to the tooth segment. The maximum permissible radial run out may be 0.1 mm.

6. Needle and roller bearings

The relevant bearings should be replaced in the event of impressions or wear on the running surfaces of the steering parts.

III. Technical data and adjustment values for the assembly

Washer (121) - worm bearing	Thickness: Stages:	2.2 to 2.8 mm from 0.01 to 0.01 mm	
Axial play - worm bearing	8090 8095/96 8097 8098	0,010 bis 0,025 mm 0,015 bis 0,030 mm 0,020 bis 0,035 mm 0,025 bis 0,040 mm	Adjustment at room temperature

Axial play - slide tube		0 to 0.1 mm
Snap ring (155) - slide tube	Thickness: Stages:	1.7 to 2.0 mm from 0.1 to 0.1 mm
Friction moment - recirculating ball part	in center region: as free from play as possible Lower tolerance limit max. 0.1 mm tilt play Upper tolerance limit max. 20 Ncm friction value outside center region: If tilt play is measured in the center region a maximum friction moment of 20 Ncm is permissible outside the center region. If friction moment is measured in the center region a friction value increase of max. 15 Ncm is permissible outside the center region.	
 Tilt play measurement (worm in center position; dial gauge on valve slide)		
 Friction moment measurement		
Types of ball - recirculating ball part	Diameter: Stages:	6.990-7.010 mm from 0.002 to 0.002 mm
Shims (113.1) - recirculating ball part	Thickness: Stages:	8090: 0.1 to 0.5 mm 8095-98 0.2 to 0.8 mm from 0.1 to 0.1 mm
Radial play - plug (112) to upper side of piston		max. 0.1 mm
Max. friction moment outside the play-free engagement of the segment shaft (steering completely assembled)	Maximum values without angular gear 8090 Ncm: 160 (i=15.2), 140 (i=18) 8095/96 Ncm: 180 (i=17), 160 (i=19.6), 140 (i=23.1) 8097 Ncm: 200 (i=16.1), 180 (i=18.9) 160 (i=21.8), 140 (i=25.7) 8098 Ncm: 220 (i=18.3), 200 (i=20.7), 180 (i=23.9) Steering designs with angular gear 80 Ncm higher	
Friction moment increase - play-free engagement of the segment shaft	After test run: 20 to 40 Ncm (when assembling, depending on the use of new parts, set maximum value e.g. 40 to 60 Ncm)	

Peening over - housing cover	8090-96	2 1/4 rotations of the screw (4) of the peening over tool .13. Depth of peening over: $1.0^{+0.3}$ mm
	8097-98	2 3/4 rotations on the screw (4) of the peening over tool .13. Depth of peening over: $1.5^{+0.2}$ mm
	Screw tightening torque occurring when peening over not greater than 18 Nm (fracture of the peening tool)	

Angular gear:

Washer (304) - bevel wheel set (306) in angular gear	Thickness:	0.1; 0.12; 0.15 and 0.2 mm
Shims (330)	Thickness:	0.1; 0.12 and 0.15 mm
Backlash in bevel wheels		free from play, max. 0.04 mm Backlash in center position

Tightening torques:

Hexagon bolts (127) - cylinder cover	8090 8095/96/97 8098	135 Nm, M 12x1.5 285 Nm, M 16x1.5 189 Nm, M 14x1.5
Valve insert - pressure limiting valves (22)		30 Nm
Valve insert - replenishing suction valves (32)		30 Nm
Locking screws (55)		40 Nm, M 16x1.5 50 Nm, M 18x1.5
Hexagon nut (129 or 38) - hydraulic steering-lock limiter	8090/95/96/97/98 8096 (in cover)	30 Nm 25 to 35 Nm

Union nut - pipelines (225 and 226)	8096	7^{+1} Nm, M 12x1
Locknut (50) - Pitman arm	8090 8095/96 8097/98	300 Nm + 10%, M 30x1.5, peened over 500 Nm + 10%, M 42x1.5, peened over 550 Nm + 10%, M 45x1.5, peened over
Cheese-head screws (204) - valve housing (203) Dual-circuit designs	8096	140 Nm, M 14x1.5
Cheese-head screws (223) - housing cover Dual-circuit designs	8096	37 Nm, M 8, 12.9 31.5 Nm, M 8, 10.9 (up to 4/88 - superseded)

Angular gear:

Hexagon bolts (352) - angular gear	8097/98	62 Nm, M 10
Cheese-head screws (334) - intermediate flange	8097/98	140 Nm, M 14x1.5
Slotted nut (313) - angular gear	8097/98	50 Nm

IV. Assembly

Caution!

In order to ensure that the steering functions safely great attention must be paid to maximum cleanliness during assembly. Under no circumstances can force be used during assembly. The damage resulting from this can lead to partial or complete failure of the steering function whilst driving.

All parts must be thoroughly cleaned before assembly. Every part must be checked for wear or other defects before being installed again and well lubricated. Seals, shaft sealing rings and O-rings are to be replaced by new ones. Remove housings and covers to eliminate remains of paint and damage. On shaft sealing rings the space between the sealing lip and the dust lip is to be filled with Texando FO 20 or equivalent calcium complex grease of the consistency class 2. The measuring and adjusting tools used must be subjected to regular accuracy checks.

1. Pre-assembling housing

1.1 Press the shaft sealing ring (8) into the housing (1) with the tool .3., with the sealing lip inwards (Illustration 15).

1.2 Put a lubricated O-ring (2) in the radial grooves of the housing.

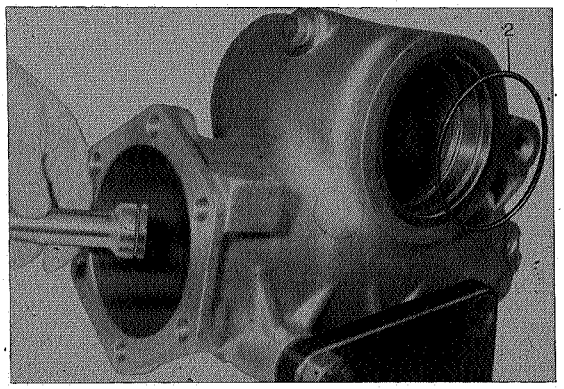


Fig. 15

2. Pre-assembling housing cover

2.1 Drive back the peening when using again and readjusting the old housing cover (4). If only a partial dismantling is to be undertaken see para. 3.2. Put support ring (6) and seal (5) in the radial grooves of the housing cover. In so doing it must be ensured that the inclined surfaces of the support rings contact the same inclined surfaces on the grooves (Illustration 16).

2.2 Using grease stick the rollers into the housing cover and put the polyamide filler piece in a gap between the rollers.

Note:

The rollers of the roller bearings of the two housing covers (4) are sorted by the manufacturer into a particular tolerance group. Therefore the two housing covers must not be exchanged.

Then put the captive rollers into the housing covers by sliding the segment shaft; this is important when subsequently fitting the segment shaft with the sealing rings (5 and 6) installed. Remove segment shaft again.

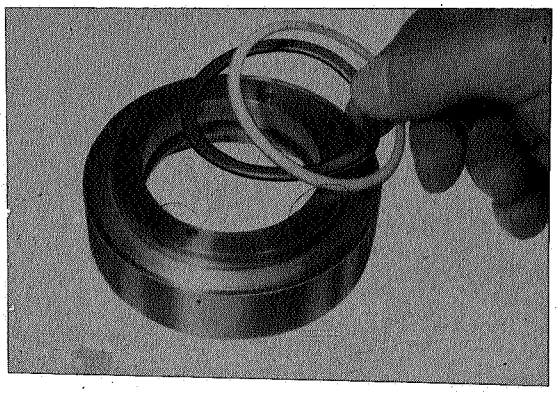


Fig. 16

3. Installing segment shaft

3.1 Insert segment shaft into the housing; pay attention to the correct side of the Pitman arm or right/left design. Push on a washer (3) with the chamfered bore in front, on each side of the segment shaft (80) (Illustration 17).

Should it be necessary to assemble the segment shaft with the piston fitted, we recommend the selection of a piston position outside of the play-free engagement before pressing on the housing cover. This prevents the segment shaft being canted over during insertion.

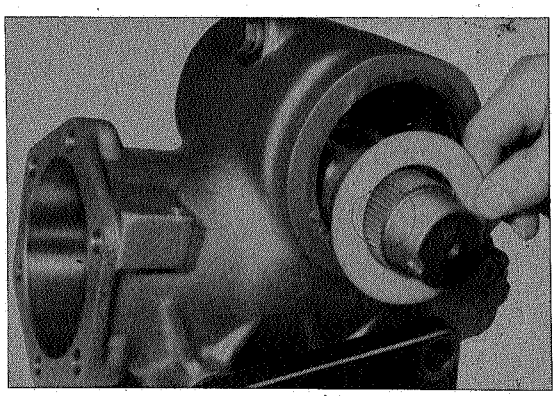


Fig. 17

3.2 Place the housing, which is on a flat support with the steering Pitman arm side upwards, under a hand press. Depending on the steering design put insertion sleeve .4. on the serrations of the segment shaft. Using the tool .5. and with the larger of the two front adjusting bores pointing upwards, press on the pre-assembled housing cover as far as the circlip recess (Illustration 18).

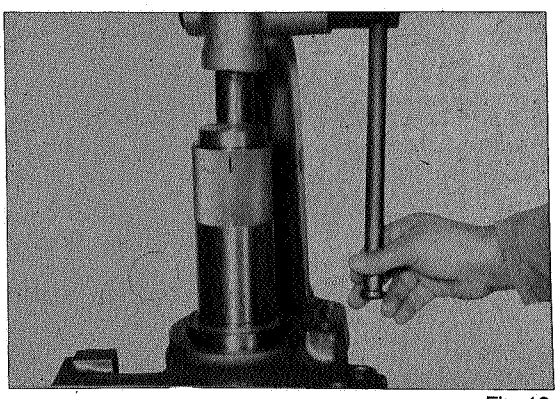


Fig. 18

Note:

In order to ensure that when re-using the old housing covers the peening over contacts another part of the cover collar, it is recommended that the housing covers are exchanged, e.g. from left to right, refer to note in Section I, para. 4.1. Ensure that the outside diameters of the housing covers are free from longitudinal scores (sealing).

In case a new adjustment of the play-free engagement of the segment shaft is not provided for, the housing covers must be re-assembled on the same side of the housing and in the same position of the peening groove, without however making a change to the peening. Do not damage peening when pressing in.

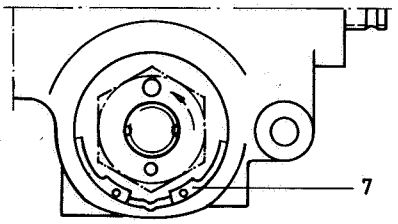


Fig. 19

3.3 Assemble the circlip (7) with the joint opening towards the peening (Illustration 19).

Press the second housing cover onto the opposite housing side in the same manner and in the same position. Assemble circlip (7) with the joint opening towards the peening.

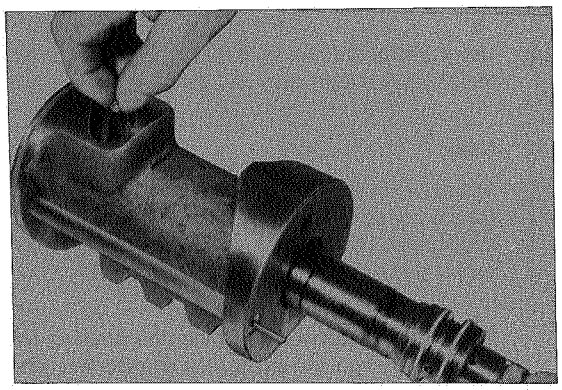


Fig. 20

4. Adjusting the recirculating ball part

4.1 Insert the worm into the bore of the piston sufficiently so that the balls of the front piston bore can be inserted into the thread of the worm for the recirculating tube thread. 37 balls are to be inserted of which a part is installed together with the recirculating ball tube (see Illustration 21). Only balls from one tolerance group may be used. Insert balls individually (see Illustration 20) and turn the worm slowly at the same time, so that all balls are in a row without any gaps. The recirculating ball thread is filled when the first ball inserted contacts the edge of the rear recirculating tube bore.

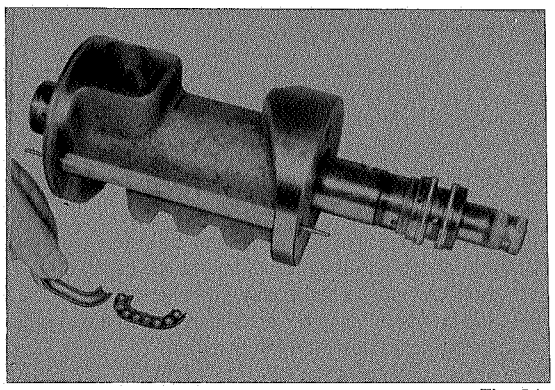


Fig. 21

4.2 Place the remaining balls in the recirculating tube (Illustration 21). Use grease to hold the outer balls in order to facilitate assembly.

Caution!

The number of balls must not be exceeded.

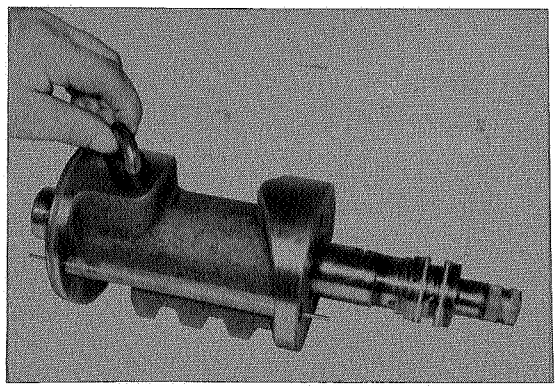


Fig. 22

4.3 Place the full recirculating tube (111) in the bores (Illustration 22).

When turning the worm in both directions the balls must circulate within the installed recirculating tube half tubes without binding.

4.4 Measure friction moment of the recirculating ball part with the torque measuring equipment .6. and the insert .7. (Illustration 23). It must adjust itself in the horizontal position when the worm is turned in and out over a range of 90°, without clamping the piston in the vice. (Friction moment for new or used steering, see Technical Data).

Balls from several tolerance groups must be available, which are selected to 0.001 mm Ø tolerance, in order to be able to maintain the exact value. Only balls from one tolerance group may be used, see Technical Data.

If there is a greater torque during testing, then the balls must be removed and those from a smaller tolerance group used. If the torque is below the permissible minimum value then larger balls are needed.

After selecting the correct balls the piston is dismantled again and the selected balls retained.

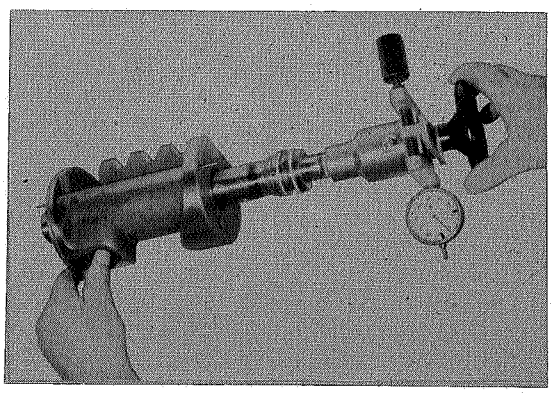


Fig. 23

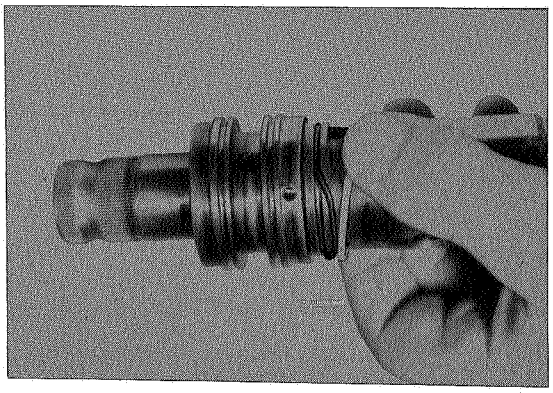


Fig. 24

5. Pre-assembling worm

5.1 Put O-ring (158) in the radial groove and the sealing ring (159) on this (Illustration 24).
If need be position the sealing rings with a conventional rubber band. Use a flat surface rubber band (39 mm span) in order to avoid damaging the sealing ring.

5.2 Put cylinder pin (162) and the two covers (163) onto the worm. Slide over slide tube (156). Engage snap ring (155) (Illustration 25). Note maximum axial play of the slide tube - see Technical Data. Carry out any correction needed by installing a snap ring of a different thickness.

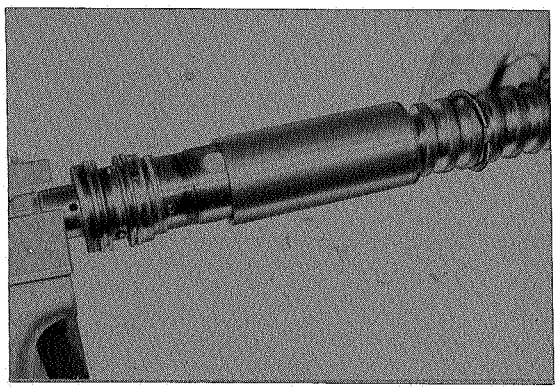


Fig. 25

5.3 Put a sealing ring (164) into the front and rear radial groove of the worm head (Illustration 26) use tool .8. for this (with distance ring for the front groove).

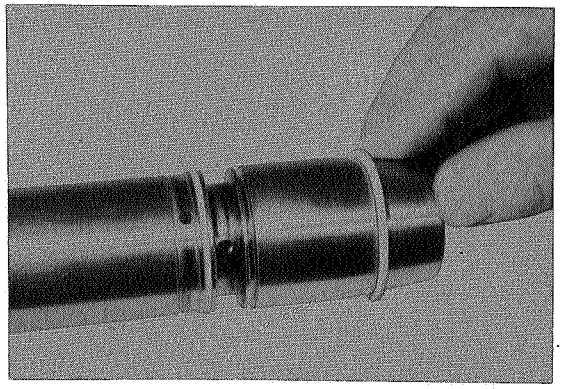


Fig. 26

5.4 Position sealing rings with tool .9. (Illustration 27).

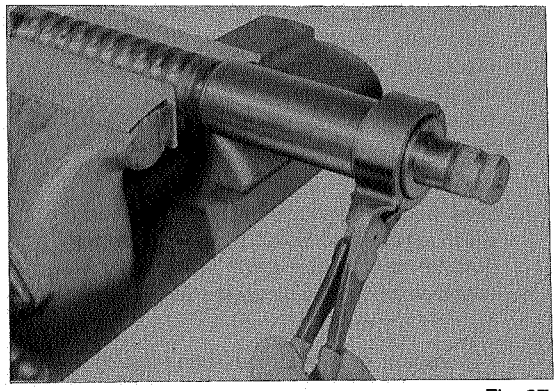


Fig. 27

6. Assembling the piston and the worm

Note:

In order to avoid damage to the sealing ring (115) during assembly we recommend removing the sharp edge of the piston recess with a hand grinder or applying a lead-in chamfer of approx. 1 x 45°.

6.1 Put sealing ring (116) in the radial groove of the piston bore and the sealing ring (117) on this (Illustration 28). Put O-ring (118) in the groove of the piston and the piston ring on this (119).

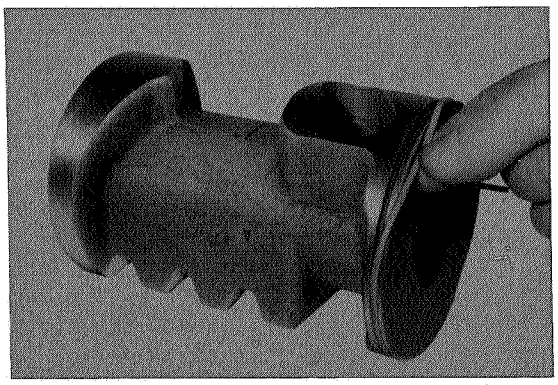


Fig. 28

6.2 Insert the worm into the piston again so that the previously selected balls can be inserted and the recirculating tube can be put in the piston (see text for Illustration 20 to 22).

Put gasket (113) and the plug (112) without O-ring (114) or sealing ring (115) on the piston. The 8090 steering design has only a one-piece plug (112) above the recirculating ball halves. Check whether the plug (112) seals flat with the piston surface (maximum radial play 0.1 mm). If necessary place one or more shims (113.1) between the seal and the plug (even if there was no shim enclosed during removal). See Technical Data for the thickness of the shim. Ensure that the plug does not project, which can lead to increased friction in the housing (Illustration 29).

Remove plugs, shims and gasket. Assemble O-ring (114) as well as sealing ring (115) on the gasket (113).

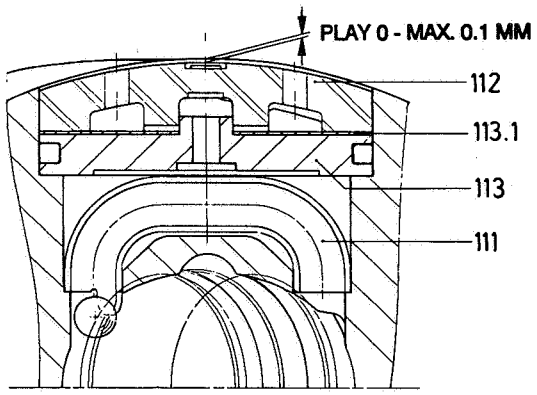


Fig. 29

6.3 Press pin (113.2) with complete gasket (113) into the piston in the sequence as shown in Illustration 30. Put the previously selected shims (113.1) and the plug (112) on the gasket (113) and check again whether this seals flat with the piston running surface - maximum radial play - see Technical Data.

Notes on steering designs 8095 to 8099:

If a pin (113.2) was not fitted during removal new parts (111, 112, 113 and 113.2) must be used. The pin (113.2) is deleted on the 8090 steering design.

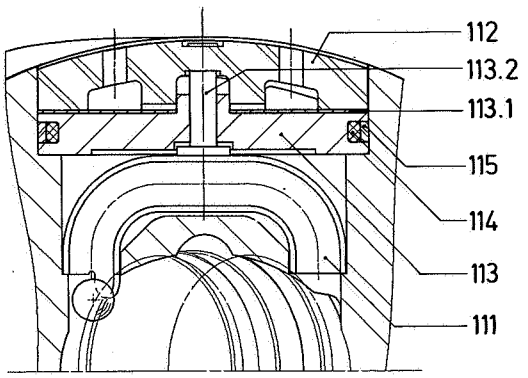


Fig. 30

7. Installing piston

7.1 Fill the space between the sealing lip and the dust lip of the shaft sealing ring (8) with grease such as Texando FO 20 or equivalent (see note in Section IV.).

Place washer (9) free from grease and needle cage (10) in the recess in the housing (Illustration 31).

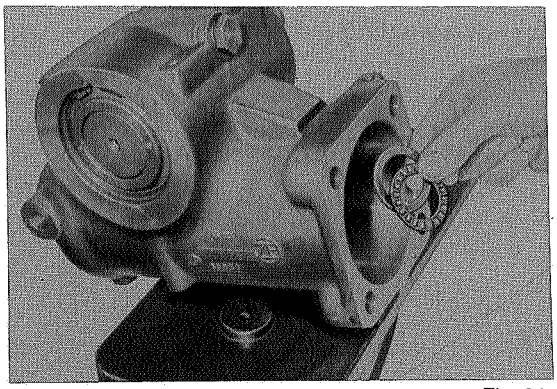


Fig. 31

7.2 Turn the segment shaft so that the tooth segment swivels in the direction of the cylinder cover (125).

On steering design without angular gear:

Place insert bush .10. on the serration at the end of the steering shaft (Illustration 32).

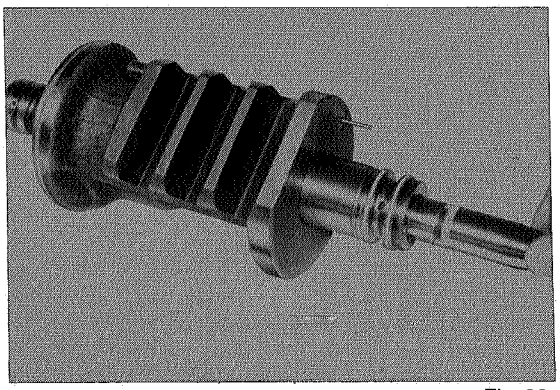


Fig. 32

7.3 Insert piston complete with worm initially sufficiently into the housing so that when rotating upwards the tooth segment engages in the first tooth spacing of the piston (Illustration 33).

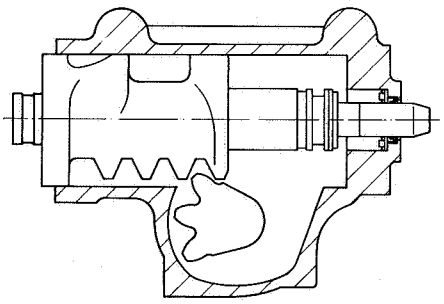


Fig. 33

7.4 In this position push the piston right in by rotating the segment shaft and supporting it by temporary use of the Pitman arm (Illustration 34).

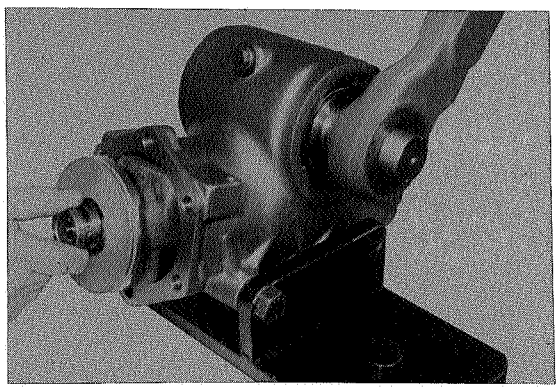


Fig. 34

8. Assembling cylinder cover

8.1 Put the washer (121), removed during dismantling, with the chamfered side forward of the needle cage (120) free from grease into the recess of the cylinder cover (Illustration 35).

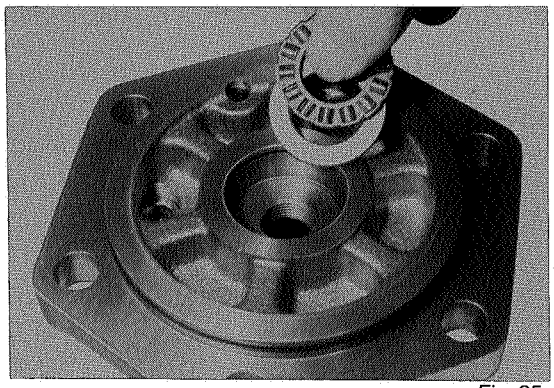


Fig. 35

8.2 Put O-ring (122) in the inner radial groove of the cylinder cover (125) and the sealing ring (159) onto this (Illustration 36).

Install the lubricated O-ring (124) in the outer radial groove.

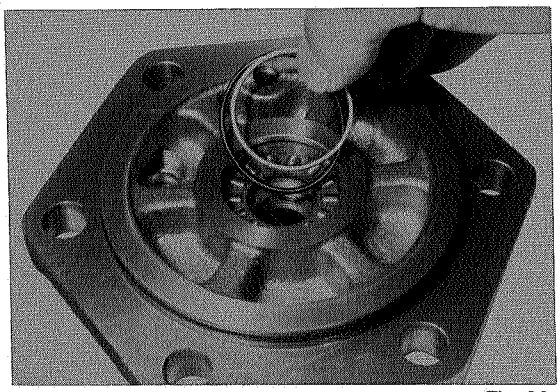


Fig. 36

8.3 Put on cylinder cover, paying attention to the sealing parts, (Illustration 37) and attach with the hexagon bolts (127) and washers beneath them (126) (for tightening torque see Technical Data).

Caution!

If one of the parts - housing (1), worm (151) or cylinder cover (125) has been renewed, the washer (121) inserted can be too thick. Re-adjust in accordance with Section 13 if necessary. Therefore tighten up the hexagon bolts (127) carefully whilst constantly turning the steering spindle, in order to be certain that there is no axial pressure exerted on the worm bearing.

For steering designs with long R dimension:

The cylinder cover (125) is formed as a steering housing and contains shaft sealing ring (8), washer (9) and needle cage (10). By contrast washer (121) and needle cage (120) are accommodated in the housing.

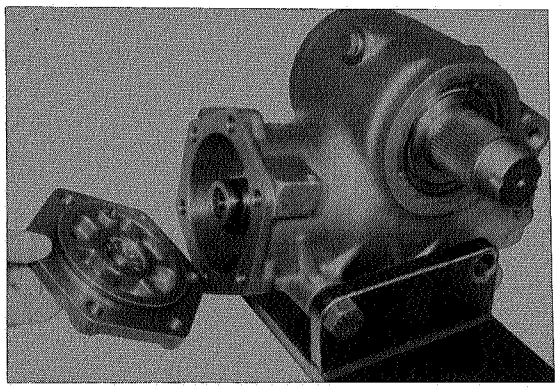


Fig. 37

9. For dual-circuit steering design 8096

9.1 Assemble steering valve for circuit II

9.1.1 Put O-ring (172) in the radial groove of the valve slide and pull the sealing ring (173) onto it. Put on ball cage (200), put bearing ring (201) and O-ring (202) in the turned part of the housing (Illustration 38).

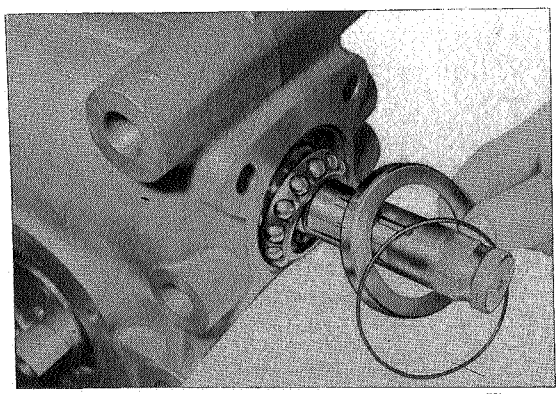


Fig. 38

9.1.2 Mount first the O-ring (164.1) and on this the sealing ring (164) in the front radial groove of the control bush (174) located on the two carrier tangs. Only pull sealing rings (164) onto the remaining three radial grooves (Illustration 39). Bring the sealing rings into position with special tool.

Put pre-assembled control bush in the engagement position until it contacts the valve slide.

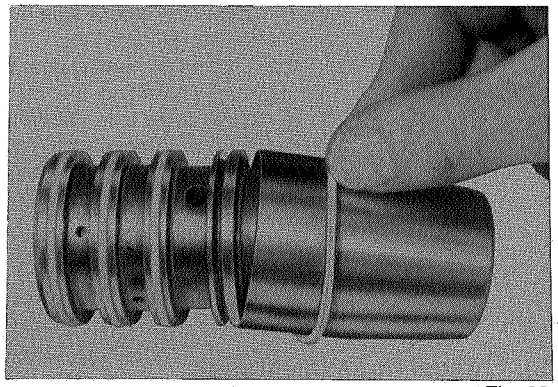


Fig. 39

9.1.3 Assemble shaft sealing ring (8), as described under 3.1. Put insert bush - special tool - on the serration at the end of steering spindle and push valve housing (203) over the control bush (Illustration 40). Screw in bolts (204). Tightening torque see Technical Data.

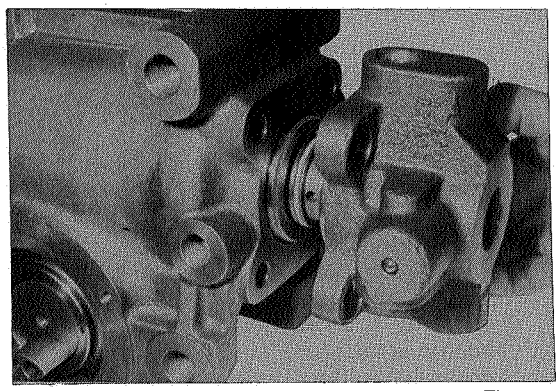


Fig. 40

10. Checking segment shaft position

Establish the total number of steering wheel rotations by turning the end of the steering spindle from lock to lock. When the engagement position of segment shaft teeth and piston teeth is correct the marking on the segment shaft front face is at a right angle to the piston axis at half the steering wheel rotation (Illustration 41).

11. Screw an adjusting screw (20) for the hydraulic steering limitation into the housing (Illustration 42). Note the parts list design. Adjusting screws, which are provided for venting must not be coated. Screw locknut onto the thread and tighten up lightly.

If fitted, screw locking screws (55) with sealing rings (54) into the housing and into the cylinder cover (Illustration 43). For tightening torque see Technical Data. Seal threaded bores for the pressure and return lines with sealing caps.

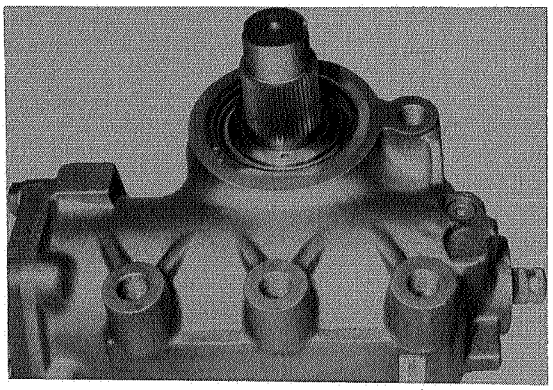


Fig. 41

12. Adjusting worm bearing

12.1 Remove paint from the front face of the housing for the dial gauge support. Attach dial gauge bracket .11. with conventional dial gauge 1/1000 mm scale on the end of the steering spindle.

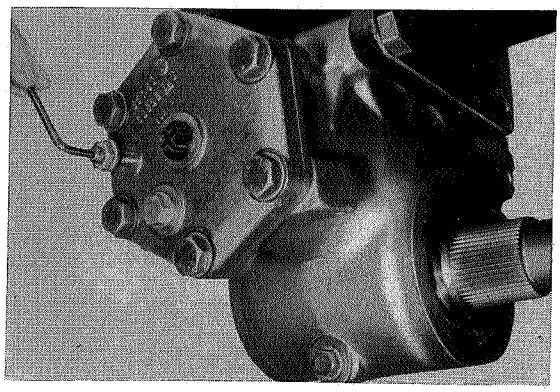


Fig. 42

12.2 Bring the worm axially into position on one side by turning the segment shaft. Position dial gauge on "0".
Bring worm axially into position by turning the segment shaft on the opposite side, preventing the dial gauge bracket rotating radially at the same time (Illustration 44). Read off result of measurement at room temperature. For permitted axial play of the worm see Technical Data. Carry out correction by installing another washer (121) in the housing cover in accordance with para. 8.1.

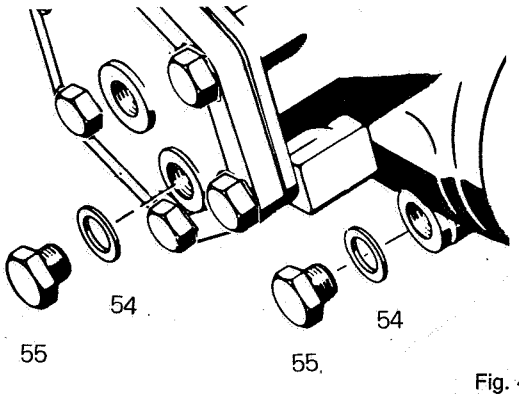


Fig. 43

13. Adjusting segment shaft

13.1 Put torque measuring equipment .6. with insert .7. on the end of the steering shaft. Bring steering into the horizontal head position.

13.2 Turn steering into the end position and measure the friction moment required to turn the steering outside the straight ahead region (approx. 1/2 rotation before end stop) or with segment shaft set back - large adjusting bores in the housing cover pointing downwards to the cylinder side.

13.3 Then measure the increase in friction moment of the steering in the straight ahead range after the segment shaft has been adjusted. To do this, turn the measuring device .6. half a revolution to the left or right over the straight ahead position at the torque and thereby shift the two housing covers with eccentric bearing by simultaneously turning by angles using the adjusting device .12. in a clockwise direction (Illustration 19 and 45) until the required increase in friction moment (see Technical Data) has been adjusted according to the measured value shown under Section 13.2. It is recommended that the maximum allowable increase in friction moment be sought, in order to compensate for the fall in the friction value after the test run (see Technical Data).

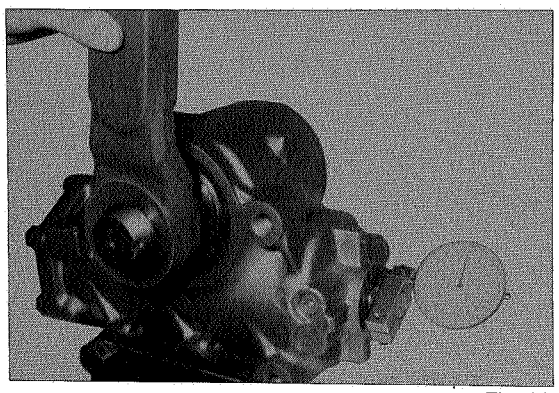


Fig. 44

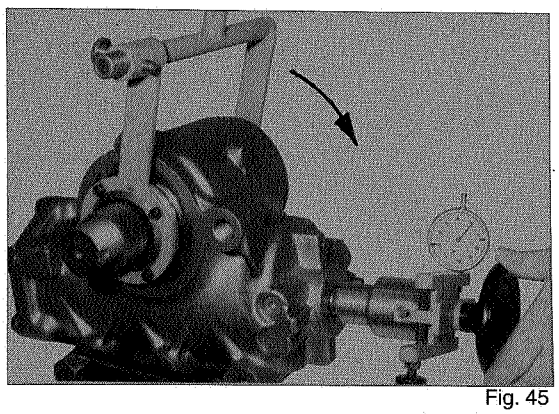


Fig. 45

14. Securing the housing cover by peening over

Note:

Request separate instructions on steering designs with three peening over places per side.

14.1 Tighten up fixture .13. in exactly the right position at the peening over position on the steering unit (Illustration 46). For this swivel up the peening over tool so that the shaped part is led into the housing groove of the same width. In this position adjust the adjusting screw (1) in the fixture, so that the peening over tool is horizontal. Attach fixing hooks (2) on the opposite side of the housing at the height specified by the pressure spindle (3). Tighten up the pressure spindle so that the housing cover contacts the circlip on the peened side.

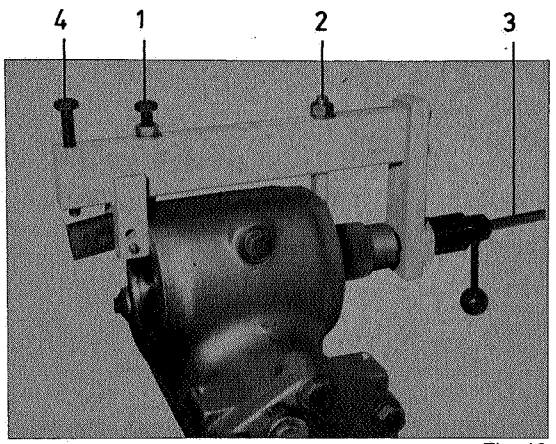


Fig. 46

14.2 Operate peening equipment. For this put the screw (4) on the fixture initially by hand onto the peening tool (without using an additional tool). Then tighten up the bolt with the specified number of rotations (see Technical Data). The bolt tightening torque arising must not exceed the maximum value (see Technical Data) (Illustration 47). A higher torque can lead to a fracture of the peening tool. Remove fixture and check the peening position by a visual inspection. Peening is carried out correctly when the housing cover collar is pressed into the housing groove over the complete width and to the peening depth specified in Illustration 48. Surface cracks on the peened rim are permitted in the area of the groove edges (Illustration 48).

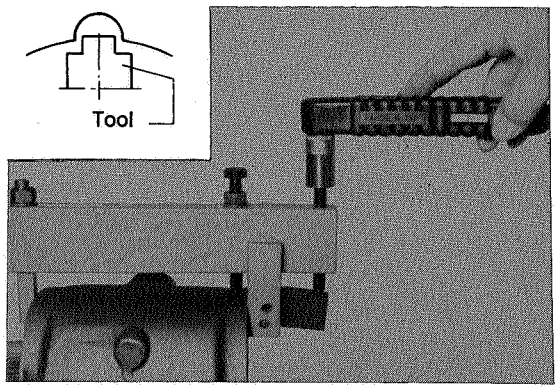


Fig. 47

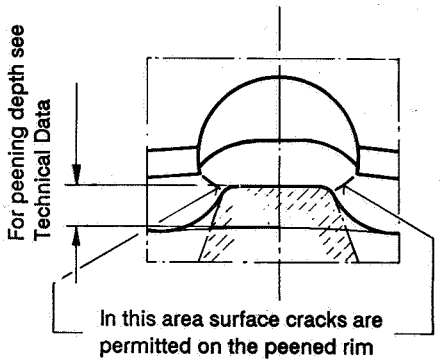


Fig. 48

14.3 Turn fixture on the steering and peen over the second housing cover in the same manner (Illustration 49).

14.4 For steering designs with retaining segments:

After peening over, remove the circlips (7) again and put a retaining segment (14), with the nose towards the peening, in the cover recess. Again assemble the circlips, with the joint opening towards the peening.

For dual-circuit steering design 8096:

15. Assembling hydraulic steering limitation

15.1 Put O-ring (220) in the axial groove of the housing cover (221). Put on housing cover. Screw in cheese-head screws (223). For tightening torque see Technical Data.

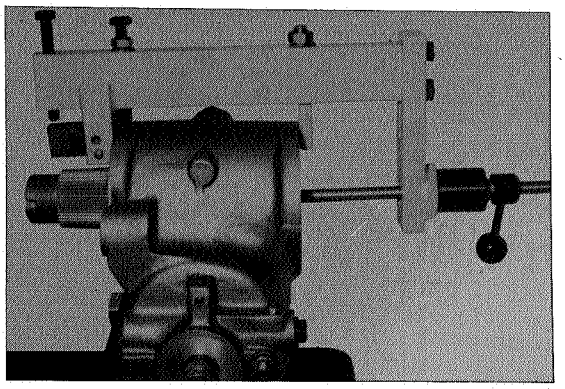


Fig. 49

15.2 Put O-ring (34 and 35) in the radial grooves of the two valves (36). Screw valves into the housing cover. Screw hexagon nuts (38) and washers (37) onto the thread and tighten up lightly (Illustration 50).

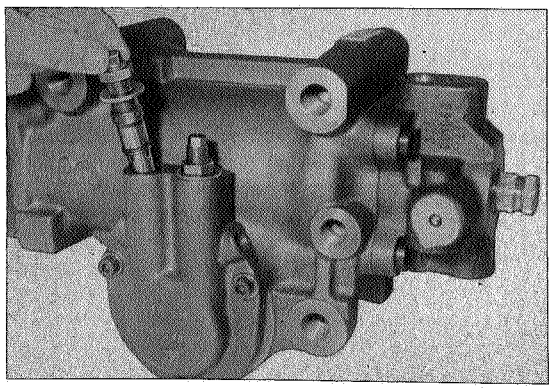


Fig. 50

15.3 Put seals (224) in the connecting bores of the housing (1), cylinder cover (125) and housing cover (221). Assemble pipelines (225 and 226) (Illustration 51).

15.4 On steering designs with hydraulic steering limitation in the II steering circuit the pipelines (225 and 226) are to be routed between the valve housing (203) and housing cover. Tightening torque for union nut see Technical Data.

The adjustment of the steering-lock limiter valves is to be carried out after installing the steering in the vehicle with the aid of a manometer - see instructions on operation, maintenance and inspection of ZF-Servocom 8096.

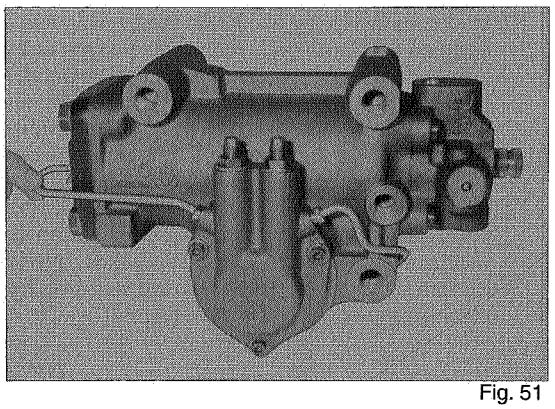


Fig. 51

16. Steering designs with flange mounted angular gear

16.1 Pre-assemble intermediate flange (335) and install.

16.1.1 Put recessed head washer (348) in the intermediate flange. Press ball bearing (343) into the intermediate flange (335) with the tool .16.

For steering designs up to 4/88:

Fit circlip (342) in the groove (Illustration 52).

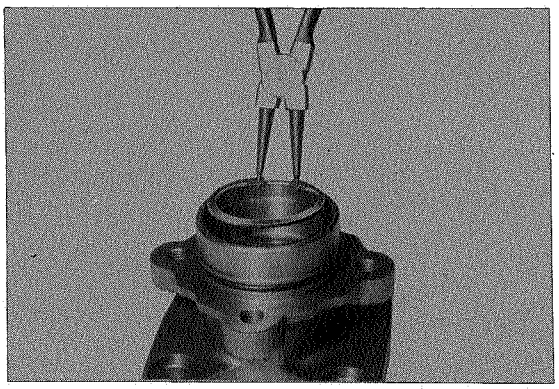


Fig. 52

16.1.2 Press ball bearing (332) on the bevel wheel (331). Press both together in the engagement point to the recessed head washer (348) into the intermediate flange (Illustration 53).

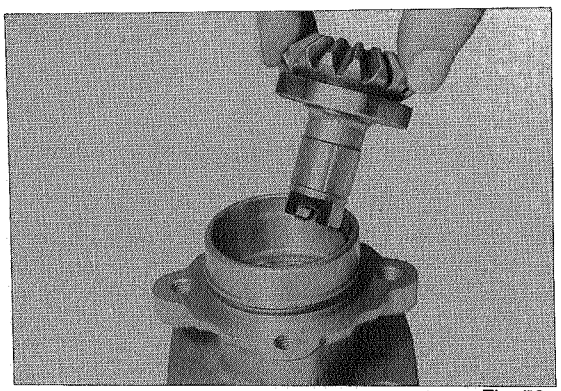


Fig. 53

16.1.3 Put on O-ring (341) and put pre-assembled intermediate flange on the steering (Illustration 54). To do this note engagement point of recessed head washer (348) and worm. Screw in bolts (334). For tightening torque refer to Technical Data.

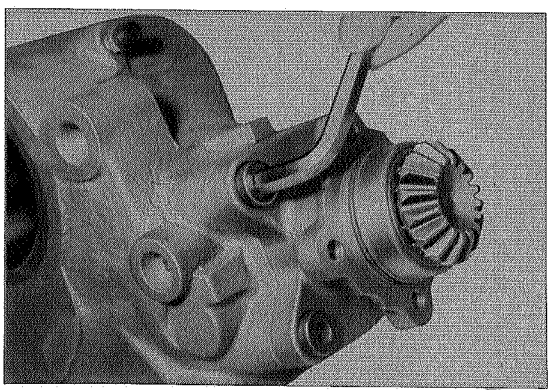


Fig. 54

16.2 Pre-assemble angular gear and install

16.2.1 Press needle sleeve (302) with the tool .17. up to the stop in the housing bore.

Put shim (304) with 0.35 mm thickness or the shims removed during dismantling, into the housing bore. Push bevel wheel (306) up to the stop in the housing (Illustration 55). Screw adjusting screw (312) into the housing and tighten up.

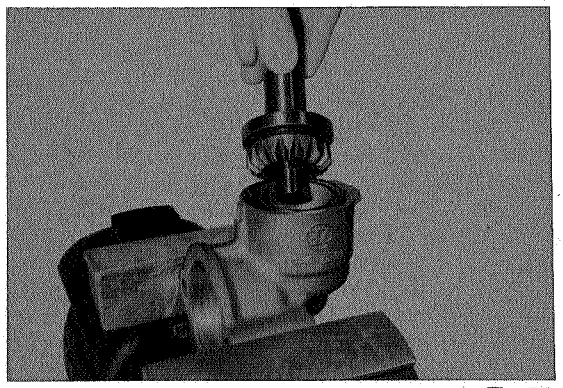


Fig. 55

16.2.2 Put a 0.2 mm shim (330) or the washers removed during dismantling on the intermediate flange.

Turn steering into the straight ahead position. Bring notch stamped on the steering spindle of the angular drive into alignment with the housing marking. In this position mark a tooth of the bevel wheel (306) in the angular gear housing and two opposite teeth of the bevel wheel (331) in the intermediate flange with chalk so that the marked teeth are engaged when the angular gear is put on. Put angular gear on the intermediate flange (Illustration 56).

Screw in bolts (352) with washers (350) evenly whilst constantly turning the steering spindle until the bevel wheels mesh with each other free from play. If the bevel wheels already contact before the flange of the angular gear has reached the stop, the screws must not be turned in any further. In this case the remaining distance is to be compensated for by shims (330), see Technical Data. If freedom from play is not achieved a thinner washer is to be used.

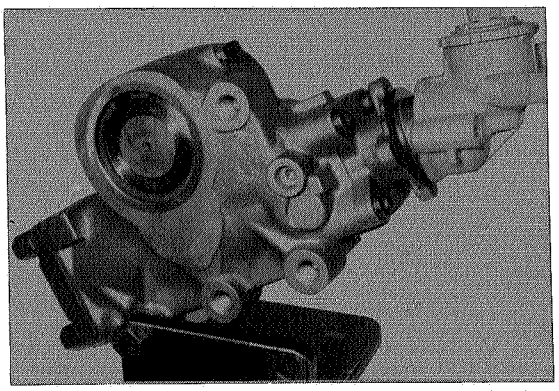


Fig. 56

16.2.3 The final adjustment must be carried out after the provisional determination of the compensation thicknesses required. This is carried out with the washers (330) and also the washers (304) on the bevel wheel (306) - see Technical Data (Illustration 57). The correct adjustment of the bevel wheels is achieved if these engage free of play without catching or binding (maximum backlash 0.04 mm). It is to be ensured that there is no play at all in the straight ahead position of the steering gear (half the total steering wheel revolutions). If freedom from play in the straight ahead position of the steering gear is not achieved the tooth mesh must be shifted by one or more teeth, until this requirement is met. Apply marking notch for straight ahead position.

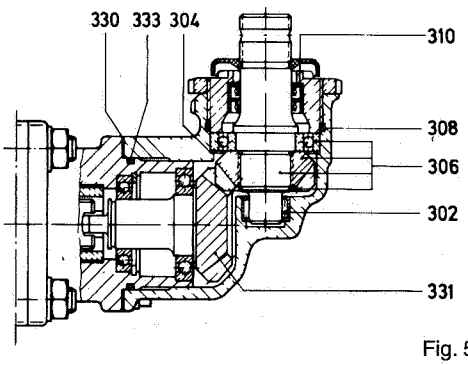


Fig. 57

16.2.4 Again remove the angular gear from the steering unit. Place lubricated O-ring (333) in the radial groove of the intermediate flange. Put the angular gear onto the steering unit again in the position shown, the selected washers (330) having been inserted prior to this. Tighten up bolts (352) with washers (350). Refer to Technical Data for tightening torque. Unscrew adjusting screw (312) from the housing. Put lubricated O-ring (308) in the radial groove of the housing behind the tapped hole. Press shaft sealing ring (310 and 310.1) onto the adjusting screw with sealing lips pointing towards inside of the housing, using tool .18. The shaft sealing ring with the dust lip is assembled on the outside. Fill grease such as Texando FO 20 or equivalent calcium complex grease of the consistency class 2 between the sealing lips and the dust lips.

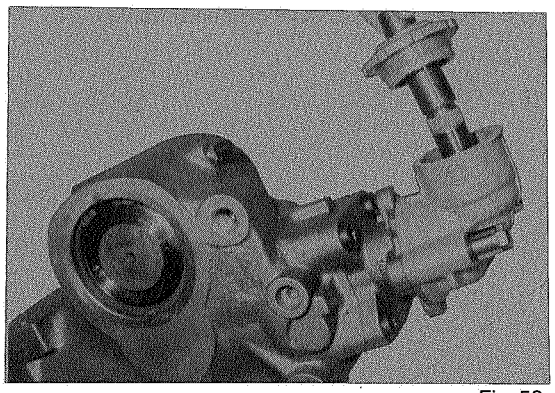


Fig. 58

For the dust cap (53) with sealing lip:

First engage the circlip (310.2) then press in inner shaft sealing ring (310.1.) from inside up to the stop on the circlip, then press in the outer shaft sealing ring (310) flush with the front face of the adjusting screw.

Put insert bush .19. on the steering spindle serration (Illustration 58). Screw adjusting screw (312) into the housing and tighten up.

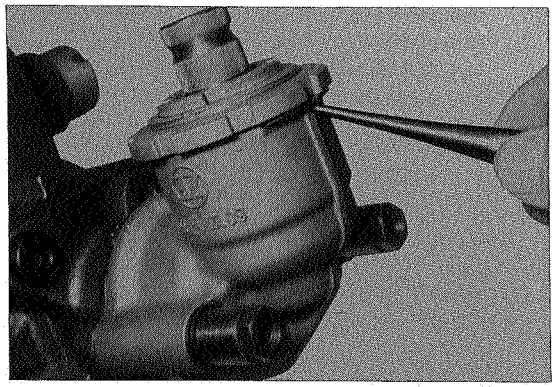


Fig. 59

16.2.5 Tighten up slotted nut (313) - tightening torque see Technical Data - tighten and secure by pressing the cast edge into a groove (Illustration 59).

Check torque set again.

17. Install pressure limiting valve

Put lubricated O-ring (23) in the groove of the valve insert (22). Screw in valve insert (Illustration 60).

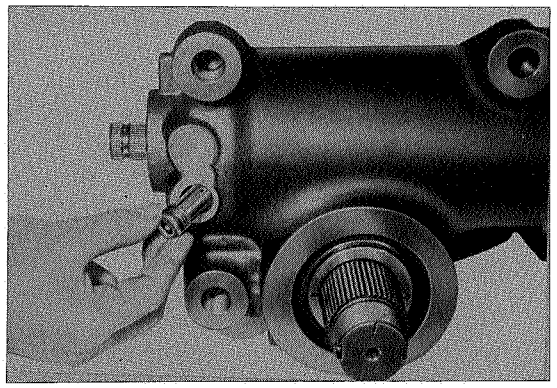


Fig. 60

18. Installing replenishing valve

For steering designs with replenishing valve:

Put valve insert (32) in the housing bore. Screw in bolt (30) with lubricated O-ring assembled (21) (Illustration 61). For tightening torque refer to Technical Data.

19. Measuring the friction moment of the fully assembled steering unit

Put torque measuring equipment .8. and insert .9. onto the end of the steering unit. Turn steering from one end position to the other, whilst measuring the friction moment outside the area with no play. For values refer to Technical Data.

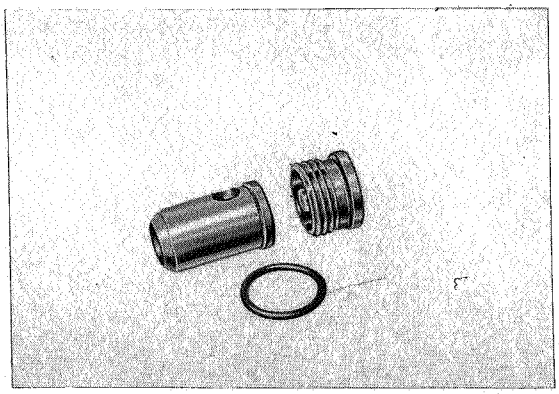


Fig. 61

Functional test

Caution!

In order to comply with road safety after being repaired, each steering unit must be subjected to a functional test on the test bench. It is not permissible to install the steering unit into the vehicle without being tested in order to establish its function on a subsequent test run.

1. Mounting the steering on the test bench

Clamp the completely assembled steering on the steering test bench. Connect pressure and return line. On dual- circuit designs seal the connections for the operating cylinder with blind plugs.

Caution! Only use lines and connections, which are certified for the maximum pressure occurring. Risk of accident!

Vent the steering system (see Maintenance and Inspection Instructions). When clamped horizontally use overhead steering limiting bolt and bring oil temperature to approx. 50°C.

The adjustment values specified in Section III are valid for the segment shaft adjustment after repairs are completed on the work-bench. The steering units are not filled with oil for this.

Adjustment values on the test bench:

Regulate test bench to the nominal pressure and flow rate which is laid down for the steering system or specified on the pump identification plate. Nominal pressure + 30 bar on steering designs fitted with pressure limiting valve.

Adjust as follows in the absence of specifications:

Test bench pressure:	150 bar		
Flow rate:	7 dm^3/min	=	8090
	12 dm^3/min	=	8095
	16 dm^3/min	=	8096 to 8098

2. Checking (test bench switched on)

2.1 Checking the maximum pressure

Lock steering in the center position (the steering can also be turned as far as the stop on steering units without hydraulic steering limitation). Turn steering wheel until maximum pressure has developed in one side of the cylinder. For this it is necessary to pull with a force of 100 - 200 N on the steering wheel circumference so that the maximum travel of the valve is reached. This is detectable on the fixed stop.

Provided the steering is equipped with a built-in pressure limiting valve, a maximum pressure must develop which corresponds to the details of the identification plate (tolerance + 10%).

The same measurement is then repeated again with the steering wheel rotated in the opposite direction. If the maximum pressure is not achieved within the specified tolerance then there is either excessive overflow oil in the steering unit or the pressure limiting valve (if fitted) is set incorrectly. The latter can also be the cause of excessive maximum pressure. The valve insert cannot be stripped down and must be replaced completely in the event of pressure deviation.

2.2 Checking overflow oil

2.2.1 Single-circuit designs

The following check can be made with the Pitman arm locked or in the end positions of the cylinder. The control valve is to be fully actuated in order to determine the overflow oil in the steering unit. Again at least approx. 100 - 200 N must be applied to the steering wheel. The check is carried out with the steering wheel rotated in both directions while the pump is running. A pressure is adjusted on the steering test bench which is 30 bar below the maximum pressure specified on the identification plate.

Maximum permitted overflow oil values:

Model	8090	1.0 dm^3/min
Model	8095 to 8098	1.5 dm^3/min

The pressure displayed is to be read off simultaneously on the test bench manometer during the leakage oil test and to be noted.

Checking the pressure increase at reduced flow rate:

Adjust the test bench to a flow rate of 2 dm^3/min. and check the adjusted pressure value on the test bench again.

Repeat overflow oil test as described and compare the pressure displayed on the test bench manometer with the pressure noted previously. If there is only a slight increase or no pressure increase this can be due to sealing rings (117 and 123) which do not contact exactly in the piston or the housing cover.

2.2.2 Dual-circuit designs

The overflow oil check for the II steering circuit takes place in the same way as for the I steering circuit. Connect pressure and return lines to the II steering circuit. Seal connections for the operation cylinder of steering circuit II with filler plugs. Perform overflow oil check in accordance with Section 2.2.1. The maximum permissible overflow oil rate per steering circuit is 1.5 dm^3/min.

An additional overflow oil measurement of the separating seals (164, 164.1 and 172, 173) is to be conducted between circuit I and circuit II as follows:

Turn the steering so that the piston assumes its lower final position in the housing. Then unscrew the screwed sealing plug (55) in the housing base or if not provided, the screwed sealing plug (55) on the cylinder cover (125) or the turn flow line involved and drain out the oil. Permit the oil to drain out until the oil level in the housing has reached the level of the overflow bore and no further oil escapes. This is the case after about 5 min.

Seal return flow connection and the two operating cylinder connections of circuit II with blind plugs. Apply pressure to the pressure line of II circuit with 3 bar set on the test bench. Collect the overflow oil escaping at the housing bore or return flow connection for exactly 1 minute in a measuring glass. The maximum permissible overflow oil must be 0.001 dm^3/min. (1 cm^3/min.).

Repeat overflow oil check at a pressure of 30 bar. The measurements are to be performed statically - control valve not actuated, and dynamically - control valve fully actuated once to the left and right.

2.3 Checking the hydraulic center

The pump runs and oil circulates through the hydraulic system of the steering. A counter force is not to be applied to the steering shaft on the steering test bench. The hydraulic steering is now turned slowly to both sides until the end stop and the torque measuring device released several times. The steering must not move automatically in one direction.

Checking with the Pitman arm locked in the center area:

Close the steering valve by turning the steering wheel in one direction of rotation until a pressure rise of 3 bar above the continuous pressure is achieved on the low pressure manometer. Read off measured value on the torque measuring equipment. Repeat the same measurement in the opposite direction of rotation of the steering wheel. The difference in torques when steering to the right or to the left must be a maximum of 30%, related to the smaller value.

2.4 Checking the control valve

With the Pitman arm locked in the central area close the control valve by turning the steering wheel and thereby build up maximum pump pressure. Then slowly release the steering wheel and again regulate a pump pressure of 10 bar above the continuous pressure. The valve must return to the zero position within 1 s, i.e. the oil pressure drop to at least 0.5 bar above the continuous pressure.

2.5 Adjusting the hydraulic steering-lock limiter

2.5.1 Single-circuit designs

Turn the steering wheel in one direction with a counter force set on the test bench, until the Pitman arm lock specified in the parts list for the switch off point of the hydraulic steering limitation is reached. Then carry out the adjustment be turning the adjusting screws (X or Y, Illustration 62) in or out until the oil pressure reduces. This can be detected immediately since the steering wheel can only be turned outwards with increased application of force. When the steering limitation is correctly adjusted and when the flow rate does not rise above 16 dm^3/min. at engine idle speed, e.g. for steering systems with a supplementary operating cylinder, an oil pressure must now be displayed on the manometer of:

40 to 45 bar at an oil temperature of 50°C or
45 to 50 bar at an oil temperature of 30°C

The following settings apply for steering systems with higher flow rates:

Above 16 dm^3/min:	50 to 55 bar at 50°C or
	55 to 60 bar at 30°C
Above 20 dm^3/min:	70 to 75 bar at 50°C or
	75 to 80 bar at 30°C

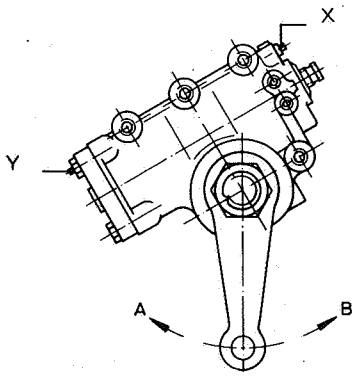


Fig. 62

To make the necessary corrections slacken the relevant locknut and turn the adjusting screw (X or Y) in or out. To do this release the steering wheel so that only continuous pressure develops during this work. Likewise perform the adjustment with the Pitman arm rotated in the opposite direction. Then tighten the hexagon nut (129) with the specified tightening torque (see Technical Data).

2.5.2 Dual-circuit designs

Carry out the adjustment by screwing the valves (36) in or out as described under 2.5.1 until the oil pressure reduces. When the adjustment is correct an oil pressure of 30 to 35 bar must be displayed on the manometer in both directions of rotation. Tighten the hexagon nut (38) with the specified tightening torque (see Technical Data).

2.6 Checking for external leakage

No leakage should be visible in the neutral position of the steering valve after a running time of 10 minutes.
The leakage at high pressure is to be established during the test in accordance with point 2.1 to 2.4. of this section.

2.7 Removing the steering unit from the test bench

With the steering unit removed, empty the test oil by repeatedly rotating the end of the steering in both directions. Measure friction moment - pressure point adjustment:

Measure the friction moment at the pressure point and outside the area free of play with the torque measuring equipment. For values refer to Technical Data.

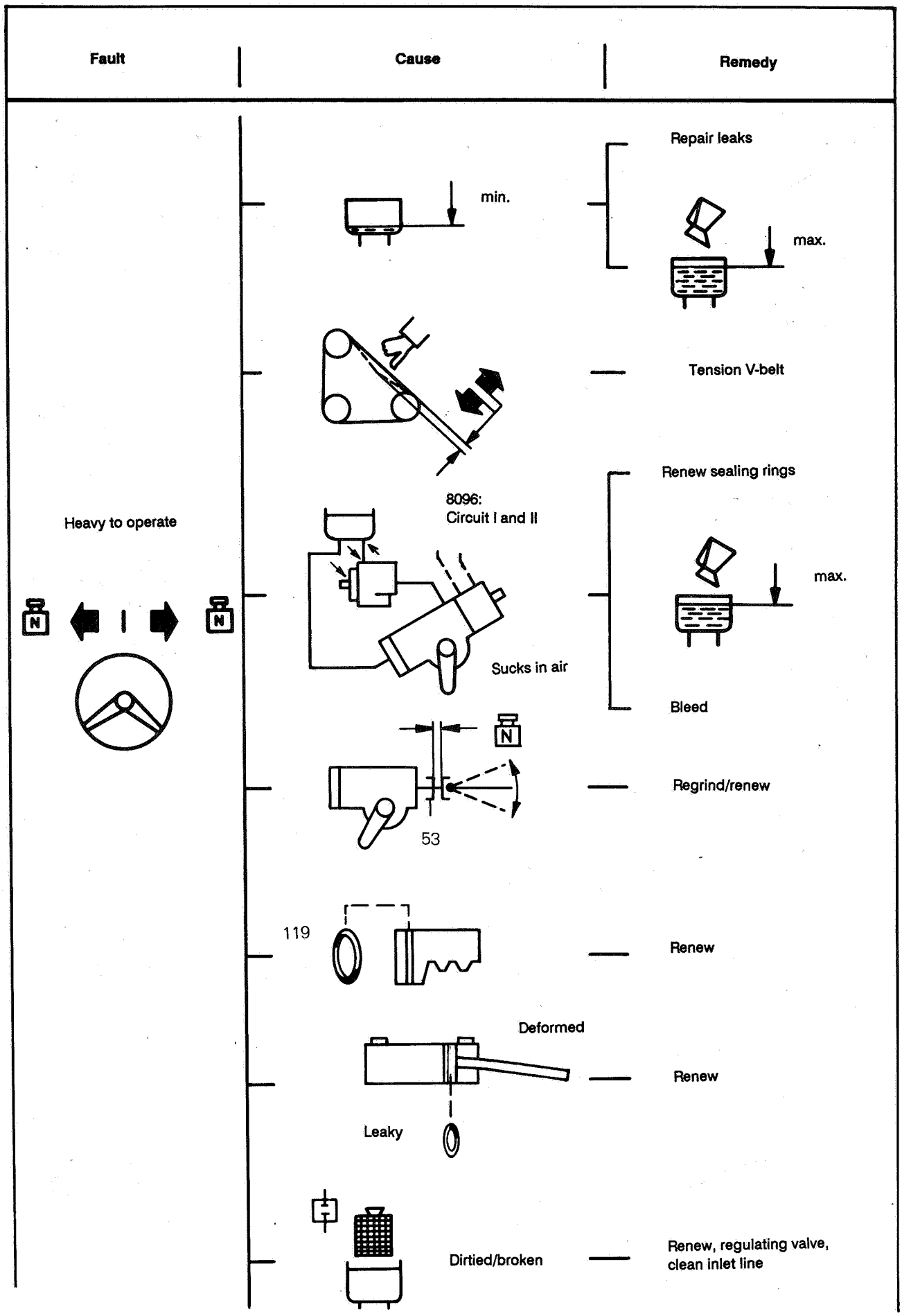
Push on dust seals (51 and 52) on the segment shaft side and opposite as well as dust cap (53 and 314) on the steering spindle side with FO 20 grease or equivalent (see note in Section IV.) between the dust lip and the housing. Ensure that the bead of the dust cap locates in the groove behind the steering spindle serration and that the markings on the dust cap and the end of the worm are aligned.

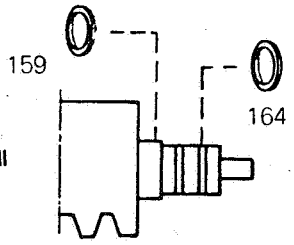
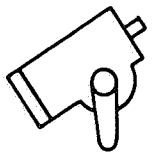
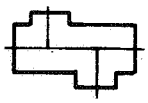
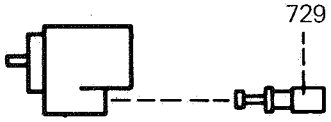
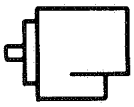
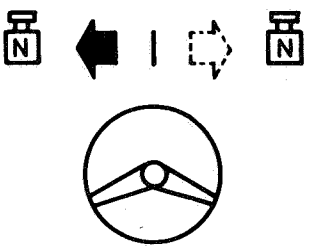
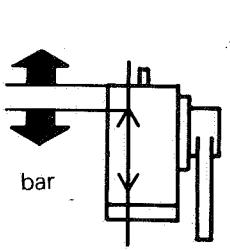
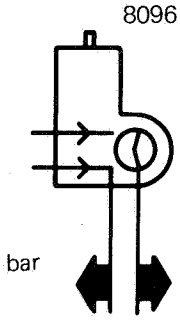
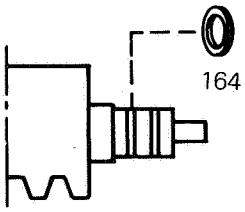
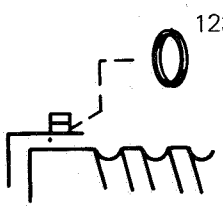
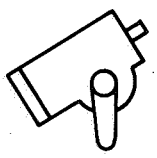
Latest design of dust caps must contact the outer edge when preloaded by the housing.

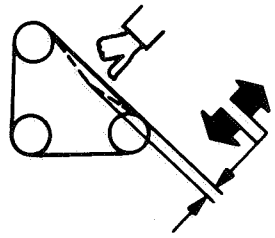
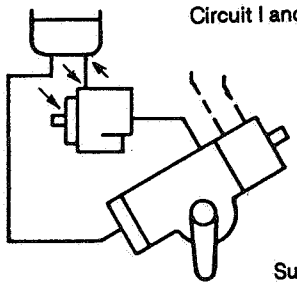
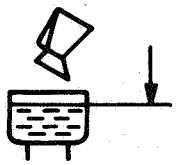
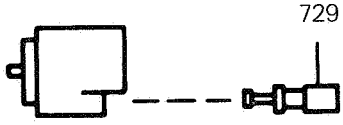
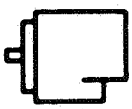
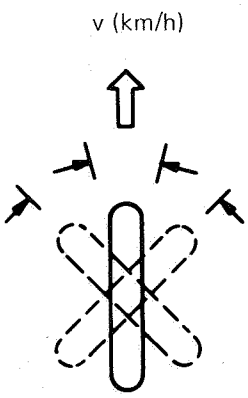
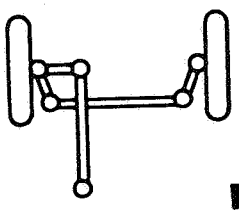
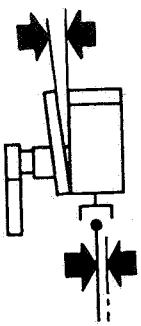
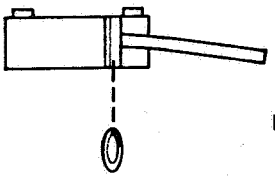
For dust cap (314) with sealing lip:

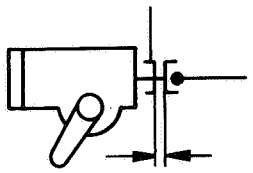
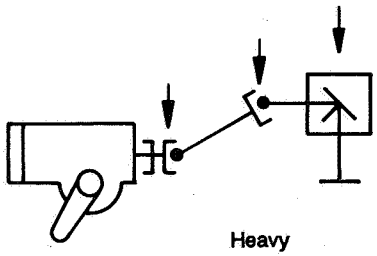
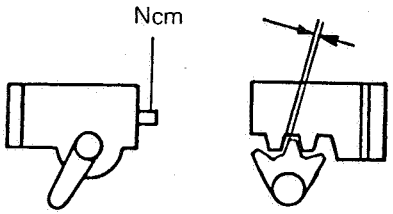
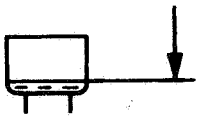
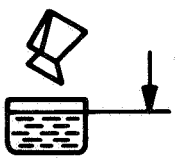
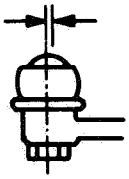
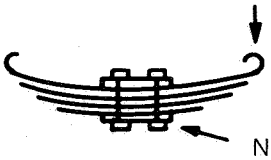
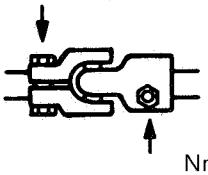
Attach dust cap with the circlips (314.1 and 314.2).

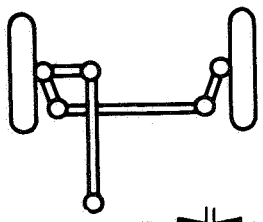
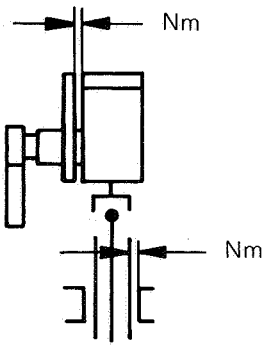
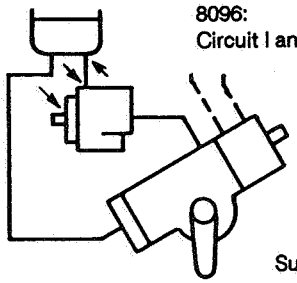
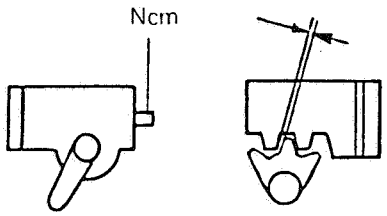
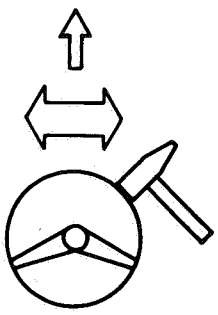
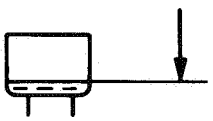
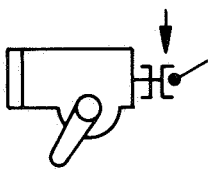
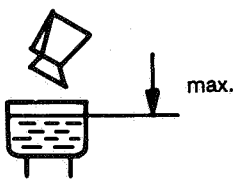
V. Troubleshooting

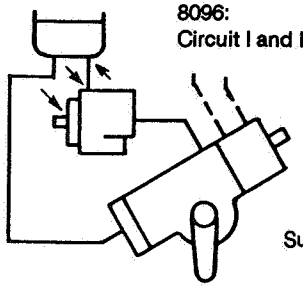
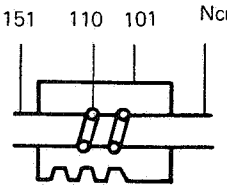
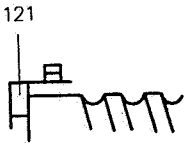
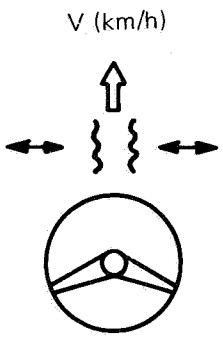
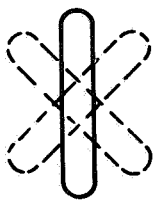
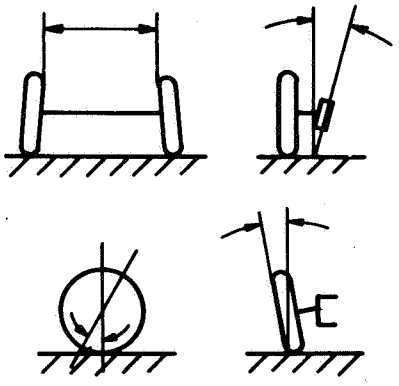
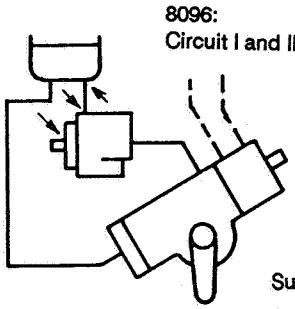


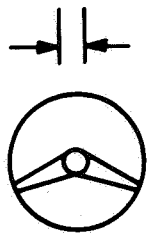
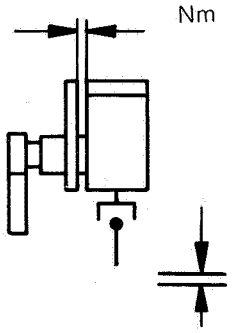
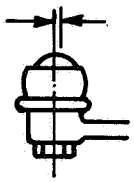
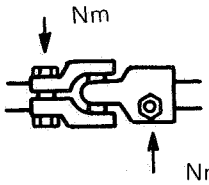
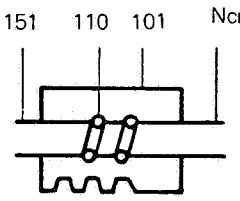
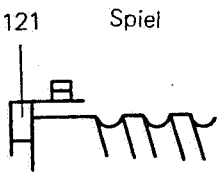
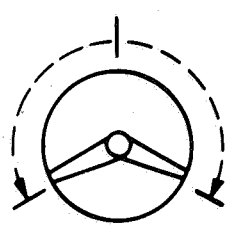
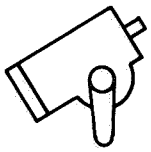
Fault	Cause	Remedy
	 8096: Circuit I and II	Renew
	 Fault internal	Exchange steering system
	 Some valves stick (8096)	Clean
	Conveying flow too low	
		Dismantle, clean, ensure easy movement
	 Fault internal	Exchange pump
Heavy to operate on one side 	 	Adjust
	 8096: Circuit I and II	Renew
		Renew
	 Fault internal	Exchange steering system

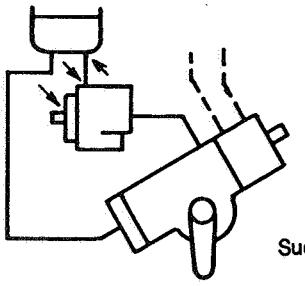
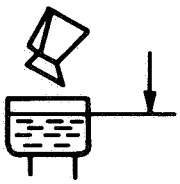
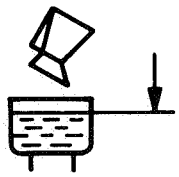
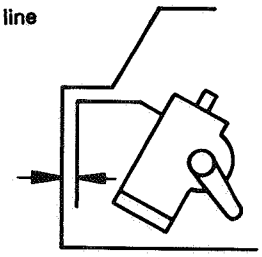
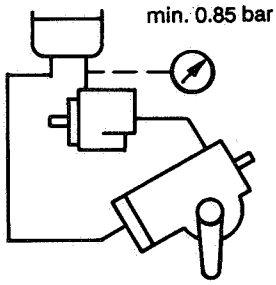
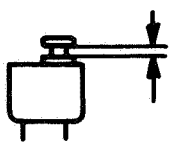
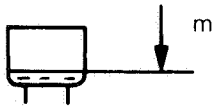
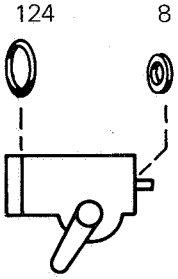
Fault	Cause	Remedy
Heavy when steering turned quickly		Tension V-belt
	8096: Circuit I and II  Sucks in air	Renew seal ring  max. Bleed
	Conveying flow too low	
	729 	Desmantle, clean, ensure easy movement
	 Fault internal	Exchange pump
Sluggish steering return  v (km/h)	Heavy 	Lubricate
	Improper fastening 	Release fastening
	 Deformed	Renew
	Leaky	

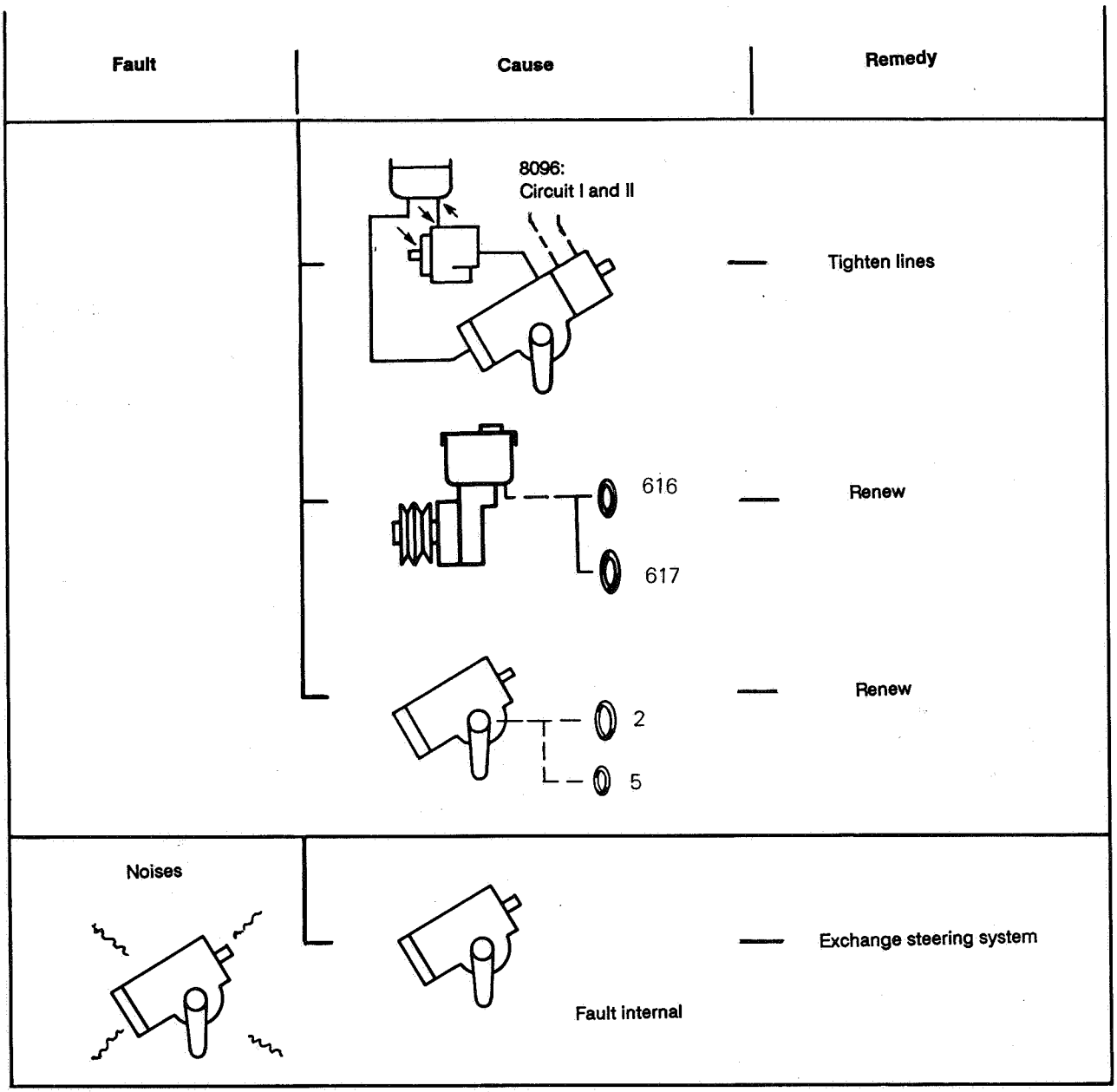
Fault	Cause	Remedy
	53 Jamming 	Regrind/renew
	 Heavy	Lubricate
	Ncm 	Section IV.
Not exact  V (km/h)	 min.	Repair leak  max. Bleed
		Tighten/replace
	 Nm	
	Nm  Nm	

Fault	Cause	Remedy
	 Heavy	Lubricate
	 Nm Nm	Tighten
	 8096: Circuit I and II Sucks in air	Renew sealing rings Bleed
	 Ncm	Section IV.
Steering wheel knocking V (km/h) 	 min.  Play	Repair leaks  max. Renew

Fault	Cause	Remedy
	 8096: Circuit I and II — Sucks in air	Renew sealing rings; Bleed
	 — Play	Section IV.
	 — Play	Section IV.
Turning vibrations 	 Out of balance	Balance
		Adjust
	 8096: Circuit I and II — Sucks in air	Renew sealing rings; Bleed

Fault	Cause	Remedy
Steering wheel play 		Tighten/replace
		Tighten/replace
		Tighten/replace
		Play — Section IV.
		Play — Section IV.
Runs off 	 Fault internal	— Exchange steering system

Fault	Cause	Remedy
Noises	8096: Circuit I and II	Renew sealing rings
	 Sucks in air	 max.
		Bleed
	 min. Pressure line	Repair leaks
		 max.
		Rubber mount
	 min. 0.85 bar	ZF Customer Service
Oil loss		Close
 min.	 124 8	Renew



ZF Servocom recirculating ball power steering systems were developed for heavy duty applications. They have been designed for trouble-free operation in normal conditions - provided they are properly maintained.

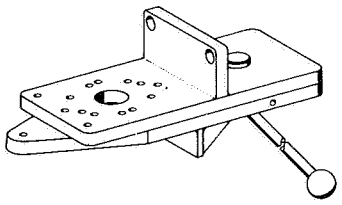
However, should a fault occur for any reason, the following notes will help locate and rectify the trouble.

Before looking for faults on the steering system, check the oil level with the engine running. The exact procedure for filling the system with oil is described in a separate section of this manual. Please note that faults can occur if oils are used which froth readily since they tend not to release air which has got into the steering system.

VI. Special tools

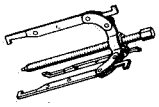
Tool .1.

Assembly vice



Tool .2.

Puller for housing cover (4) - housing



Tool .3.

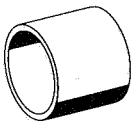
Mandrel for shaft sealing ring (8) - steering spindle

Tool .4.

Insert bush for housing cover (4) - segment shaft

Tool .5.

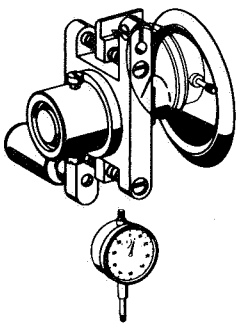
Sleeve for pressing on the housing cover (4) - housing



Tool .6.

a) Torque measuring equipment (without insert item 7, without dial gauge)

b) Dial gauge, large design, 1/100 mm graduation



Tool .7.

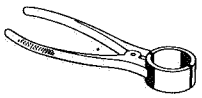
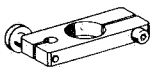
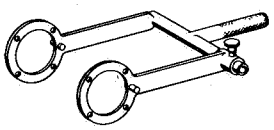
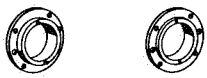
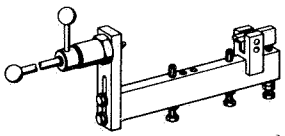
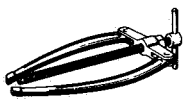
Socket for torque measuring equipment item 6

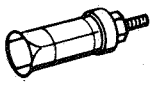
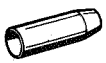
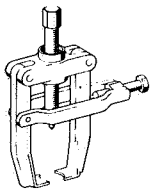
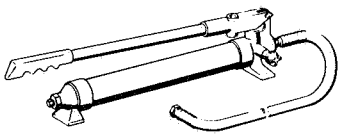
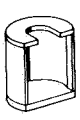
a) cyl. spline 1x54 serrations

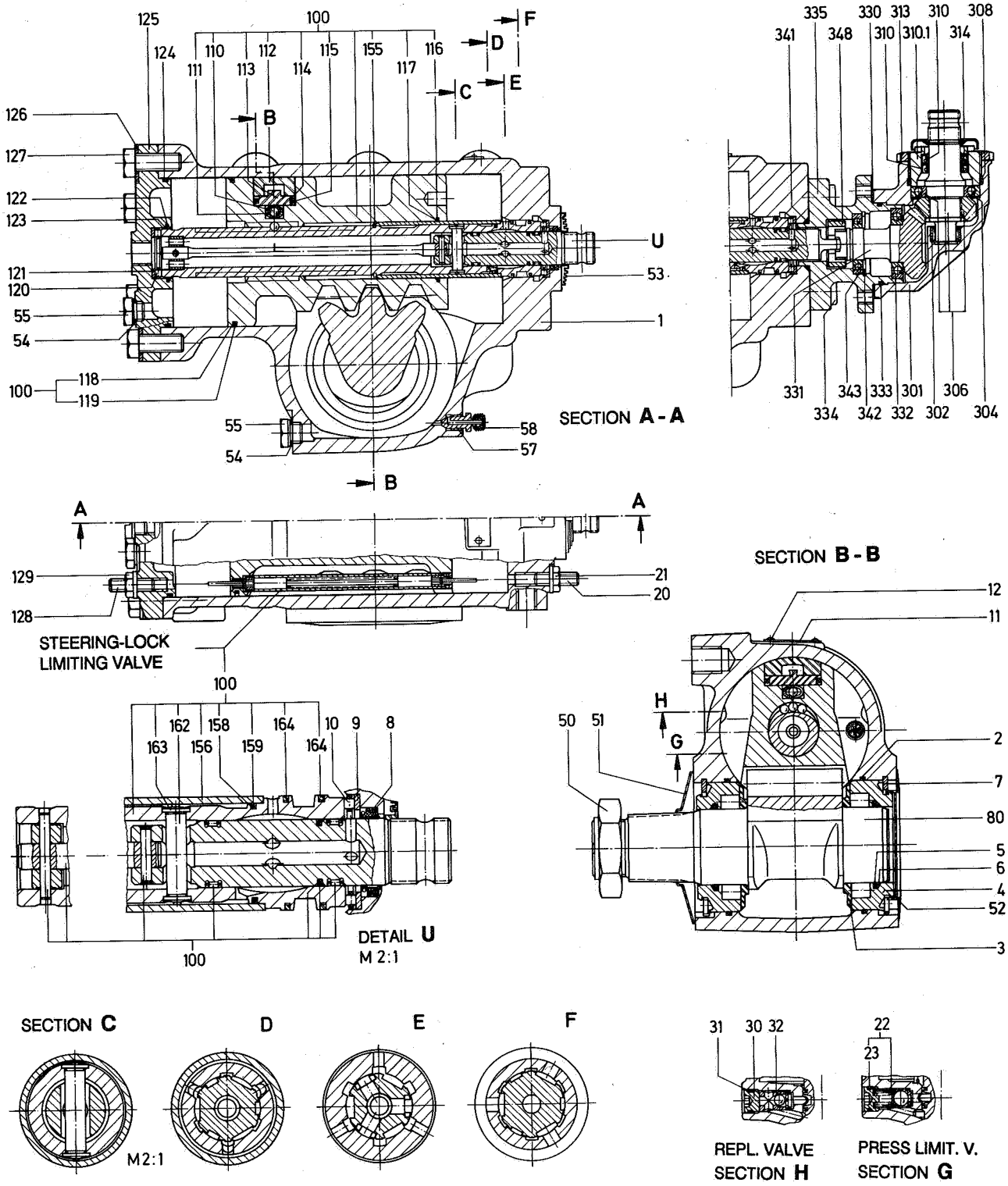
b) cyl. spline 1x79 serrations

c) with bore - angular gear design

8090	**8095 8096**	**8097**	**8098**
7418 798 654			
8090 798 201			
8090 798 052	8090 798 051		
	8043 798 001		
8090 798 006	8095 798 002	8097 798 002	8098 798 002
7470 798 703			
7470 798 706			
8052 798 552			
	7419 798 551		
	8065 798 552	7421 798 551	

		8090	8095 8096	8097	8098
Tool .8. Insert bush for sealing ring (164) - worm		8090 798 004	8090 798 001		
Tool .9. Assembly pliers for pressing on sealing rings (164) - worm		8090 798 652	8090 798 651		
Tool .10. Insert bush for shaft sealing ring (8) - steering spindle		8090 798 002	8090 798 003		
Tool .11. a) Dial gauge bracket for adjusting axial play - worm (151) (without dial gauge)		8090 798 101	8095 798 101		
b) Dial gauge 1/1000 mm graduation for dial gauge bracket item 11a)		7016 798 704			
Tool .12. a) Fixture for adjusting the segment shaft with no play (pressure point) - without insert		8090 798 151			
b) 2 inserts for fixture item 12a)		8090 798 551	8095 798 551	8097 798 551	8098 798 551
Tool .13. Fixture for locking the housing cover (4) (for design with 1 peening point per side)		8090 798 654			
Tool .14. Counter support for internal extractor item 15 - angular gear			7421 798 351		

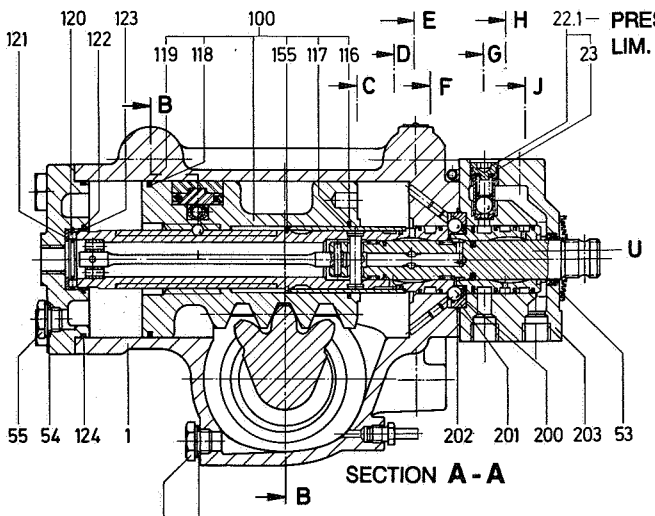
		8090	8095 8096	8097	8098
Tool .15. Puller for needle sleeve (302) - angular gear			7421 798 201		
Tool .16. Mandrel for needle bearing (343) - intermediate flange - angular gear				7421 798 051	
Tool .17. Mandrel for needle sleeve (302) - angular gear			7677 798 051		
Tool .18. Mandrel for shaft sealing ring (310 and 310.1) - angular gear			7418 798 051		
Tool .19. Insert bush for shaft sealing ring (310 and 310.1) - angular gear			7418 798 006		
Tool .20. Puller for Pitman arm					
a) Mech. claw puller		7418 798 202			
b) Hydraulic puller					
Handpump		7016 798 201			
Pressure cylinder with coupling sleeve		0646 121 048			
Bell		7418 798 214	7418 798 213		

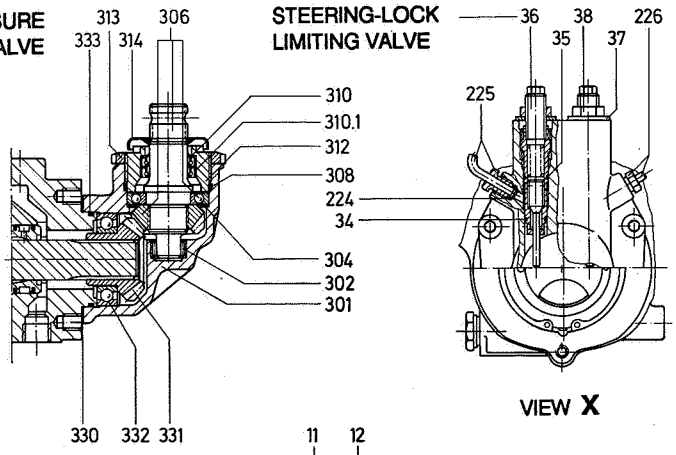


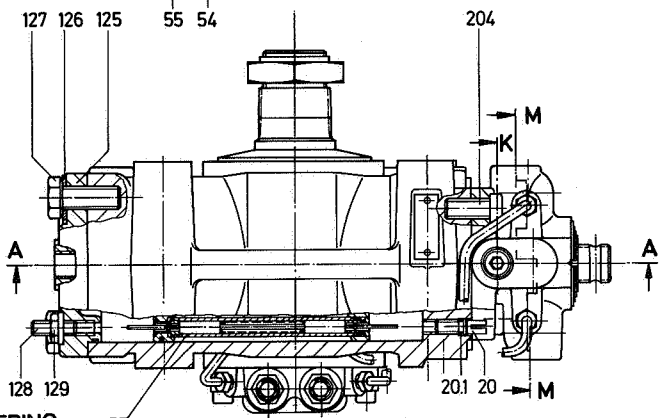
WE RESERVE THE RIGHT TO MAKE DESIGN CHANGES

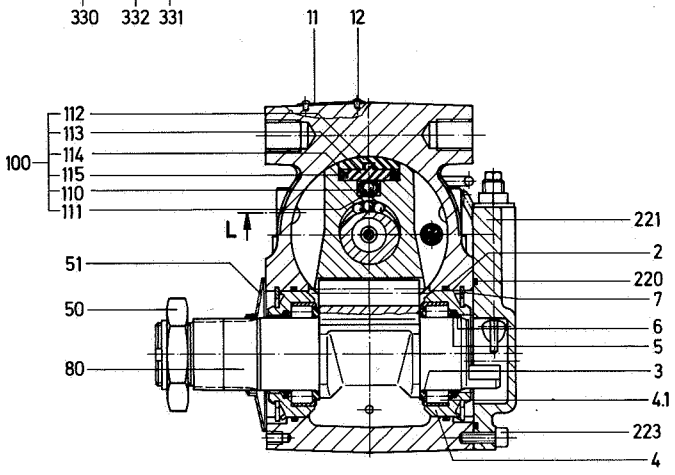
LEGEND SEE OVERLEAF

ZF-Servocom, Model 8096

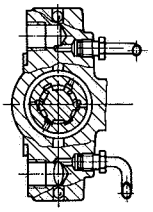






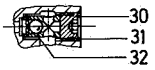


SECTION M - M



SECTION B - B

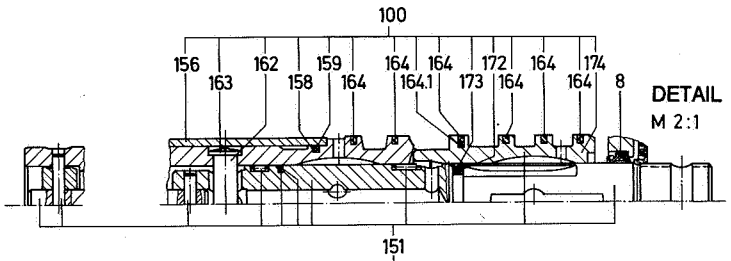
SECTION K
REPLENISHING VALVE



WE RESERVE THE RIGHT TO
MAKE DESIGN CHANGES

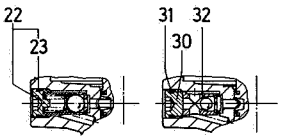
LEGEND SEE OVERLEAF

STEERING-LOCK LIMITING CIRCUIT I

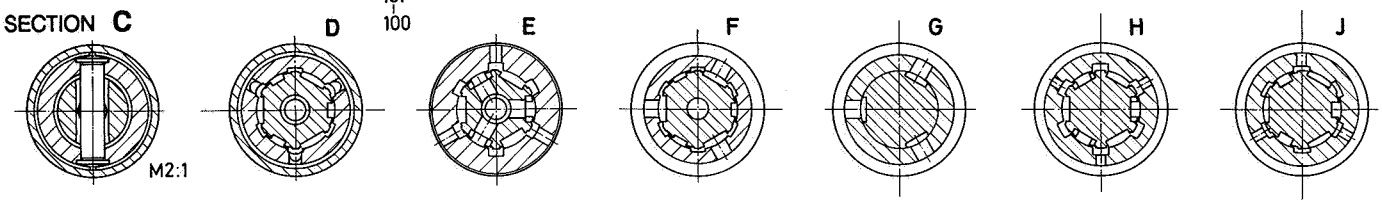


SECTION L

PRESSURE LIMITING VALVE REPLENISHING VALVE



SECTION C



VII. Ordering spare parts

Please quote on your order the
1. 10-digit type number and
2. serial number

of the faulty unit concerned.

If you require only spare parts and have Part Lists or Instruction Manuals, please quote the 10-digit part number or the key number of the part in the exploded drawing as well as the number of the exploded drawing.

Please let us have the following information with your order:

1. Your exact address and company name
2. Method of shipment (normal or express mail, forwarding agent etc.)
3. Station of destination for shipment by rail
4. Your purchase order number

We shall be able to complete your orders quickly and correctly with this information.

All deliveries are subject to our "General Conditions for the Supply of Gears, Vehicle Transmissions and Steering Systems".

Damaged samples submitted to us will be scrapped at the factory unless we are explicitly requested to return them.

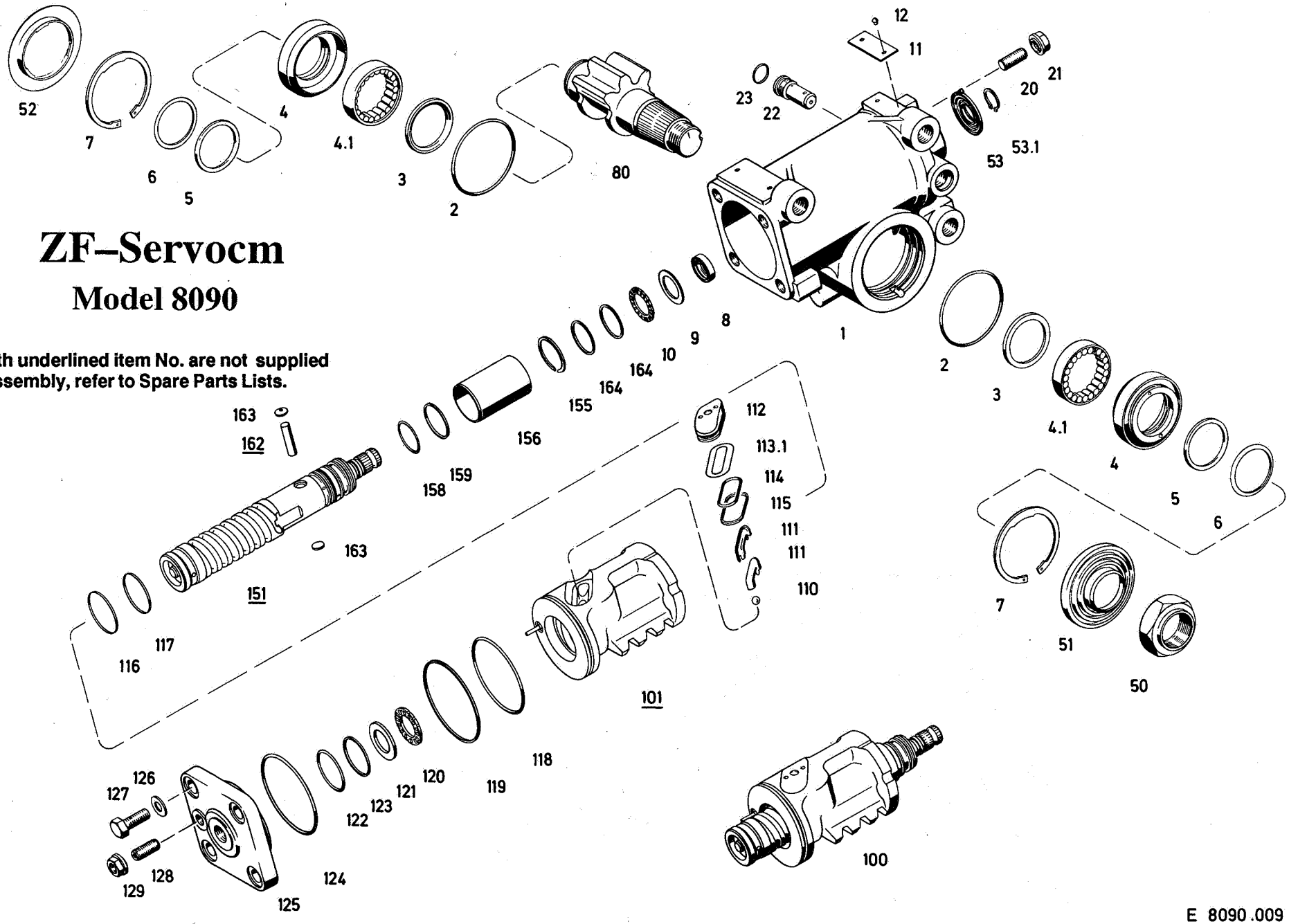
VIII. Key to illustrations and exploded drawings

1	Housing
2	O-ring
3	Washer
4	Housing cover
5	Gasket
6	Backing ring
7	Circlip
8	Oil seal
9	Washer
10	Needle cage
11	Rating plate
12	Notched pin
14	Retaining segment
20	Grub screw
21	Collar nut
22	Pressure limiting valve
23	O-ring
30	Screw
31	O-ring
32	Recuperation valve
34	O-ring (small)
35	O-ring (large)
36	Valve
37	Washer
38	Hexagon nut
50	Locknut
51	Dust seal
52	Plug
53	Dust cap
53.1	Circlip
54	Sealing ring
55	Locking screw
56	Protective sleeve
57	Venting screw
58	Sealing cap
59	Tab washer
80	Rocker shaft
100	Piston assembly
101	Piston
109	Steering limit valve
110	Set of balls
111	Recirculating ball tube (two halves)
112	Plug
113	Gasket
113.1	Shim
113.2	Pin
114	O-ring
115	Sealing ring
116	Sealing ring
117	Sealing ring
118	O-ring
119	Gasket
120	Needle cage
121	Washer
122	O-ring
123	Sealing ring
124	O-ring
125	Cylinder cover
126	Washer
127	Hex head screw
128	Grub screw
129	Collar nut
151	Worm assembly
155	Snap ring
156	Sliding tube
157	Bush
158	O-ring
159	Sealing ring
160	Pin
161	Worm
162	Pin
163	Plug
164	Sealing ring
165	Torsion bar
166	Needle cage
166.1	Snap ring
167	Pin
168	Valve slide
169	O-ring
170	Sealing ring
203	Valve housing
204	Cheese-head screws
220	O-ring
221	Cover
223	Screw
224	Gasket
225	Pipeline (short)
226	Pipeline (long)
301	Housing
302	Needle sleeve
304	Shim
306	Bevel wheel
308	O-ring
310	Outer shaft sealing ring
310.1	Inner shaft sealing ring
312	Adjusting screw
313	Slotted nut
314	Dust cap
331	Bevel wheel
332	Ball bearing
333	O-ring
334	Stud
334.1	Washer
334.2	Nut
335	Intermediate flange
341	O-ring
342	Circlip
343	Ball bearing
348	Cross recessed washer

ZF–Servocm

Model 8090

The parts with underlined item No. are not supplied loose. For assembly, refer to Spare Parts Lists.

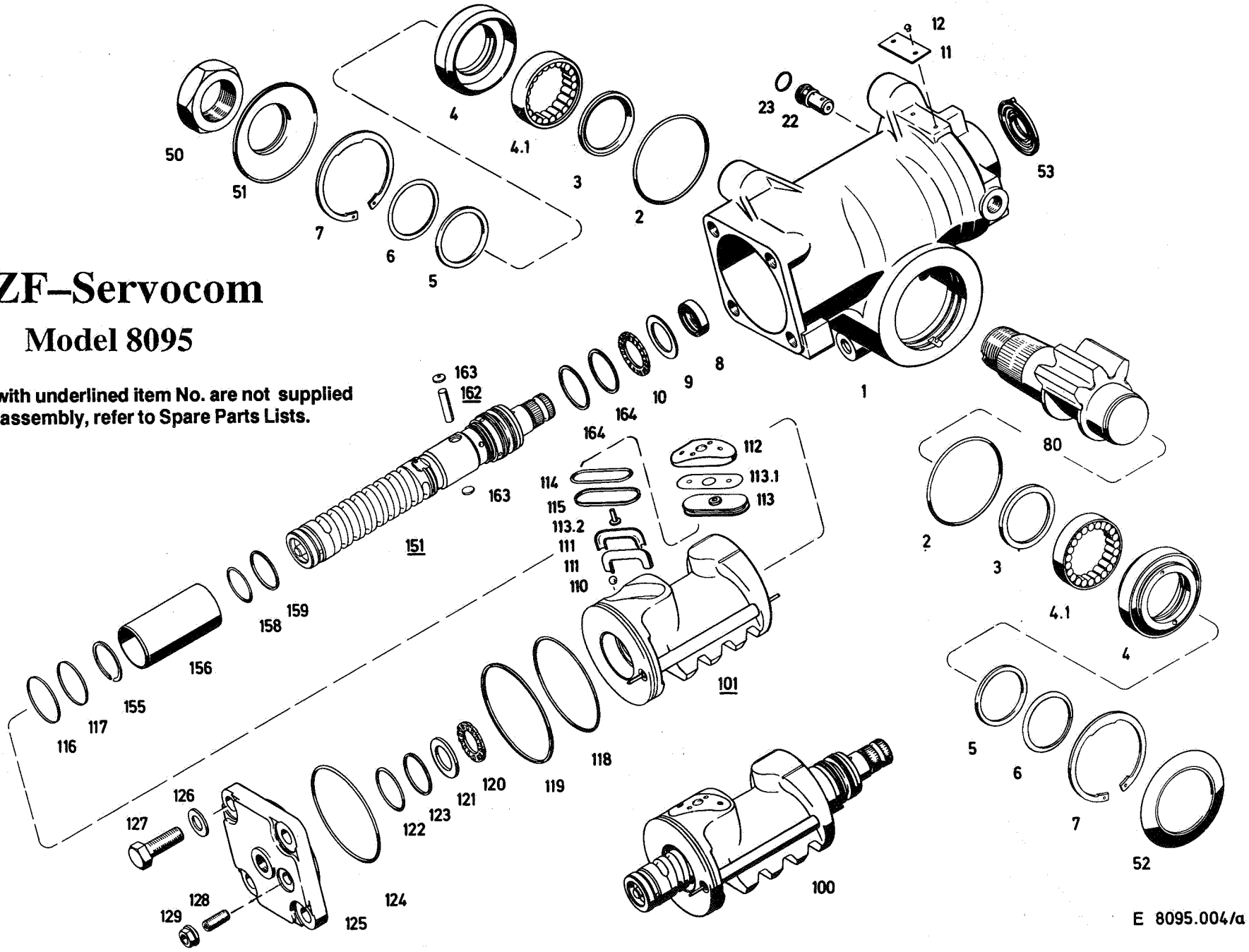


E 8090.009

ZF–Servocom

Model 8095

The parts with underlined item No. are not supplied loose. For assembly, refer to Spare Parts Lists.

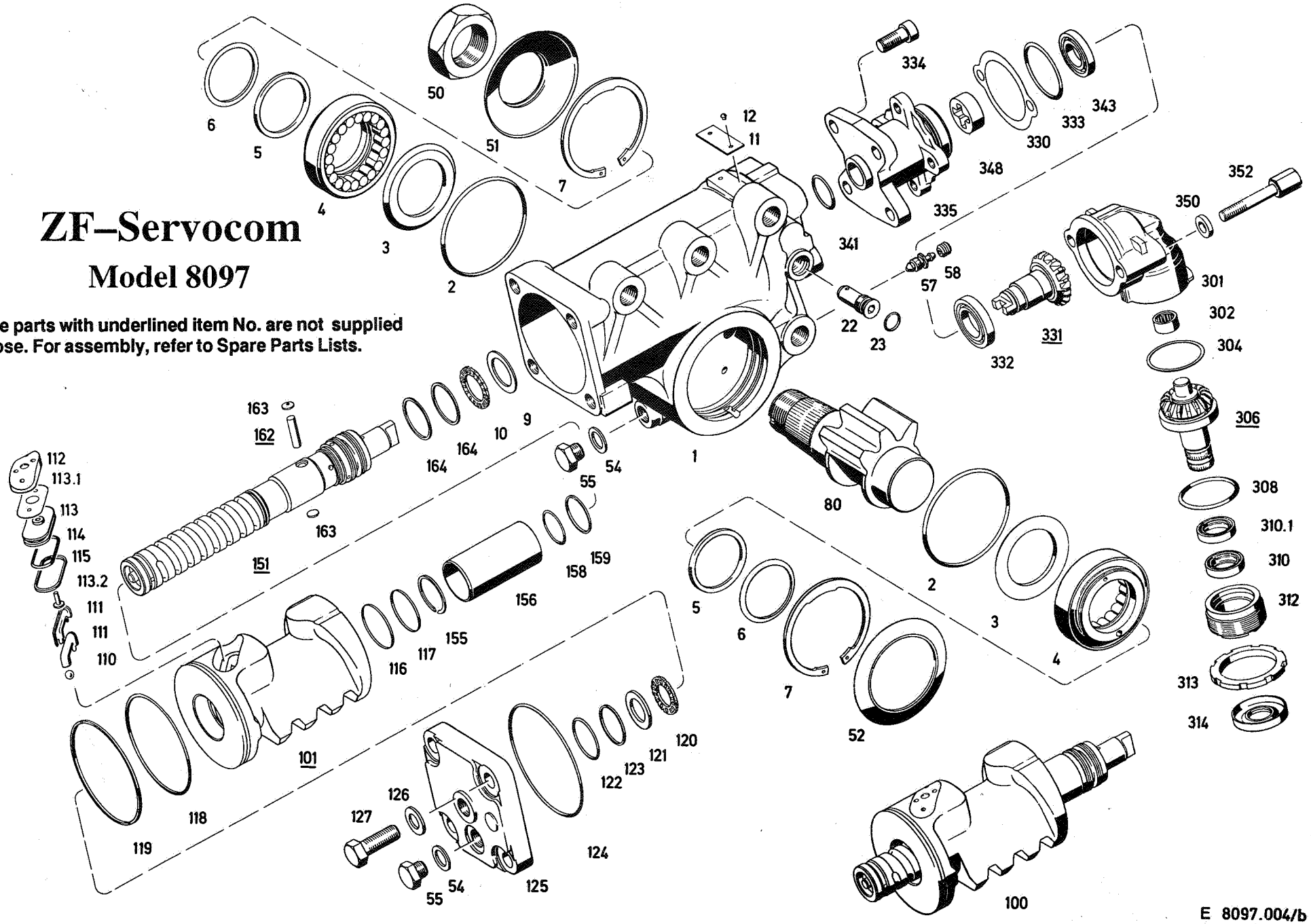


E 8095.004/a

ZF–Servocom

Model 8097

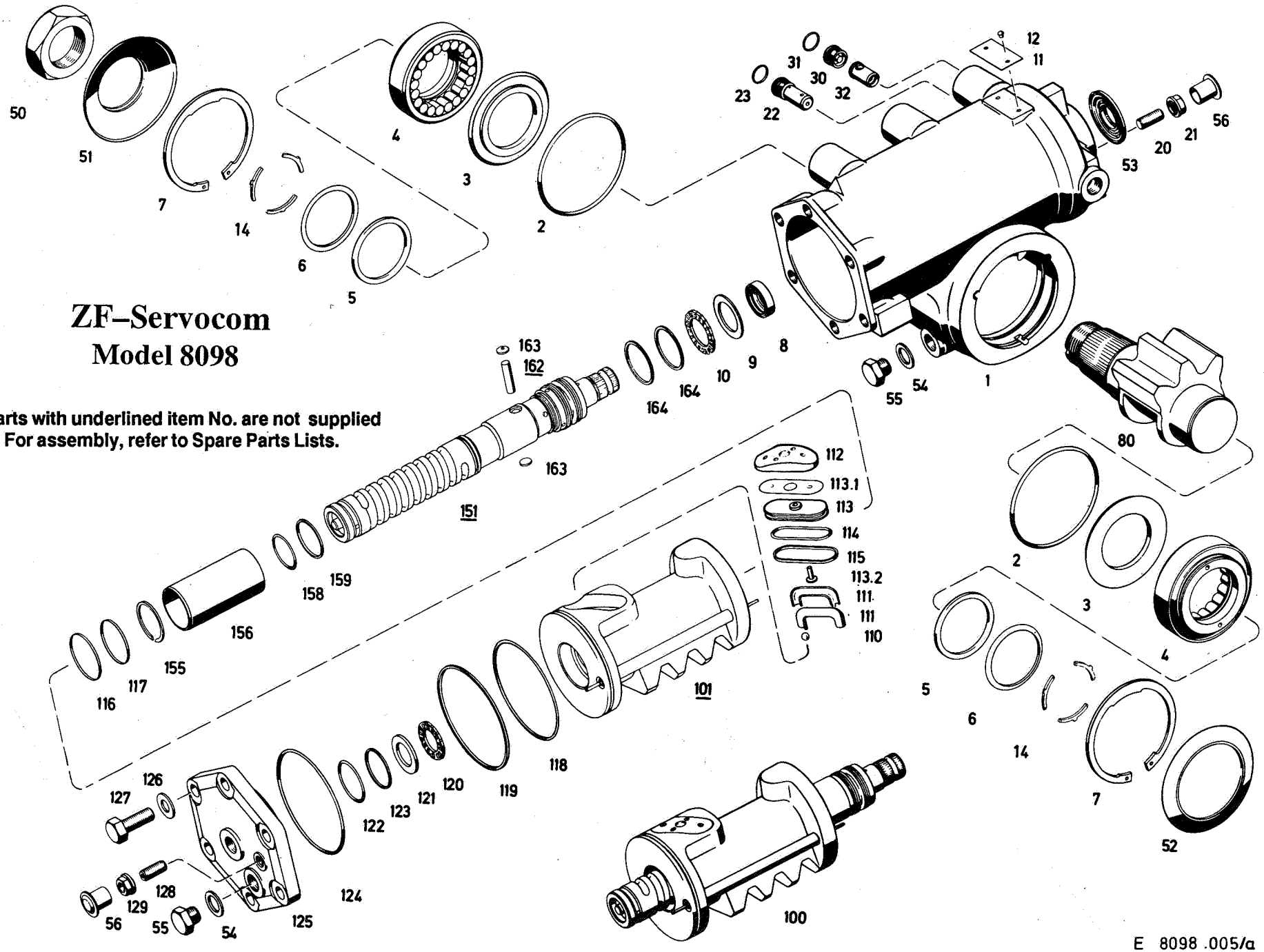
The parts with underlined item No. are not supplied loose. For assembly, refer to Spare Parts Lists.



E 8097.004/b

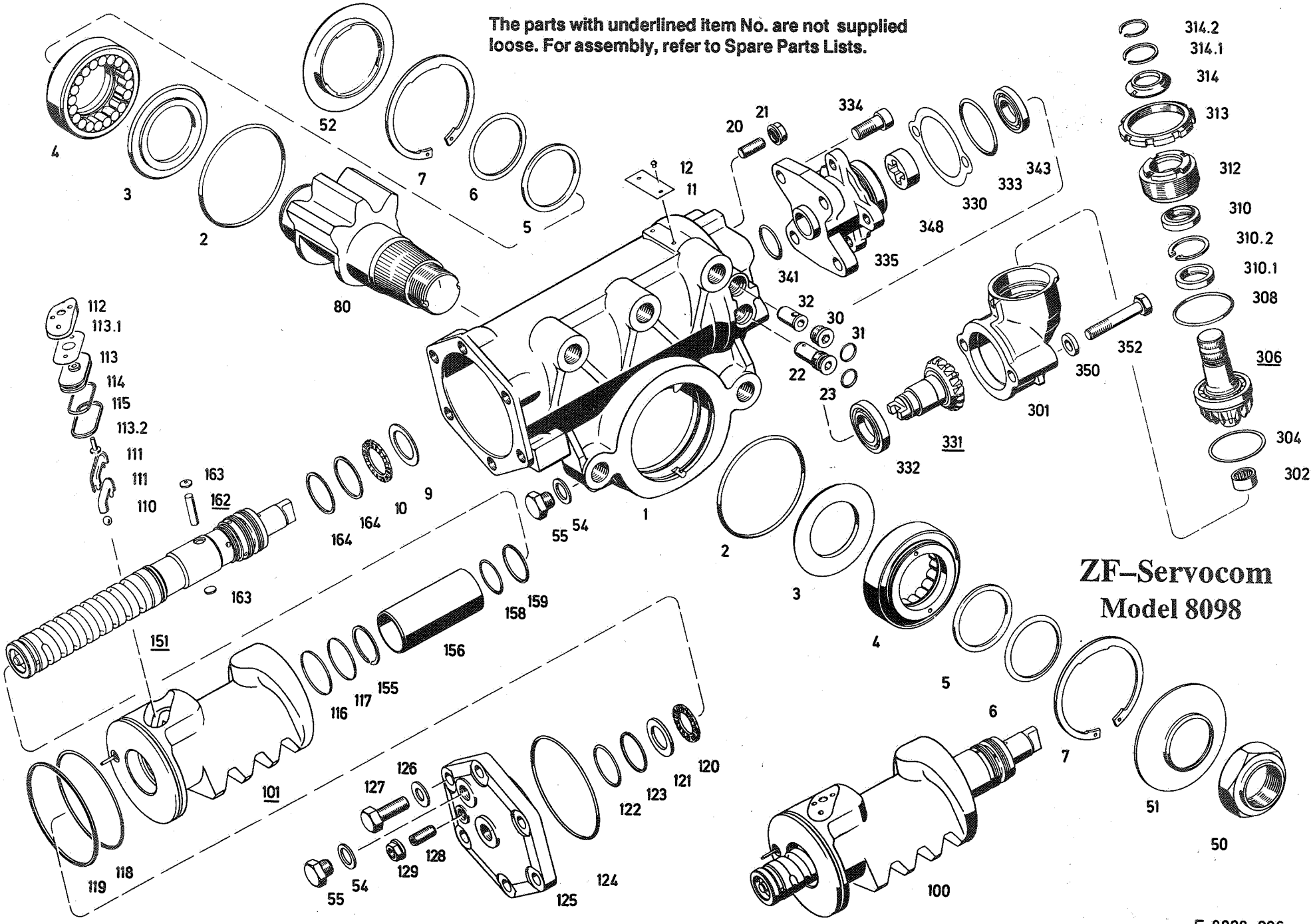
ZF–Servocom
Model 8098

The parts with underlined item No. are not supplied loose. For assembly, refer to Spare Parts Lists.

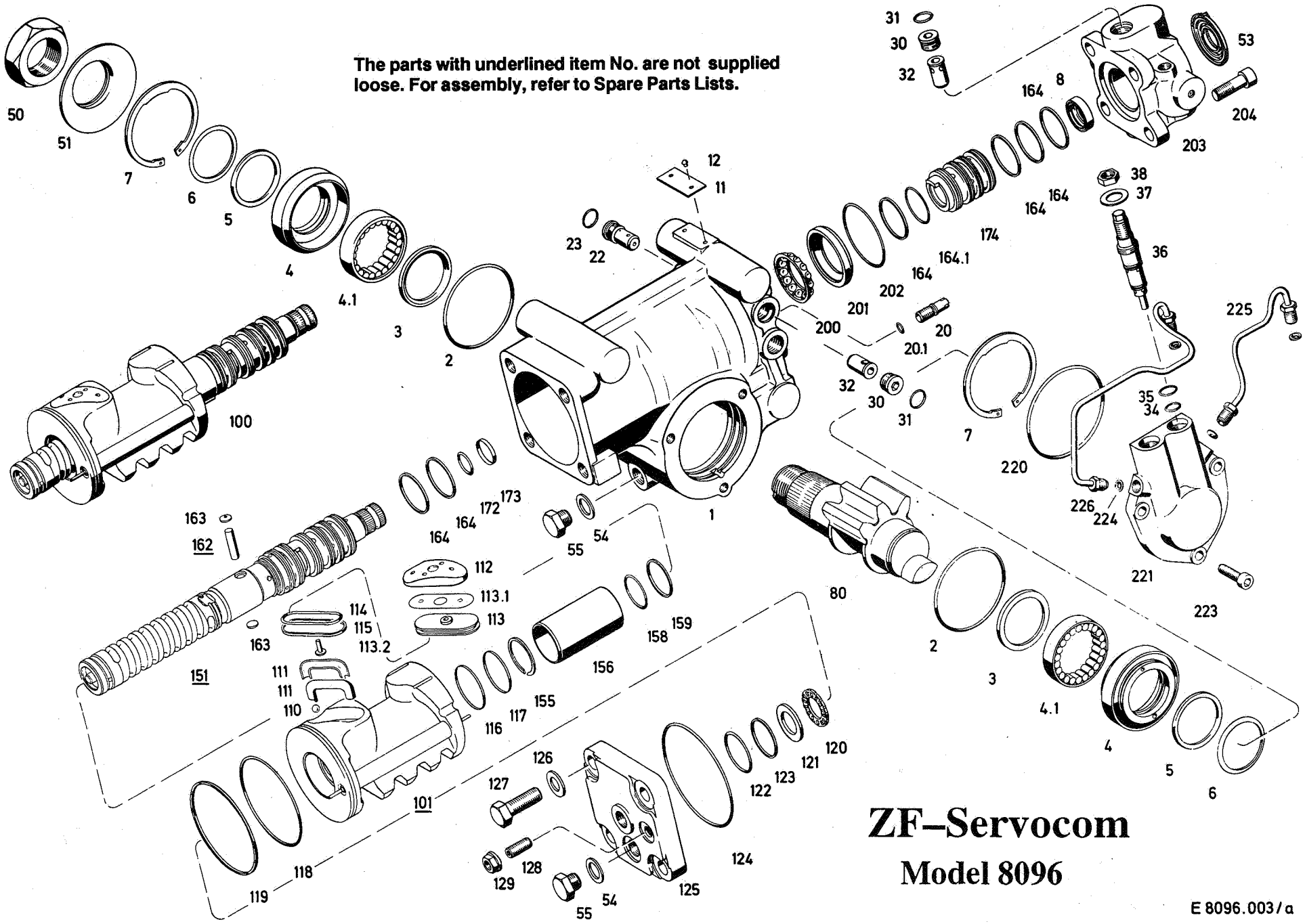


E 8098 .005/a

The parts with underlined item No. are not supplied loose. For assembly, refer to Spare Parts Lists.



The parts with underlined item No. are not supplied loose. For assembly, refer to Spare Parts Lists.



ZF–Servocom

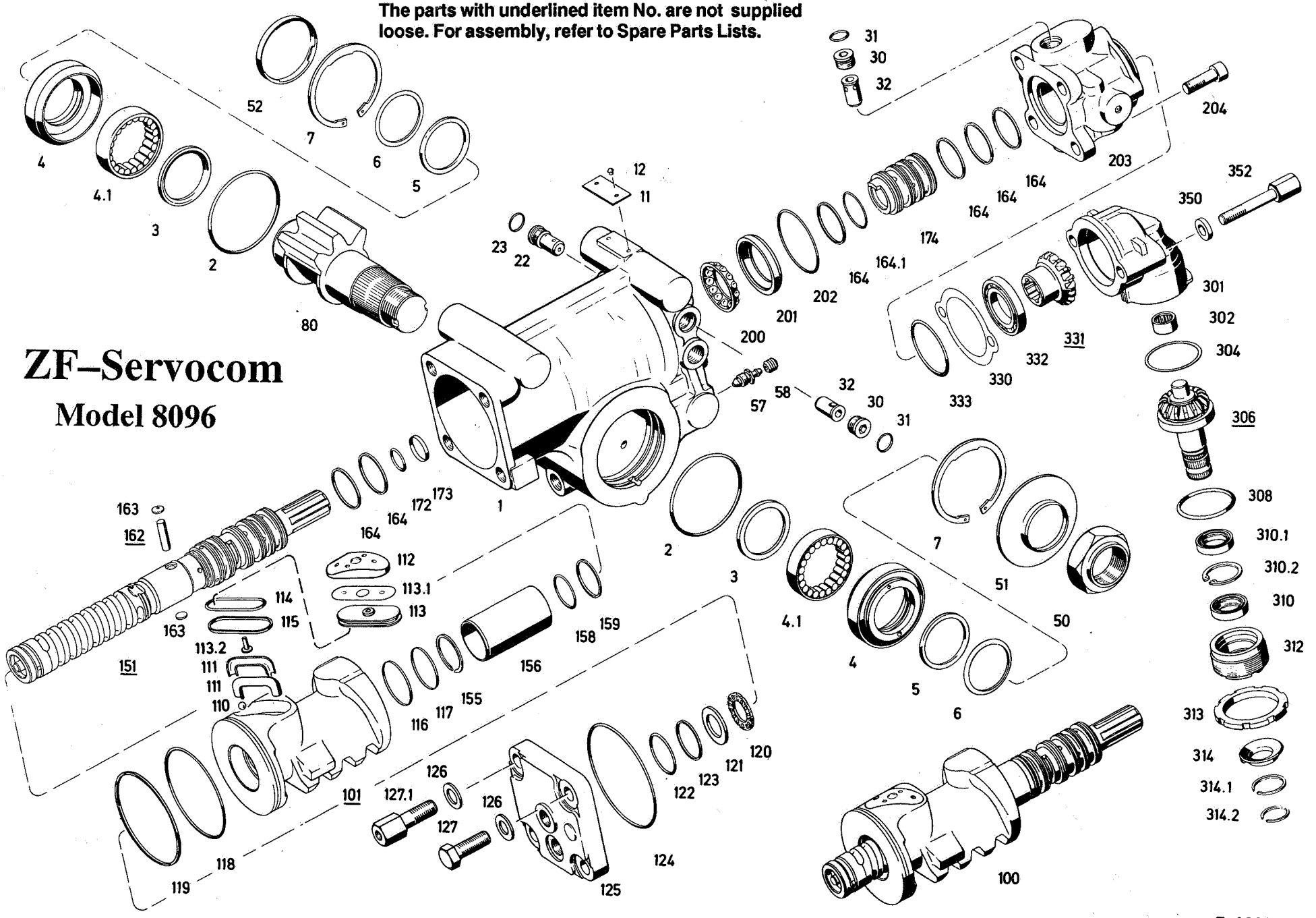
Model 8096

E 8096.003/a

The parts with underlined item No. are not supplied loose. For assembly, refer to Spare Parts Lists.

ZF–Servocom

Model 8096



E 8096.005/a