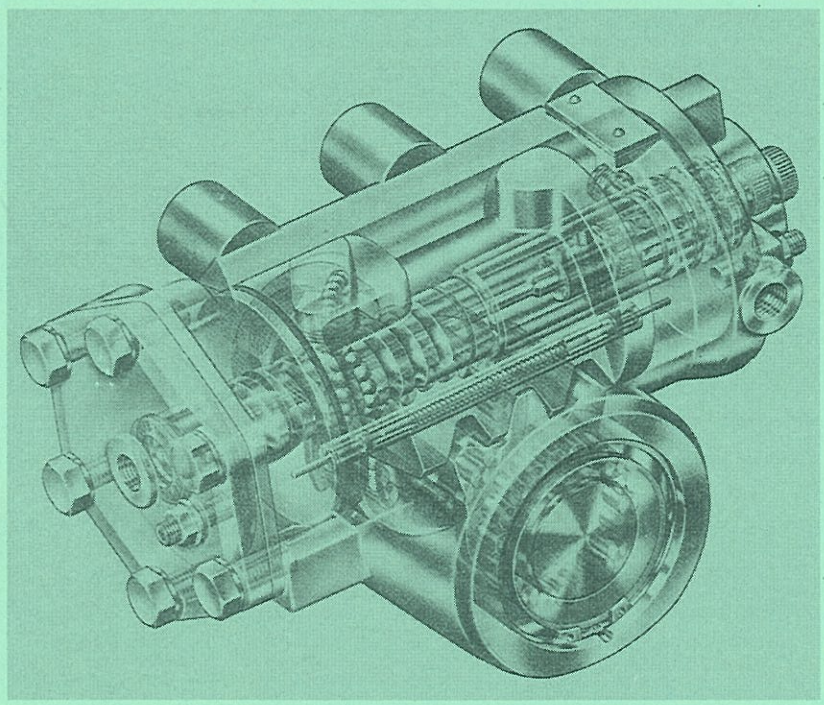
ZF-Servocom

Types 8090 - 8099
(Single and dual-circuit versions)

Repair Manual



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→ The present Manual aims to help the user properly to execute the necessary maintenance and repair work on the ZF product.

→ Read the Manual before starting any inspection and repair work.

→ On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ☞ ***employ trained personnel***
- ☞ ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ☞ ***use ZF genuine spare parts.***

→ This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.

→ All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.

→ The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.

→ This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.

Attention: Where incorrect and careless work can lead to personal injury and endanger life.

→ This Manual is not part of the updating service.

→ The contents of the additional service information bulletins must also be observed.

Contents

I. Disassembly

Attention:
Utmost cleanliness must be maintained when disassembling and storing the parts in order to ensure that the steering operates reliably. Force must never be used when disassembling parts, as this may damage the sealing ring seats, sealing faces, etc. The resultant damage may lead to partial or total failure of the steering.

Notes:

→ The figures in round brackets, e.g. (348), refer to the part numbers used in Chapter VIII and the list of spare parts.

→ The figures in square brackets, e.g. [1], refer to the special tools listed in Chapter VII.

1 Preparing the steering for disassembly

Clamp steering in tool [1] or between the soft jaws of a standard vice.

Turn the steering through from end to end and note the total number of turns (reference value for function tests).

Set the steering to straight-ahead position (half the total number of turns) and check or restore the markings for straight-ahead.

2 Removal and disassembly of the bevel box

2.1 Versions with cross disc (348)

2.1.1 Remove bevel box

Mark position of bevel box and intermediate flange (335).

Unscrew cap screws / hexagon screws (352) with washers (350) ***(Fig.1)***.

Remove complete bevel box.

Remove shim plate (330) and O-ring (333).

2.1.2 Disassembly of intermediate flange (335)

Unscrew cap screws (334).

Remove intermediate flange (335) with cross disc (348) and ball bearing (343).

Remove O-ring (341).

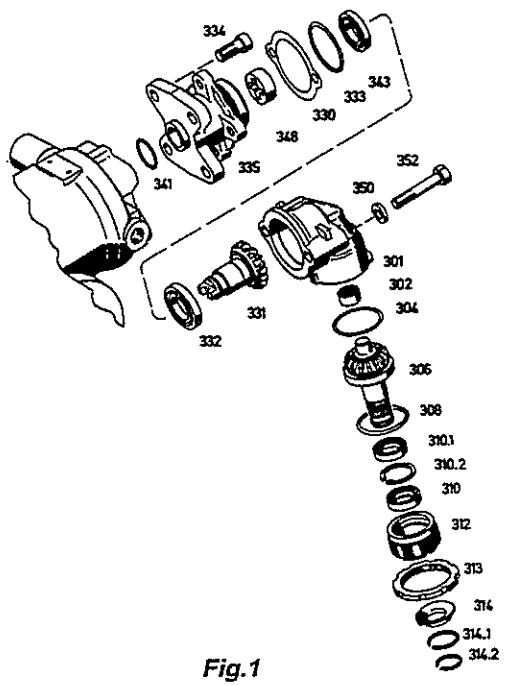


Fig.1

2.1.3 Disassembly of bevel box

Note:
The bevel gear (306) must not be forced off in order to replace the ball bearing, as it cannot be ensured that the notched gearing locks securely when the bevel gear (306) is pressed into position a second time.

Remove snap ring (314.1 and 314.2) and draw dust seal (314) off steering shaft stub.

Unscrew slotted nut (313) and unscrew adjusting screw (312) from housing with tool [25].

Remove O-ring (308). Remove shaft seal (310), retaining ring (310.2) and shaft seal (310.1).

Draw bevel gear (306) out of housing with ball bearing. Remove washer (304).

Note:
Needle sleeve (302) should only be removed if the bearing journal of the bevel gear assembly is found to be damaged. If necessary, needle sleeve (302) can be drawn out with tools [26] and [27].

Dismantle ball bearing (332) and remove bevel gear (331).

2.2 Versions with coupling sleeve (349)

2.2.1 Remove bevel box

Mark position of bevel box in relation to housing (1).

Unscrew hexagon screw (352) and remove complete bevel box ***(see Fig.4)***.

Remove coupling sleeve (349), centering ring (346) and O-ring (333).

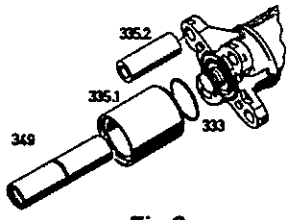


Fig.2

2.2.2 Remove pipes

Remove pipes (335.1 and 335.2). Dismantle O-ring (333) ***(Fig.2)***.

2.2.3 Disassembly of bevel box

Remove protecting cap (314) and draw off shaft seal (310) with tool [33] ***(see Fig.4)***.

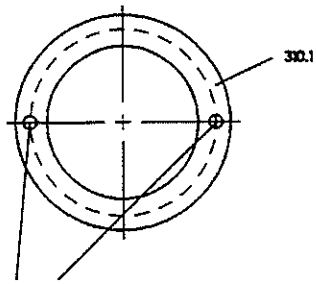


Fig.3

Unspring retaining ring (310.2). Drill holes through shaft seal (310.1) as shown in ***Fig.3*** (diameter of holes approx. 0.3 mm smaller than core diameter of the sheet metal screws required to pull out the shaft seal).

Screw in the sheet metal screws and pull out complete with shaft seal (310.1) with the aid of two pliers.

Unspring retaining ring (310.3) and remove any burr produced ***(Fig.4)***.
Clamp bevel gear (306) in soft jaws and drive it out of the housing by knocking against the housing (301) with a plastic mallet.

Unspring retaining ring (310.4), remove any burr produced and remove the bevel gear (331).
Note:
Needle sleeves (302) should only be removed if the bearing journal of the bevel gears (306 and 331) is damaged.

Use tools [27] and [34] for this purpose.

Tool [35] must also be used additionally to remove the lower-level needle sleeve (302).

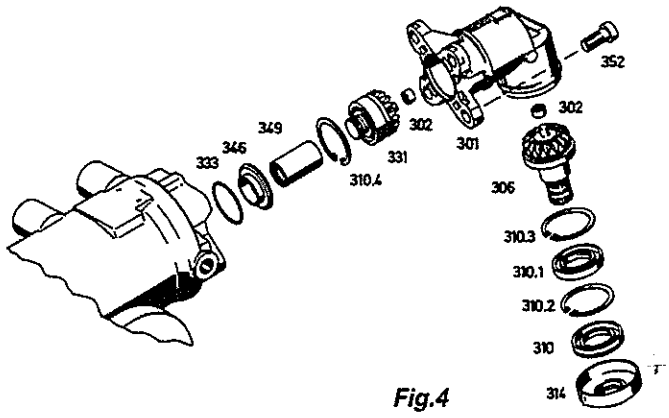


Fig.4

3 Removal and disassembly of valve housing (203)

Remove protecting cap (53) and gasket (53.3) ***(Fig.5)***.

Mark position of valve housing (203).
Remove piping (225 and 226) and pipe unions (205 and 206) in the case of versions with add-on cylinder (250) ***see Fig.8***.

Unscrew cap screws (204) and lift off valve housing (203).

Remove control sleeve (174), bearing ring (201) and ball cage (200).

Dismantle screw (30) with O-ring (31) and valve insert (32) (replenishing valve).

Unscrew valve insert (22.1) with O-ring (23) (pressure limiting valve).c
Note:
Valve inserts (22.1 and 32) cannot be dismantled. The complete valve insert must be replaced if a fault develops.

Remove sealing elements (8 and 202).

Unscrew adjusting screw (20) and remove O-ring (20.1).

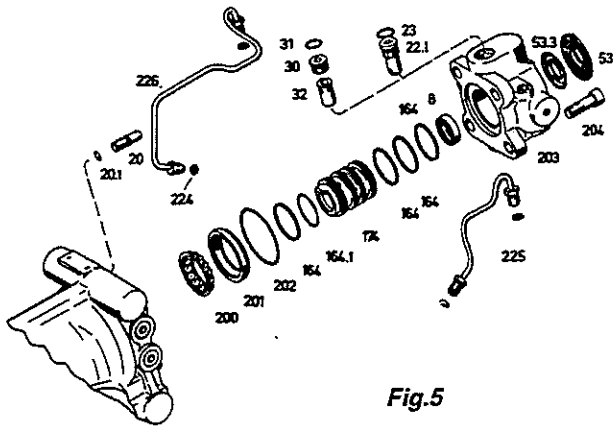


Fig.5

4 Removal and disassembly of housing cover (221)

4.1 Versions with valves (36) - steering limiter valves

Unscrew hex nut (38) and remove washers (37) ***(Fig.6)***.

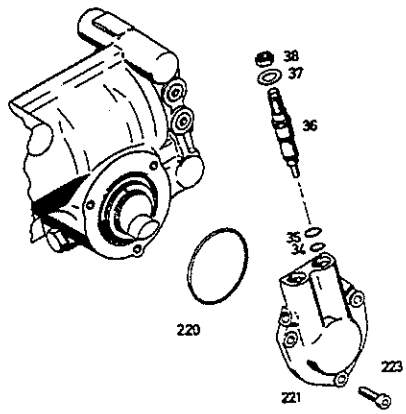


Fig.6

Unscrew valves (36) and remove O-rings (34 and 35). Remove cap screws (223) and lift off housing cover (221).

4.2. For versions with switch (222)

Mark position of cover (221) in relation to housing (1). Unscrew cap screws (223) and remove cover (221) with cam disc (227) and retaining ring (228) ***(Fig.7)***.

Remove O-ring (220). Unspring retaining ring (228) and remove cam disc (227).

Remove switch (222) with washer (222.1).

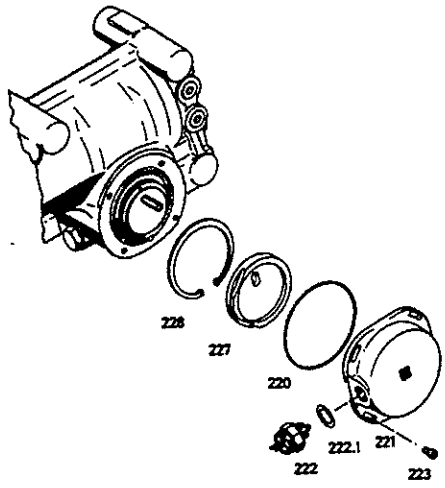


Fig.7

5 Removal and disassembly of add-on cylinder (250)

Unscrew pipe unions (205 and 206).

Unscrew hexagon screws (252) with washers (251) and remove add-on cylinder (250) ***(Fig.8)***.

Unspring retaining rings (261). Prise off cylinder cover (259) and remove O-ring (260).

Draw out piston (258) and remove gaskets (257) and O-rings (256).

Remove gear (254) and bush (253), as well as O-ring (255).

Unscrew Torx screws (250.1).

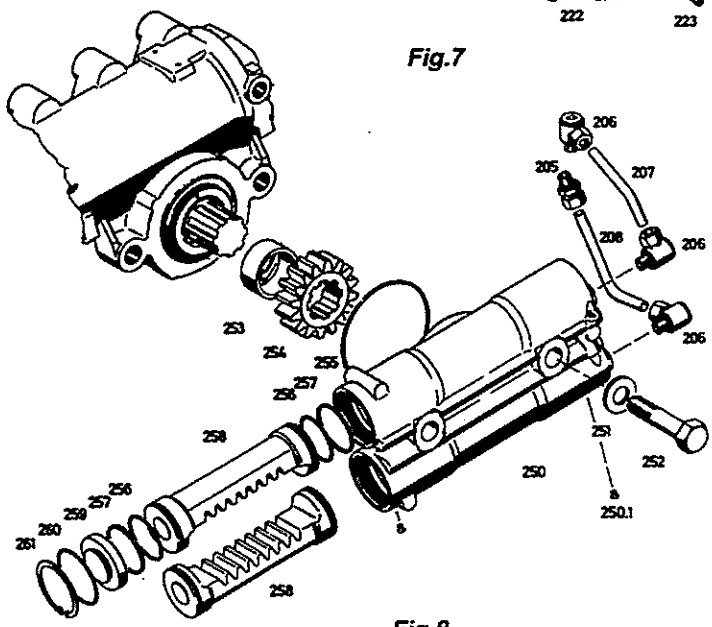


Fig.8

6 Removal and disassembly of cylinder cover (125)

Unscrew hexagon screws (127) with or without washers (126) ***(Fig.9)***.

Note:
Retract piston (101) towards bottom of housing so that the valve tappet of valve insert (109) is not damaged when turning the cylinder cover (125).

Slip steering drop arm onto sector shaft (80).

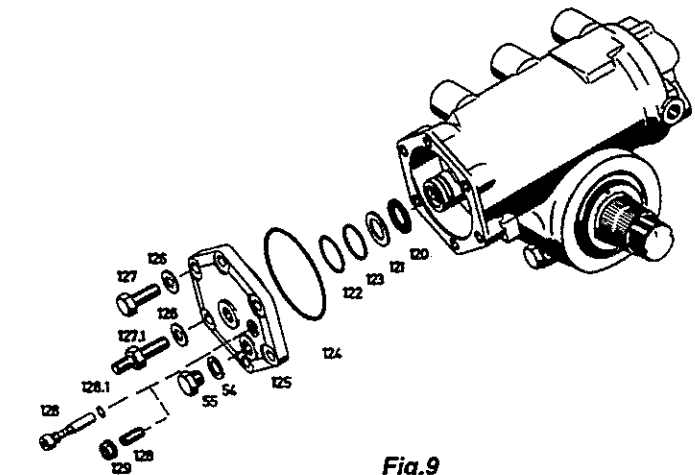


Fig.9

Turn worm (151) to remove cylinder cover (125).

Remove needle cage (120) and washer (121). Remove screw (128) and O-ring (128.1) and set aside for later use (required for function tests, chapter IV).

Remove sealing elements (122, 123 and 124). Unscrew screw plug (55) with sealing ring (54).

Unscrew set screw (128) and collar nut (129).

7 Removal and disassembly of piston (100)

7.1 Draw piston (100) out of housing (1) together with worm (151), turning the steering drop arm which is still mounted on the sector shaft (80) at the same time ***(Fig.10)***.

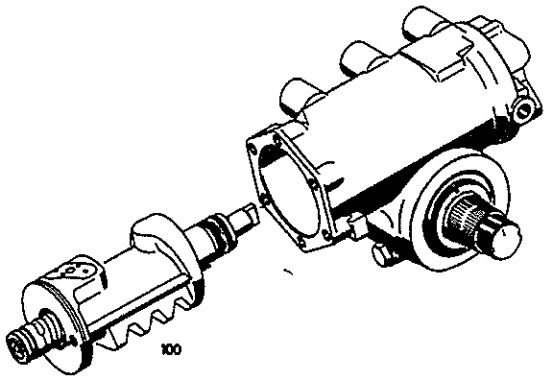


Fig.10

Attention:
The tappet of the valve insert (109) ***(see Fig. 13)*** installed in piston (101) must not be damaged.

7.2 Remove gasket/plug (112) complete with compensating plate (113.1), gasket (113), sealing elements (114 and 115), pin (113.2) and recirculating half tubes (111) ***(Fig.11)***.

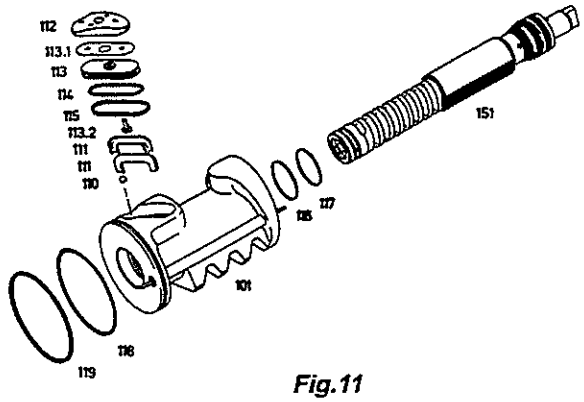


Fig.11

Turn worm (151) to release the balls (110) and carefully set them aside for later use.

Remove sealing elements (116, 117, 118 and 119).

7.3 Check the valve insert (109) installed in piston (101) ***(see Fig.13)*** for radial or axial play, mechanical damage and any internal leaks.

Check caulking of valve insert (109).

The complete valve insert (109) must be replaced if any of the above defects is observed.

7.3.1 Versions with caulked valve insert (109) - steering limiter valve

Position piston (101) upright so that the caulking on valve insert (109) points upwards ***(Fig.12)***.

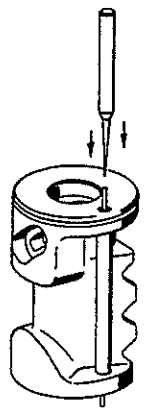


Fig.12

Using a cylindrical punch, dia. 4.5 mm, press tappet inwards and drive valve insert (109) down and out.

7.3.2 Versions with screwed valve insert (109) - steering limiter valve

Release caulking and screw valve insert (109) out of piston (101) with tool [2] ***(Fig.13)***.

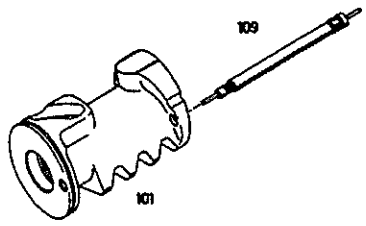


Fig.13

8 Disassembly of worm (151)

8.1 Unspring snap ring (155) and pull off sliding tube (156) ***(Fig.14)***.

Remove plug (163) and pin (162).

Remove sealing elements (158, 159, 164).

Further disassembly of the worm (151) is not permitted, since the hydraulic centre is then no longer set correctly.

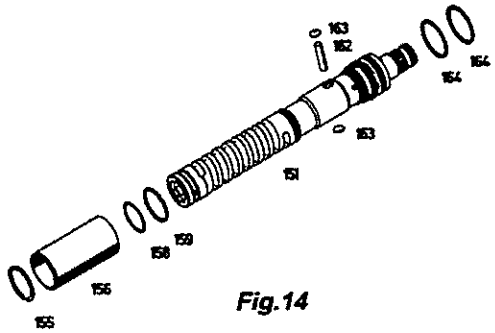


Fig.14

8.2 **Exception:**
Sealing ring (170) may be replaced by specially trained personnel:

Mark position of valve slide (168) and worm (161) ***(Fig.15)***.

Remove caulking from worm (161).

Drive out pin (160).

Pull valve slide (168) out of worm (161) together with torsion bar (165).

Remove O-ring (169) and sealing ring (170).

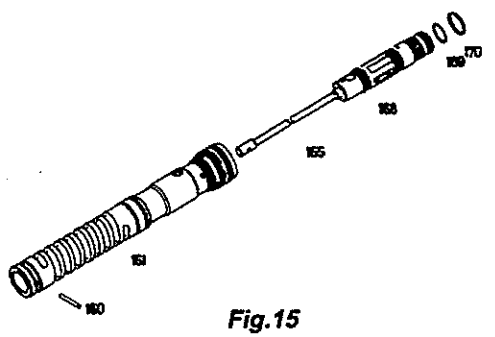


Fig.15

8.3 Additionally required for dual-circuit versions:

Remove sealing elements (172 and 173) ***(Fig.16)***.

Remove sealing rings (164) and O-ring (164.1) from control sleeve (174).

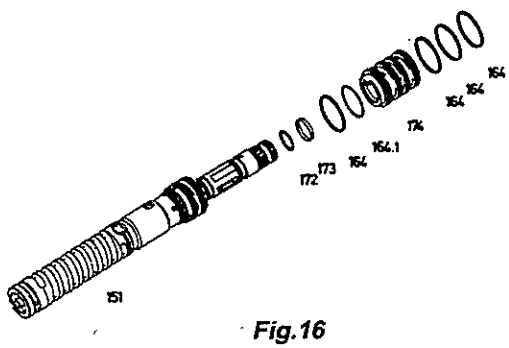


Fig.16

9 Removal of sector shaft (80)

Remove dust seal (51), stop-ring (51.1), gasket (51.2) and plug (52) on both sides ***(Fig.17)***.

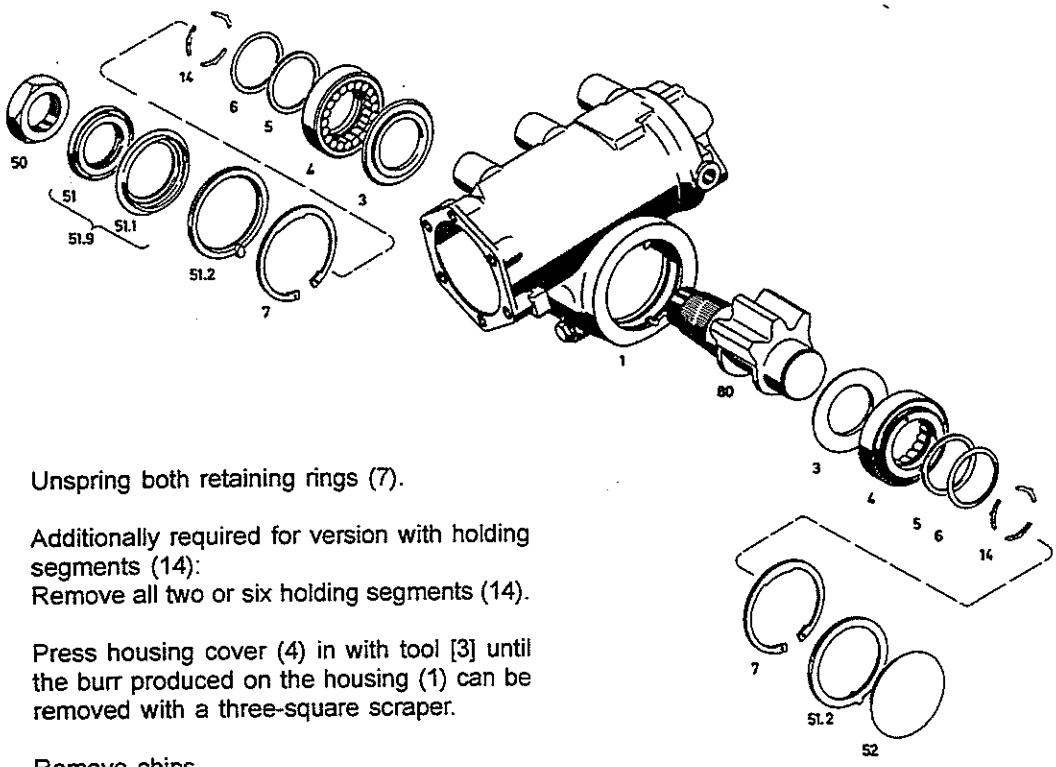


Fig.17

Unspring both retaining rings (7).

Additionally required for version with holding segments (14):
Remove all two or six holding segments (14).

Press housing cover (4) in with tool [3] until the burr produced on the housing (1) can be removed with a three-square scraper.

Remove chips.

Draw housing cover (4) out with tool [4].

Note:
The spindle of tool [4] must not be inserted in the centering bore of the sector shaft (80), otherwise the sector shaft (80) may tilt due to eccentricity.

Draw support rings (6) and gaskets (5) out of the grooves.

Notes:

→ The housing covers (4) must not be refitted in the same position otherwise they cannot be caulked correctly.

→ The individual rolls must not be exchanged between housing covers (4).

→ If one of the rolls is defective, the complete housing cover (4) must be replaced.

Draw washers (3) off the sector shaft (80).

Mark the side on which the notched serration of the sector shaft (80) is installed.

Remove sector shaft (80) from housing (1).

10 Disassembly of housing (1)

10.1 Remove needle cage (10), washer (9) and shaft seal (8) from housing (1) ***(Fig.18)***.

Remove O-rings (2).

Disassemble set screw (20) with collar nut (21) or screw (20) with O-ring (20.1) and set aside for later use (required for function testing).

Unscrew screw plug (55) with sealing ring (54).

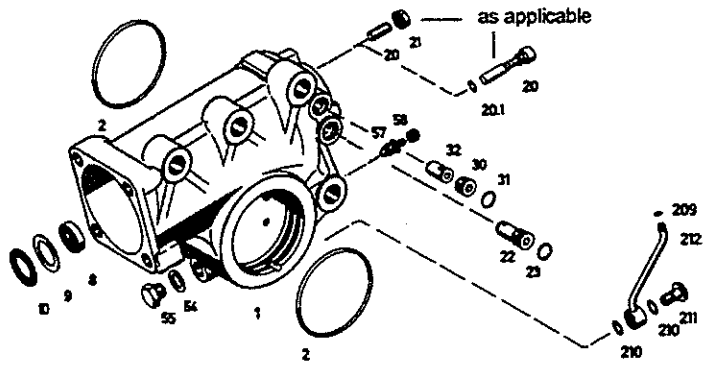


Fig.18

Remove breather (57) with protective cap (58).

Unscrew screw (30) with O-ring (31) and remove valve insert (32) - replenishment valve.

Unscrew valve insert (22) - pressure limiting valve - with O-ring (23).

Note:
Valve inserts (22 and 23) cannot be disassembled. The complete valve inserts must therefore be replaced if a defect develops.

10.2 Additionally required for versions with pipe (212)

Unscrew union screw (211).

Remove pipe (212) with O-rings (209 and 210).

II. Examining the individual parts

→ All parts must be cleaned thoroughly.

Note:
Sealing rings and other rubber parts must not be allowed to come in contact with chlorinated hydrocarbons, as they may swell.

→ All parts must be examined for wear, corrosion, pressure damage or other defects and assessed from the point of view of reusability.

→ Flange faces and sealing faces (e.g. the mating faces of sealing rings) must be repolished or ground if necessary.

Attention:
Experience and a conscientious approach are essential when examining the parts. The fitter must personally decide whether or not the parts need to be replaced.

The following must be examined:

1 Housing (1)

→ Cylinder bore: minor scoring must be eliminated by removing the elevations, e.g. with the aid of a serrated washer.

→ Recesses in retaining rings: any elevations must be removed to avoid scratches when fitting the housing covers (absence of leaks).

→ Running faces of the worm head (151)

→ Screw thread

→ Outer seat of shaft seal must be examined for signs of rubberization

→ Face side of housing must be examined for signs of sag due to sudden, accidental impacts around the axial needle bearing for the worm. Apply a ruler to the machined face side for the protecting cap (53). Housing (1) must be replaced if a distinct sag is evident.

2 Cylinder cover (125)

→ Outer seat of shaft seal must be examined for signs of rubberization

→ Face side of cover must be examined for signs of sag due to sudden, accidental impacts around the axial needle bearing for the worm (151). Apply a ruler to the machined face for the return port. Cylinder cover (125) must be replaced if a distinct sag is evident.

3 Piston (101)

→ Outside diameter

→ Valve insert (109) - steering limiter valve - must be examined for leaks, loose fit, damage (even slight external mechanical damage can cause the valve to jam).

→ Serration must be examined for wear (longitudinal and transverse crack testing using a suitable method, e.g. ferrofluxing).

Attention:
Cracked parts must be scrapped.

→ Recirculating ball screw:
Both piston (101) and worm (151) must be replaced if any signs of damage or wear are observed.

→ Check friction value in assembly with worm (151) - see chapter III.

→ **Caulked valve insert (109) - steering limiter valve:**

Tight fit: radial or axial play and damage are not permissible.

→ **Screwed valve insert (109) - steering limiter valve:**

Check that valve insert (109) is not twisted or damaged.

Caulking

4 Worm (151)

→ Recirculating ball screw: piston (101) and worm (151) must both be replaced if any signs of damage or wear are observed. Check friction value in assembly with piston (101) - see chapter III.

→ Notched serration of valve slide (168)

→ Running surfaces of needle bearings and shaft seal. Indentations on the face-end running surfaces of the needle bearings (10 and 120) may be due to accidental impacts. In this case, the housing (1) and cylinder cover (125) must be examined for signs of sagging around the needle bearing (120).

→ Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing). (The liquid jet must be directed in such a way that the valve body is not wetted so that iron particles cannot enter the control grooves.)

Attention:
Cracked parts must be scrapped.

→ O-ring recesses must be examined for hammer marks

→ The complete worm (151) must be replaced if the O-rings are found to have hardened on account of excessive service temperatures, since the O-ring (169) between valve slide (168) and worm (161) will also have been damaged in this case.

5 Sector shaft (80)

→ Toothed segment

→ Serrations

→ Running surfaces of the sealing rings

→ Running surfaces of the roller bearings

→ Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing).

Attention:
Cracked parts must be scrapped.

→ Caulking points on housing cover (4)

→ Longitudinal scoring on outside diameter

→ Screw thread

→ Radial run–out (warping) of the sector shaft (80) need only be checked if roller bearing imprints due to impacts have been observed, for instance on the face ends of the worm.
Mount the sector shaft (80) between centres and measure the maximum permissible radial run–out on the running surface of the roller bearing on the steering drop arm side, beside the tooth segment. The max. permissible radial run–out must not exceed 0.1 mm.

Additionally required for versions with switch (222):

→ Check grooved pin for tight fit and wear

→ Slot on grooved pin must point towards the middle tooth or be at 180° to it.

6 Housing cover(4)

→ Scoring and rust on outside diameter

→ Sealing faces

7 Needle, cage and roller bearings

→ The corresponding bearings must be replaced if indentations and wear are observed on the running surfaces of the steering elements.

→ Check needles, balls and rollers for signs of wear and damage.

8 Valve insert (22, 22.1 and 32) and breather (57)

→ Outside diameter (scoring, wear, damage and jamming in the valve bore)

→ Ensure that bore holes are clean

9 Additionally required for dual-circuit versions

9.1 Housing cover (221)

→ Screw thread

→ Flange face

→ O-ring seats

→ Pipe / line connections

9.2 Valve housing (203)

→ Screw thread

→ Rubberization on seat of shaft seal

→ Pipe connections

→ Running surface of sealing rings

→ O-ring seats

9.3 Additionally required for versions with add-on cylinder (250)

9.3.1 Add-on cylinder (250)

→ Scoring in cylinder bores

→ O-ring seats

→ Pipe connections

9.3.2 Piston (258)

→ Sealing ring seats

→ Signs of wear on serration (longitudinal and transverse crack testing using suitable methods, e.g. ferrofluxing)

Attention:
Cracked parts must be scrapped.

9.3.3 Gear (254)

→ Signs of wear on serrations (longitudinal and transverse crack testing using suitable methods, e.g. ferrofluxing)

Attention:
Cracked parts must be scrapped.

10 Additionally required for versions with switch (222)

→ Easy movement of actuating cam on switch (222)

→ Check cam ways of cam disc (227) for signs of wear

11 Additionally required for versions with bevel box

→ Bevel gears (306 and 331):
Signs of wear and indentations on serrations
Damage and corrosion on running surfaces of shaft seals

Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing), particularly for cracks at the bottom of the teeth.

Attention:
Cracked parts must be scrapped

→ Intermediate flange (335) and housing (301):
Flange faces, screw thread and sealing ring seats

→ Cross disc (348): signs of wear in driving grooves

→ Screw thread

III. Assembly

Attention:

Utmost cleanliness must be maintained during assembly in order to ensure that the steering operates reliably. Force must never be used when assembling parts, as this may damage the sealing ring seats, sealing faces, etc. The resultant damage may lead to partial or total failure of the steering.

Notes:

→ All parts must be cleaned thoroughly before assembling the steering. Each part must be examined for signs of wear and other defects (see chapter II.) and oiled before being assembled.

→ New gaskets, shaft seals and O-rings must always be fitted and the face ends of the housings and covers ground down to remove any paint residues and damage.

→ In the case of shaft seals, the space between the sealing lip and dust lip must be filled with grease type Spectron FO 20 made by Messrs. DEA or an equivalent calcium complexing grease of consistency class 2.

→ The accuracy of the measuring and adjusting tools used for repairs must be verified at regular intervals.

→ The specified tightening torques apply when tightening screws and bolts with a torque wrench by hand.

→ Before starting the assembly work, the spare parts list must be consulted to determine whether it specifies tightening torques and insertion depths or information on the installed position of special screws and holders. The following values and descriptions apply if nothing is specified in the spare parts list.

1 Preassembly of housing (1)

1.1 Screw in valve insert (22) - pressure limiting valve - with preassembled O-ring (23) (tightening torque: 30+10 Nm) ***(Fig.19)***.

Fit valve insert (32) - replenishing valve - in housing. Fit screw (30) with fitted O-ring (31) (tightening torque: 30+10 Nm).

Screw in breather (57) (tightening torque: 30 Nm) and plug on protective cap (58).

Fit screw plug (55) with sealing ring (54) (tightening torque: M16: 40 Nm; M18: 50 Nm).

Insert O-rings (2) in housing (1).

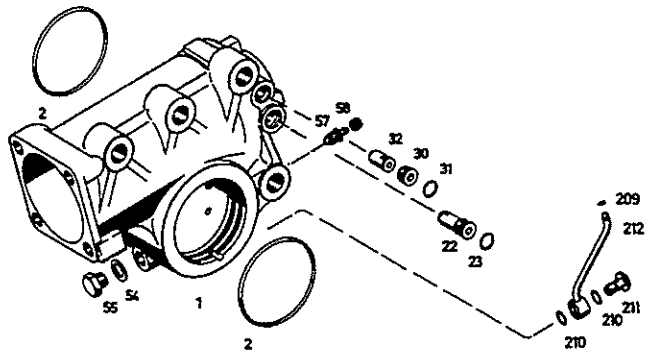


Fig.19

1.2 Additionally required for versions with pipe (212)

Mount pipe (212) with new O-rings (209 and 210). Torque union screw (211) down with 20±2 Nm.

2 Preassembly of housing cover (4)

Notes:

→ The housing covers (4) must not be reinstalled on the same side.

→ The individual rollers must not be interchanged between housing covers (4).

→ The complete housing cover (4) must be replaced if one of the rollers is defective.

Any rollers which have dropped out must be bonded into the housing cover (4) with grease (type of grease, see Note in chapter III.) and a pad fitted in the roller gap.

Fit gasket (5) and support ring (6) in housing cover (4) ***(Fig.20)***.

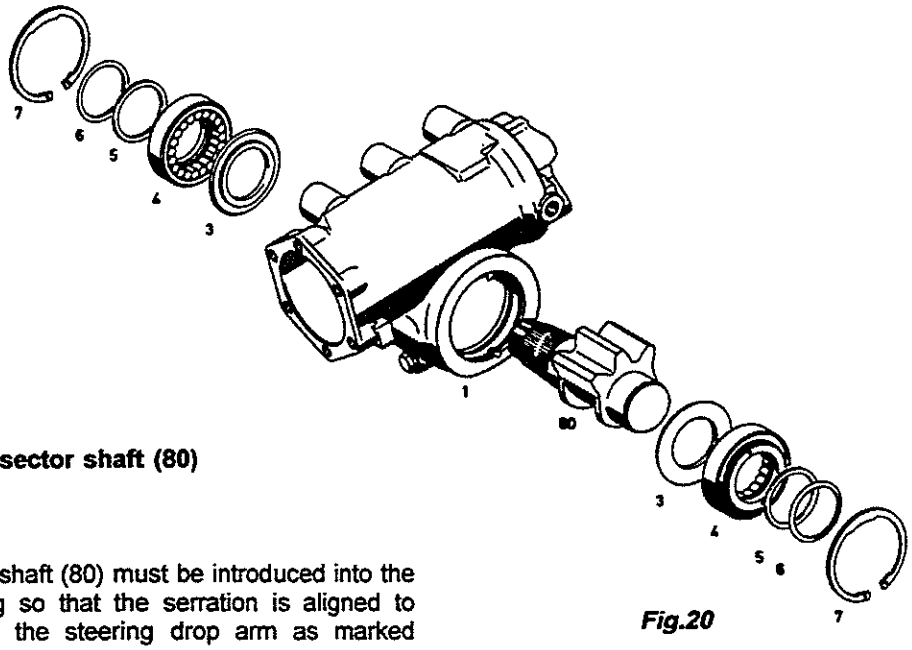


Fig.20

3 Install sector shaft (80)

Sector shaft (80) must be introduced into the housing so that the serration is aligned to receive the steering drop arm as marked during disassembly.

Fit washers (3) on sector shaft (80).

Place housing (1) on a flat surface underneath a hand-operated press with the steering drop arm side facing upwards.

Mount tool [5] on the serration.

Press the preassembled housing cover (4) up to the recess in the retaining ring (7) with tool [3] and with the larger of the two face-end holes or marks facing upwards (towards the piston).

Fit retaining ring (7) so that the gap is on the caulked side opposite the piston (101).

Attention:
Check that retaining rings (7) are seated correctly.

4 Adjustment of recirculating ball element

4.1 Assembly of recirculating ball element

Insert worm (151) into the bore in piston (101) so that the balls (110) from the front piston bore for the recirculating pipe can be filled into the threaded bore of worm (151) ***(Fig.21)***.

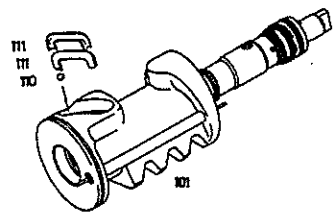


Fig.21

Attention:
37 balls (110) must be used. All the balls (110) used must belong to the same tolerance group.

The balls (110) must be filled in separately and the worm (151) turned slowly at the same time so that all balls (110) are lined up side-by-side (direction of rotation depends on the spiral direction of the worm (151)).

The recirculating ball screw is not full until the first ball (110) inserted reaches the edge of the rear bore in the recirculating pipe (30 balls).

Attention:
None of the balls (110) may drop out of the threaded bore into the longitudinal bore of the piston (101), as this could result in partial or complete failure of the steering.

Place the remaining balls (110) in the recirculating half tube (111).

To facilitate assembly, the outer balls (110) can be bonded into place with grease. Type of grease, see note in chapter III.

Insert both the filled recirculating half tubes (111) into the bore holes.

4.2 Check the friction torque

❑ **New parts**

The friction torque of the recirculating ball element must be measured in a horizontal position using tools [8], [9] and [10] while simultaneously holding the recirculating half tubes (111) tight in the piston (100).

→ In the middle area:

The following friction torques must be obtained when turning the worm through 90°:

Type 8090:	5 - 20 Ncm
Types 8095-8099:	5 - 30 Ncm

→ Outside the middle area:

The friction torque measured in the middle area must increase by no more than 15 Ncm.

❑ **Used parts**

Check friction torque and tilting clearance (hold recirculating half tubes (111) tight)

The friction torque of the recirculating ball element (111) must be measured in a horizontal position with tools [8], [9] and [10]. ***Fig.22.*** The tilting clearance must be measured in a horizontal position as shown in ***Fig.22.***

Measurement of friction torque

Measurement of tilting clearance

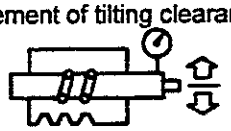


Fig.22

→ In middle area:
The value measured must lie within the following range when worm (151) is turned through 90° .

Upper limit: max friction torque:	8090:	5-20 Ncm
	8095-99:	5-30 Ncm
Lower limit: max. tilting clearance:	0.1 mm	

→ Outside the middle area:

The friction torque may increase to max. 35 Ncm for type 8090 and to max. 60 Ncm for types 8095-8099.

4.3 If a higher friction torque is obtained, the balls (110) must be removed and replaced with balls from a smaller tolerance group.

If the friction torque is below the permissible minimum value or if the tilting clearance is too large, larger balls (110) must be fitted and the measurement repeated.

Once the correct balls (110) have been chosen, piston (100) must be disassembled again and the selected balls (110) carefully set aside.

5 Preassembly of worm (151)

5.1 Fit O-ring (169) and sealing ring (170). Install torsion bar (165) with valve slide (168) as marked during disassembly. Press in pin (160) and caulk to the same depth and form as before ***(Fig.23).***

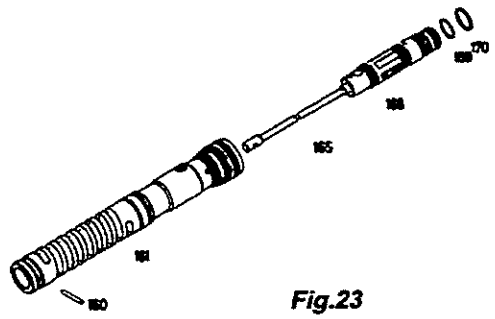


Fig.23

5.2 Place O-ring (158) in radial groove and slip on sealing ring (159) ***(Fig.24).***

Fit pin (162) with plug (163).
Carefully slide on sliding tube (156).

Fit snap ring (155) and check axial play of sliding tube (156).

The axial play must not exceed max. 0.1 mm and can be corrected by using a different snap ring (155).

Use tool [11] to slip on sealing rings (164) and press them home with tool [12].

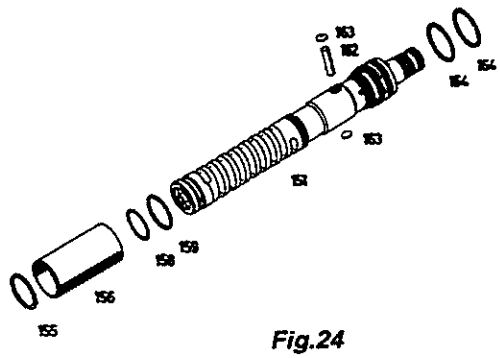


Fig.24

5.3 Additionally required for dual-circuit versions:

Slip O-ring (164.1) and sealing rings (164) onto control sleeve (174) with tool [11] ***(Fig.25)***.

Then draw in sealing ring (164) with tool [11].

Mount tool [13] on worm (151).

Fit O-ring (172) and sealing ring (173) and press home with a suitable tool (e.g. hose clip).

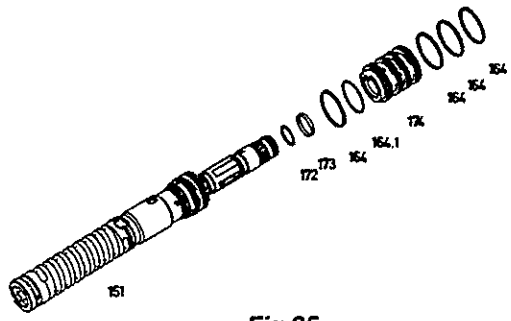


Fig.25

6 Preassembly of piston (100)

Note:
This preassembly is only required if the valve insert (109) - steering limiter valve - was disassembled.

6.1 Versions with caulked valve insert (109) - steering limiter valve

Introduce valve insert (109) as far as possible in piston (100). Mount piston in tool [6] with the caulked area pointing upwards ***(Fig.26)***.

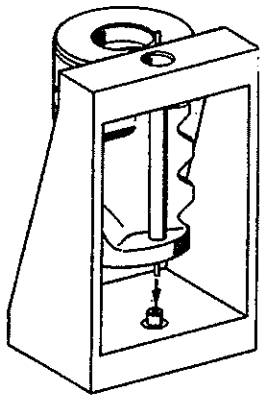


Fig.26

At the same time, ensure that valve tappet protruding beyond the piston is introduced into the bore in tool [6].

Adjust the supporting screw of tool [6] so that a gap of 0.1 - 0.2 mm is obtained between the fixture and piston when the latter has been fitted ***(Fig.27)***.

Screw caulking die of tool [6] onto a pressure pickup and insert it in the upper bore of tool [6].

Caulk the metal edge of the valve insert with a press applying a force of 7000 N + 800 N without backlash.

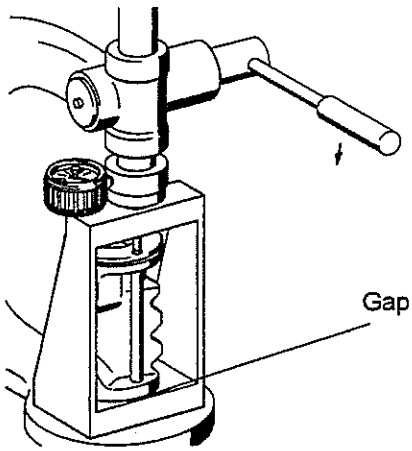


Fig.27

Attention:
Correct operation of the steering may be impaired if the caulking force is too high or too low.

Check that the valve insert (109) is seated securely.

6.2 Versions with screwed valve insert (109) - steering limiter valve

Screw valve insert (109) into piston as far as possible with tool [2] ***(Fig.28)*** (tightening torque: 15±1 Nm).

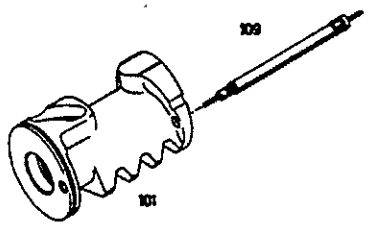


Fig.28

Note:
Hold the tube of the valve insert (109) tight when screwing in the valve insert so that only the larger threaded sleeve is entrained.

Align tool [7] with the two cutting edges so that they are centered in the groove. Then press tool [7] towards the piston until it rests against valve insert (109).

Caulk with tool [7] as shown in ***Fig.29*** (caulk to the same depth on both sides).

Attention:
Check that the valve insert (109) is tightly seated and that the valve tappet moves easily.

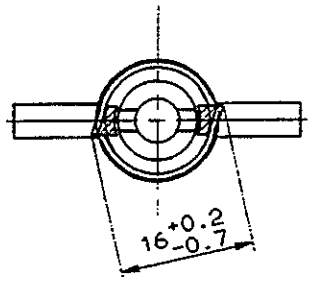


Fig.29

7 Assembly of piston (100) and worm (151)

First fit sealing ring (116) and then insert sealing ring (117) ***(Fig.30)***.

Fit O-ring (118) and then slip on gasket (119).

Reinsert worm (151) into piston (100) so that the balls (110) selected earlier can be fitted and the recirculating tube (111) can be inserted in piston (100) ***(see Fig.21)***.

Note for steering versions 8095 to 8099:

New parts (111, 112, 113 and 113.2) must be used if a pin (113.2) was not present during removal.

Place gasket (113) and plug (112) in piston without O-ring (114) or sealing ring (115).

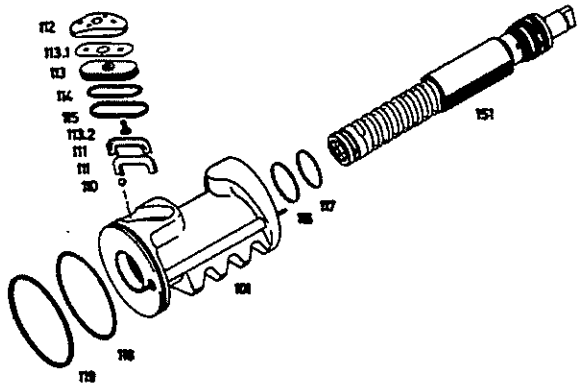


Fig.30

Check that plug (112) is flush with the piston surface ***(Fig.31)*** or does not exceed the following maximum clearance:

Max. permissible clearance:

Type 8090:	max. 0.1 mm
Types 8095-8099:	max. 0.5 mm
Type 8099: (with add-on cylinder)	max. 0.2 mm

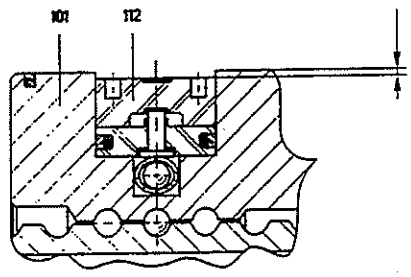


Fig.31

If necessary, insert a compensating plate (113.1) between gasket (113) and plug (112) (even if a compensating plate was not present during removal).

Ensure that the plug does not protrude in a way leading to increased friction.

Remove plug (112), compensating plates (113.1) and gasket (113).

Fit O-ring (114) and sealing ring (115) on gasket (113).

Press pin (113.2) into piston (101) with complete gasket (113).

Place the compensating plates (113.1) and plug (112) selected beforehand on gasket (113) and check again that plug (112) is flush with the piston face or does not exceed the maximum clearance.

8 Installation of piston/worm assembly

8.1 For 1-circuit versions and versions with bevel box

Fill space between sealing lip and dust lip of shaft seal (8) with grease (see note in chapter III.).

Press shaft seal (8) in as far as possible with tool [14] ***(Fig.32)***.

Place washer (9) and needle cage (10) in turned recess of housing (1). Washer must be free of grease.

Slip tool [15] onto serration of worm (151).

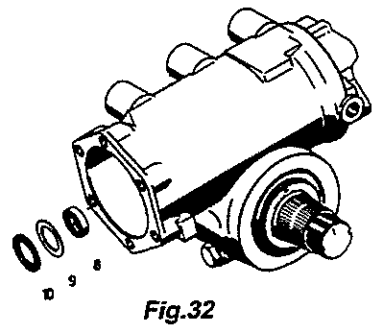


Fig.32

8.2 All versions

Turn sector shaft (80) so that the toothed segment swings towards the cylinder cover (125).

First introduce piston (100) into housing complete with worm (151) until toothed segment engages the first gap in the teeth of piston (100) when swung upwards ***(Fig.33)***.

In this position, insert piston (100) completely by turning the sector shaft (80) with the aid of the provisionally attached steering drop arm.

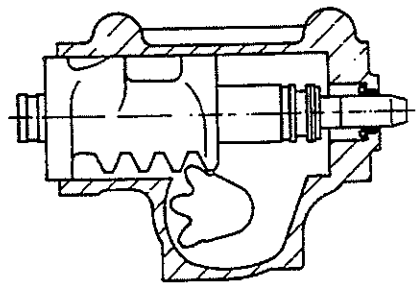


Fig.33

9 Assembly of cylinder cover (125)

Note:
Only for 1-circuit version and versions without bevel box

Screw in screw plug (55) with sealing ring (54).

Tightening torque: M16: 40 Nm
M18: 50 Nm

Place washer (121), which was removed during disassembly, in the recess in cylinder cover (125) with the bevelled side first; needle cage (120) must be fitted without grease ***(Fig.34)***.

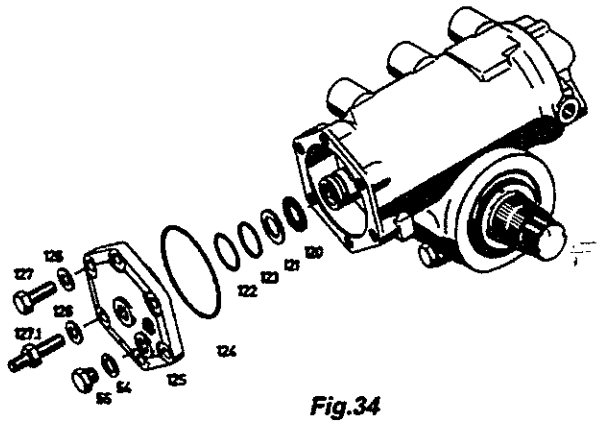


Fig.34

Note:
The following sealing elements should not be fitted until the worm bearing - section 12 - has been adjusted.

Place O-ring (122) in the inner radial groove in cylinder cover (125) and lay sealing ring (123) on top of it.

Place the greased O-ring (124) in the outer radial groove.

Place cylinder cover (125) on housing (1) without damaging the sealing elements.

Attention:
The inserted washer (121) may be too thick if any of the parts housing (1), worm (151) or cylinder cover (125) has been replaced. A complete readjustment as described in section 12 is required in this case.

If present during disassembly, the hex screws (127) with washers (126) must be carefully tightened while constantly turning the steering shaft in order to ensure that the worm bearing is not subjected to axial pressure.

Hex screws (127) and screw (127.1) must be torqued down as specified below.

Type 8090: (M12x1.5)	135 Nm
Type 8095/8096/8097: (M16x1.5)	285 Nm
Type 8098/8099: (M14x1.5)	189 Nm

10 Assembly of valve housing (203)

Note:
Dual-circuit version only

Screw in valve insert (22.1) - pressure limiting valve - with O-ring (23) ***(Fig.35)*** (Tightening torque: 30+10 Nm).

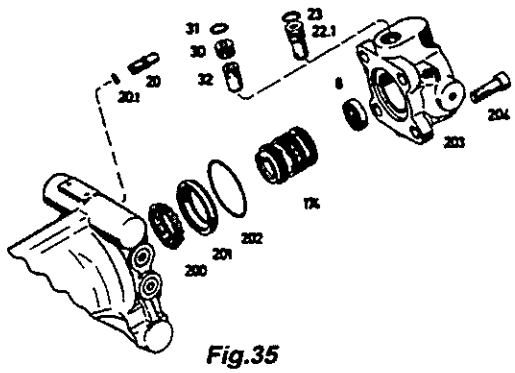


Fig.35

Fit valve insert (32) - replenishing valve - and screw (30) with O-ring (31) (tightening torque: 30+10 Nm).

Press bearing ring (201) into valve housing (203).

Position ball cage (200) on worm (151).

Insert preassembled control sleeve (174) in worm (151) (note position of drivers).

Screw adjusting screw (20) in by at least three turns.

Fill space between sealing lip and dust lip of shaft seal (8) with grease (see note in chapter III.).

Press shaft seal (8) in as far as possible with tool [14].

Mount tool [15] on serration of worm (151).

Insert O-ring (202) and mount valve housing (203) as marked during disassembly.

Torque cap screws (204) down to 140 Nm.

Fit pipes (225 and 226) ***(see Fig.43)*** with new O-rings (224).

Tightening torque: 8096: 12+2 Nm
8099: 18+2 Nm

11 Check sector shaft position and total turns of steering wheel

Turn the steering through from one end to the other and check that the number of turns equals that counted during disassembly.

Turn steering to straight-ahead position and check that the mark on the sector shaft is at the top and perpendicular to the piston axis ***(Fig.36)***.

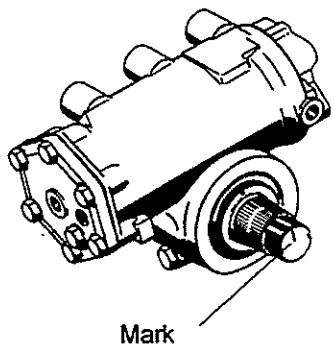


Fig.36

12 Adjustment of worm bearing

Note:
This setting must be checked at room temperature.

Strip paint from face end of housing in order to mount the dial gauge of tool [17].

Secure tools [16] and [17] on the steering shaft stub ***(Fig.37).***

Turn sector shaft (80) until worm (151) axially comes to rest on one side. Set dial gauge to "zero".

Turn sector shaft (80) until worm (151) axially comes to rest on the opposite side without tool [16] being radially entrained and check the permissible axial backlash.

Required values:

Type 8090:	0.005 - 0.025 mm
Types 8095/8096:	0.010 - 0.030 mm
Type 8097:	0.015 - 0.035 mm
Types 8098/8099:	0.020 - 0.040 mm

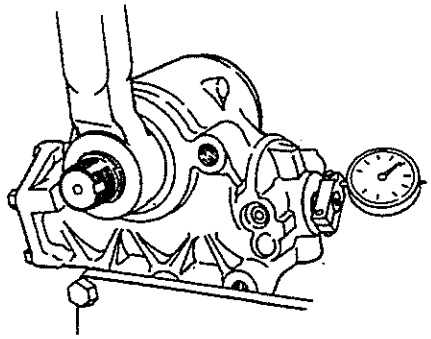


Fig.37

Fit a different washer (121) to correct a divergent axial backlash.
Remove cylinder cover (125).
Install sealing elements as described in section 9 and fit cylinder cover (125).

13 Set pressure point

Note:
The bevel box must be installed first as described in section 17 in versions with bevel box.

Clamp steering horizontally and mount tools [18] and [19].

Turn housing cover (4) so that the larger of the two face-end bores and the mark point towards piston (100).

Move steering to one of the limit positions.

Measure the friction torque required to turn the steering ouside the straight-ahead range (approx. half a turn short of the limit position).

Turn steering approx. one half-turn to the right and left beyond the middle position with tools [8], [9] and [10]. Measure the associated increase in friction torque.

Required increase in friction torque:

Type 8090:	20-60 Ncm
Type 8095/8096:	20-80 Ncm
Type 8097-8099:	20-100 Ncm

Turn both housing covers (4) with tools [18] and [19], keeping the same angle (in the direction of the arrow), until the required increase in friction torque is obtained ***(Fig.38).***

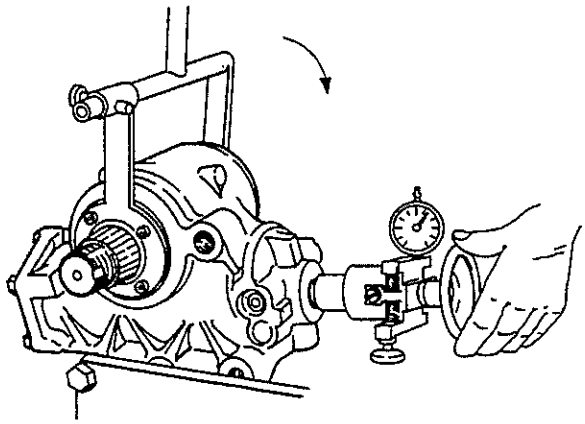


Fig.38

While making the adjustment with tools [18] and [19], use tools [8], [9] and [10] to turn the steering several times approx. one half-turn to the right and left beyond the middle position.

Note:
The max. permissible friction torque should be set if possible when making this adjustment.

14 Caulking housing cover (4)

14.1 Versions with single caulk

14.1.1 Screw tool [20] onto the steering so that it is parallel to the steering. The caulking tool must fit into the caulking groove as accurately as possible ***(Fig.39)***.

Tool [21] must be used additionally for steering versions with a C-value greater than 137 mm.

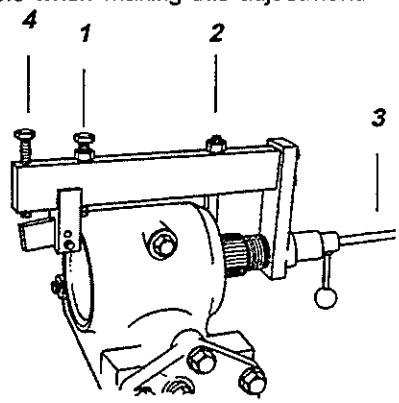


Fig.39

In this position, set adjusting screw ***1*** on the fixture so that the caulking tool is horizontal.

Secure fixing hook ***2*** on the opposite side of the housing at the height indicated by thrust spindle ***3***.

Tighten thrust spindle ***3*** until housing cover (4) comes to rest on retaining ring (7) on the caulking side.

Tighten screw ***4*** on the fixture by hand (without using additional tools) until it rests on the caulking tool.

Turn screw ***4*** through - value specified below - with a torque wrench (maximum value of 18 Nm must not be exceeded, otherwise the tool may break !).

Turns of screw ***4***:	Types 8090-8097: approx. 2.75 Types 8098/8099: approx. 3.50

Remove fixture and check caulked area.
The housing has been caulked correctly when the collar of the housing cover is pressed into the housing groove to the depth specified in the following table.

Caulking depth:

Types 8090/8095/8096:	1.3+0.4 mm
Type 8097:	1.4+0.4 mm
Types 8098/8099:	1.7+0.4 mm

Slight cracks are permissible in the caulking edge at the edge of the groove ***(Fig.40)***.

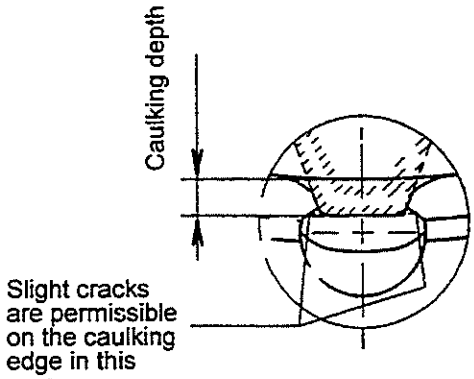


Fig.40

Additionally required for versions with holding segments (14):

Holding segments (14) must be pressed in until flush ***(Fig.41)***.

Fit retaining ring (7) so that the gap is located at the caulking point opposite the piston (100).

Attention:
Check that retaining ring (7) is seated securely.

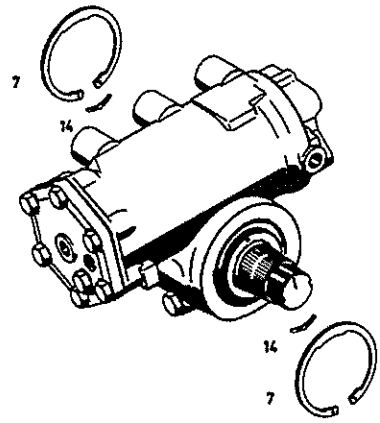


Fig.41

14.1.2 Repeat the complete procedure for the other side as described in section 14.1.1.

14.2 Versions with three-fold caulking

14.2.1 Carry out single caulking on both sides as described in section 14.1.

Remove retaining ring (7) and insert tool [22] (without caulking tool) in the caulking grooves of the housing with the three pilot pins.

Turn tool [22] through 60° in the groove of the retaining ring until one of the two caulking points is reached. Secure tool [22] with a stop pin to prevent it twisting and fit the caulking tool.

Proceed as described in section 14.1. Remove caulking tool. Release stop pin and turn fixture through 120° until the third caulking point is reached.

Proceed as described in section 14.1 for the third caulk.

Dismount tool [22] from the steering and check the caulked area as described in section 14.1.1.

Additionally required for versions with holding segments (14):

Press holding segments (14) in until flush ***(Fig.42)***.

Fit retaining ring (7) so that the gap is located on the caulking point opposite the piston (100).

Attention:
Check that retaining ring (7) is seated securely.

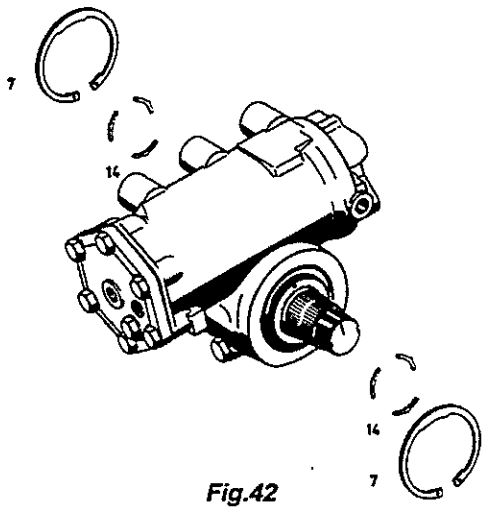


Fig.42

14.2.2 Repeat the complete procedure for the other side as described in section 14.1.1.

15 Assembly of housing cover (221)

15.1 Dual-circuit versions

Insert O-ring (220) ***(Fig.43)***.

Install housing cover (221) with cap screws (223) (tightening torque: 37 Nm).

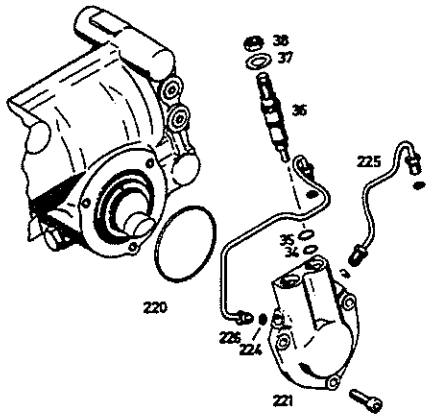


Fig.43

Install pipes (225 and 226) with new O-rings (224).

Tightening torque: Type 8096: 12+2 Nm
Type 8099: 18+2 Nm

Screw in valves (36) - steering limiter valves - with O-rings (34 and 35).

Fit hex nut (38) with washer (37) and torque down to 25-35 Nm after adjustment.

15.2 Versions with switch (222)

Note:
The housing cover should not be installed until the setting and functional test - chapter IV. - is complete, otherwise it cannot be tested for leakages.

Insert cam disc (227) in housing cover (221) so that the cam ways point towards switch (222) ***(Fig.44)***.

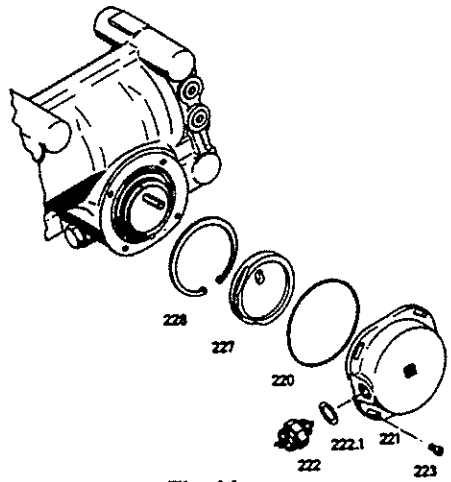


Fig.44

Fit retaining ring (228).

Place O-ring (220) in annular groove of housing cover (221).

Fit complete housing cover (221) as marked during disassembly so that the driver in the sector shaft engages in the longitudinal groove in cam disc (227).

Turn housing cover (221) so that the cam points towards the threaded bore of switch (222) when the steering is in the straight-ahead position.

Torque cap screws (223) down to 5.5 Nm.

Note:
The switching range of switch (222) can be adjusted on a test bench by using washers (222.1) of a different thickness.

Fill cover area with 50 cm^3 oil (oil sort see List of Lubricants TE–ML 09).

Screw in switch (222) with washer (222.1) (tightening torque: 50 Nm).

16 Assembly and installation of add-on cylinder (250)

Set steering to straight-ahead position.

Slide bush (253) and gear (254) as far as possible onto sector shaft (80) ***(Fig.45)***.

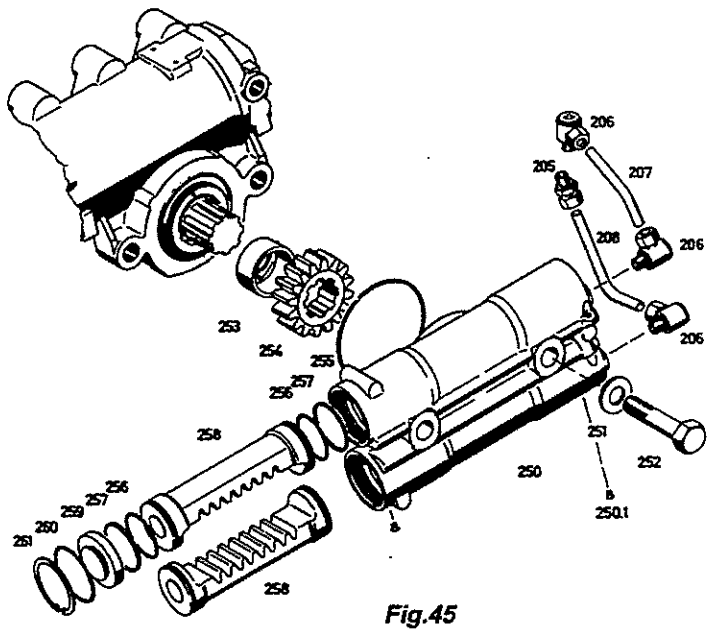


Fig.45

Slip two O-rings (256) and two gaskets (257) onto each piston (258).

Slide both pistons (258) into add-on cylinder (250) up to the middle position (installed value 60.7 ±0.2 mm) ***(Fig.46)***.

Notes:

→ The middle tooth of both pistons (258) is marked on both face ends.

→ The centered bore (with installed breather valve) in pistons (258) must point towards the closed end of add-on cylinder (250).

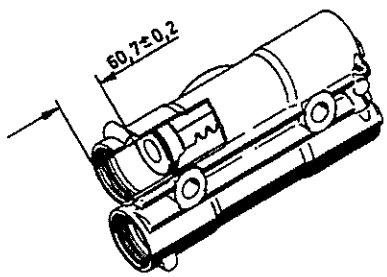


Fig.46

Screw add-on cylinder (250) onto the steering so that the middle tooth of piston (258) engages in the gap in gear (254) in each case ***(Fig.47)***.

Screw in hexagon screw (252) with washers (251) (tightening torque: 500 Nm).

Turn steering through from end to end and then back to the straight-ahead position.

Check that the installed value equals 60.7 ±0.2 mm for both pistons (258).

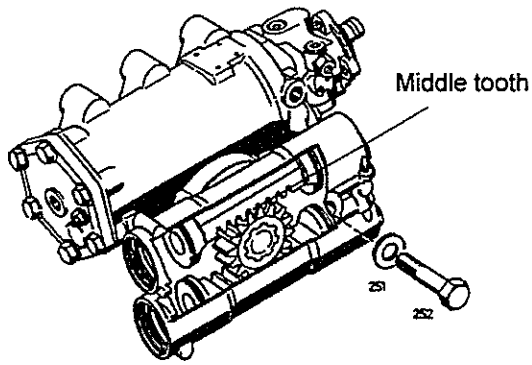


Fig.47

Place O-ring (260) in radial groove of cylinder bore and press cylinder cover (259) in until the retaining rings (261) can be fitted ***(see Fig.45)***.

Fit retaining rings (261).

Install pipes (207) and (208).

Tightening torques:

Pipe union (205):	50 Nm
Pipe union (206):	39 Nm
Screw plugs for both pipe unions (205 and 206):	59 Nm

Tighten Torx screw (250.1) with tool [23] (tightening torque: 5 Nm).

17 Preassembly and installation of bevel box

17.1 Versions with cross disc (348)

17.1.1 Fit intermediate flange (335)

Slip O-ring (341) onto intermediate flange (335). Press cross disc (348) and ball bearing (343) onto intermediate flange (335) ***(Fig.48)***. Use tool [28] for this purpose.

Secure intermediate flange (335) with cap screws (334) as marked during disassembly (tightening torque: 140 Nm).

Slip shim plate (330) onto intermediate flange (335).

17.1.2 Preassemble bevel box

Press needle sleeve (302) into housing (301) as far as possible with tool [29] ***(Fig.48)***.

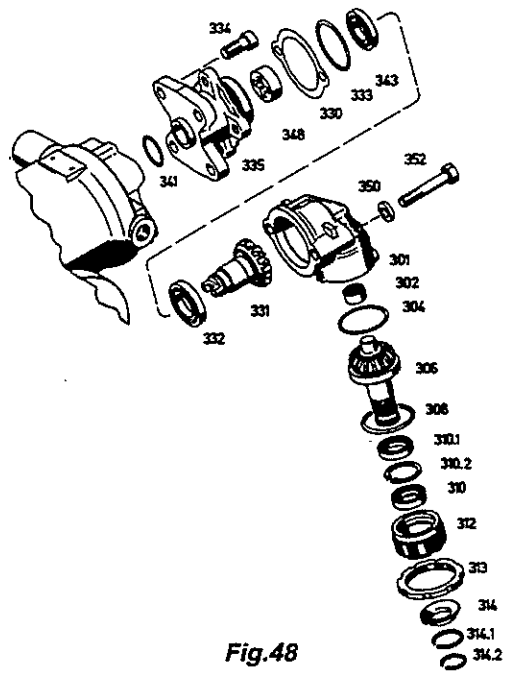


Fig.48

Press ball bearing (332) onto bevel gear (331) with tool [30].

Place 0.35 mm thick washers (304) or the washers (304) removed during disassembly into the housing bore. Slide bevel gear (306) as far as possible into housing (301).

Screw adjusting screw (312) into housing (301) without shaft seals (310 and 310.1), using tool [25] (tightening torque: 50 Nm).

Set bevel box to straight-ahead position. Align notch in steering shaft of bevel box with the mark on the housing.

In this position, mark one tooth on bevel gear (306) in the housing and two opposing teeth on bevel gear (331) in intermediate flange (335) with chalk so that the marked teeth engage when the bevel box is mounted.

17.1.3 Installation of bevel box

Slip on bevel box.

Uniformly screw in screws (352) with fitted washers (350), while simultaneously and constantly turning the steering shaft, until bevel gears (306 and 331) engage without backlash.

Screws (352) must not be turned further if bevel gears (306 and 331) engage before the flange of the bevel box comes to rest.

The remaining gap must be compensated with shim plates (330) in this case.

A thinner shim plate (330) must be used if zero backlash cannot be obtained.

The bevel gear must be precision adjusted when zero backlash has been obtained. Both the shim plates (330) and the washers (304) on bevel gear (306) are used for this purpose.

The bevel gears are correctly set when they engage with virtually no backlash and without jamming (max. backlash 0.04 mm).

Note:
However, the adjustment must be made in straight-ahead position so that the backlash is absolutely zero.

If the backlash is not zero when the steering gear is set to the straight-ahead position, the tooth contact must be relocated by one or more teeth until this requirement is met.

Make a new notch marking the straight-ahead position and take the bevel box off the steering again.

Place a greased O-ring (333) in the radial groove of the intermediate flange (335).

Place the bevel box back on the steering in the position marked after fitting the chosen washers (330).

Screw in screws (352) with fitted washers (350) (tightening torque: 62 Nm).

Unscrew adjusting screw (312) from housing (301).

Place a greased O-ring (308) in the radial groove of housing (301), behind the threaded bore.

Fill space between sealing lip and dust lip of shaft seal (310 and 310.1) with grease, see note in chapter III.

Mount tool [32] on bevel gear (306).

Fit retaining ring (310.2) in adjusting screw (312).

Press inner shaft seal (310.1) in as far as possible with tool [31].

Fit outer shaft seal (310) in adjusting screw (312) flush with face end.

Screw adjusting screw (312) into housing (301) with tool [25] and a torque of 50 Nm.

Tighten slotted nut (313) to a torque of 50 Nm.

Depress cast edge of housing to secure slotted nut (313) and prevent it twisting.

Check set friction value again (required value: max. 80 Ncm).

17.2 Versions with coupling sleeve (349)

17.2.1 Preassembly of bevel box

Press needle sleeves (302) in as far as possible with tool [36]. Install bevel gear (306) ***(Fig.49)***.

Select a retaining ring (310.3) leaving the bevel gear (306) with a max. backlash of 0.06 mm.

Install bevel gear (331).

Choose a retaining ring (310.4) ensuring zero backlash over the largest possible angle of rotation while simultaneously allowing the bevel box to run as smoothly as possible.

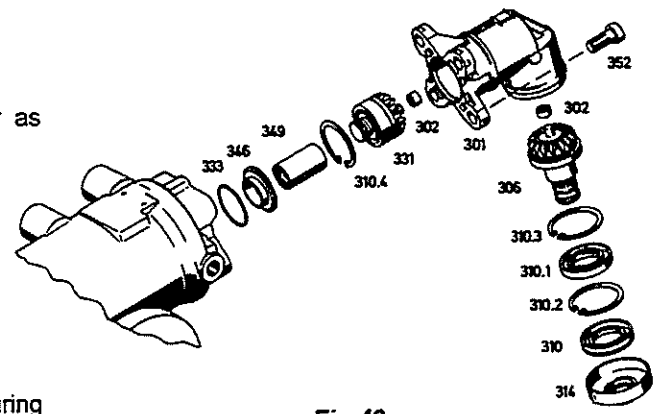


Fig.49

Fit retaining ring (310.4).

Mount tool [38] on bevel gear (306).

Grease space between sealing lip and dust lip of shaft seal (310.1) (see note in chapter III.) and press it in, together with retaining ring (310.2), with tool [37] until they engage completely.

Press a greased shaft seal (310) - see note in chapter III. with regard to the type of grease - in as far as possible with tool [39].

Measure friction torque with tools [8], [9] and [10] (required value: max. 60 Ncm).

Turn to find a zero-backlash area and fit protecting cap (314) with the mark pointing towards the steering gear. Remove former straight-ahead marking.

Fit O-ring (333).

Slip on centering ring (346) and coupling sleeve (349).

Note:
Coupling sleeve (349) must be fitted so that the inner chamfer points towards the steering gear.

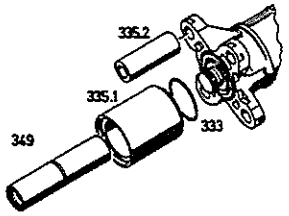


Fig.50

17.2.2 Fit pipes

Fit O-ring (333). Slip on pipes (335.1 and 335.2) ***(Fig.50).***

17.2.3 Install bevel box

Secure bevel box with cap screws (352) as marked during disassembly (tightening torque: 62 Nm).

Turn steering to straight-ahead position and fit protecting cap (314) with the mark pointing towards the steering gear.

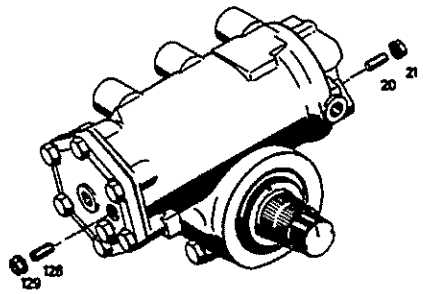


Fig.51

18 Assembly of set screw/screw (20 and 128)

18.1 Versions with collar nut (21 and 129)

Screw set screws (20 and 128) in by at least three turns and secure with collar nuts (21 and 129) (tightening torque: 20+10 Nm) ***(Fig.51).***

18.2 Versions with screws (20 and 128)

Refit the screws (20 and 128) which were removed during disassembly (tightening torque: 12+3 Nm) ***(Fig.52).***

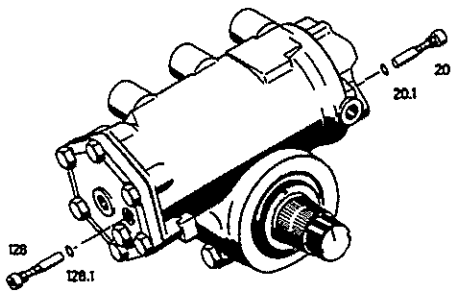


Fig.52

Attention:

→ These screws (20 and 128) may only be used for the functional tests described below.

→ New screws (20 and 128) must be fitted after the functional tests (tightening torque: 12+3 Nm).

→ The steering must subsequently not be turned to either limit position before being installed in the vehicle, otherwise the hydraulic steering limiter cannot be adjusted as specified.

19 Final assembly of steering gear

Note:
The final assembly described here must not be undertaken until the setting and functional tests (chapter IV.) have been completed on the test bench.

19.1 Fit plug (52)

19.1.1 Versions with gasket (51.2)

Oil or grease the inner groove of dust seal (51), the outer circumference of gasket (51.2) and the mating face of gasket (51.2) on housing (1) (see note in chapter III. with regard to type of grease) ***(Fig.53)***.

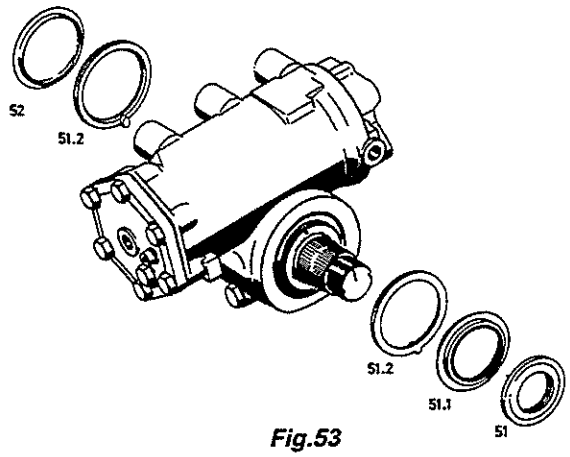


Fig.53

Insert stop-ring (51.1) in the groove of dust seal (51) and place gaskets (51.2) on the inside of stop-ring (51.1) or plug (52) so that the protruding nose points away from plug (52) and stop-ring (51.1).

Slide the assembled dust seal (51) over the serration of sector shaft (80) by hand (the sector shaft must be kept as free of grease as possible) and press it into housing (1) until stop-ring (51.1) is flush with housing (1).

When fitting dust seal (51), ensure that the nose on gasket (51.2) fits exactly in the groove in housing (1).

On the opposite side of the serration on the sector shaft, press the preassembled plug (52) into housing (1) by hand until it is flush with housing (1).

When fitting plug (52), ensure that the nose on gasket (51.2) fits exactly in the groove in the housing.

Note:
Plug (52) may arch outwards due to air trapped under it during installation. For this reason, insert a small screwdriver between gasket (51.2) and housing (1) so that the trapped air can escape.

19.1.2 Versions without gasket (51.2)

Slip dust seal (51) and plug (52) onto sector shaft (80) after ensuring that the space between the dust lip and housing (1) is filled with grease (see note in chapter III. with regard to the type of grease) ***(Fig.54)***.

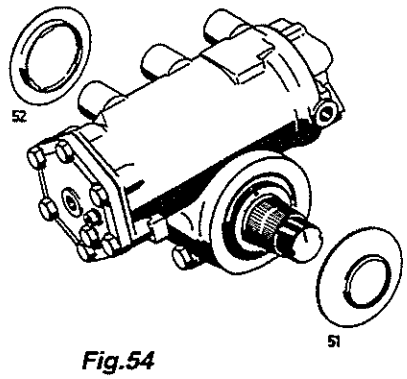


Fig.54

19.2 Fit protecting cap (53)

19.2.1 Versions with gasket (53.3)

Fit gasket (53.3) on the worm stub so that it fits exactly into the recess ***(Fig.55)***.

Press protecting cap (53) on as far as possible with tool [24]. Check assembly value of 5.4-0.2 mm (see illustration).

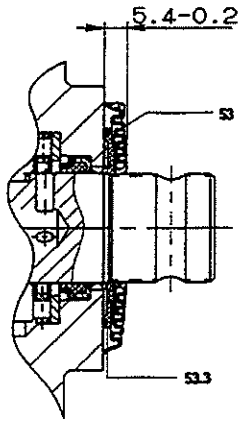


Fig.55

19.2.2 Versions without gasket (53.3)

Fit protecting cap (53) on the worm stub as far as possible with tool [24] after ensuring that the gap between dust lip and housing (1) is filled with grease (see note in chapter III. with regard to the type of grease).

19.2.3 Versions with retaining ring (53.1)

Slip protecting cap (53) onto the worm stub and fit retaining ring (53.1) ***(Fig.56)***.

19.3 Fit dust seal (314)

19.3.1 Bevel box versions with cross disc (348)

Fit dust seal (314) on bevel gear (306) after ensuring that the gap between adjusting screw (312) and dust lip is filled with grease (see note in chapter III. with regard to the type of grease) ***(see Fig.48)***.

Fit snap rings (314.1 and 314.2).

19.3.2 Angular gear versions with coupling sleeve (349)

Fit dust seal (314) on bevel gear (306) ***(see Fig.49)***.

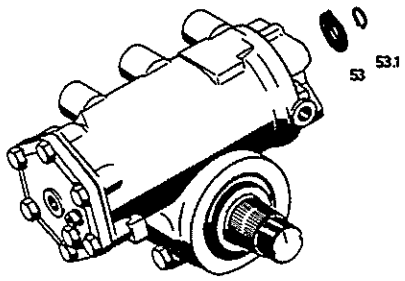


Fig.56

19.3.3 Check that the markings for the straight-ahead position are present as shown in ***Fig.57***.

Exception:
The markings may be in a different position in special versions. This is then indicated on the technical cover sheet of the spare parts list.

19.4 Versions with automatically adjusted steering limiter

Fit new screws (20 and 128) with new O-rings (20.1 and 128.1) (tightening torque: 12+3 Nm) ***(Fig.58)***.

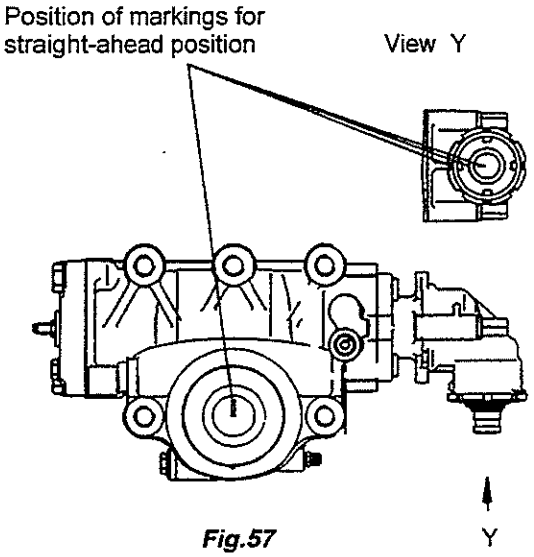


Fig.57

Attention:
The steering must not subsequently be turned to either limit position, otherwise the sliding sleeves of screws (20 and 128) are displaced into their limit position.

This then makes it impossible to adjust the hydraulic steering limiter in the vehicle as specified.

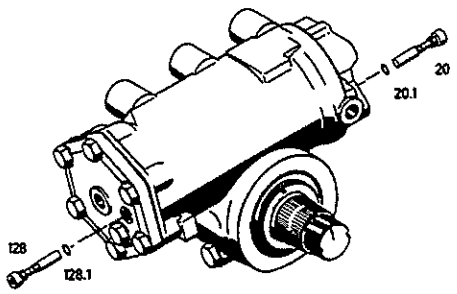


Fig.58

20 Checking the friction torque of the completely assembled steering gear

Mount tools [8], [9] and [10] on the steering shaft. Turn steering through from end to end and measure the friction torque outside the pressure point. Required value, see chapter VI.

The torque may vary by up to 40 Ncm when the steering is turned uniformly.

IV. Setting and functional test

Attention:
Every steering must undergo a setting and functional test on the test bench after being repaired in order to ensure traffic safety. The steering **must not** be installed in the vehicle without functional testing so that its correct function can subsequently be verified in a test drive.

Note:

→ All the required values, tolerances etc. necessary for this functional test are specified in the spare parts list. The values mentioned below apply if nothing is specified in the spare parts list.

→ The notes contained in the Instruction Manual for the test bench apply regardless of the following description.

1 Prepare steering for functional test

Set up completely assembled steering on test bench.

Connect delivery and return lines.

Attention:
Only lines and connections approved for the maximum pressure encountered may be used.

Additionally required for dual-circuit versions:
Seal ports for working cylinder with dummy plugs.

1.1 Bleed the steering:

❑ Versions with automatic bleeding:

These versions are fitted with automatic breather valves. It is therefore not necessary to open any breathers.

To bleed the steering, it must be turned from end to end several times. An unnecessarily high build-up of pressure must be avoided, since the breather valves are only effective in the continuous pressure range.

❑ Versions with breather (57):

Turn the steering so that breather (57) is positioned as near the top as possible.

Adjust the test bench to the flow rate specified below and do not turn the steering wheel.

Remove protecting cap (58) and open breather (57) by roughly one-half or a full turn.

Let air escape and reclose breather (57) when oil emerges.

Rapidly turn steering wheel from end to end several times and repeat bleeding procedure.

Torque breather (57) down to 30 Nm.

Refit protecting cap (58).

1.2 Set test bench: (Test temperature 50° C)

Note:
Test bench must be set to 20 bar above the maximum pressure specified on the rating plate for steering versions with built-in pressure limiter valve.

Pressure	Flow rate		
Type	8090:	150 bar	7 l/min
Type	8090 N:	170 bar	8 l/min
Type	8095:	150 bar	12 l/min
Types	8096-8099:	150 bar	16 l/min

2 Setting and functional test

2.1 Check absence of external leaks

The absence of external leaks must also be checked while carrying out the following tests 2.2 to 3.

2.2 Check maximum pressure

→ Determine the straight-ahead position by halving the total number of turns of the steering wheel or total steering angle.

→ Check or mark the middle on the steering shaft.

→ Lock steering in straight-ahead position.

→ Close steering valve by turning steering wheel in one direction.

→ A maximum pressure corresponding to the value set on the test bench must build up when the steering valve is fully deflected (approx. 100 N manual force applied to the steering wheel).

Note:
A maximum pressure corresponding to the value specified on the rating plate (tolerance: +10%) must build up if the steering is equipped with a pressure limiting valve.

→ Repeat the test for the other direction of rotation.

→ If the maximum pressure is not reached, this may be due to excessive leakage oil in the steering or to a defective pressure limiting valve.

→ If the maximum pressure is exceeded, the pressure limiting valve must be replaced or the setting of the pressure limiting valve on the test bench checked if the steering does not have a built-in pressure limiting valve.

2.3 Check oil leakage

2.3.1 Check oil leakage at a high flow rate

→ Lock steering in straight-ahead position.

→ The leakage oil draining into the return line should be measured at the following pressure when the steering valve is fully deflected (approx. 100 N manual force applied to the steering wheel):

Steering systems with built-in pressure limiting valve:
20 bar below the maximum pressure specified on the rating plate.

Steering systems without pressure limiting valve:
150 bar

Maximum permissible oil leakage:

Type 8090:	1.5 l/min
Types 8095-8099:	2.0 l/min

2.3.2 Check oil leakage at reduced flow rate

→ Set test bench to a flow rate of 2-3 l/min.

→ Check oil leakage as described above. The oil leakage established in section 2.3.1 must not be exceeded.

2.4 Check hydraulic centre

2.4.1 Steering not locked

→ Slowly turn steering through to the end in both directions with tools [8], [9] and [10], letting it go several times in the process.

The steering must not move in either direction of its own accord.

2.4.2 Steering locked in straight-ahead position

→ Turn steering shaft to lock steering valve in one direction until the pressure on the pressure gauge has risen 3 bar above the continuous pressure.

→ Read off the value on tools [9] and [10].

→ Repeat the measurement in the opposite direction.

The difference in torques when steering to the right or left must not exceed 30% referred to the higher value.

2.5 Valve reset

→ Lock steering in straight-ahead position.

→ Set test bench to previous values.

→ Turn steering wheel to close steering valve, thus building up the maximum pressure.

Slowly release the steering wheel and adjust to a pump pressure 10 bar above the continuous pressure.

The valve must then return to the neutral position, i.e. the oil pressure must drop to the continuous pressure within one second.

→ Check steering hitch:

There must not be any perceptible hitch when alternately turning the steering wheel in the other direction three times in succession at approx. 50 bar (hydraulic steering hitch).

2.6 Set hydraulic steering limiter

→ Set counterforce on test bench.

2.6.1 Versions with manually adjusted steering limiter (identified through collar nuts (21 and 129))

→ Turn the steering until the steering drop arm is deflected 47° and the hydraulic steering limiter is tripped.

Note:
Steering systems for which a different special switching range of 35 - 42°, for example, is specified in the spare parts list must be set to the explicitly specified maximum value, e.g. 42°.

→ Turn set screw (20 or 128) until the oil pressure drops to 40 - 50 bar and a considerably greater effort is required to turn the steering outwards.

Attention:
In all cases, ensure that the set screws (20 and 128) are screwed in by at least three turns, otherwise they may be forced out when the maximum pressure is applied.

→ Tighten the collar nut (21 or 129) down to 20+10 Nm.

→ Repeat adjustment for other side.

2.6.2 Versions with automatically adjusted steering limiter (identified through screws (20 and 128))

Note:
The screws (20 and 128) originally fitted are merely used to check whether the steering limiter valve opens, but without adjusting the switching range.

Attention:
The steering limiter may only be adjusted after installation and with new screws (20 and 128) in the case of these versions.

→ Turn steering in one direction and check that the pressure drops to 40 - 50 bar when the steering limiter valve opens.

→ Repeat test for other side.

3 Additionally required for dual-circuit versions

3.1 Check the maximum pressure, the hydraulic centre and valve reset for the second circuit as described in section 2.

3.2 Check oil leakage

3.2.1 Check oil leakage for circuit II

→ Connect delivery and return lines to circuit II.

→ Seal ports for working cylinder of circuit II with dummy plugs.

→ Check oil leakage as described in section 2.3.

Maximum permissible oil leakage for circuit II: 2 l/min

3.2.2 Measure oil leakage for sealing elements (164, 164.1, 172 and 173) separating circuits I and II.

→ Lock steering in straight-ahead position.

→ Then remove the screw plug (55) in the bottom of the housing or screw plug (55) in cylinder cover (125) if the former is not installed or unscrew the corresponding return line and drain off the oil

→ Drain the oil until the oil level in the housing reaches the drainage hole and the flow of oil ceases.

→ Seal the two working cylinder ports in circuit II with dummy plugs. Apply a pressure set to 3 bar above the continuous pressure on the test bench to the delivery line of circuit II. Collect the oil leaking from the housing bore or return line port of circuit I in a beaker for precisely one minute.

Max. permissible oil leakage: 0.001 dm^3/min (1 cm^3/min).

→ This test must be performed statically with the control valve not deflected.

→ Check oil leakage again dynamically at a pressure of 30 bar (set on the test bench), steering valve fully deflected once to the right and left.

3.3 Set hydraulic steering limiter

3.3.1 Steering limiter in piston

Set as described in section 2.6.

3.3.2 Steering limiter in housing cover

Turn steering in one direction until the steering drop arm is deflected as specified in the spare parts list for steering circuit II to trip the hydraulic steering limiter.

Turn valves (36) until the oil pressure drops to 30 - 40 bar and a considerably greater effort is required to turn the steering further outwards.

Torque hex nuts (38) down to 25 - 35 Nm.

4 Remove steering from test bench

Drain off the test oil by turning the steering shaft several times in both directions.

Remove steering from test bench.

Versions with automatically adjusted steering limiter

→ Affix note on settings, order number 7012 782 115, to the steering.

Versions with manually adjusted steering limiter

→ Affix note on settings, order number 7012 782 116, to the steering.

5 Check friction torque of completely assembled steering

Mount tools [8], [9] and [10] on steering shaft.

Turn steering through from end to end and measure friction torque within and beyond the pressure point.

Required values, see chapter VI.

The torque may deviate by up to max. 40 Ncm outside the pressure point when the steering is turned uniformly.

6 Affix repair code number

7 Carry out final assembly as described in chapter III. section 19.

V. Troubleshooting

Notes:

→ The ZF Servocom hydraulic steering has been built for heavy loads. It is designed in such a way that faults cannot develop if it is serviced correctly and operated normally.

→ If faults do develop, however, the following sections will help to locate and eliminate them.→ Before attempting to locate individual faults in the steering, the oil level must be checked with the engine running.

→ At the same time, attention is explicitly drawn to the fact that faults can occur when using oil with a strong tendency to foam, since such oil releases very little or none of the air entrained into the steering system.

Fault	Cause	Remedy
Moves stiffly in both directions	→ Sealing elements (116, 117, 119, 169, 170) defective	→ Replace
	→ Internal fault	→ Repair
		→ Replace
	→ Valve insert (22) defective	→ Replace
For dual-circuit versions also:		—
	→ Working cylinder defective	→ Repair
		→ Replace
	→ Sealing elements (159/164) defective	→ Replace
Moves stiffly in one direction	→ Valve insert (109) defective	→ Replace
	→ Sealing element (123) defective	→ Replace
	→ Internal fault	→ Repair
		→ Replace
For dual-circuit versions also:		
	→ Valves (36) defective/ wrongly set	→ Repair → Replace
		→ Adjust
	→ Sealing element (164) defective	→ Replace
Steering hitch	→ Air in oil	→ Bleed

Fault	Cause	Remedy
Obstructed return travel	→ Excessive friction torque in steering	→ Check friction torque - see chapter IV.
Imprecise straight-ahead travel	→ Wrong friction torque	→ Check friction torque - see chapter IV.
Steering wheel knocks	→ Backlash in recirculating ball element or wrong friction torque	→ Check - see chapter III.
	→ Excessive backlash in worm bearing	→ Check - see chapter III.
	→ Centre engagement piston - sector shaft	→ Check - see chapter III.
Backlash in steering wheel	→ Backlash in recirculating ball element or wrong torque	→ Check - see chapter III.
	→ Excessive backlash in worm bearing	→ Check - see chapter III.
	→ Centre engagement piston - sector shaft	→ Check - see chapter III.
Steering drifts	→ Hydraulic centre not OK	→ Replace piston/ worm assembly
Loss of oil	Sealing elements (2, 5, 8, 124, 310 and 310.1) defective	→ Replace - see chapter III.
	→ Leak in lines or connections	→ Repair [1]
Noises	→ Worm defective	→ Repair → Replace
	→ Valve insert (22) and(32) defective	→ Repair → Replace
	→ Air in oil	→ Bleed
	→ Loose connections	→ Retighten

[1] See vehicle manufacturer's manual

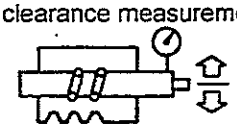
VI. Friction torques, adjustment values and tightening torques

❑ Friction torques:

Recirculating ball element:

Friction torque measurement

Tilting clearance measurement



New parts	Disassembled parts
In middle area: Type 8090: 5-20 Ncm Types 8095-8099: 5-30 Ncm	In middle area: max. 0.1 mm Tilting clearance or for type 8090: max. 20 Ncm for types 8095-8099: max. 30 Ncm
Outside the middle area: Additional increase of max. 15 Ncm	Outside the middle area: Max. increase to for type 8090: 35 Ncm for types 8095-8099: 60 Ncm

Increase in friction torque at the pressure point:

Type	8090:	20-60 Ncm
Types	8095/8096:	20-80 Ncm
Types	8097-8099:	20-100 Ncm

Completely assembled steering outside the pressure point:

Type Transmission constant (e.g. i_1, i_2 ...) and variable (e.g. iv_1, iv_2 ...)	Friction torque [Ncm] without bevel box	Friction torque [Ncm] with bevel box
8090		
i_1 = 15.2 : 1	max. 160	max. 240
iv_1 = 16.6 : 1 / 14.0 :1		
i_2 = 18.0 : 1	max. 140	max. 220
iv_2 = 19.6 : 1 / 16.6 : 1		

				8095						
i_1	=	17.0	:	1				max. 180		max. 260
iv_1	=	18.5	:	1	/	15.6	:1	max. 160		max. 240
i_2	=	19.6	:	1						
iv_2	=	21.3	:	1	/	18.1	:1	max. 140		max. 220
i_3	=	23.1	:	1						
iv_3	=	25.2	:	1	/	21.3	:1			
				8097						
i_1	=	16.6	:	1				max. 200		max. 280
iv_1	=	18.2	:	1	/	15.4	:1			
i_2	=	18.9	:	1				max. 180		max. 260
iv_2	=	20.6	:	1	/	17.4	:1			
i_3	=	21.8	:	1				max. 160		max. 240
iv_3	=	23.7	:	1	/	20.1	:1			
i_4	=	25.7	:	1				max. 140		max. 220
iv_4	=	28.1	:	1		23.8	: 1			
				8098						
i_1	=	18.3	:	1				max. 220		max. 300
iv_1	=	20.1	:	1	/	17.0	:1			
i_2	=	20.7	:	1				max. 200		max. 280
iv_2	=	22.6	:	1		19.2	: 1			
i_3	=	23.9	:	1				max. 180		max. 260
iv_3	=	26.1	:	1		22.1	: 1			

Type Transmission constant (e.g. i_1, i_2 ...) and variable (e.g. iv_1, iv_2...)								**Friction torque [Ncm] without bevel box - add-on cylinder**	**without bevel box + add-on cylinder**	**with bevel box - add-on cylinder**	**with bevel box + add-on cylinder**
		8096									
i_1	=	17.0	:	1				max. 210	-	max. 290	-
iv_1	=	18.5	:	1	/	15.6:1					
i2	=	19.6	:	1				max. 190	-	max. 270	-
iv_2	=	21.3	:	1	/	18.1:1					
i_3	=	23.1	:	1				max. 170	-	max. 250	-
iv_3	=	25.2	:	1		21.3:1					
		8099									
i_1	=	18.3	:	1				max. 250	max. 320	max. 330	max. 400
iv_1	=	20.1	:	1	/	17.0:1					
i_2	=	20.7	:	1				max. 230	max. 300	max. 310	max. 380
iv_2	=	22.6	:	1		19.2:1					
i_3	=	23.9	:	1				max. 210	max. 280	max. 290	max. 360
iv_3	=	26.1	:	1	/	22.2:1					

❑ Adjustment values:

Protecting cap (53) - Fitting value			5.4 - 0.2 mm
Plug (112) - Radial clearance	Type	8090:	max. 0.1 mm
	Types	8095-8099:	max. 0.5 mm
	Type	8099 with add-on cylinder:	max. 0.2 mm
Needle cage (120) - Axial clearance (at room temperature)	Type	8090:	0.005 - 0.025 mm
	Types	8095/8096:	0.010 - 0.030 mm
	Type	8097:	0.015 - 0.035 mm
	Types	8098/8099:	0.020 - 0.040 mm
Sliding tube (156) - Axial clearance			max.0.1 mm
Piston (258) - Installed value			60.7±0.2 mm

❑ Tightening torques:

Screw (20)		12+3 Nm
Collar nut (21)		20+10 Nm
Valve insert (22)		30+10 Nm
Valve insert (22.1)		30+10 Nm
Screw (30)		30+10 Nm
Hex nut (38)		25-35 Nm
Screw plug (55)	M16:	40 Nm
	M18:	50 Nm
Breather (57)		30 Nm
Valve insert (109)		15±1 Nm

Hexagon screws (127)	Type	8090 (M12x1.5):	135 Nm
	Types	8095/8096/8097 (M16x1.5):	285 Nm
	Types	8098/8099 (M14x1.5):	189 Nm
Screw (128)			12+3 Nm

Collar nut (129)		20+10 Nm
Cap screws (204)		140 Nm
Pipe union (205)		50 Nm
Pipe union (206)		50 Nm
Screw plug for pipe unions (205) and (206)		59 Nm
Union screws (211)		20±2 Nm
Switch (222)		50 Nm
Cap screw (223)	Type 8096 (M8):	37 Nm
	Type 8098 (M6) (version with switch):	5.5 Nm
Pipes (225)	Type 8096:	12+2 Nm
	Type 8099:	18+2 Nm
Pipes (226)	Type 8096:	12+2 Nm
	Type 8099:	18+2 Nm
Torx screw (250.1)		5 Nm
Hexagon screw (252)		500 Nm
Adjusting screw (312)		50 Nm
Slotted nut (313)		50 Nm
Cap screw (334)		140 Nm
Hexagon screw (352)		62 Nm

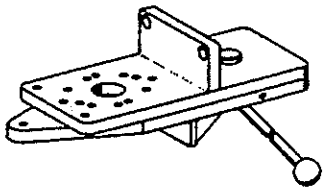
VII. Special tools

Note:
The special tools listed below refer to the standard version and the design version on the basis of which the entire manual has been compiled. Other tools may consequently be required for the particular unit in question.

8090	8095	8096	8097	8098	8099
7418 798 654					
8098 798 151					
8090 798 006	8095 798 002		8097 798 002	8098 798 002	
8090 798 201					

Tool [1]

Assembly vice

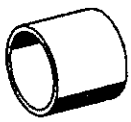


Tool [2]

Insert for screw–out and screw–in the valve insert (109)

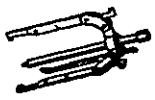
Tool [3]

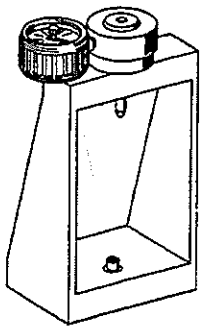
Sleeve for pressing the housing covers (4)



Tool [4]

Puller for housing cover (4)

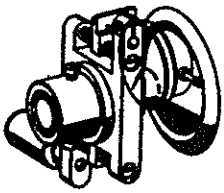


	8090	8095	8096	8097	8098	8099
Tool [5] Guide bush for housing cover (4) 		8043 798 001				
Tool [6] Peening fixture for valve insert (109) 		8090 798 655				
Tool [7] Punch for screwed valve insert (109) 		8098 798 654				
Tool [8] Insert for tool [9]  	serration 1x54	7/8"x48	1x79	1x75	7/8x48	1x79
	8052 798 552	8043 798 551	7419 798 551	7418 798 553	8043 798 551	7419 798 551
		serration 1x79	A6x23x26	1x79	1x79	A6x23x26
		7419 798 551	8065 798 552	7419 798 551	7419 798 551	8065 798 552

8090	8095	8096	8097	8098	8099
Valve slide			ø25	ø25,99	
			7421 798 551	8097 798 554	
Valve slide serration			ø25,99	24/48x22	
			8097 798 554	8038 798 551	
7470 798 703					
7470 798 706					
8090 798 004	8090 798 001				
		8090 798 005		8090 798 005	

Tool [9]

Torque measuring device



Tool [10]

Dial gauge: Graduation 0.01 mm

Tool [11]

Guide bush for sealing rings (164)

for dual–circuit version

Tool [12]

Pliers for pressing on the sealing rings (164)

Tool [13]

Sleeve for mounting the O–ring (172) and the sealing ring (173)

Tool [14]

Mandrel for shaft seal (8)

Tool [15]

Guide bush for shaft seal (8)

8090	8095	8096	8097	8098	8099
8090 798 652	8090 798 651				
		8096 798 001			8096 798 001
8090 798 052	8090 798 051				
8090 798 002	8090 798 003				

Tool [16]

Dial gauge holder for adjustment of axial play–worm

8090	8095	8096	8097	8098	8099
		serration			
1x54	7/8"x48	1x79	1x75	7/8x48	1x79
8090 798 101	8095 798 102	8095 798 101	8097 798 101	8095 798 102	8095 798 101
		serration			
	1x79	A6x23x26	1x79	1x79	A6x23x26
	8095 798 101	8097 798 102	8095 798 101	8095 798 101	8097 798 102
			Valve slide ø25	serration 24/48x22	
			8095 798 101	8097 798 101	
			Valve slide ø25.99		
			8097 798 102		

Tool [17]

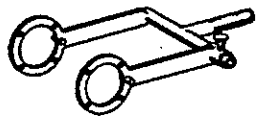
Dial gauge graduation 0.001 mm for tool [16]

7016 798 704

8090	8095	8096	8097	8098	8099
8090 798 151					
8090 798 551	8095 798 551		8097 798 551	8098 798 551	
8090 798 654					
				8090 798 656	

Tool [18]

Adjusting device for pressure point setting

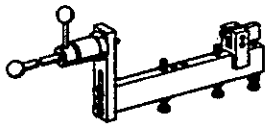


Tool [19]

Insert for tool [18]
(2 pieces are required)

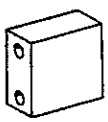
Tool [20]

Assembly tool for prying over of housing covers (4)



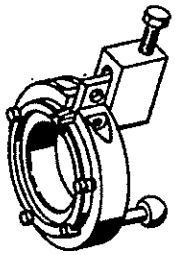
Tool [21]

Extension for tool [20]
for steerings with C–mass >137 mm



Tool [22]

Assembly tool for threefold prying

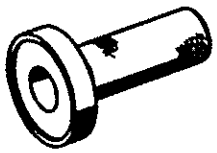


Tool [23]

Insert for torx screw (250.1)

Tool [24]

Mandrel for pressing the protecting cap (53)

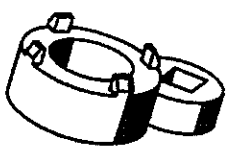


8090	8095	8096	8097	8098	8099
		8096 798 651		8098 798 651	
					7016 798 152
8090 798 053	8095 798 051				

Bevel box with cross disc (348)

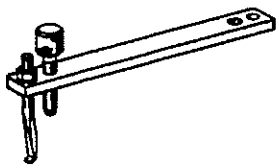
Tool [25]

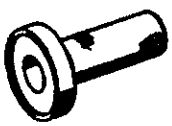
Grooved nut wrench for adjusting screw (312)



8096	8097	8098	8099
1249 898 151			

	8096	8097	8098	8099
Tool [26] Puller for needle sleeve (302) 	7421 798 201			
Tool [27] Counter for tool [26] and [34] 	7421 798 351			
Tool [28] Mandrel for ball bearing (343) 	7421 798 051			
Tool [29] Mandrel for needle sleeve (302) 	7677 798 051			
Tool [30] Press–in sleeve for ball bearing (332) 	7330 798 053			

	8096	8097	8098	8099
Tool [31] Mandrel for shaft seal (310 and 310.1) 	7418 798 051			
Tool [32] Guide bush for shaft seal (310 und 310.1) 	8090 798 003			
Bevel box with coupling sleeve (349)				
Tool [33] Puller for shaft seal (310) 	8052 798 201			
Tool [34] Puller for needle sleeve (302) 	8098 798 201			
Tool [35] Extension for tool [34] 	8098 798 202			

	8096	8097	8098	8099
Tool [36] Mandrel for needle sleeve (302) 	8098 798 052			
Tool [37] Sleeve for shaft seal (310.1) 	8090 798 006			
Tool [38] Guide bush for shaft seal (310) 	8098 798 003			
Tool [39] Mandrel for shaft seal (310) 	8098 798 051			

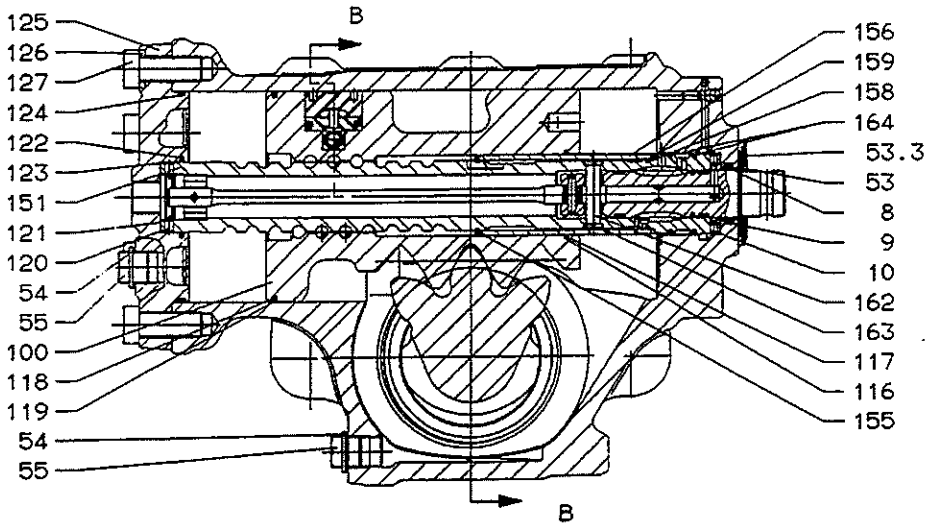
VIII. Key to numbers in figures, sectional drawings and exploded drawings

1.0	Housing
2.0	O-ring
3.0	Washer
4.0	Housing cover
5.0	Gasket
6.0	Support ring
7.0	Retaining ring
8.0	Shaft seal
9.0	Axial-, washer
10.0	Needle cage
11.0	Type plate
12.0	Grooved stud
14.0	Holding segment
20.0	Set screw / Adjusting screw / Screw
20.1	O-ring
21.0	Collar nut
22.0	Valve insert
22.1	Valve insert
23.0	O-ring
30.0	Screw
31.0	O-ring
32.0	Valve insert
34.0	O-ring
35.0	O-ring
36.0	Valve
37.0	Washer
38.0	Hex nut
50.0	Locking nut
51.0	Dust seal
51.1	Stop-ring
51.2	Gasket
51.9	Dust seal
52.0	Plug
53.0	Protecting cap
53.1	Retaining ring
53.3	Gasket
54.0	Sealing ring
55.0	Screw plug
56.0	Protecting sleeve
57.0	Breather
58.0	Protecting cap
63.0	Stick-on label
80.0	Sector shaft
100.0	Piston
101.0	Piston
109.0	Valve insert
110.0	Ball set
111.0	Recirculating half tube
112.0	Gasket/Plug
113.0	Gasket
113.1	Compensating plate
113.2	Pin
114.0	O-ring
115.0	Sealing ring
116.0	Sealing ring
117.0	Sealing ring
118.0	O-ring
119.0	Gasket
120.0	Needle cage
121.0	Washer
122.0	O-ring
123.0	Sealing ring
124.0	O-ring
125.0	Cylinder cover
126.0	Washer
127.0	Hexagon screw
127.1	Screw
128.0	Set screw / Screw
128.1	O-ring
129.0	Collar nut
150.0	Worm
151.0	Worm
155.0	Snap ring
156.0	Sliding tube
157.0	Bush
158.0	O-ring
159.0	Sealing ring
160.0	Pin
161.0	Worm
162.0	Pin

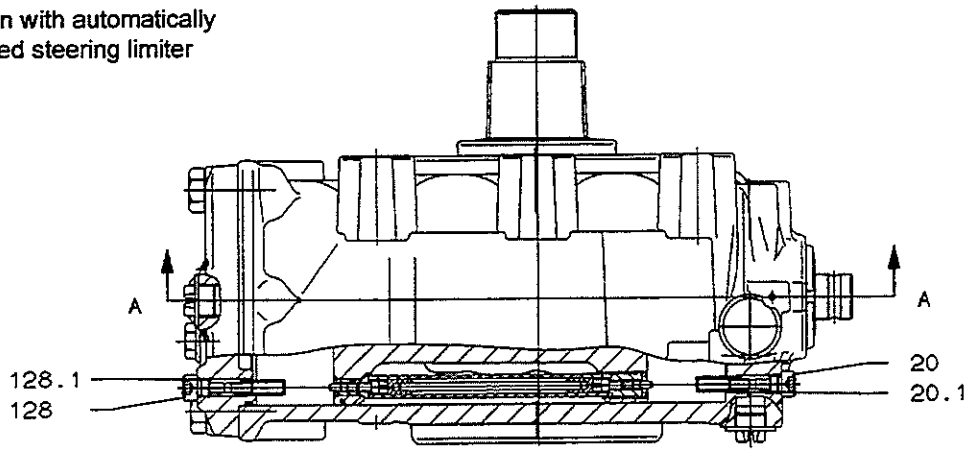
163.0	Plug
164.0	Sealing ring
164.1	O-ring
165.0	Torsion bar
166.0	Needle cage
166.1	Snap ring
167.0	Pin
168.0	Valve slide
169.0	O-ring
170.0	Sealing ring
171.0	Needle cage
172.0	O-ring
173.0	Sealing ring
174.0	Control sleeve
200.0	Ball cage
201.0	Bearing ring
202.0	O-ring
203.0	Valve housing
204.0	Cap screw
205.0	Pipe union
206.0	Pipe union
207.0	Pipe
208.0	Pipe
209.0	O-ring
210.0	O-ring
211.0	Union screw
212.0	Pipe
220.0	O-ring
221.0	Housing cover / Cover
222.0	Steering limiter kit / Switch
222.1	Washer
223.0	Cap screw
224.0	O-ring
225.0	Pipe
226.0	Pipe
227.0	Cam disc
228.0	Retaining ring
250.0	Add-on cylinder
250.1	Torx screw
251.0	Washer
252.0	Hexagon screw
253.0	Bush
254.0	Gear
255.0	O-ring
256.0	O-ring
257.0	Gasket
258.0	Piston
259.0	Cylinder cover
260.0	O-ring
261.0	Retaining ring
301.0	Housing
302.0	Needle sleeve
304.0	Washer
306.0	Bevel gear
308.0	O-ring
310.0	Shaft seal
310.1	Shaft seal
310.2	Retaining ring
310.3	Retaining ring
310.4	Retaining ring
312.0	Adjusting screw
313.0	Slotted nut
314.0	Dust seal / Protecting cap
314.1	Snap ring
314.2	Snap ring
330.0	Shim plate
331.0	Bevel gear
332.0	Ball bearing
333.0	O-ring
334.0	Cap screw
335.0	Intermediate flange
335.1	Pipe
335.2	Pipe
341.0	O-ring
343.0	Ball bearing
346.0	Centering ring
348.0	Cross disc
349.0	Coupling sleeve
350.0	Washer
352.0	Hexagon screw/Screw/ Cap screw

Types 8090 - 8099

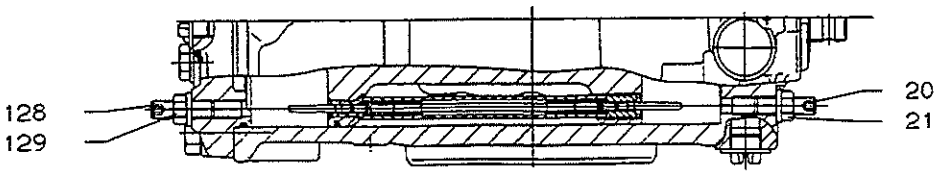
Section A-A



Version with automatically adjusted steering limiter

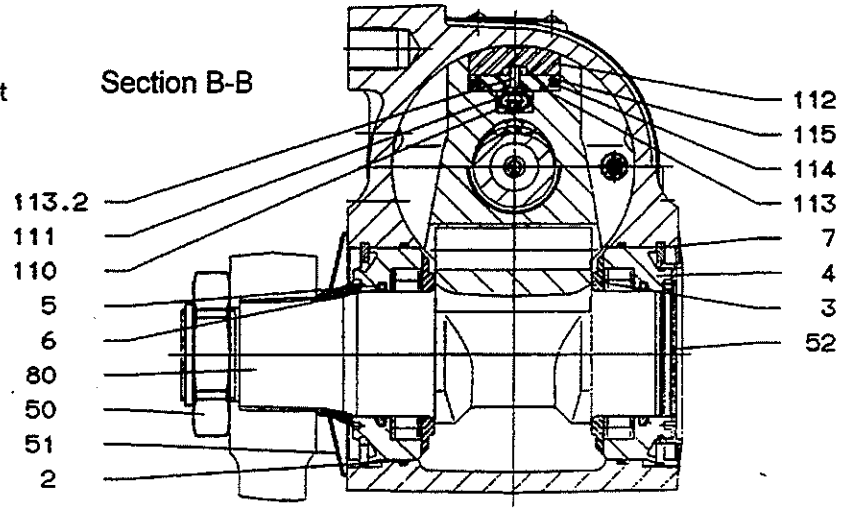


Version with manually adjusted steering limiter



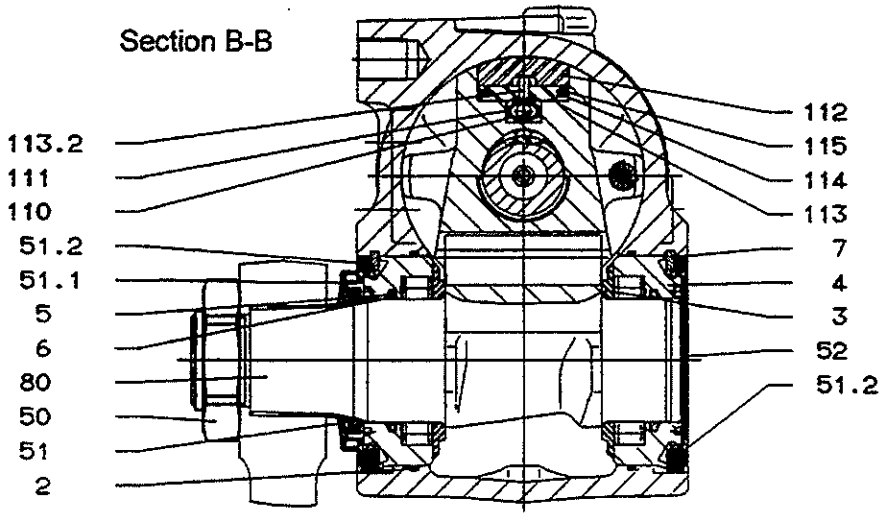
Version without gasket (51.2)

Section B-B



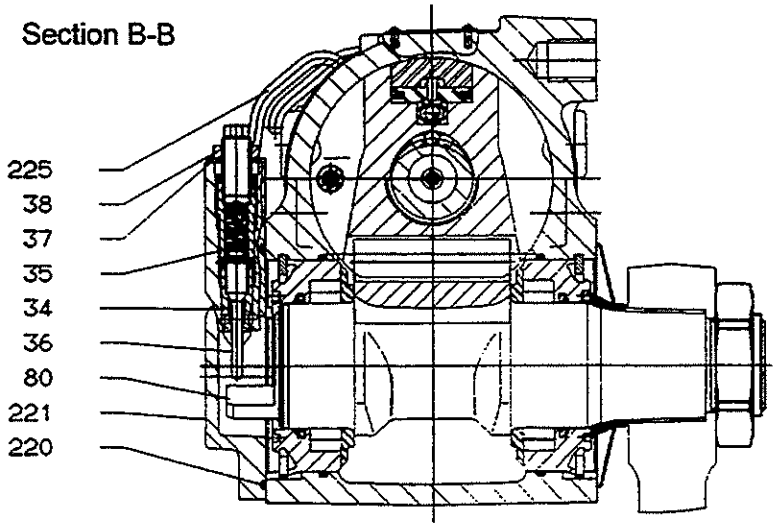
Version with gasket (51.2)

Section B-B

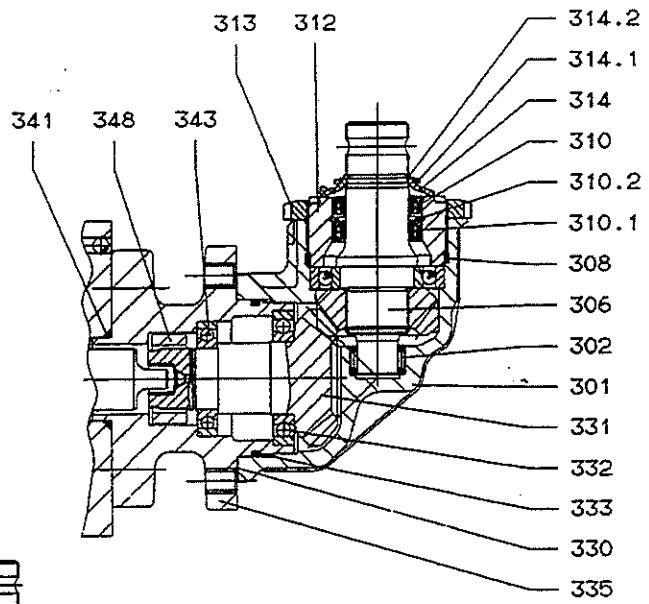


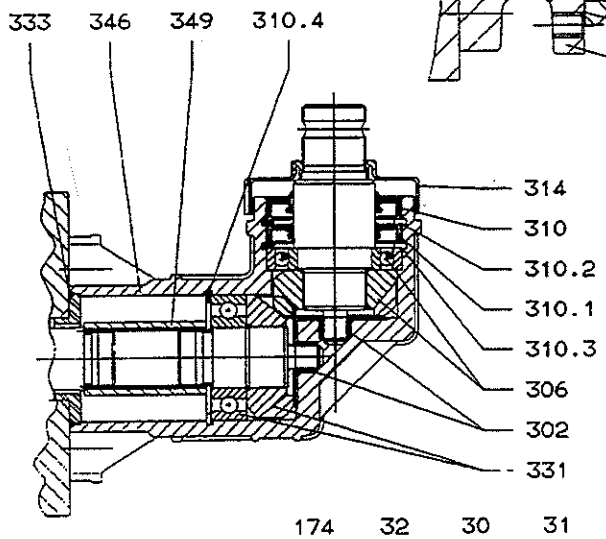
Dual–circuit version with steering limiter in housing cover (221)

Section B-B



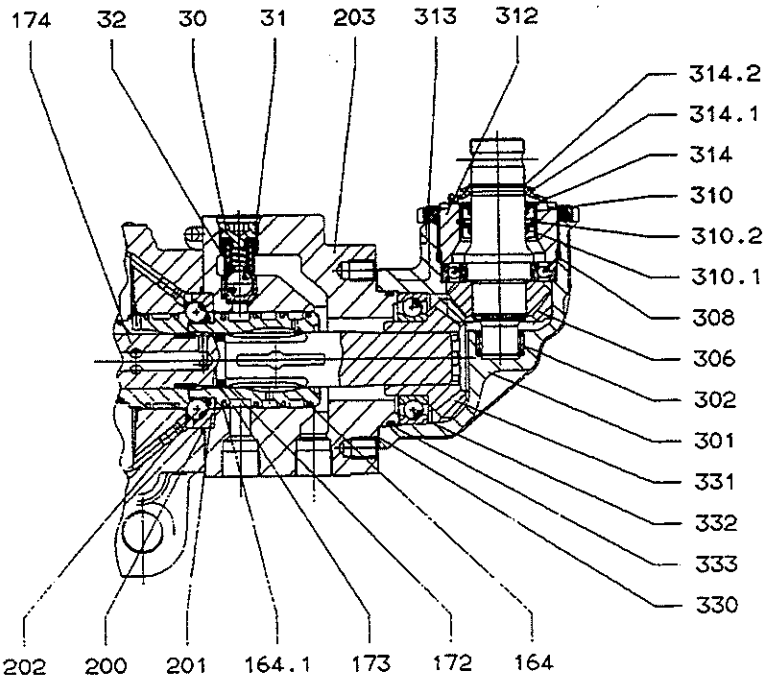
Bevel box with cross disc (348)

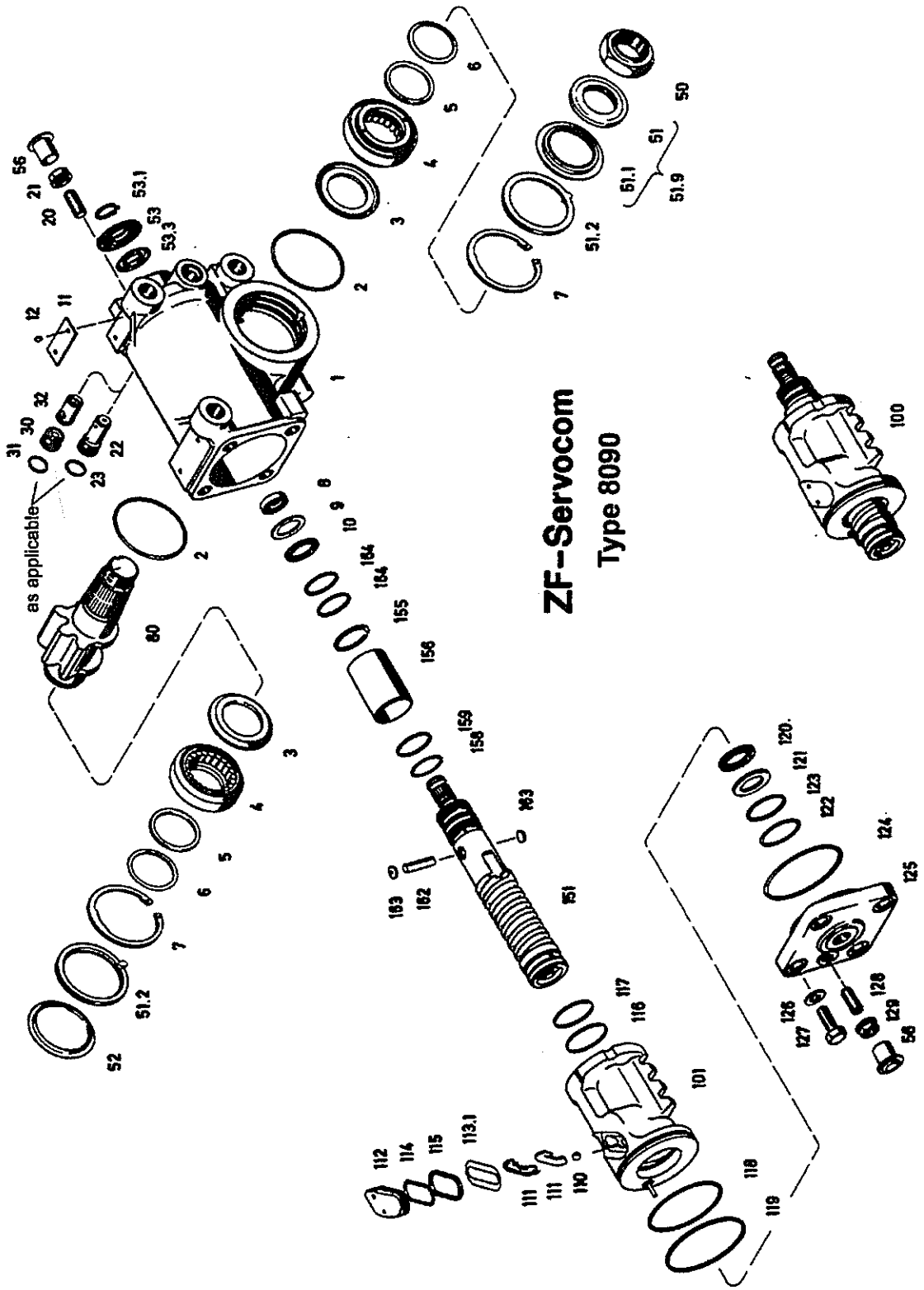


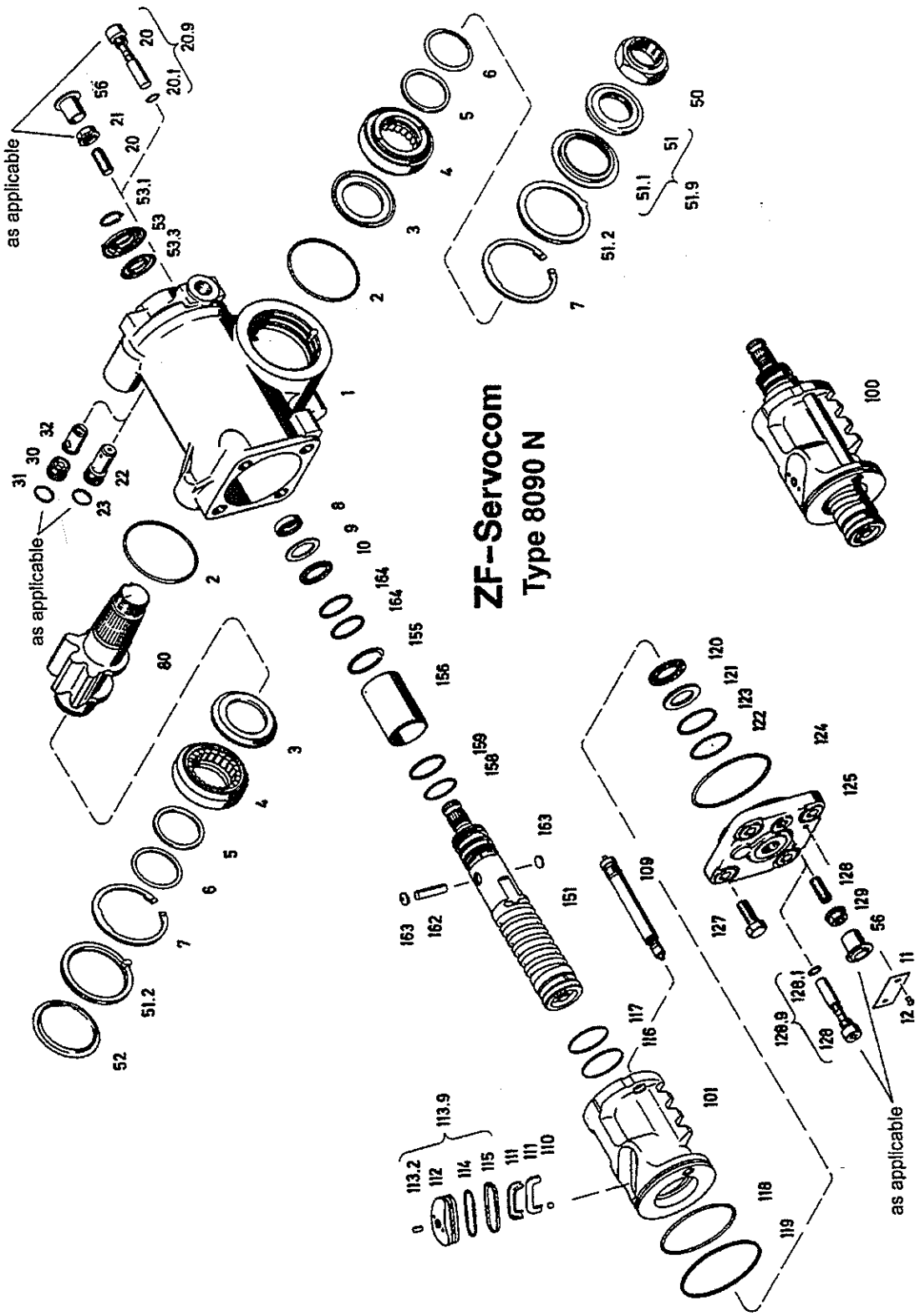


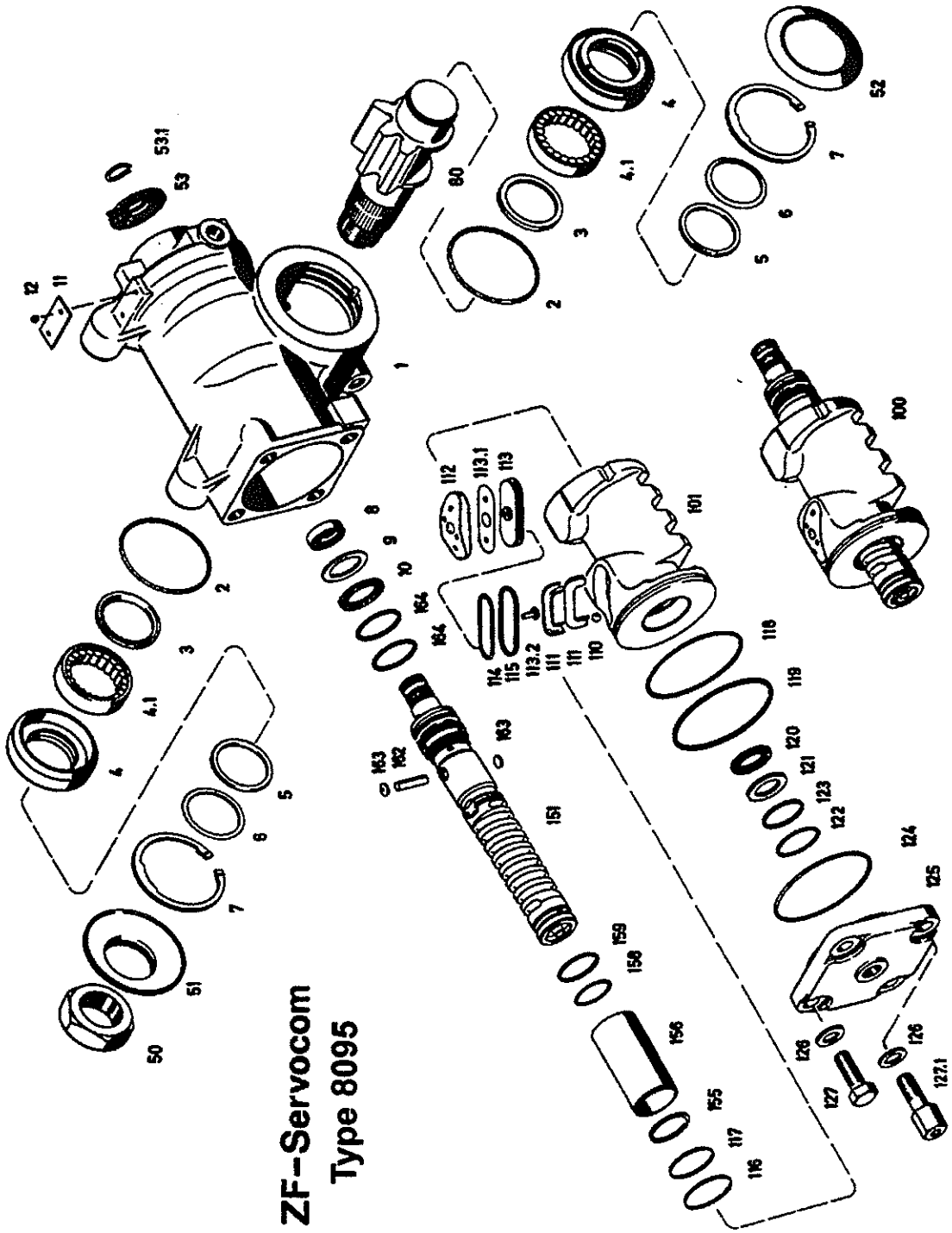
Bevel box with coupling sleeve (349)

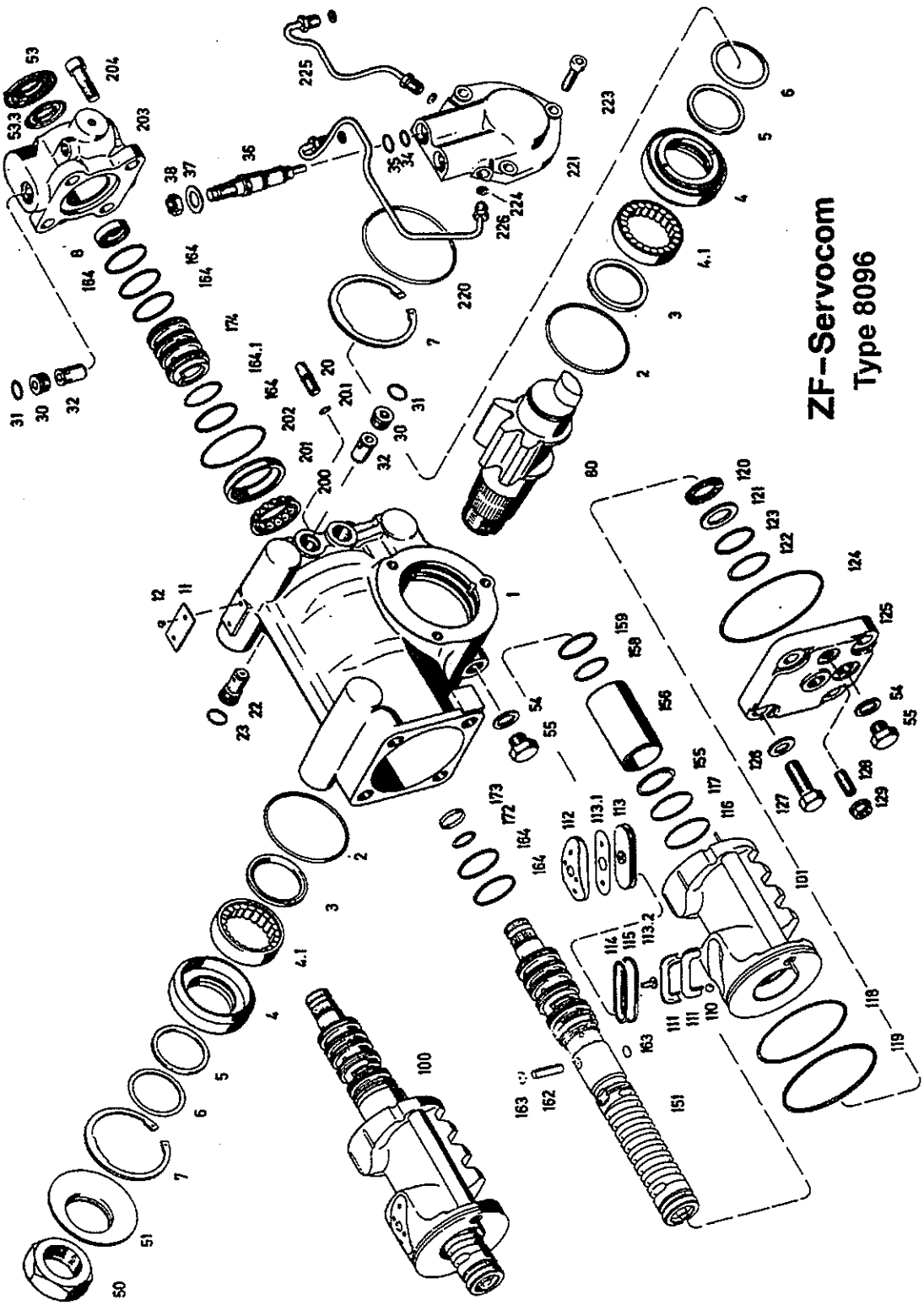
Dual–circuit version with bevel box

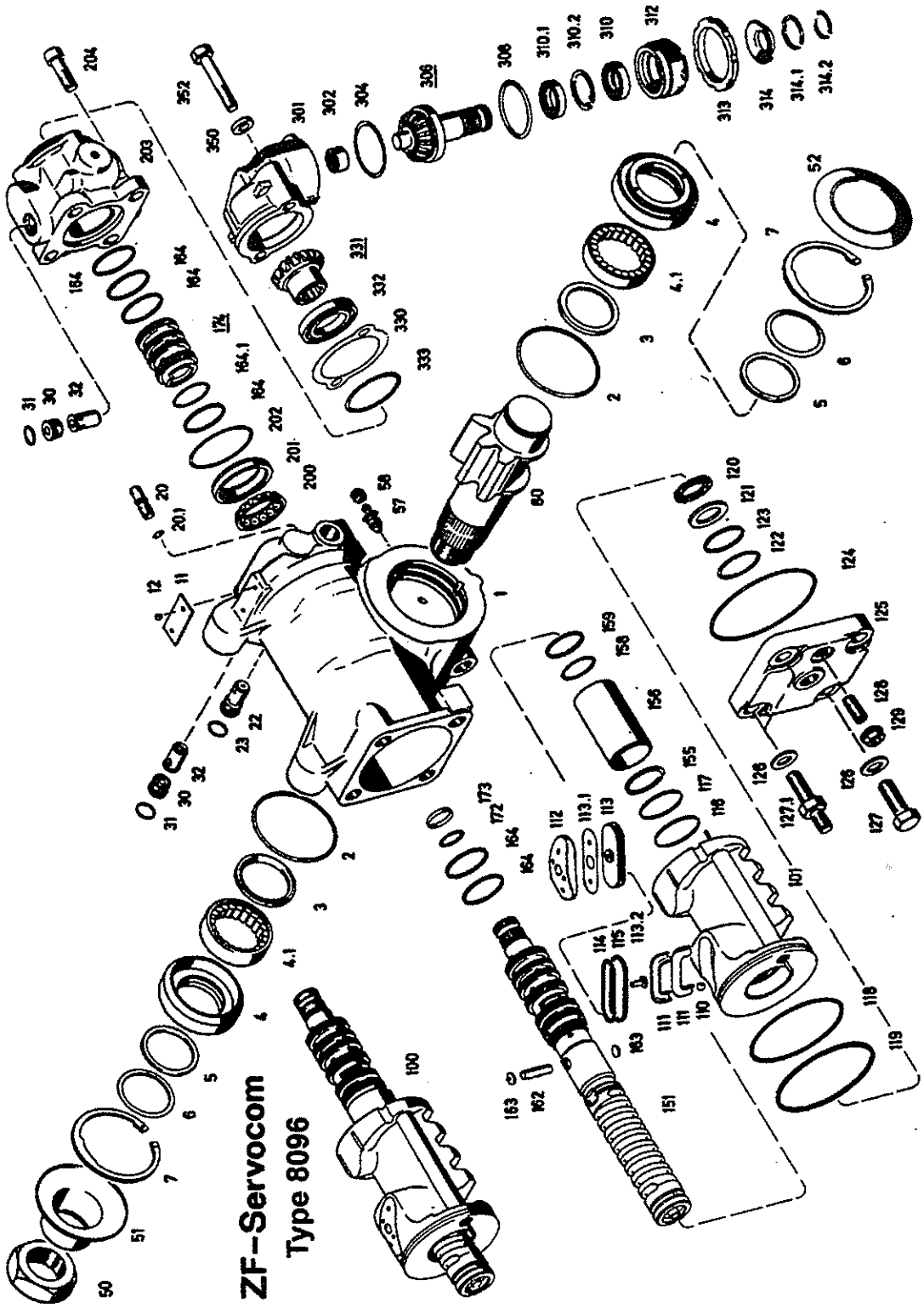


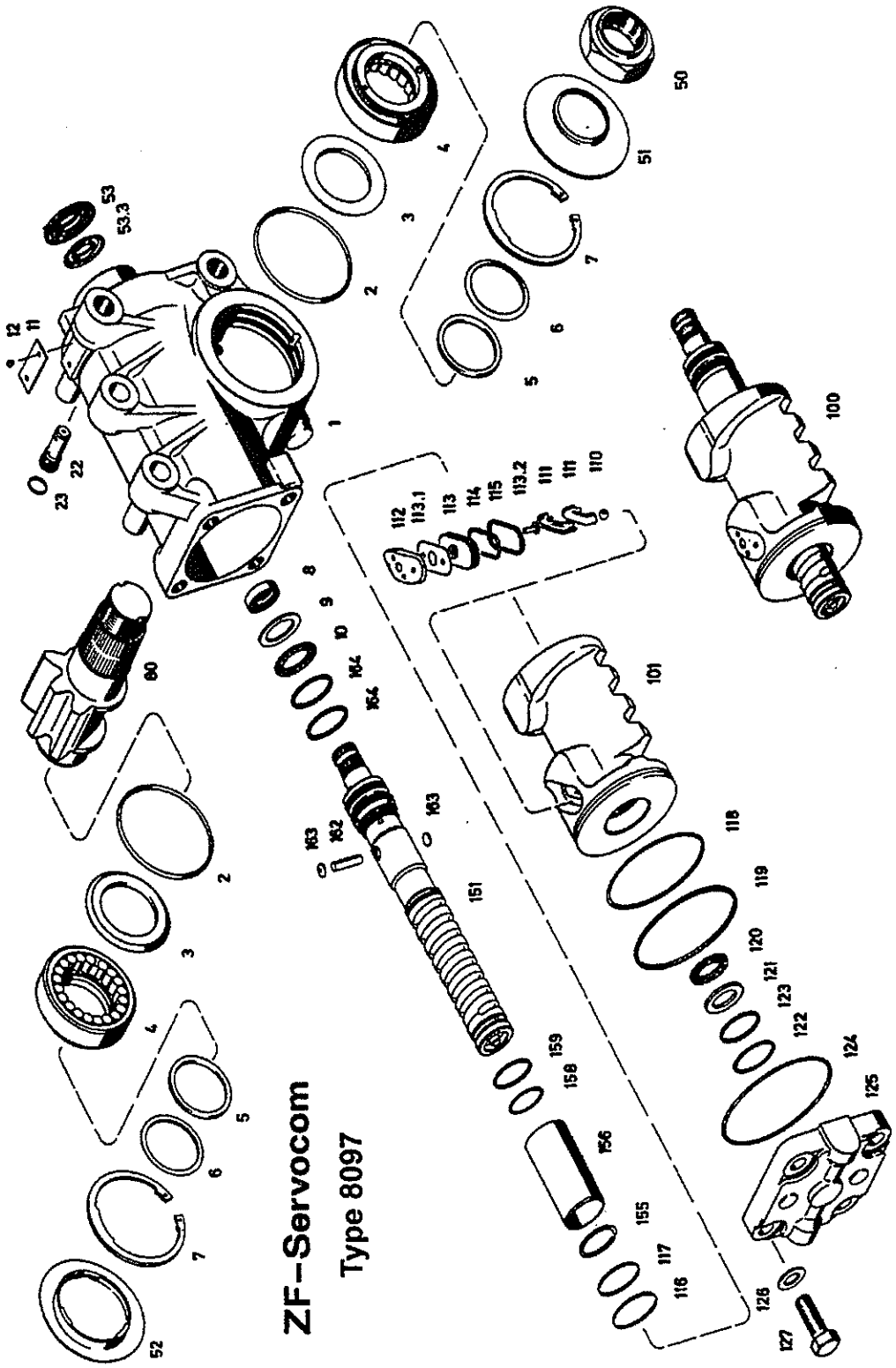

ZF-Servocom
Type 8090
as applicable

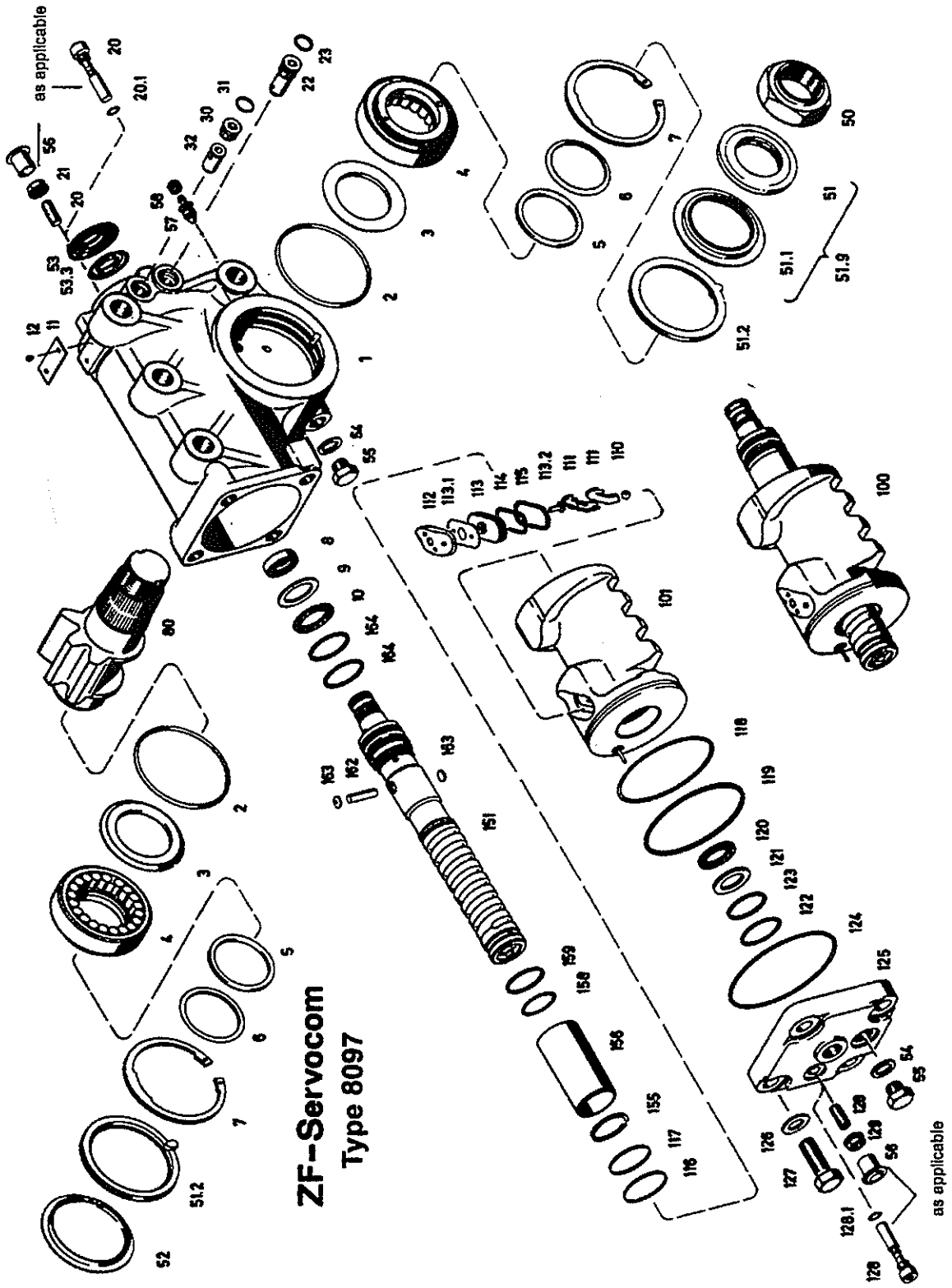

ZF-Servocom
Type 8090 N
as applicable
as applicable
as applicable

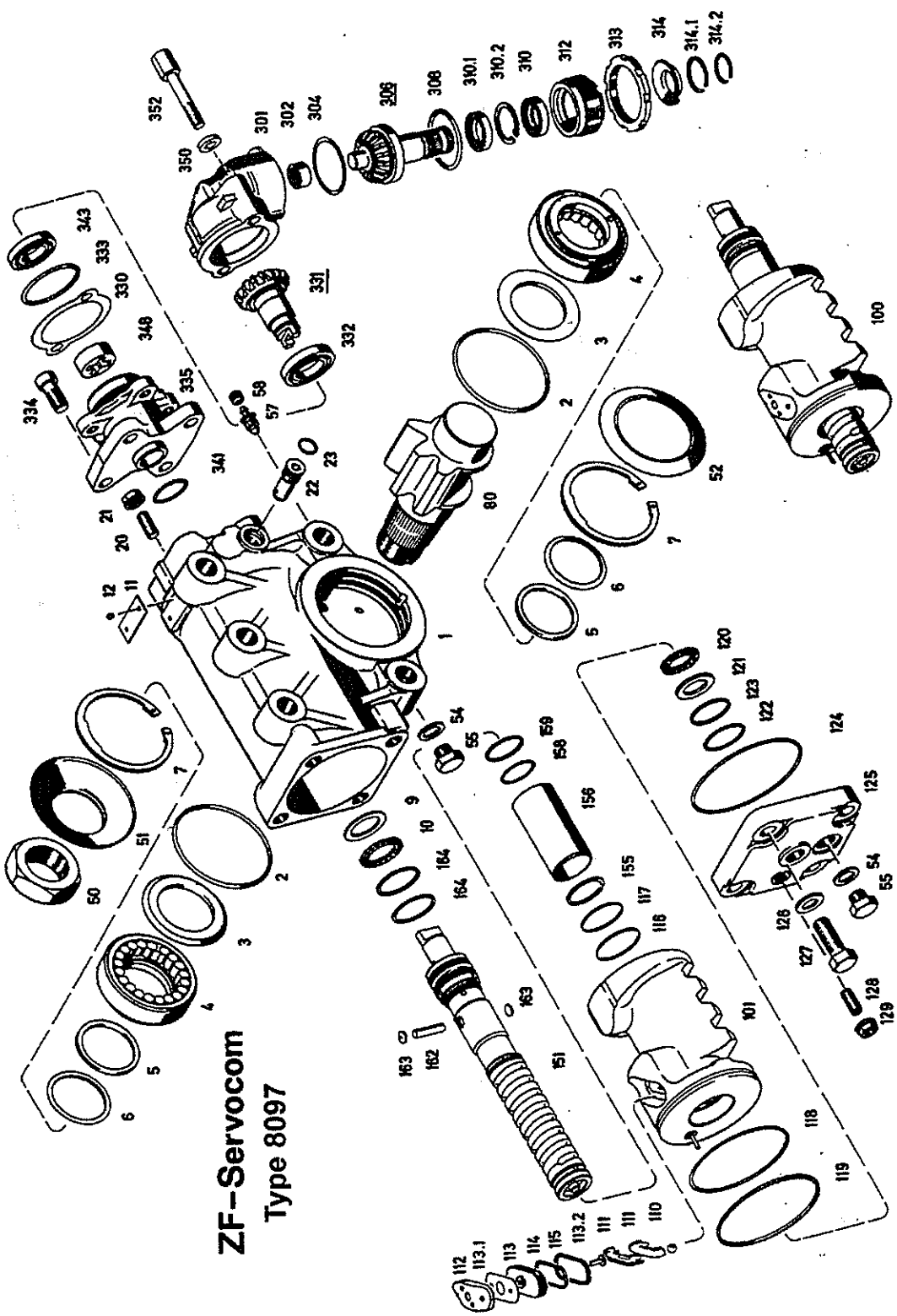

ZF-Servocom
Type 8095

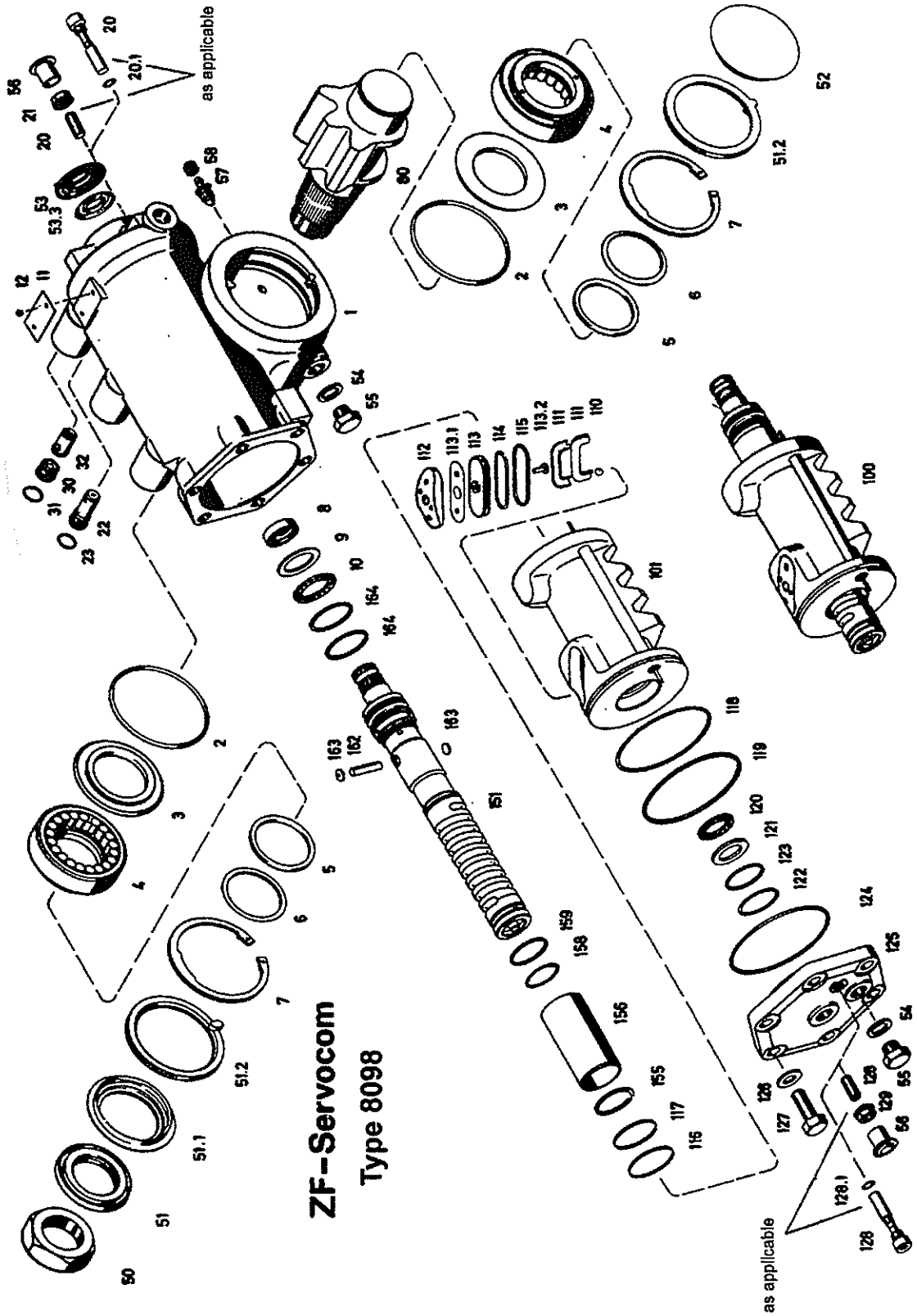

ZF-Servocom
Type 8096

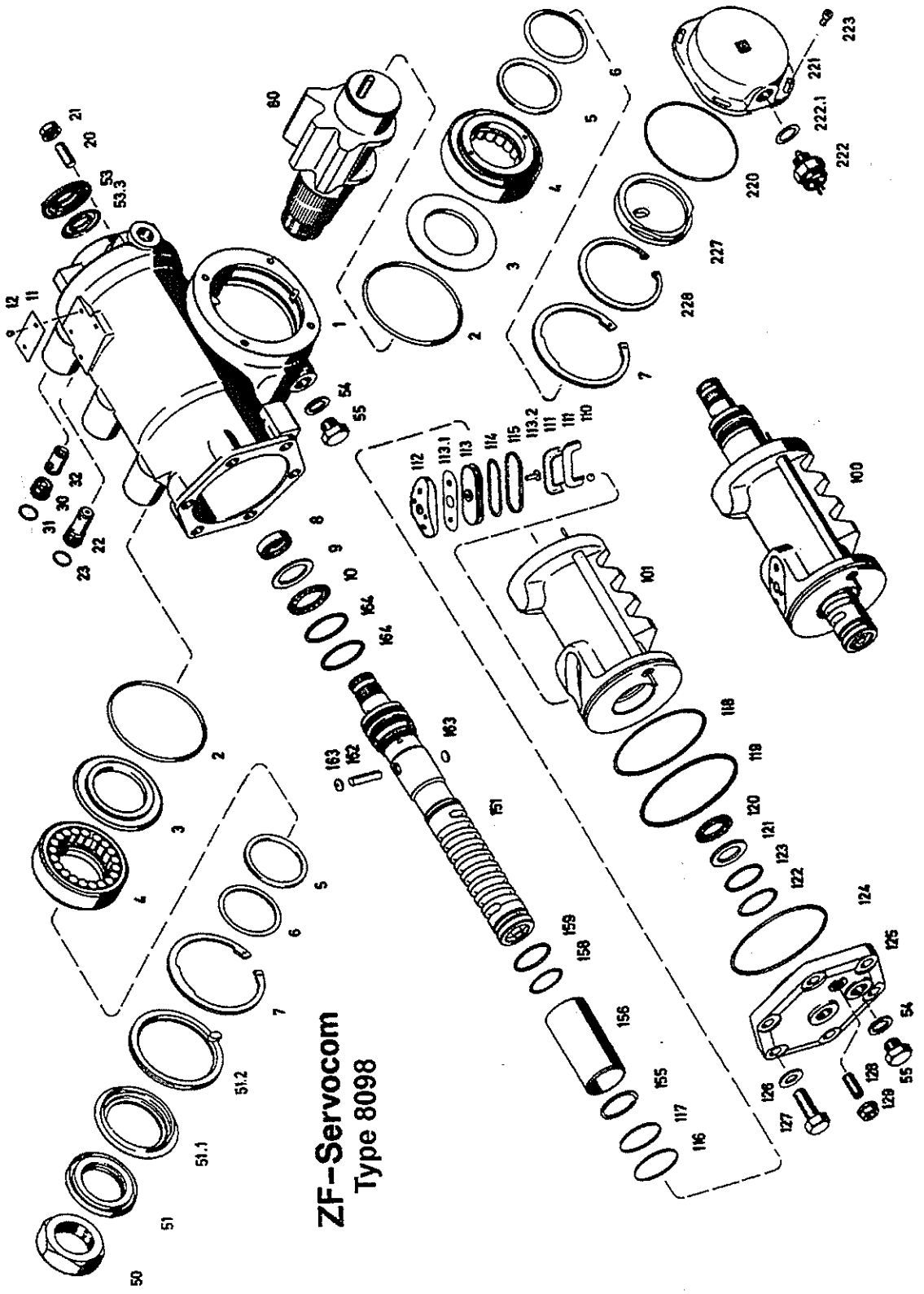

ZF-Servocom
Type 8096

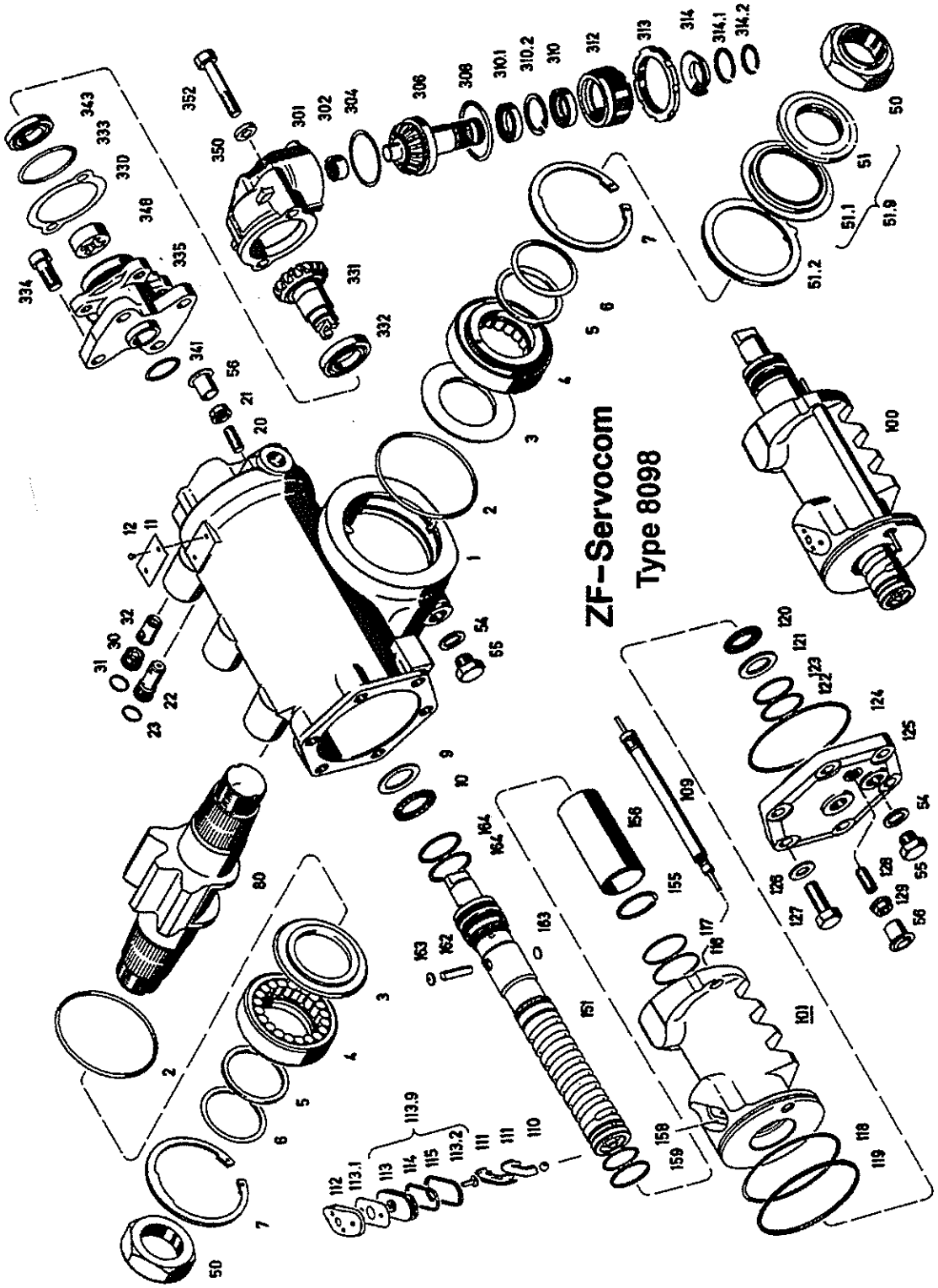

ZF-Servocom
Type 8097

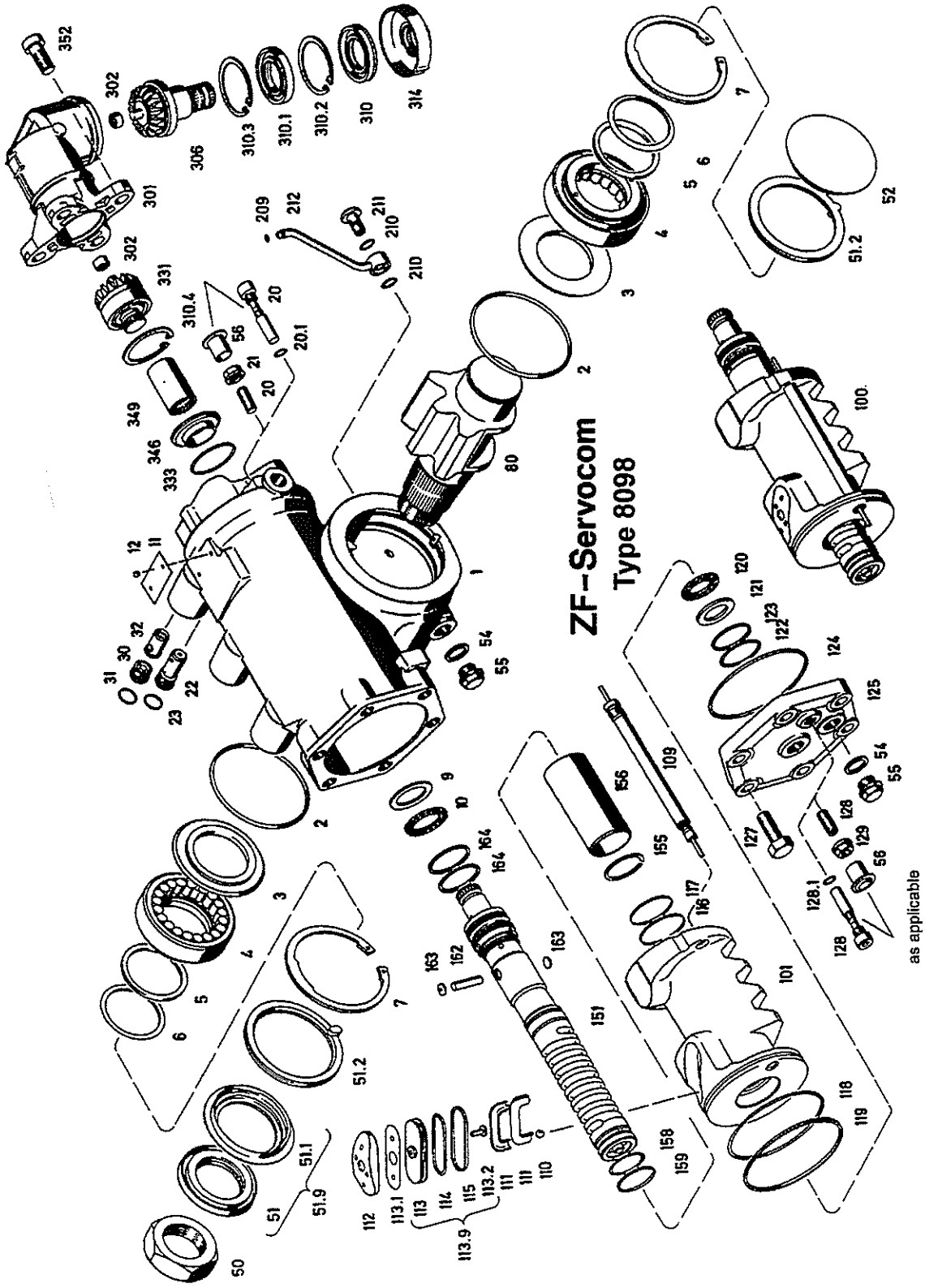

ZF-Servocom
Type 8097
as applicable
as applicable

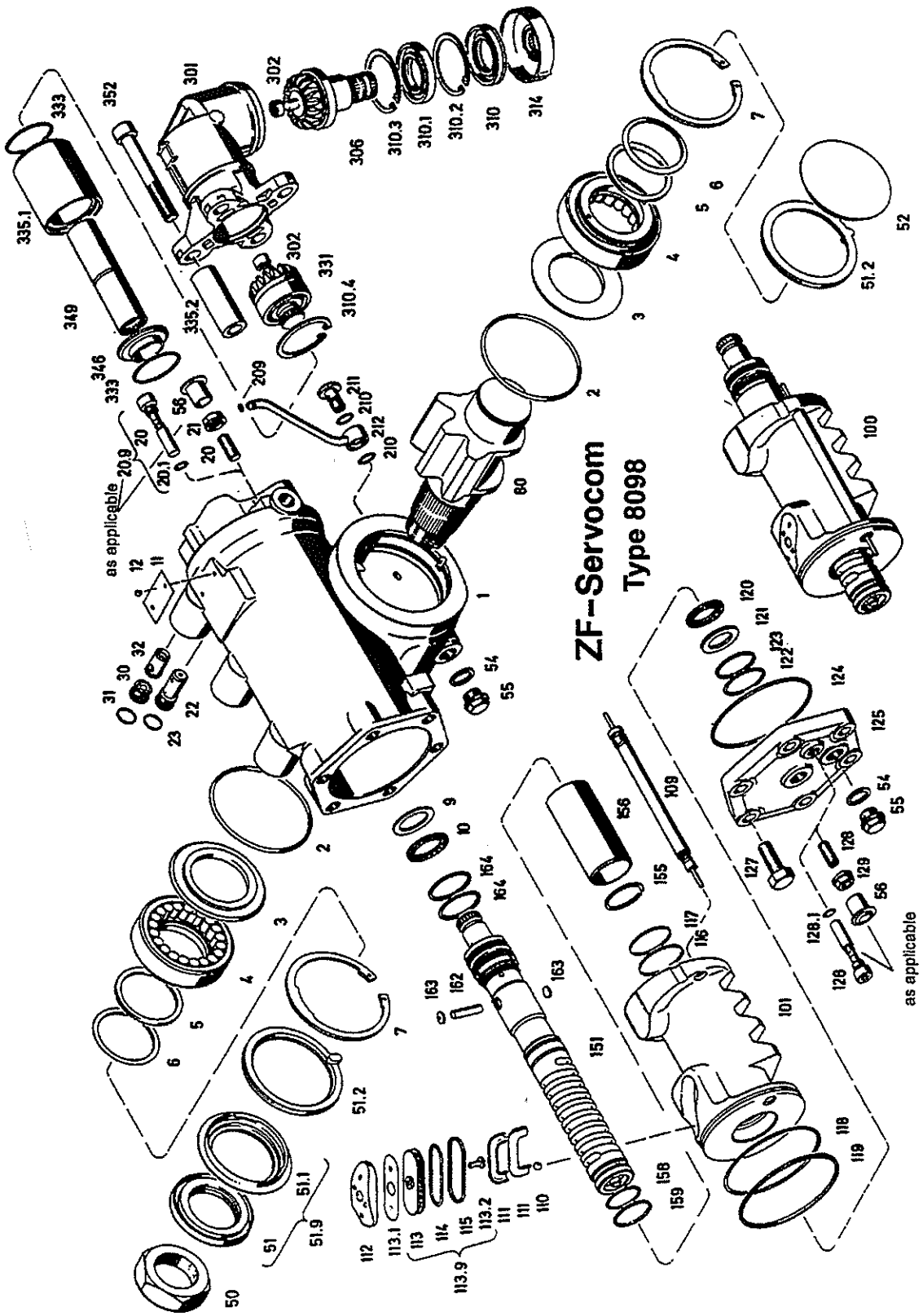

ZF-Servocom
Type 8097

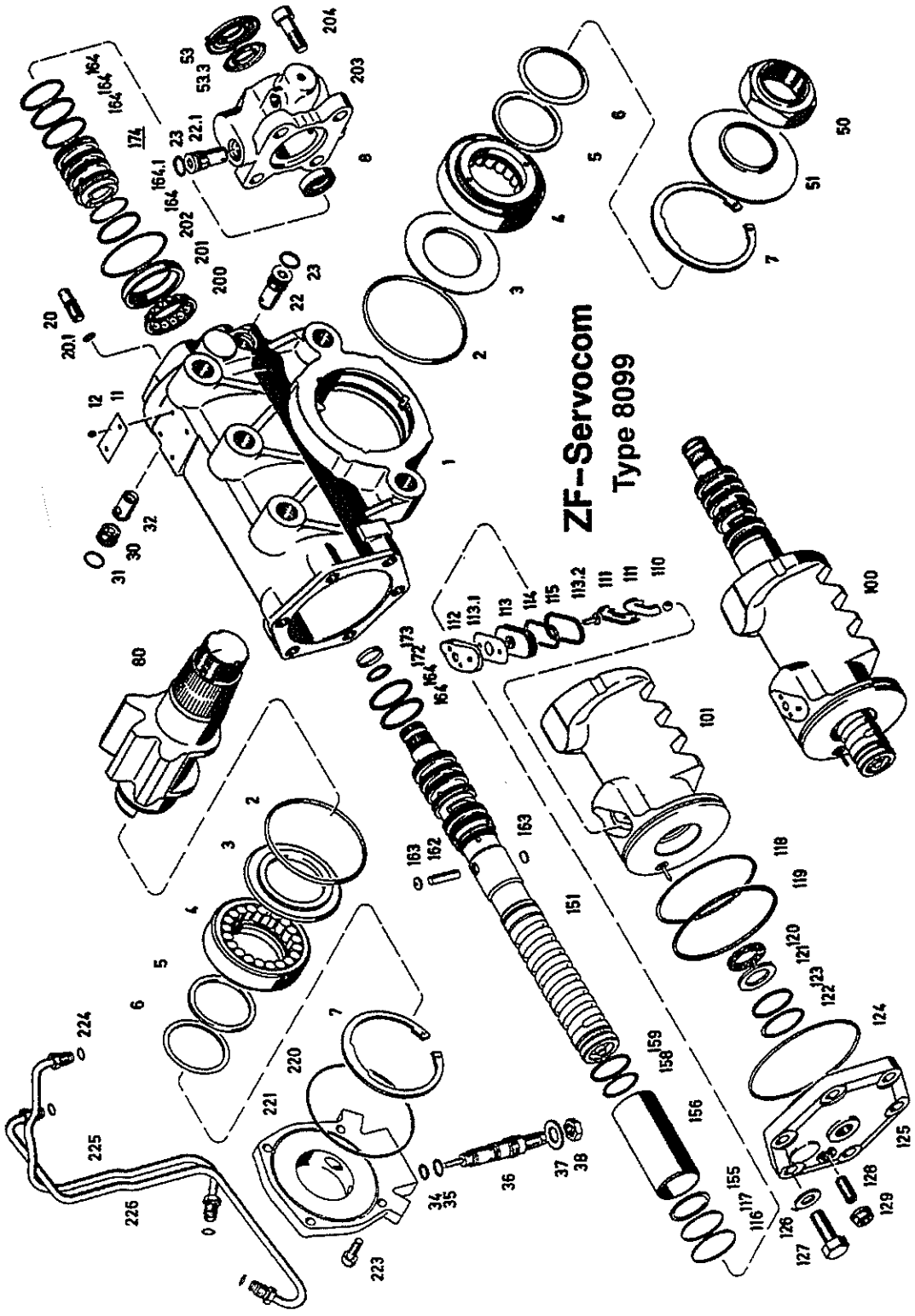

ZF-Servocom
Type 8098
as applicable
as applicable

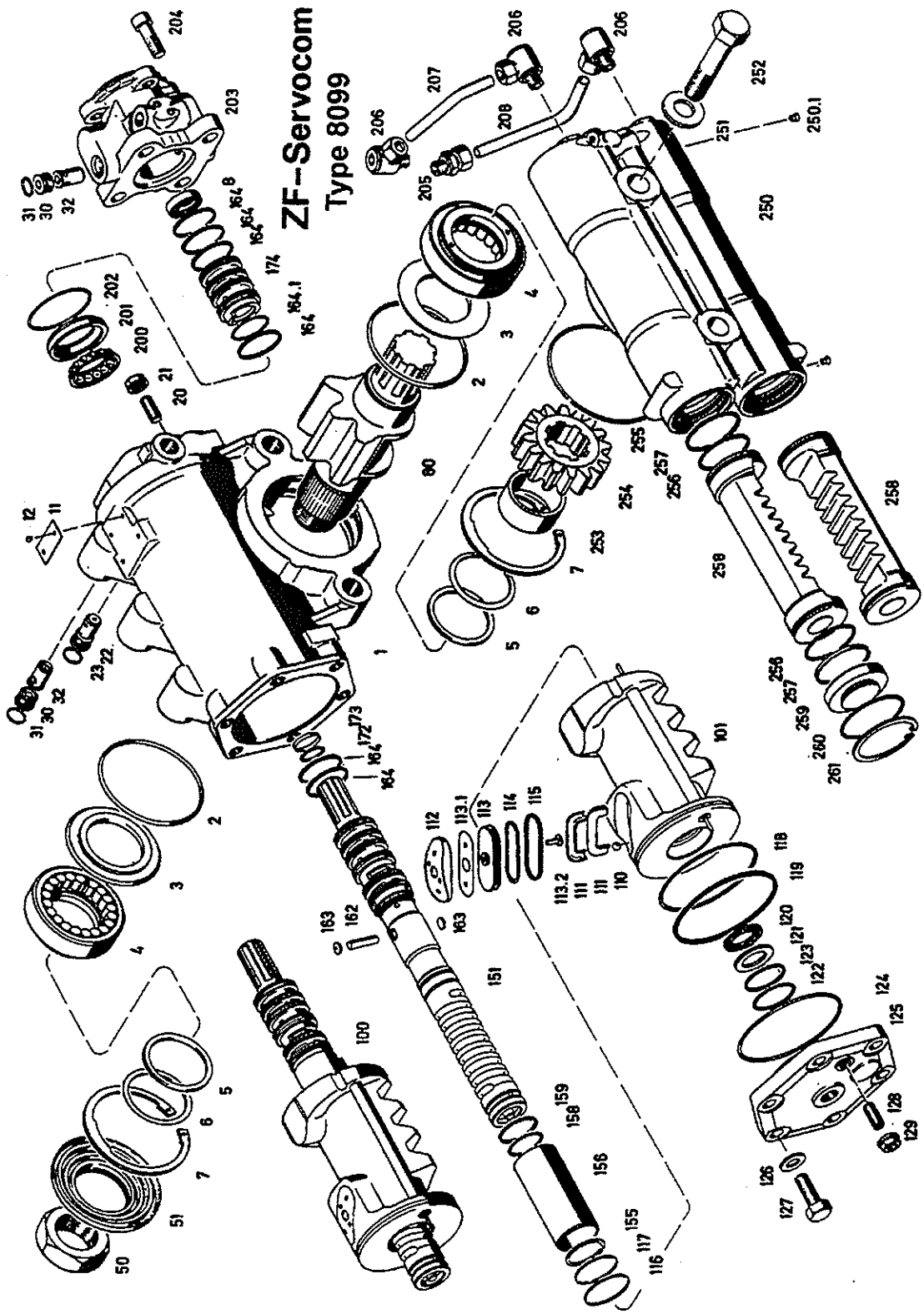

ZF-Servocom
Type 8098


ZF-Servocom
Type 8098


ZF-Servocom
Type 8098
as applicable


ZF-Servocom
Type 8098
as applicable
as applicable


ZF-Servocom
Type 8099


ZF-Servocom
Type 8099