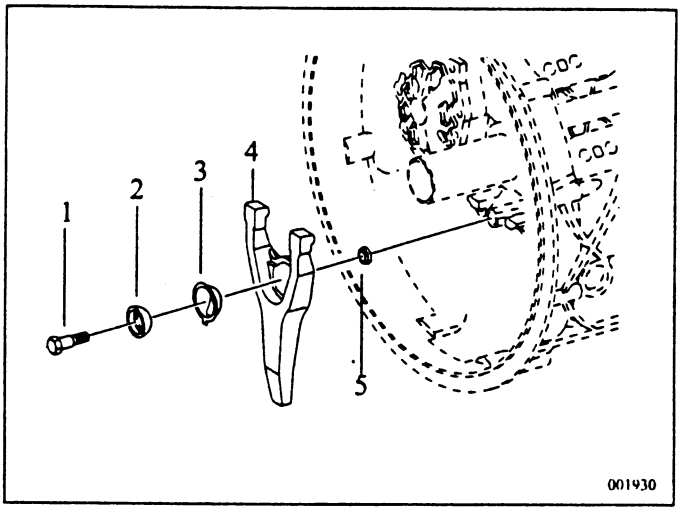
# Removal/Clutch housing 16 S 221

## 3 Removal of clutch housing components

### 3.1 Release fork

1 Remove bolt (1), bush (2) and ball cup (3).

2 Remove release fork (4) and pressure disc (5).




### 3.2 Connection plate with integrated pump Versions A and B

1 Unscrew hex bolts and nuts from connection plate (1) and pump cover (2).

2 Remove connection plate (1) with pump/pump cover (2).

3 Remove washer (8), spacer ring (9) and washer (10) from connection plate or input shaft.

4 Remove gasket (3).

5 Using plastic rod, drive out shaft sealing ring (4).

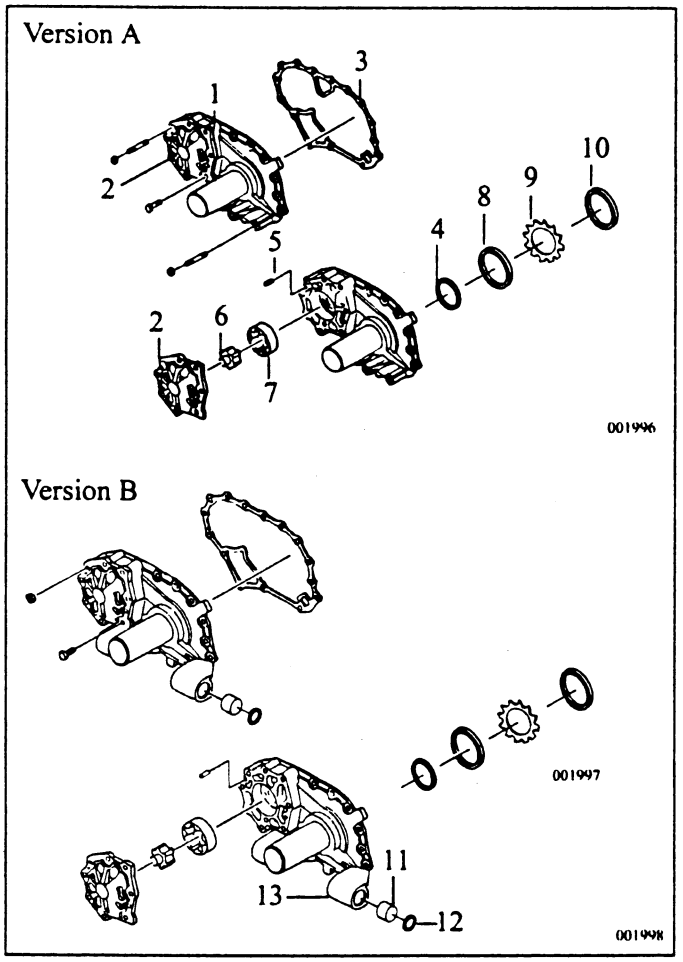
6 Lever pump cover (2) off connection plate (1). Drive cylindrical pin (5) out of pump cover or connection plate.

7 Remove pump shaft (internal rotor 6 and external rotor 7).

8 Remove shim for input shaft and layshaft.

Steps 1 to 8 are identical for **versions A and B.**

9 For version B, remove bush (11) and sealing ring (12) from bearing (13).



# 16 S 221 Removal/Clutch housing

## 3.3 Clutch housing

**⚠ DANGER**
**Ensure mounting brackets and rope are firmly connected.**

1 Remove 13 hex bolts from inside and 9 hex bolts from outside.

2 Fix two hooks 1X56 136 564 to clutch housing.

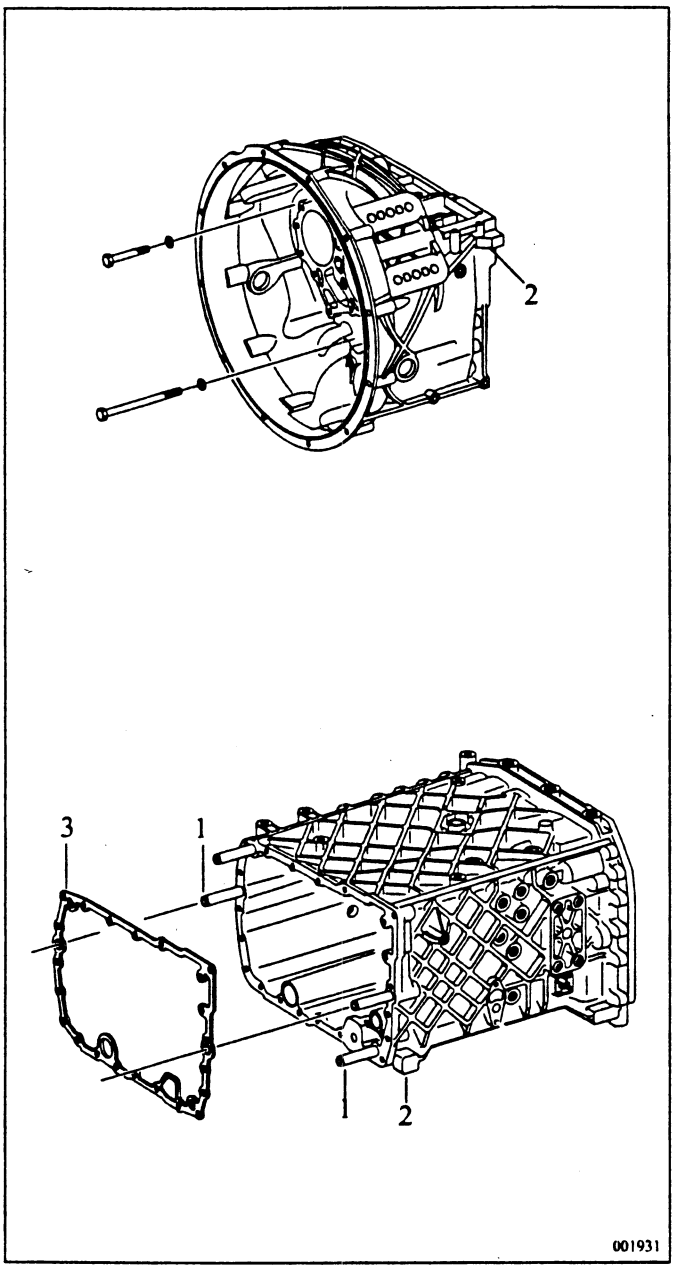
3 Exert tension on mounting brackets.

Hint: The clutch housing is positioned on housing section 2 using 4 cylindrical pins (1). Ensure clutch housing is level before separating from housing section 2.

4 Hit sidebars (2) of housing section 2 and clutch housing using plastic hammer.

**CAUTION**
Do not insert any lever between the housing sealing faces.

5 Remove clutch housing and take off gasket (3).



# Removal/Selector rods/Mid-housing 16 S 221

## 4 Removal of components

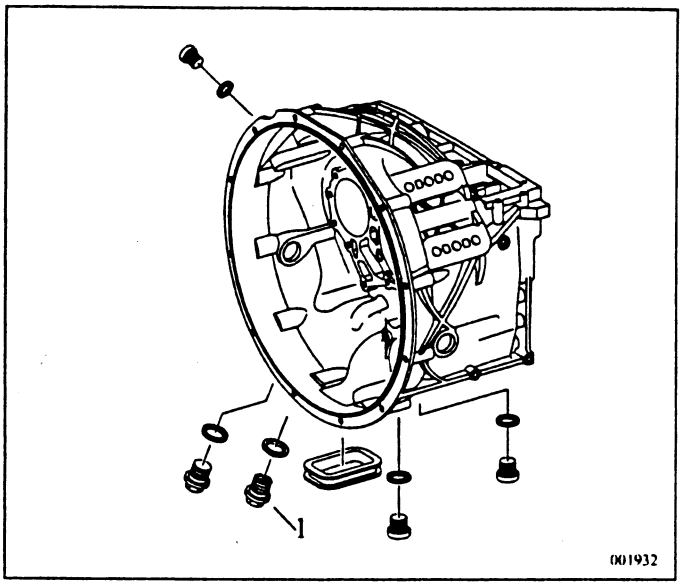
### 4.1 Removal of components/clutch housing

1 Remove all plugs and seals.

2 Remove magnetic screw plug (1) and clean.

3 Replace sealing cap if required.

4 Drive tapered roller bearing outer rings for input shaft and layshaft from clutch housing if required.




### 4.2 Splitter group selector rods/housing section 2

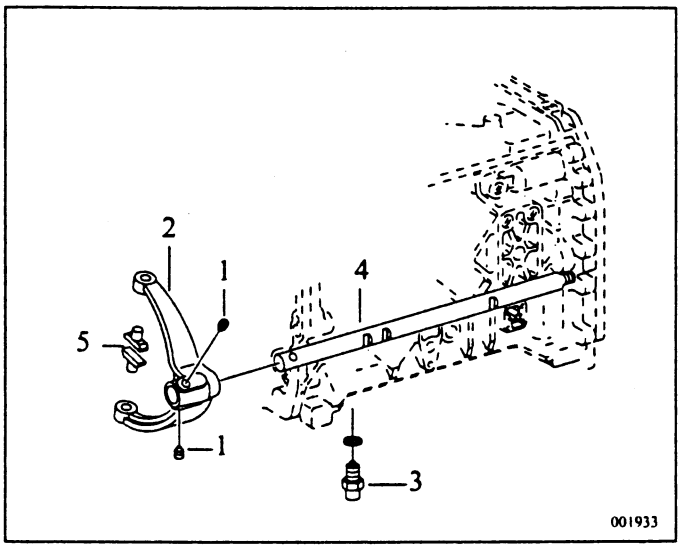
1 Remove grub screws (1) from selector fork (2).

2 Remove detent plunger (3) for splitter group selector rods.

3 Drive selector rod (4) towards the output end to remove it from shift fork (2).

4 Remove selector fork (2) and fulcrum pads (5) from selector rod (4).

5 Remove selector rod (4).



## 16 S 221 Removal/Mid-housing

### 4.3 Removal of shafts

For Steps 1 - 6, see Section 4.4

⚠ **DANGER**
Ensure mounting brackets and rope are firmly connected.

1 Unscrew cover (9) together with gasket.

2 For first transmission version, remove locking bolt (1) and washer (2).

3 Using rod, drive pin (3) out of housing section 2 towards output end.

4 Remove reverse idler (4) and needle cages (5).

5 Remove screw plug (6) and sealing ring.

6 Screw locking bolt (1X56 137 287) into empty threaded hole in housing. This forces interlock locking pin (7) back against spring pressure.

7 Position lifting device (17) 1X56 137 122 over input shaft (18), shift rods (19) and onto layshaft (21) using centring ring 1X56 137 921. Position disc 1X56 137 933 between lifting device and layshaft. Insert holding device (20) 1X56 137 918 onto lifting device and fit onto shift rod.

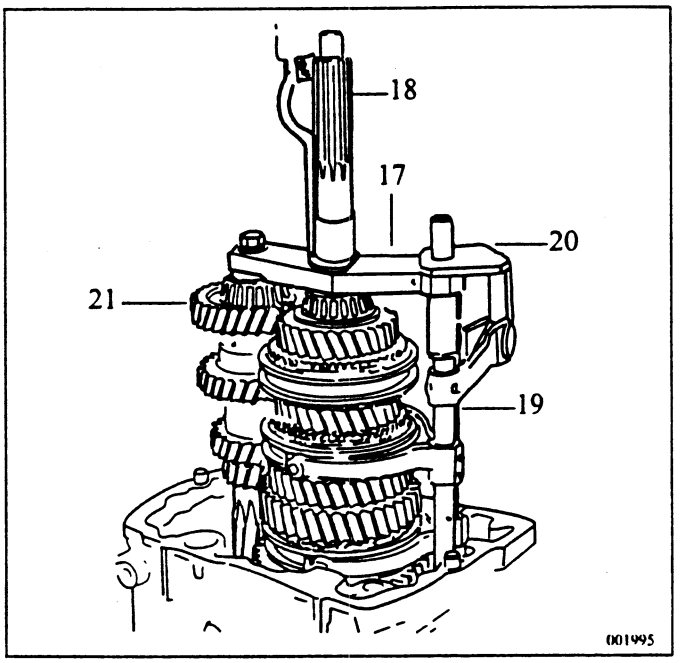
8 Screw layshaft (21) tightly onto lifting device (17). Tightening torque = 85 Nm.

9 Pull shafts and shift rod out of housing section 2 without twisting and lower carefully.

10 Remove lifting device (17) and accessories.

11 Remove fulcrum pads from selector forks.

**NOTE:** Do not dismantle shift rods any further. In this condition they form a complete unit.




### 4.4 Removal of components/housing section 2

1 Unscrew locking bolt 1X56 137 287 and remove locking pin (7) and pressure spring (8).

2 Remove all screw plugs and seals, connecting plugs and pins and filler necks and seals.

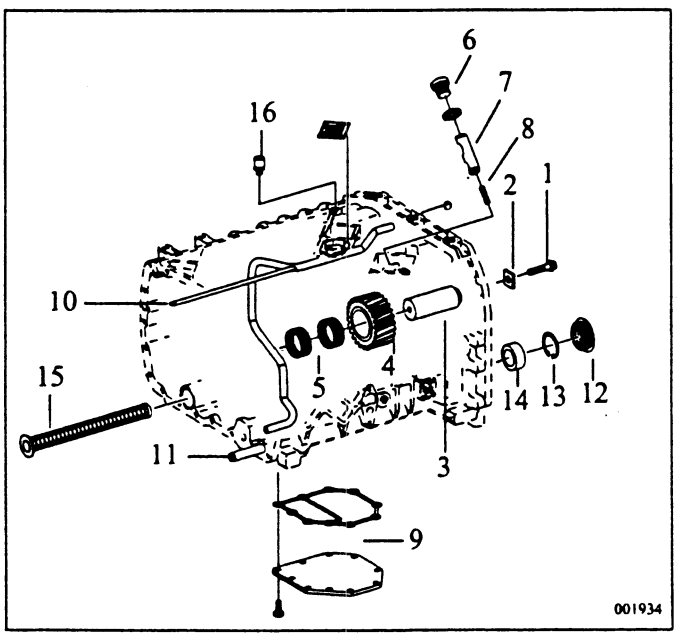
3 Remove spray tube (10), type-plate and cylindrical pins (11).

4 Remove cap collar (12), circlip (13) and bearing bush (14).

5 Remove roller bearing outer rings for main shaft and layshaft from housing section 2. Remove towards inside of housing.

6 Clean filter (15) or replace.

7 Remove breather (16).



# Removal/Input shaft 16 S 221

## 4.5 Input shaft

### 4.5.1 Disassembly of input shaft

1 Remove complete input shaft unit from main shaft. Hint: Stand input shaft in tube section of connection plate.

2 Remove clutch body (1) and synchronizer ring (2) from input shaft synchronizer or main shaft.

3 Remove ring (6) from inside of clutch body.

4 Pull sliding sleeve (3) off input shaft.

**⚠ DANGER**
**Pressure pieces are spring-loaded. Prevent pressure pieces from jumping out.**

Collect pressure pieces (4) and pressure springs (5).

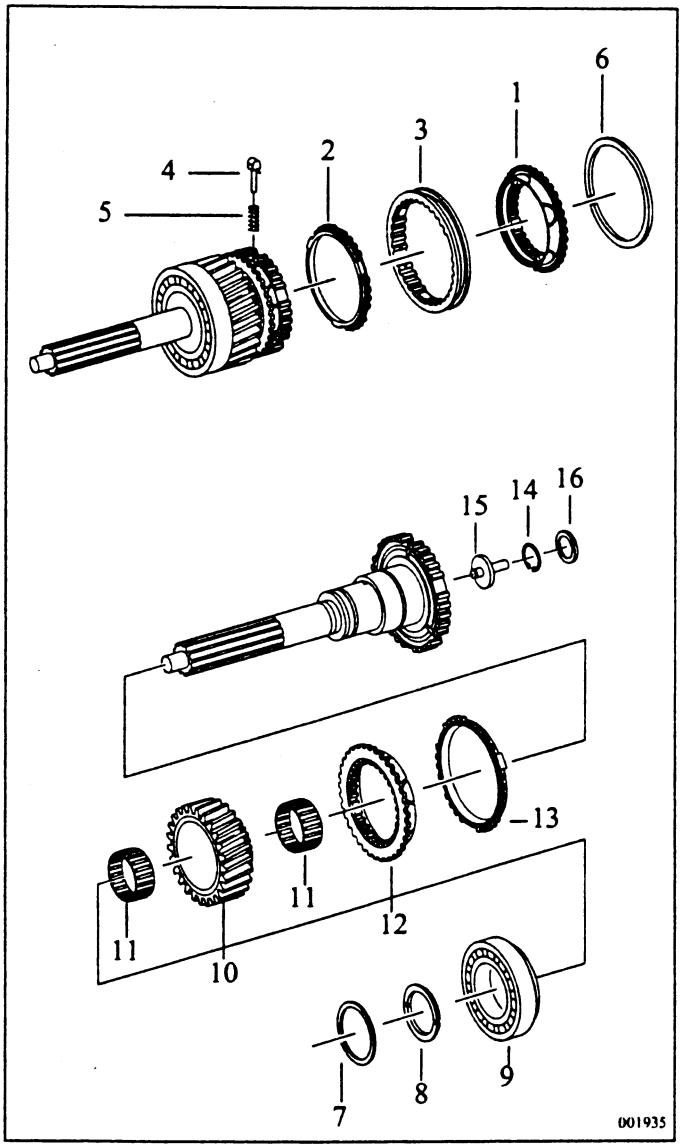
5 Loosen retaining ring (7) and remove. Remove split ring (8).

6 Pull roller bearing inner ring (9) from input shaft using gripping tool 1X56 136 722, extension piece 1X56 122 310, threaded tool 1X56 122 303 and basic tool 1X56 122 304. Slide gripping tool 1X56 136 722 over roller bearing inner ring until firmly seated against rollers and tighten using knurled ring.

7 Remove helical gear (10) and needle cages (11) from input shaft.

8 Remove clutch body (12) and synchronizer ring (13) from input shaft.

9 Remove oil baffle plate (16), unclip circlip (14) and remove pipe (15) from the input shaft.



## 16 S 221 Assembly/Input shaft

### 4.5.2 Assembly of input shaft

1 Check wear limits of synchronizer components (see Section 6, Synchronizers/wear limits).

2 Place pipe (1) into input shaft and clip circlip (2) into annular groove. Press new oil baffle plate (16) into the input shaft using punch 1X56 137 979.

3 Place synchronizer ring (4) and clutch body (3) onto input shaft.

**NOTE:** Lugs of synchronizer ring must locate in recesses in synchronizer body section of input shaft.

4 Lightly oil the running faces of both needle cages (11) and push onto input shaft.

5 Push helical gear (12) over needle cages.

**NOTE:** Engaging gears of helical gear must point towards output and mesh with internal gearing of clutch body.

6 Heat roller bearing inner ring (13) to approx. 100° C and push onto input shaft. Ensure seating is correct when roller bearing cools.

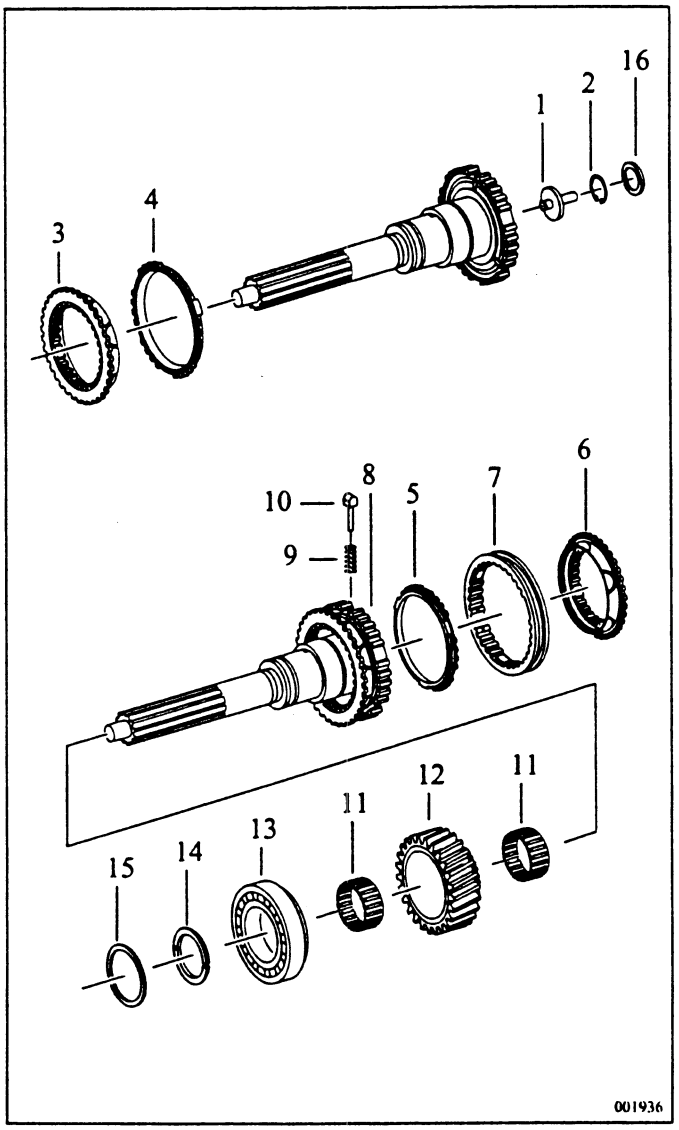
7 Using special tool 1X56 136 573, insert split ring (14) into annular groove. Set play between 0.05 mm end float and 0.05 mm pre-load.

8 Push new locking ring (15) onto split ring. Ensure split ring is firmly seated. Secure locking ring at three points.

9 Place sliding sleeve (7) onto synchronizer body section (8) and locate correctly. Insert new pressure springs (9) and pressure pieces (10) into synchronizer body section (8) and, using appropriate tool, fit into sliding sleeve (7).

10 Place synchronizer ring (5) and clutch body (6) onto input shaft.

11 Move sliding sleeve into centre position. Push against clutch body (6). You should clearly hear the pressure pieces clicking into place.



# Removal/Main shaft 16 S 221

## 4.6 Main shaft

### 4.6.1 Disassembly of main shaft

**CAUTION**

Do not damage main shaft. Always use aluminium clamping jaws when clamping main shaft in vice or other clamping equipment.

1 Clamp main shaft in vice at output end.
Hint: Use special tool 1X56 137 200 to position and rotate main shaft. Remove the oil tube before doing this.

2 Remove locking ring (1) and split ring (2).

3 Slide gripping tool 1X56 136 743 over bearing inner ring (3) and tighten firmly against bearing rollers using knurled ring. Place suitable pressure piece on main shaft. Screw on basic tool 1X56 122 304 and pull off bearing inner ring.

4 Remove axial washer (4).

5 Clamp main shaft in vice with bearing journals on output end.

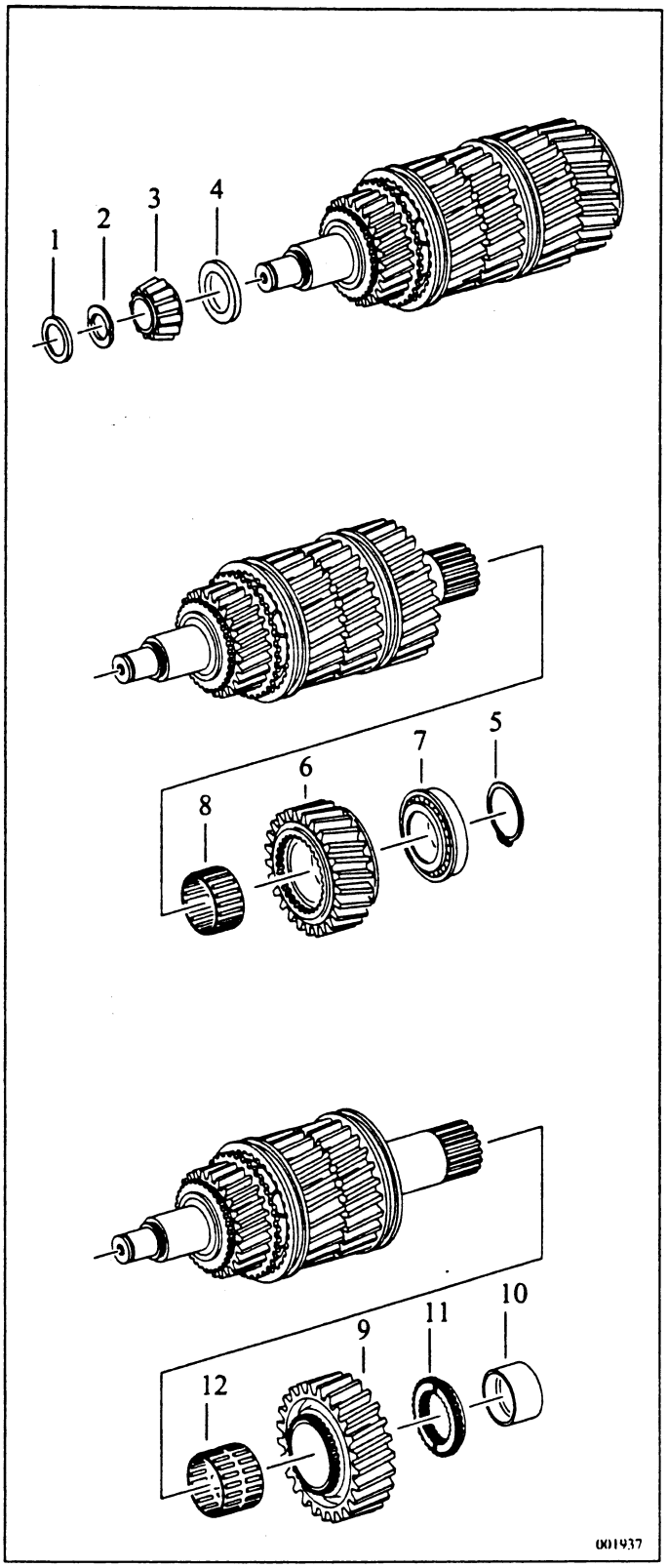
6 Take circlip (5) out of annular groove.

7 Place pressure piece on main shaft (remove spray tube). Grip underside of reverse gear helical gear (6) using 2 or 3-arm pullers and pull off with roller bearing inner ring (7).

8 Remove needle cage (8).

9 Place pressure piece on main shaft. Grip underside of 1st gear helical gear (9) using 2 or 3-arm pullers and pull off with bush (10) and clutch body (11).

10 Remove needle cage (12).



## 16 S 221 Removal/Main shaft

**NOTE:** Dual-cone synchronizers for 1st and 2nd gear. Mark position of pressure pieces in synchronizer body and sliding sleeve using felt-tip pen.

11 Remove clutch disc (13) of dual-cone synchronizer for 1st/5th gear.

12 Remove inner ring (14).

13 Remove intermediate ring (15) from synchronizer.

14 Remove outer ring (16).

15 Pull off sliding sleeve. Use cloth to catch pressure pieces and pressure springs.

16 Remove 3 clutch parts (18) from synchronizer body (19).

17 Place pressure piece on output end of main shaft. Grip underside of 2nd gear helical gear (20) using 2 or 3-arm pullers and pull off helical gear with bush (21), clutch disc (22), inner ring (23), intermediate ring (24), outer ring (25) and synchronizer body (19).

18 Remove needle cage (26).

19 Clamp main shaft at output end.

20 Place pressure piece on input end of main shaft. Grip underside of sliding sleeve (27) using 2 or 3-arm pullers and pull off synchronizer ring (28) together with clutch body (29), roller bearing (30) and helical gear (31).

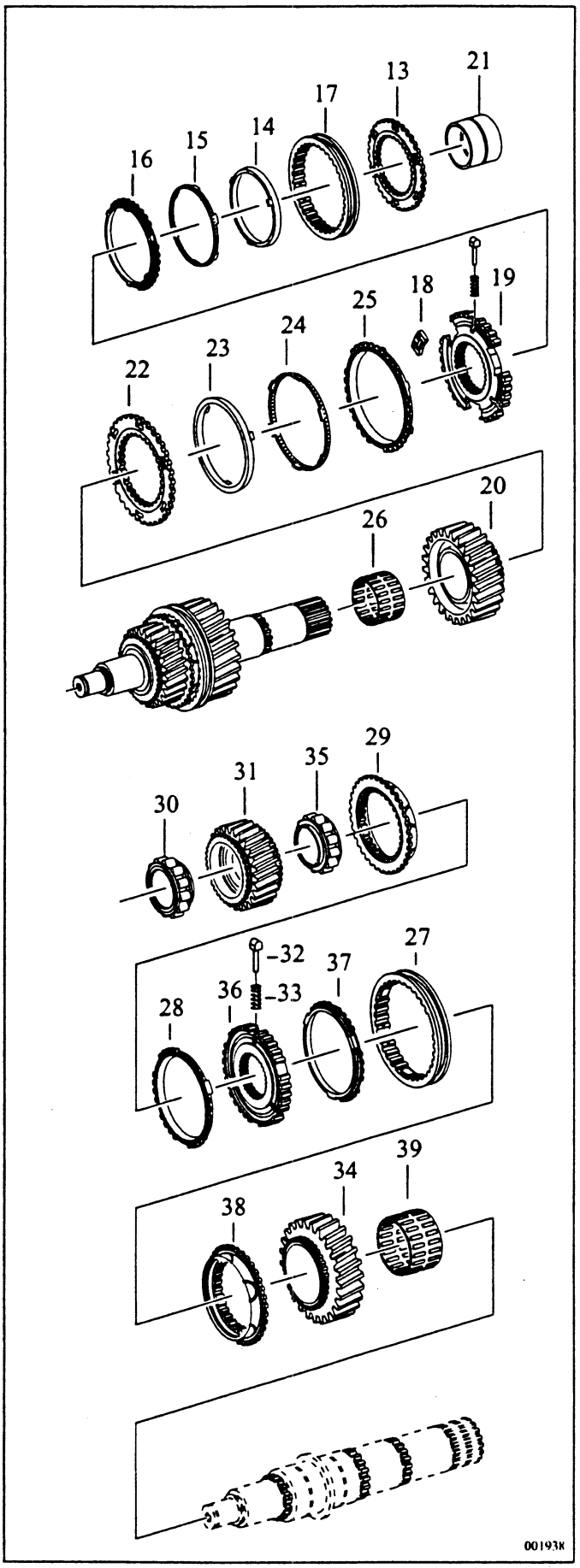
**NOTE:** Catch 3 pressure pieces (32) and 3 pressure springs (33) in a cloth when pulling off sliding sleeve.

21 Remove pressure piece. Grip underside of 3rd gear helical gear (34) with 2 or 3-arm pullers and pull off together with roller bearing (35), synchronizer body (36), synchronizer ring (37) and clutch body (38).

**CAUTION**

Do not support pullers against collar of main shaft.

22 Remove needle cage (39).



### 4.6.2 Synchronizer assembly

**Version ZF-BK**

1 Check wear limits according to Section 6.

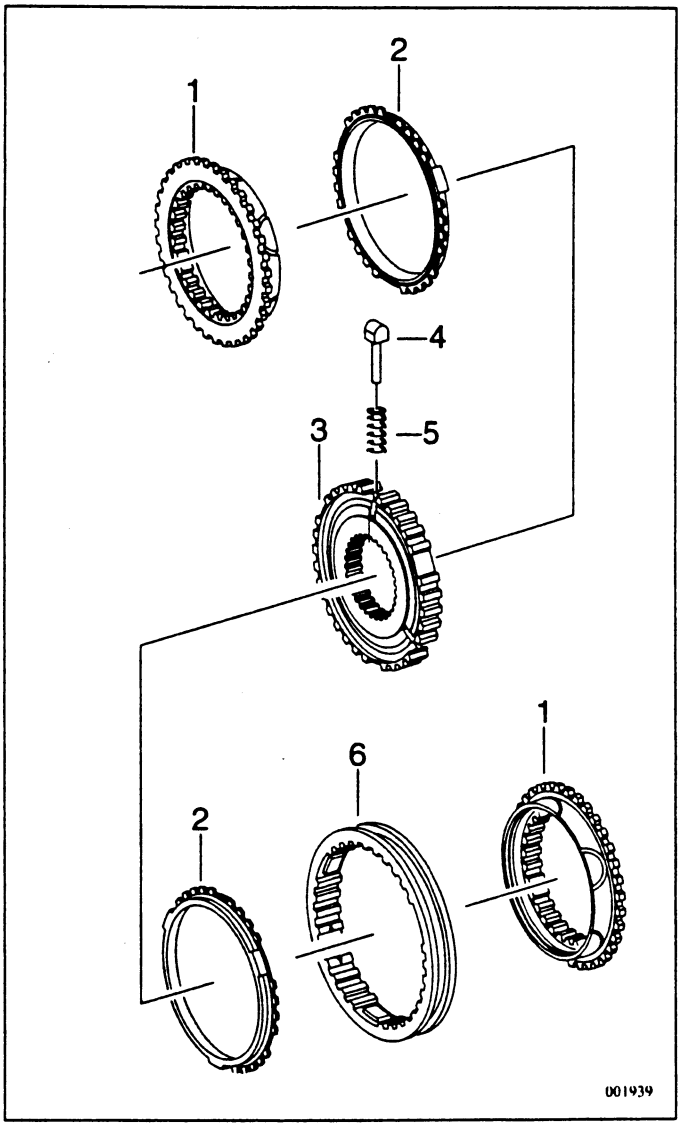
2 Replace pressure springs (5) with new springs. This guarantees prescribed shift force for sliding sleeve (6).

3 Synchronizers may be assembled individually or on the main shaft.

4 Push sliding sleeve (6) onto synchronizer body. Insert new pressure springs (5) and pressure pieces (4) into synchronizer body (3). Hold pin against centre of pressure pieces and guide pressure pieces into sliding sleeve (6).

5 Position clutch body (1) and synchronizer ring (2) and push sliding sleeve (6) into middle position.

**NOTE:** Ensure correct position of pressure pieces.




### 4.6.2.1 Section view of synchronizer/ZF-BK

1 Clutch body

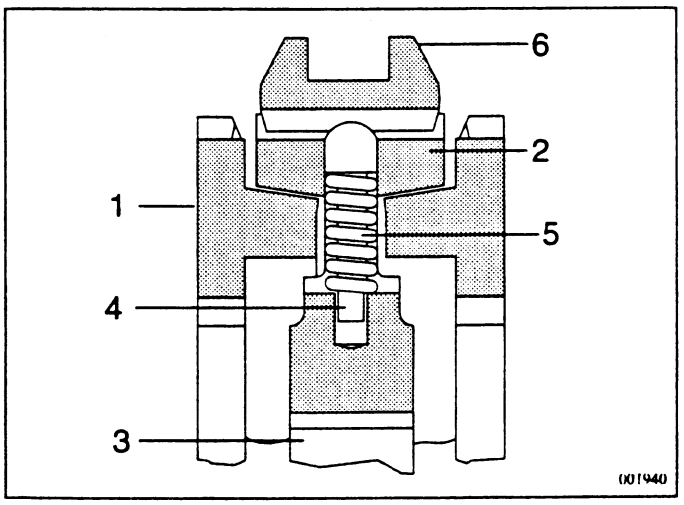
2 Synchronizer ring

3 Synchronizer body

4 Pressure piece

5 Pressure spring

6 Sliding sleeve



# 16 S 221 Synchronizers

### 4.6.2.2 Synchronizer assembly

**Version ZF-D**

1 Assembly procedure basically similar to version ZF-BK.

2 Teeth of sliding sleeve (6) have 3 recesses covering 3 teeth each. Align middle tooth with narrow recess in synchronizer body (3), the pressure piece groove. Replace pressure springs with new springs.

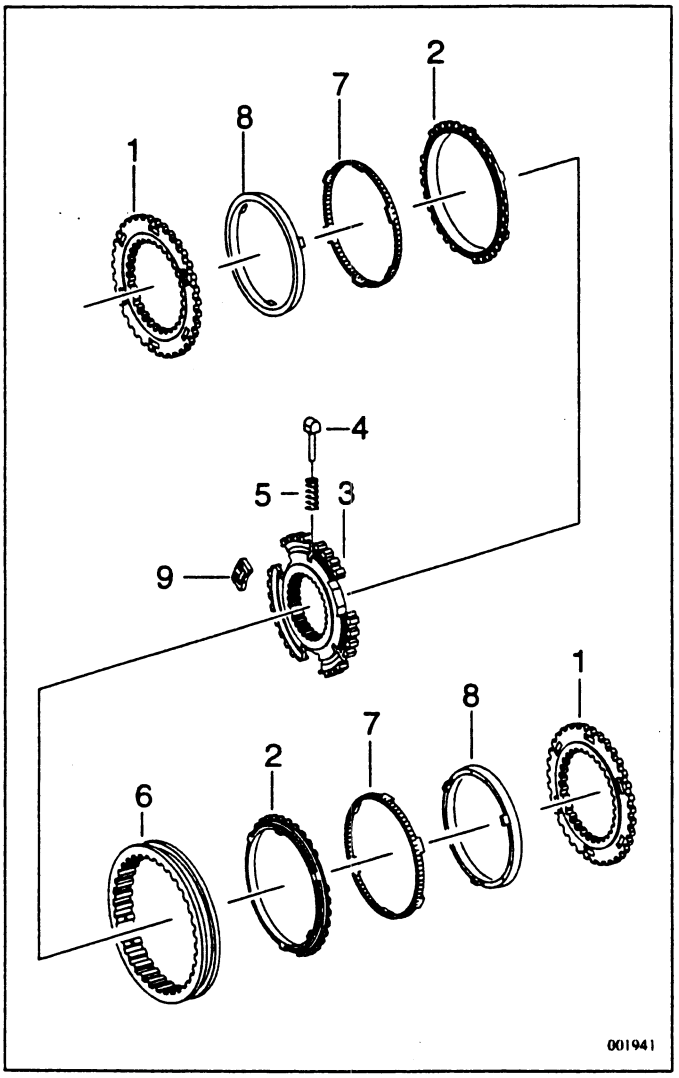
3 Insert new pressure springs (5) and pressure pieces (4) into synchronizer body. Fit pressure pieces so round head of pressure pieces juts into recess in sliding sleeve teeth.

4 Insert clutch parts (9).

5 Insert outer ring (2), intermediate ring (7) and inner ring (8).

6 Place clutch disc (1) in position.

**NOTE:** Ensure correct position of pressure pieces.




### 4.6.2.3 Sectional view of synchronizer/ZF-D

1 Clutch disc

2 Outer ring

3 Synchronizer body

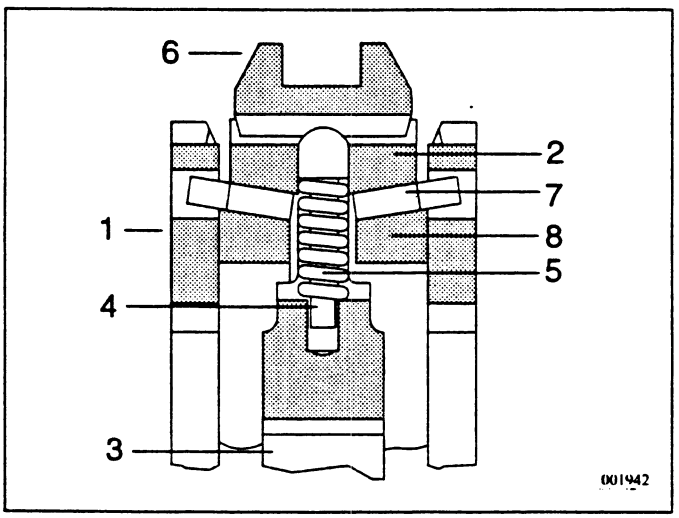
4 Pressure piece

5 Pressure spring

6 Sliding sleeve

7 Intermediate ring

8 Inner ring

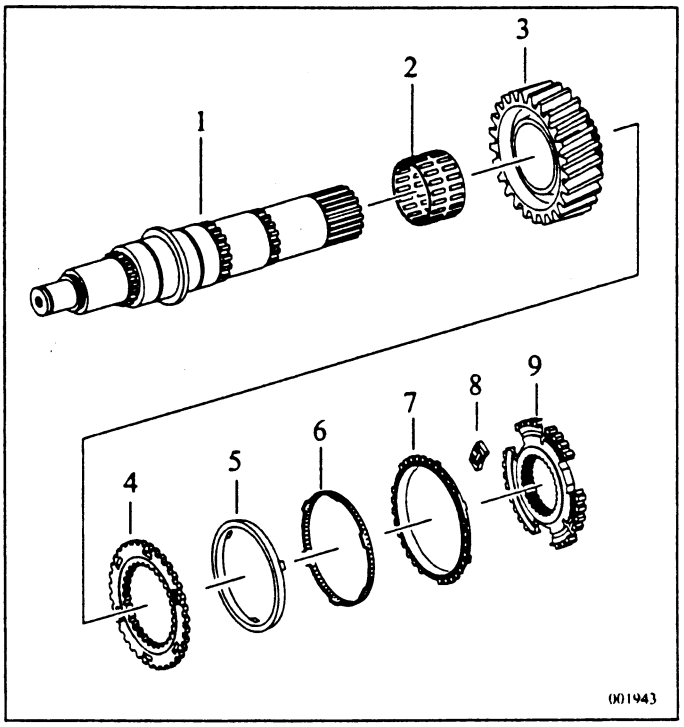


## Assembly/Main shaft 16 S 221

### 4.6.3 Assembly of main shaft

**CAUTION**

Do not damage main shaft. Always use aluminium clamping jaws when clamping main shaft in vice or other clamping equipment.




1 Clamp main shaft (1) at output end.

2 Lightly oil needle cage (2) and slide onto main shaft.

3 Push 2nd gear helical gear (3) onto main shaft with clutch body meshing teeth pointing towards the output end.

4 Check wear limit of synchronizer parts (see Section 6).

5 Place clutch disc (4) on meshing teeth of helical gear (3). Ensure the slightly raised internal teeth of clutch disc point towards the output end.

6 Place inner ring (5) onto clutch disc. Ensure lugs point towards the output end.

7 Position intermediate ring (6). Ensure lugs locate in recesses in clutch disc.

8 Position outer ring (7). Ensure lugs are pointing towards the output end.

9 Position lugs on outer ring (7) and lugs on inner ring (5) using 3 clutch parts (8). Position inner and outer ring lugs to cover clutch parts, so that the clutch parts will later locate in recesses in the synchronizer body (9) and fit over the lugs. After adjustment remove clutch parts.

10 Heat synchronizer body (9) to approx. 120° C and push onto splines of main shaft. Ensure lugs of inner, intermediate and outer ring locate in recesses of the synchronizer body. Use plastic rod to drive synchronizer body on.

## 16 S 221 Assembly/Main shaft

11 Helical gear (3) end float must be at least 0.20 mm.

12 Insert clutch parts (8) into synchronizer body (9).

13 Slide sliding sleeve (10) over synchronizer body and outer ring and locate against clutch disc.

**NOTE:** Ensure the 3 recesses inside the sliding sleeve line up with the synchronizer body reference points for the pressure springs. Incorrect installation or the shape of the pressure pieces can lead to them being installed 90° offset. This damages the dual-cone synchronizer.

14 Insert new pressure springs (11) and pressure pieces (12) in the synchronizer body.

**NOTE:** Ensure dual-cone synchronizer pressure pieces are inserted correctly as indicated in the synchronizer body.

15 Use appropriate tool to insert pressure pieces into the synchronizer body and sliding sleeve.

16 Place outer ring (13) in position. The lugs must engage with clutch pieces and locate in the synchronizer body.

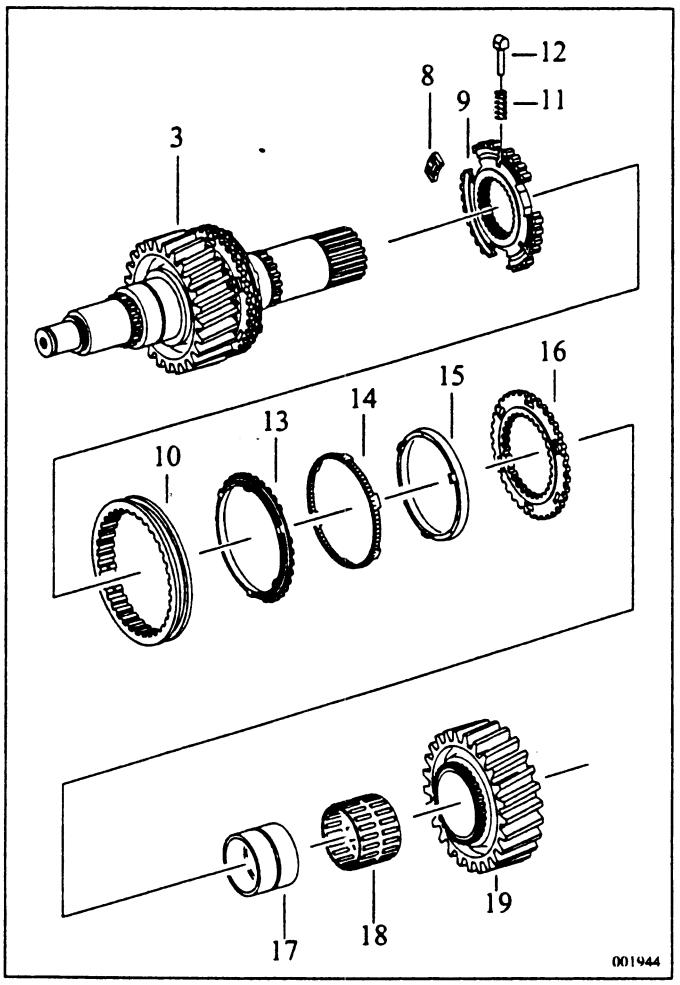
17 Place intermediate ring (14) in position. Lugs must point towards the output end. Place inner ring (15) in position and mesh lugs with clutch parts.

18 Place clutch disc (16) in position with raised internal teeth pointing towards input end and engage with intermediate ring (14). Move sliding sleeve to neutral position, pressing against clutch disc. You should hear the pressure pieces clicking into place.

19 Heat bush (17) to 120° C and push onto main shaft until firmly seated. Use plastic rod to drive on if required.

20 Lightly oil needle cage (18) and push over bush (17).

21 Place 1st/5th gear helical gear (19) onto needle cage (18) so the engaging teeth mesh with clutch disc.



## Assembly/Main shaft 16 S 221

22 Heat clutch body (20) to 120° C and push onto main shaft until firmly located.

**NOTE:** Ensure clutch body collar points towards output end.

23 End float of 1st/5th gear helical gear must be at least 0.20 mm.

24 Heat bush (21) to 120° C and push onto main shaft until firmly seated.

25 Lightly oil needle cage (22) and push over bush (21).

26 Push reverse gear helical gear (23) onto main shaft over needle cage. Ensure engaging teeth point towards input end.

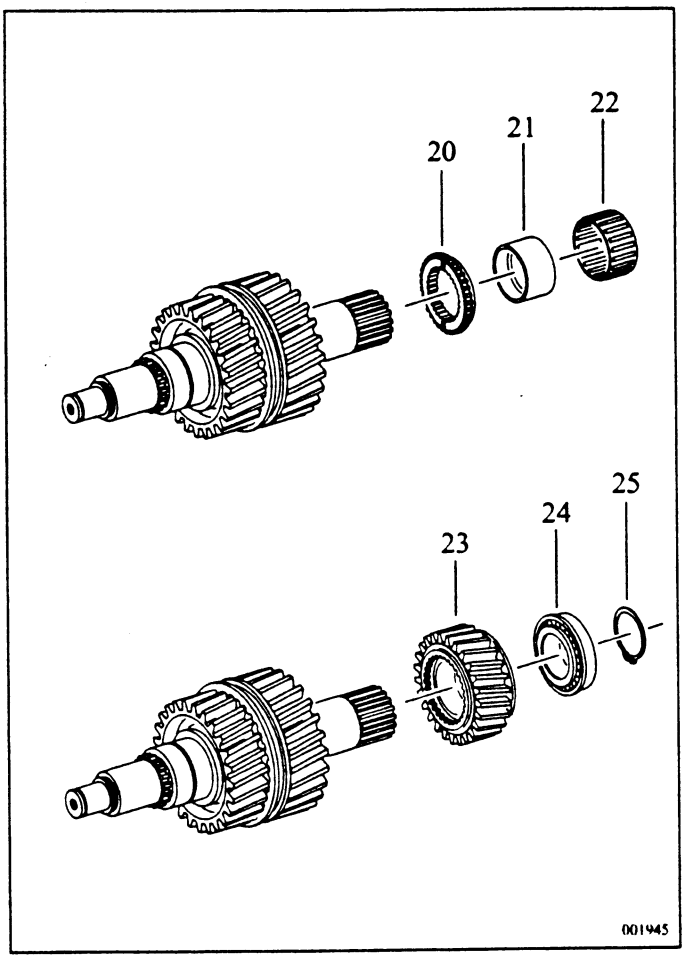
27 Heat roller bearing (24) to approx. 100° C and push onto main shaft until firmly seated. Use plastic rod to drive on if necessary.

28 Clip circlip (25) into annular groove on main shaft.

**NOTE:** End float of circlip must be between 0 and 0.05 mm. Select correct circlip from spare parts catalogue.
The main shaft weights over 20 kg.

29 Clamp output end of main shaft.

**CAUTION**
Do not damage main shaft. Always use aluminium clamping jaws when clamping main shaft in vice or other clamping equipment.



## 16 S 221 Assembly/Main shaft

30 Oil needle cage (26) and push onto main shaft.

31 Push 3rd gear helical gear (27) over needle cage. Engaging teeth of helical gear must point towards output end.

32 Place clutch body (28) on engaging teeth of helical gear.

33 Place synchronizer ring (29) on clutch body.

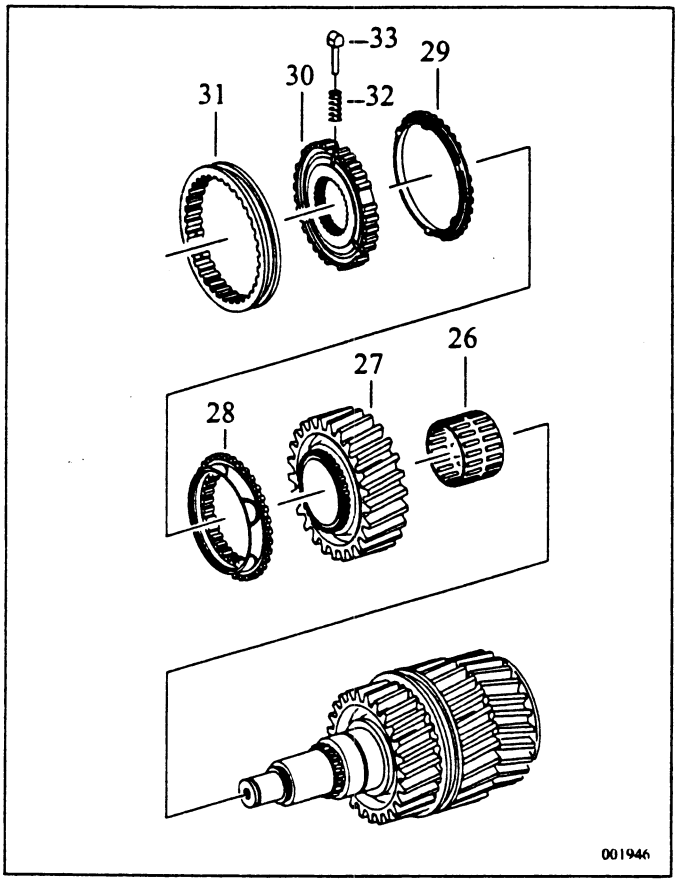
34 Heat synchronizer body (30) to 120° C and push onto main shaft splines. Ensure correct seating, use plastic rod to drive on if necessary.

**NOTE:** Synchronizer ring lugs must locate in recesses in synchronizer body.

35 Place sliding sleeve (31) in position on 3rd gear helical gear.

**NOTE:** Recesses inside sliding sleeve must line up with reference points of synchronizer body for pressure springs (32) and pressure pieces(33).

36 Insert new pressure springs and pressure pieces into holes in synchronizer body and fit into sliding sleeve.



## Assembly/Main shaft 16 S 221

37 Position synchronizer ring (34) so lugs locate in recesses in synchronizer body.

38 Place clutch body (35) on synchronizer ring.

39 Move sliding sleeve into neutral position, pressing synchronizer ring (34) and clutch body (35). You should hear the pressure pieces clicking into place.

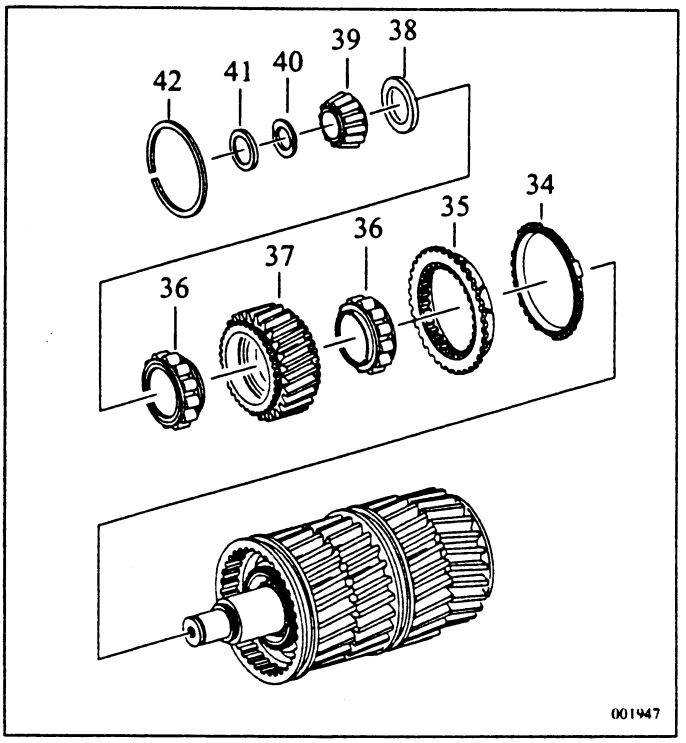
40 Insert both roller bearings (36) into 4th gear helical gear (37).

**NOTE:** Lubricating holes on roller bearings must point outwards.

41 Heat roller bearings and helical gear to 100° C and push onto main shaft until bearing pack is correctly seated. Bevelled meshing teeth of helical gear must point towards output end.

42 End float of helical gear must be at least 0.05 mm.

Hint: Axial washer (38), roller bearing (39), split ring (40), locking ring (41) and ring (42) are only fitted in Section 11, adjustment of shafts.



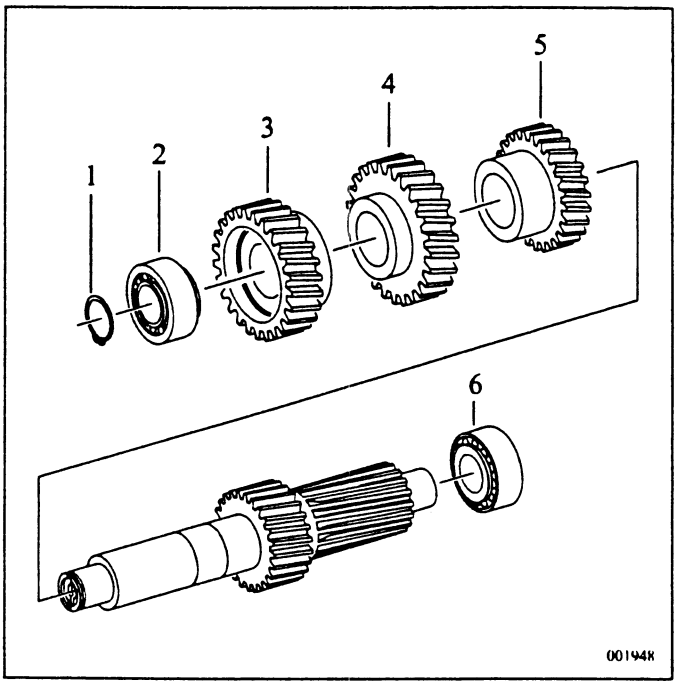
## 16 S 221 Removal/Layshaft

### 4.7 Layshaft

#### 4.7.1 Disassembly of layshaft

**CAUTION**

Do not damage layshaft. Always use aluminium clamping jaws when clamping layshaft in clamping equipment.




1 Clamp output end of layshaft without touching roller bearing (6).

2 Remove circlip (1) from annular groove.

3 Slide gripping piece 1X56 136 756 over roller bearing inner ring (2) towards output and tighten knurled ring to grip roller bearing firmly. Place pressure piece on input end of layshaft. Screw on basic tool 1X56 122 304 and pull off roller bearing (2).

4 Clamp layshaft at input end.

5 Slide gripping piece 1X56 136 710 over roller bearing inner ring (6) towards input and tighten knurled ring to grip roller bearing firmly. Place pressure piece on output end of layshaft. Screw on basic tool 1X56 122 304 and pull off roller bearing (6).

6 Press off helical gears (3), (4) and (5) individually in that order.

# Assembly/Layshaft 16 S 221

### 4.7.2 Assembly of layshaft

1 Ensure centre holes of helical gears (3), (4) and (5) and shaft seats on layshaft are free of grease and dust.

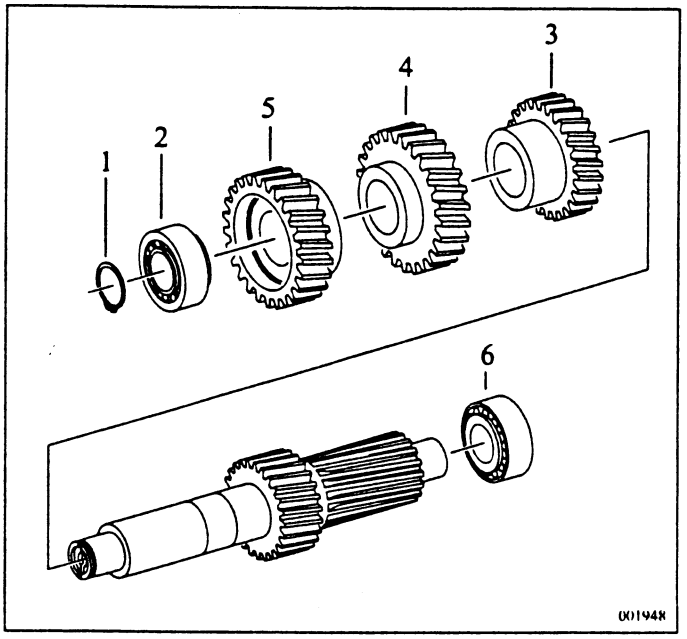
2 Heat helical gears to 160 - 180° C for max. 15 min. and push onto layshaft in the order (3), (4) and (5). Press helical gears on immediately. Ensure these do not have any end play.

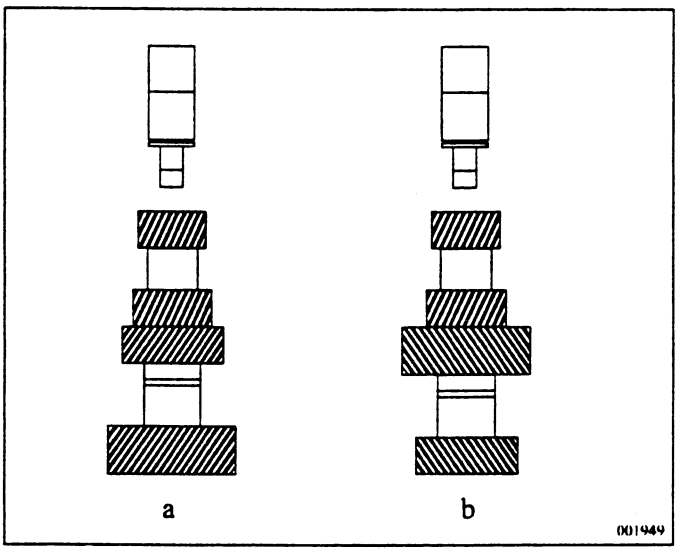
3 Heat inner ring of roller bearing (6) to 100° C and push onto layshaft. Press roller bearing on until firmly seated, with no play at output end.

4 Heat inner ring of roller bearing (2) to 100° C and push onto layshaft. Press roller bearing on until firmly seated, with no play at input end.

5 Clip circlip (1) into annular groove on input end of layshaft. End float of circlip must not exceed 0.1 mm. Select correct circlip from spare parts catalogue.

**NOTE:** a = Direct drive
b = Overdrive

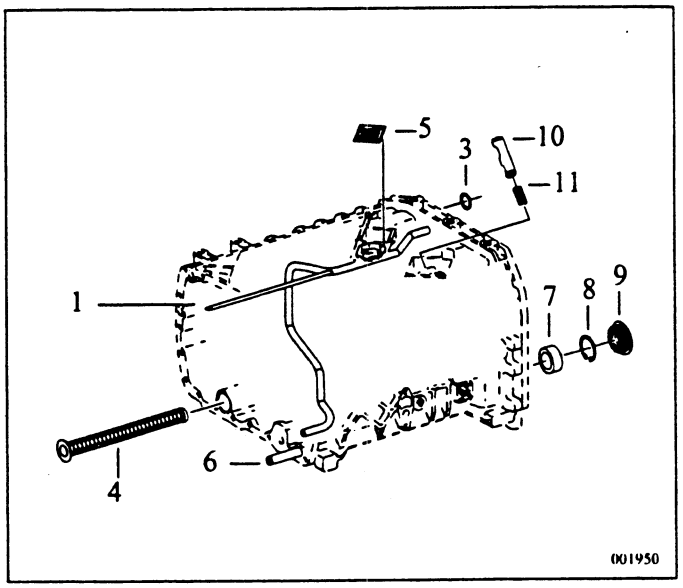


# 16 S 221 Assembly/Mid-housing

## 5 Installation of components

### 5.1 Housing section 2




1 Fit all screw plugs, pressure switches and filler necks with new sealing rings or gaskets and screw in. Tightening torques: see Adjustment data, Tightening torques.

2 Fit spray tube (1) if removed. Using rolling tool 1X20 155 653, roll ends into holes in housing. Rolling torque = 5 to 6 Nm. Insert O-ring (3).

3 Insert new or cleaned filter (4).

4 If removed, fit type-plate (5) using notched pins.

5 If removed, fit new cylindrical pins (6) into housing.

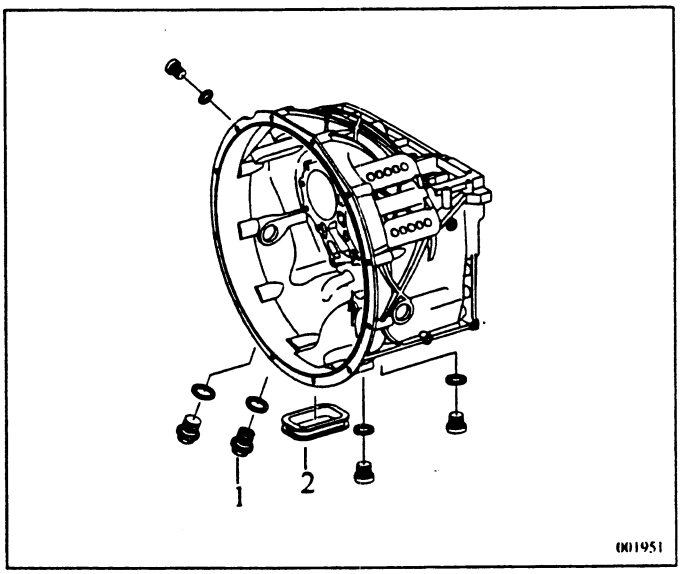
6 Drive in new tapered roller bearing outer rings for main shaft and layshaft in housing section 2 if removed.

**NOTE:** Heat bearing bore to approx. 60°C.

7 Using plastic rod, insert bearing bush (7), circlip (8) and new cap collar (9). Ensure correct seating.

8 Insert pressure spring (11) and locking pin (10). Screw in locking bolt 1X56 137 287.

### 5.2 Clutch housing




1 Insert tapered roller bearing outer rings for the input shaft and layshaft into bearing bores in the clutch housing.

**NOTE:** Input shaft bearing outer ring protrudes past sealing face and layshaft bearing outer ring is recessed.

2 Fit screw plugs with new sealing rings and screw in.
Tightening torque: M18x1.5 = 35 Nm,
M22x1.5 = 50 Nm,
M24x1.5 = 60 Nm.

3 Screw in cleaned oil drain plug and magnetic plug (1).
Tightening torque = 140 Nm.

4 Fit sealing cap (2).

## Wear limit/Synchronizer 16 S 221

### 6 Synchronizers/wear limits

### 6.1 Determination of wear limit (not 1st and 2nd gears)

Check condition of synchronizer rings and clutch bodies before assembly of synchronizers.

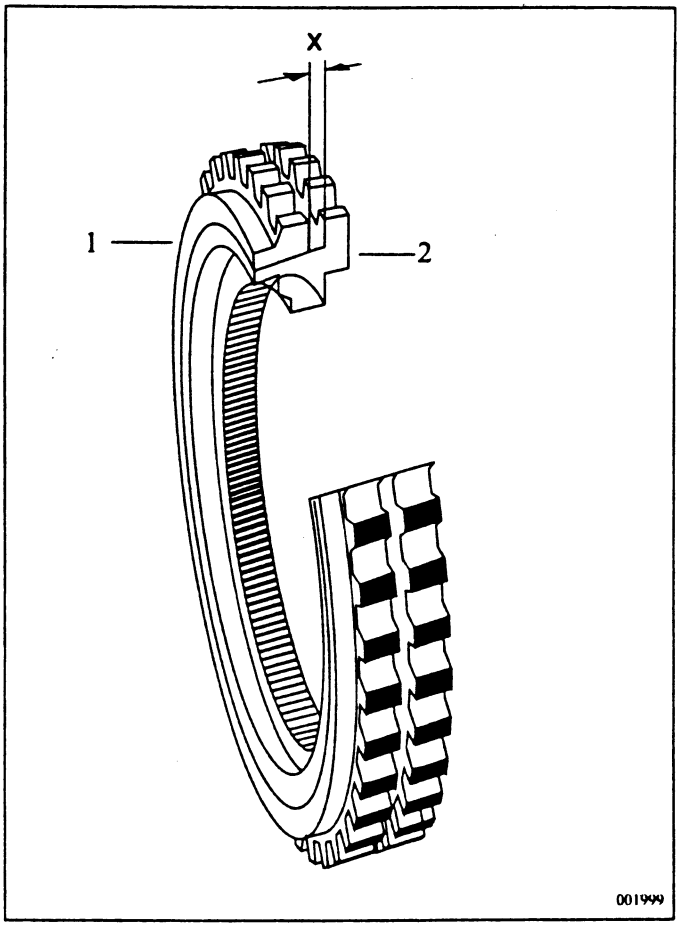
**NOTE:** Do not exchange synchronizer parts.

1 Place synchronizer ring (1) on its own clutch body (2). Turn synchronizer parts so cones run evenly and in parallel.

Wear limit for synchronizer rings on 3rd and 4th gear and splitter group synchronizers is 0.8 mm. Wear limit for range-change group 1.0 mm.

2 Using feeler gauge, measure distance (X) between clutch body and synchronizer ring at two opposing points. If wear limit is below 0.8 or 1.0 mm, exchange synchronizer ring and/or clutch body.

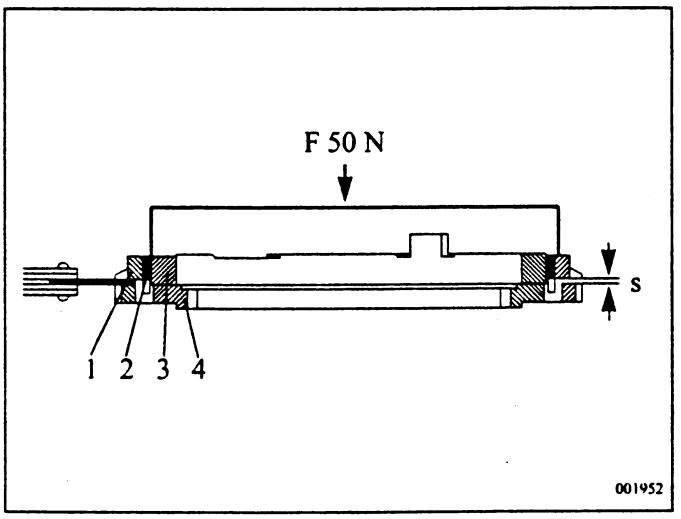
3 Check condition of synchronizer parts (visual check). Replace synchronizer parts if surface is wavy. Do not exchange parts which have been tested together (mark parts accordingly).




### 6.2 Determination of wear limit (for 1st and 2nd gears)

1 Place inner ring (3), intermediate ring (2) and outer ring (1) of 1st and 2nd gear synchronizer on clutch disc (4). Turn outer ring to make cones run evenly. Load outer ring with even load of F = 50 Nm.

2 Using a feeler gauge, measure distance (s) between clutch disc and outer ring at two opposing points. The wear limit is 1.5 mm. If distance (s) is below wear limit, use new intermediate and/or outer ring and inner ring.



## 7 Adjustment of main shaft

### 7.1 Choosing thrust washer and shim

1 Place main shaft into housing section 2 using lifting device 1X56 137 200.

2 Place ring (1) into clutch body (2). Put parts on 4th gear helical gear.

3 Take several measurements of distance between top edge of clutch body and mid-housing sealing face with gasket fitted. Calculate average distance.

4 Nominal dimension X of 19.2 + 0.2 mm must be achieved. If the average distance is different, choose ring to get nominal distance (see Table).

5 Select thrust washer (3) from the following table.

If a 3.6 mm ring is required, use 8.1 mm thrust washer.

Ring (1): 3.0/3.2/3.4/**3.6**/3.8/4.0/4.2

Thrust washer (3): 7.5/7.7/7.9/**8.1**/8.3/8.5/8.7

6 Remove main shaft from housing section 2 and place thrust washer on main shaft with raised collar towards helical gear.

7 Heat new bearing inner ring (4) to 100° C and place on bearing journals of main shaft until firmly seated. Drive on using plastic rod.

8 Coat the entire bearing inner ring with lubricating grease (e.g. "Aralub HL2", approx. 4g), according to the specification. Apply the grease between the inner ring and the cage, on the collar side of the bearing inner ring which faces towards the axial shim (3), see arrow.

**NOTE:** Make sure no grease is applied to the outside of the bearing rollers. Grease applied here may block the input shaft lube bores.

9 Using special tool 1X56 137 676, insert split ring (5) into annular groove on main shaft to give end float or pre-load of - 0.05 mm to + 0.05 mm. Split rings are available in 0.1 mm steps.

10 Slide new locking ring (6) over split ring and crimp in 3 places.