

9. TRANSMISSION (ZF16S151/221)

9-1. TRANSMISSION SPECIFICATIONS

Item		Model(two-wheel drive mode)					
Type	Synchromesh type	16S 130	16S 151	16S 160		16S 190	16S 221
	Constant mesh type	16K 130	16K 150	16K 160		16K 190	16K 220
Input torque	Max torque (N·m)	1,400	1,700	1,400	1,600	1,900	2,200
	Gear ratio group	III, VI	IV, VII	VIII	VI	I, III	IV, VII
Installation		This transmission can be installed on the mounting plate or dismantled off the engine. (Installation location depends on the engine type or control mode.)					
Gear zone	Synchromesh type	Forward moving gears are operated by fixed synchronizer, while reverse gear is operated on constant mesh mode.					
	Constant mesh type	Forward moving and reverse gears are operated on constant mesh mode. (Clutch brake is available as an additional item of ZF Company.)					
Range change group		Operated by fixed synchronizer					
Splitter group		Operated by fixed synchronizer					
Operation	4th gear zone	Adjusted mechanically by rotary shaft adjustment or shift lever. (Double "H" pattern shifting structure)					
	Range change group	Formed automatically and adjusted by compressed air(6.3~8.2 bar).					
	Splitter group	Adjusted by the toggle switch on the gearshift lever and compressed air					
Weight (kg)	Synchromesh type	350	290	365		365	320
	Constant mesh type	325	330	340		340	355
Fill capacity (L)	Synchromesh type	16	11	16.5		16.5	13
	Constant mesh type	15	14	16		16	16
Recommended oil	Engine oil API CD/CE/CF/SF/ SG or SAE30	As the existing engine oil is inferior in physical property ratings(heat resistance, anti-abrasion, viscosity, etc.), the interval of its use should be shortened half.					
Oil change intervals	Engine oil API CD/CE/CF/SF/ SG or SAE30	Change at end of first 5,000km, check and replenish every 4,000km thereafter, change every 45,000km					

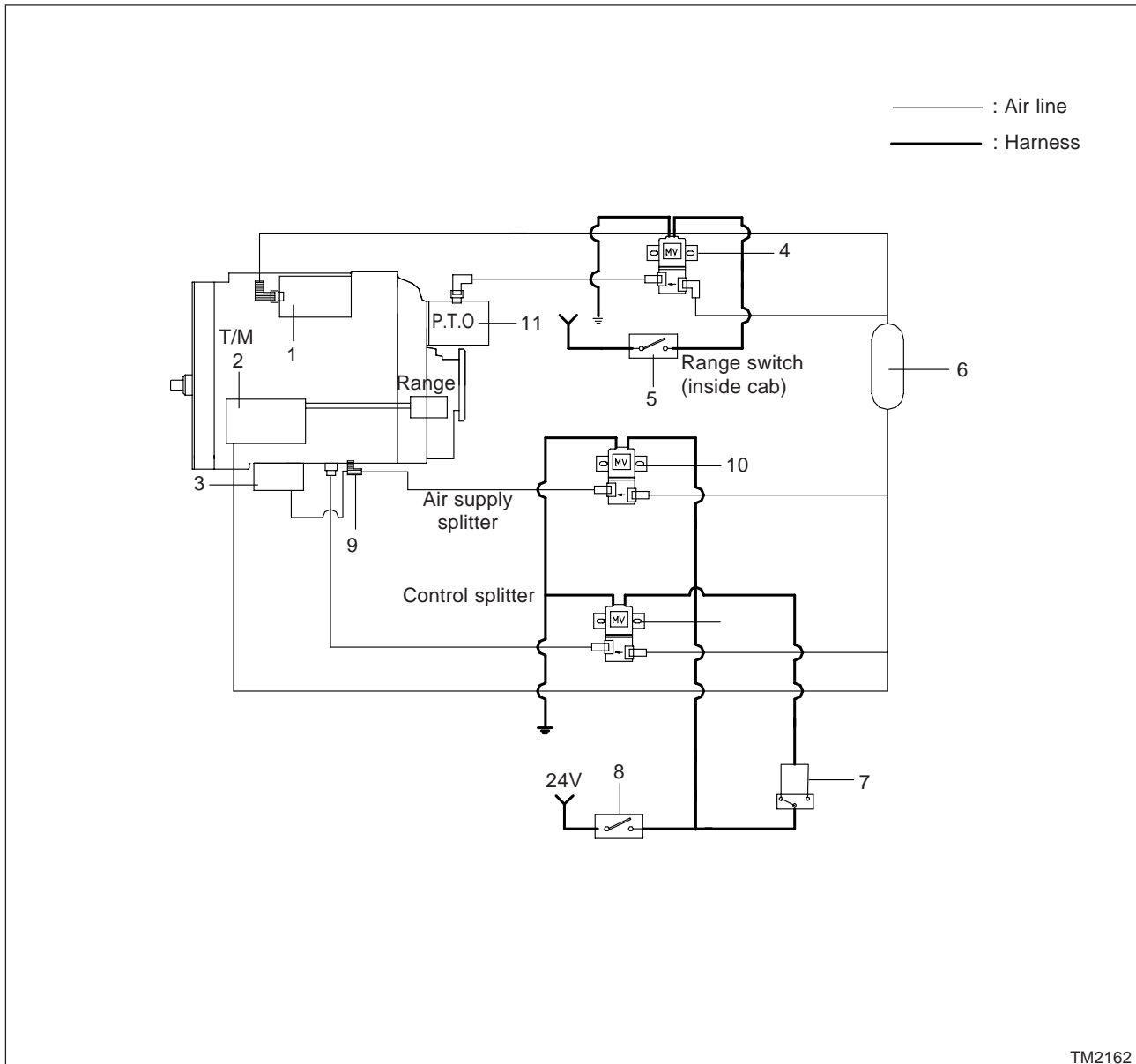
3. TRANSMISSION

(Applicable to all kinds of transmission manufactured by Z/F Company)

Item		Gear ratio group								
		I	II	III	IV	V	VI	VII	VIII	IX
1st gear	L	11.46	11.74	13.68	13.80	14.14	14.29	16.47	17.06	17.47
	H	9.75	9.99	11.64	11.55	11.83	11.71	13.79	13.98	14.32
2nd gear	L	7.96	8.15	9.40	9.59	9.82	9.93	11.32	11.72	12.01
	H	6.77	6.94	8.00	8.02	8.22	8.14	9.48	9.61	9.84
3rd gear	L	5.65	5.79	6.73	6.81	6.98	7.05	7.79	8.07	8.27
	H	4.81	4.93	5.73	5.70	5.84	5.78	6.52	6.61	6.78
4th gear	L	4.07	4.17	4.79	4.58	4.69	4.58	7.79	8.07	8.27
	H	3.47	3.55	4.07	3.84	3.93	3.76	4.58	4.58	4.70
5th gear	L	2.81	2.88	3.36	3.01	3.08	3.12	3.59	3.72	3.81
	H	2.39	2.45	2.86	2.52	2.58	2.56	3.01	3.05	3.12
6th gear	L	1.95	2.00	2.31	2.09	2.14	2.17	2.47	2.56	2.62
	H	1.66	1.70	1.96	1.75	1.79	1.78	2.07	2.10	2.15
7th gear	L	1.39	1.42	1.65	1.49	1.53	1.54	1.70	1.76	1.80
	H	1.88	1.21	1.41	1.24	1.27	1.26	1.42	1.44	1.48
8th gear	L	1.00	1.02	1.18	1.00	1.02	1.00	1.20	1.22	1.25
	H	0.85	0.87	1.00	0.84	0.87	0.82	1.00	1.00	1.02
Reverse gear	L	10.15	11.40	11.06	13.17	12.53	12.66	13.32	13.79	14.13
	H	8.64	8.85	9.41	11.03	10.49	10.37	11.15	11.30	11.58

1. Low : (L) Gear ratio
2. High : (H) Gear ratio
3. IV : ZF16S-151, ZF16S-221

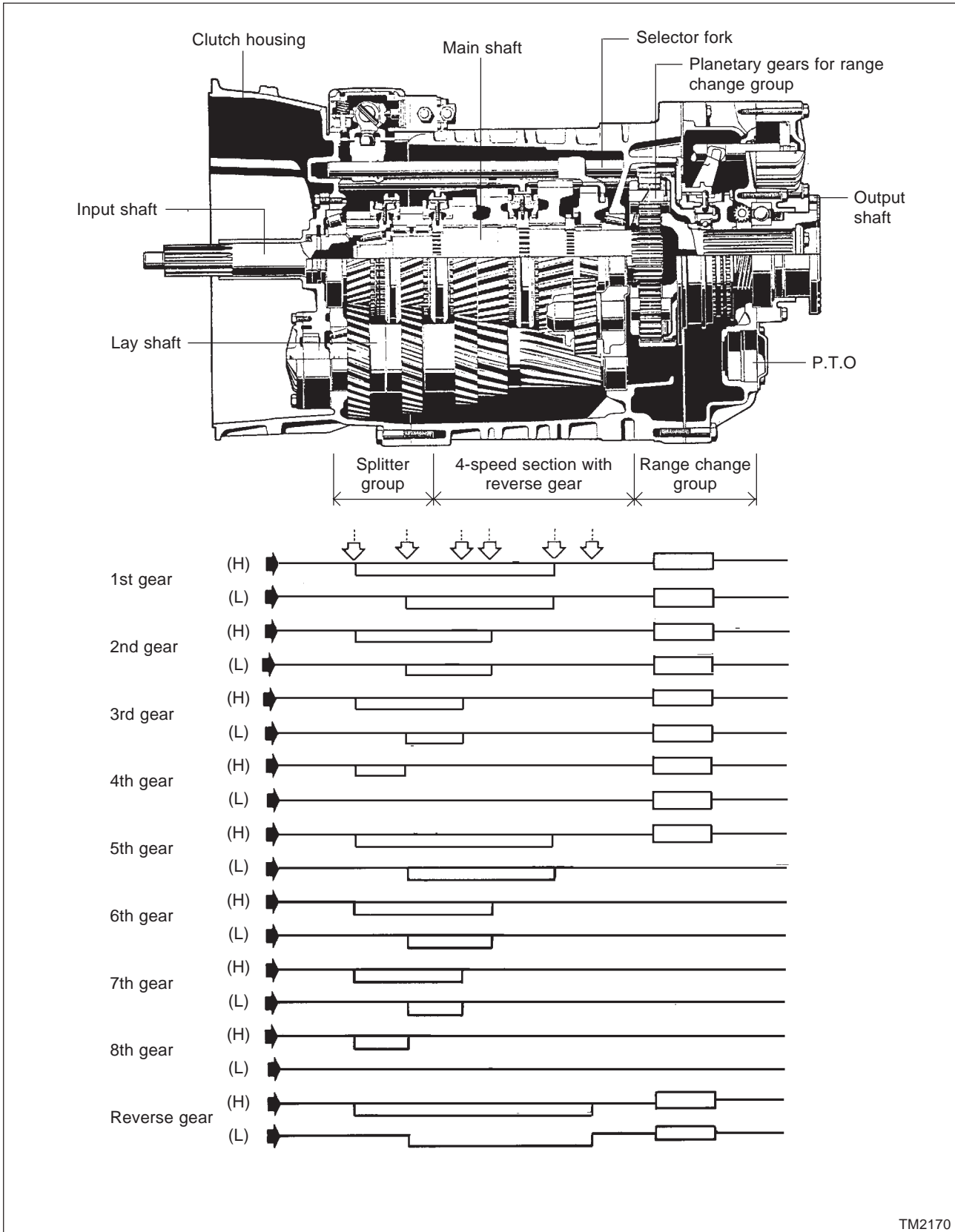
9-2. CONNECTION DIAGRAM FOR PNEUMATIC CONTROL(ZF16S)



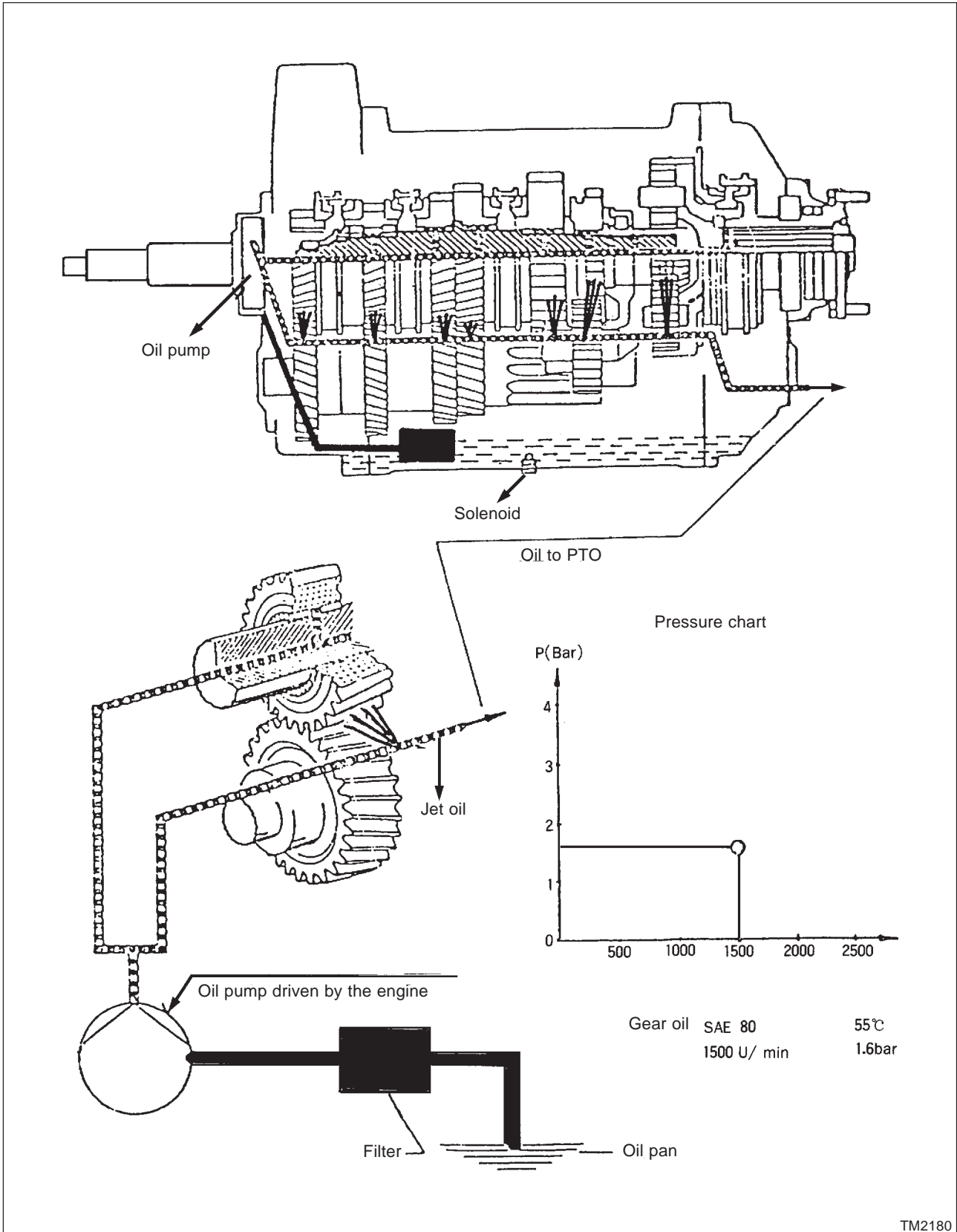
TM2162

- | | |
|---------------------------|------------------------------------|
| 1. Clutch booster | 7. High/low switch |
| 2. Range change cylinder | 8. Clutch pedal |
| 3. Shift housing | 9. Splitter relay valve |
| 4. Magnetic valve | 10. Magnetic valve |
| 5. Splitter change switch | 11. P.T.O(Power takeoff operation) |
| 6. Air tank | |

9-3. POWER FLOW DIAGRAM

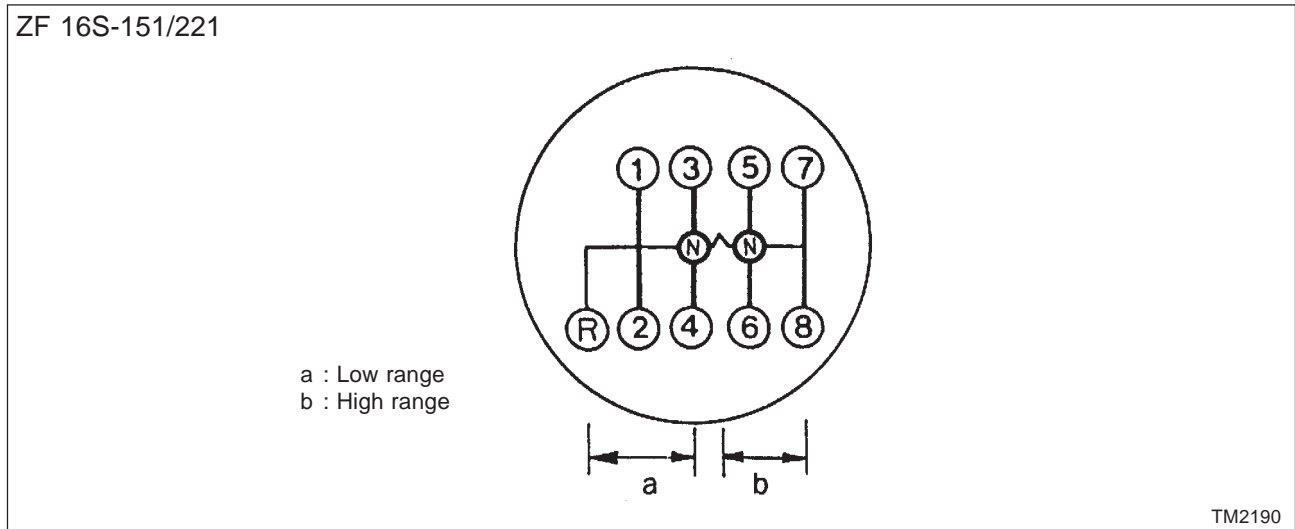


9-4. LUBRICATION DIAGRAM



9-5. CHARACTERISTICS OF ZF TRANSMISSION

9-5-a. OPERATION



As ZF transmission is of synchro mesh change gear type, gear shifting can be performed with no need to use double clutch, and so it is very easy to manipulate it.

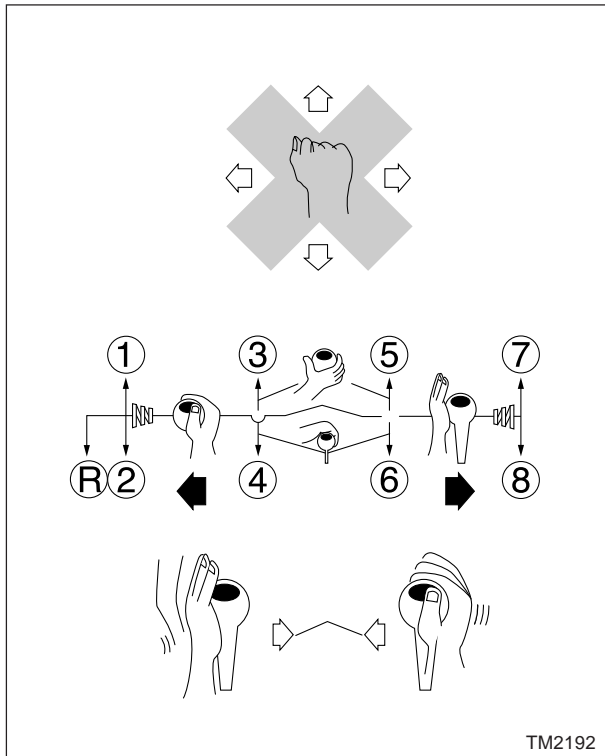
1. Gearshift of 4-speed section with range change group

Double "H" gearshift pattern provides eight(8) forward gearshifts and one(1) reverse gearshift. The neutral position of gearshift lever in LOW RANGE stays on the shaft for the 3rd and 4th gears, while in HIGH RANGE it remains on the shaft for the 5th and 6th gears. Namely, there are two neutral positions available. Therefore, when changing gears from high range to low range or vice versa, it is necessary to quickly change gears so that the engine speed may not be reduced abruptly. In addition, as the reverse gear is of dog clutch type, when attempting to change to reverse gear, do so after the vehicle is stopped completely. Otherwise, gears may be damaged.

If gears are abruptly changed to low range at high engine rpm, or especially, when gears are changed abruptly from high range to low range, damage may be caused to the clutch, engine, or transmission.

Low range control system

The transmission is equipped with a low range control system designed to protect the engine. If you change gears from high range to low range by toggling down the range change switch when your vehicle speed is 25Km/h or over, the vehicle speed is reduced enough to prevent the inside of the transmission from changing to low range until the engine is no longer affected adversely.

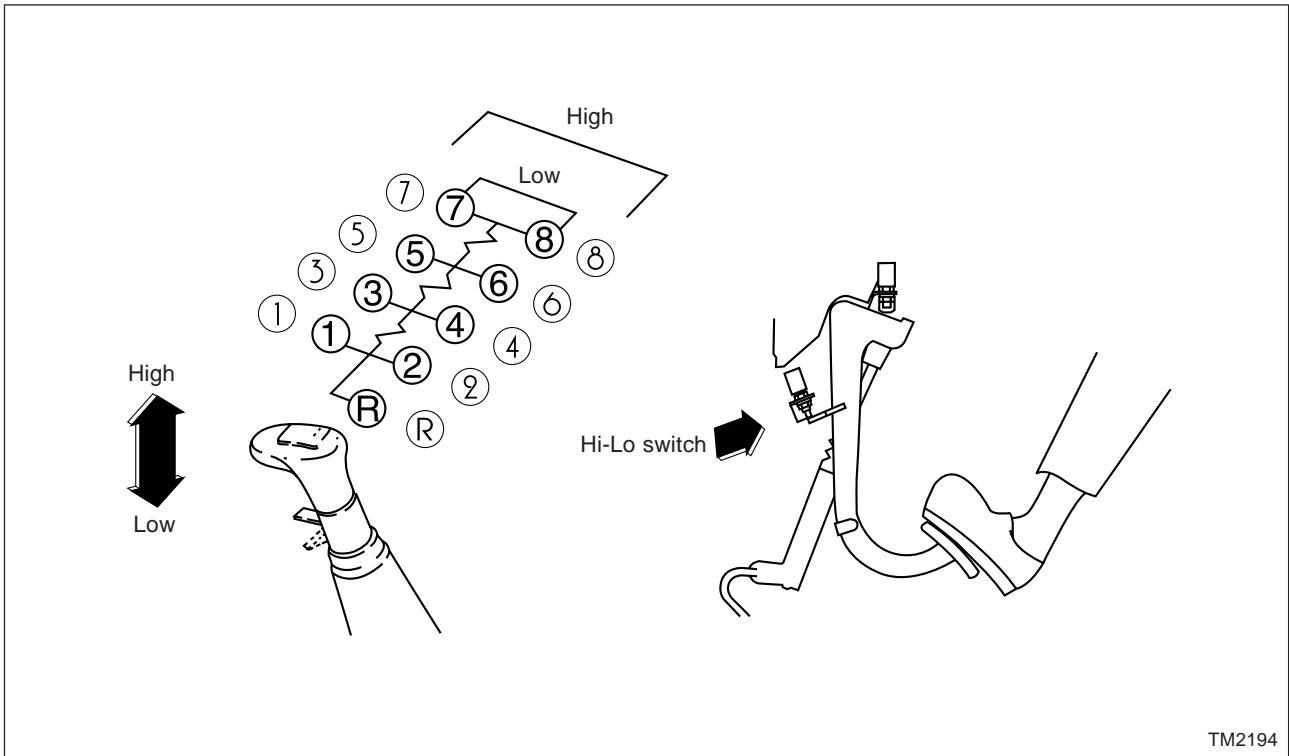


2. How to change ranges

- a. As ZF transmission is of synchro mesh change gear type, avoid changing gears forcibly.
- b. When changing ranges in the neutral section, lightly tap to right or left with the palm for gear changing operation.
- c. Namely, when changing gears from the fourth to the fifth, draw back the gearshift lever (to the neutral position between 3rd and 4th gears), then lightly tap to right with the palm. And then, lightly push forward the gearshift lever which has been in the neutral position between 5th and 6th gears to change to the 5th gear.

Note

You may feel a slight resistance when changing gears for the first time. It indicates that the synchro meshes are being engaged synchronously. At this time, do not apply unnecessary force to change gears.



3. Operation of the splitter

As high and low ranges are provided at each gearshift position, the splitter offers diverse gear ratios to ensure economical operation of the vehicle and to increase in traction efficiency.

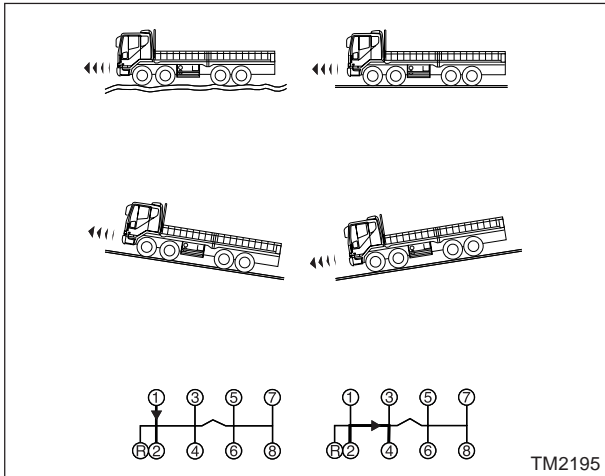
- a. Select the HI or LO switch installed on the gearshift lever knob depending on traffic condition.
- b. After the proper switch, depress the clutch pedal gently all the way without changing the position of the gearshift lever, then release it.

★ Advantages of the splitter select valve

- Loss of engine power and excessive engine turning due to gear changes can be prevented.
- Optimum operation economy can be obtained.

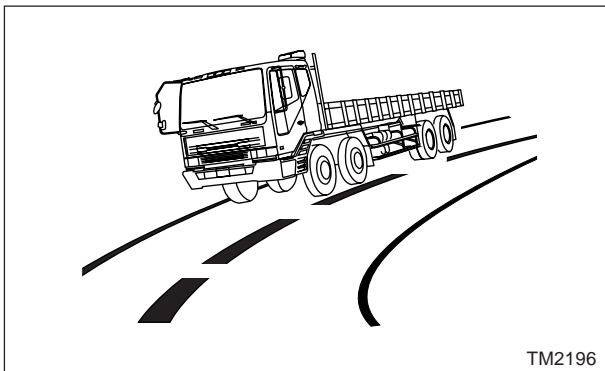
★ Examples of the use of splitter

- To produce sufficient engine output when passing a vehicle ahead or driving on an uphill or it is difficult to raise the speed after driving off the vehicle.
- For a vehicle towing a heavy cargo on a pavement, the splitter can be used to achieve economical operation such as reduction of fuel consumption.



4. Gear jump

- ZF transmission has the change range from HIGH 8th gear to LOW 8th gear and can be manipulated as desired, irrespective of road condition.
- In the case of bad road condition or running on slope, apply gears in stage like "3rd gear → 4th gear → 5th gear".
- When running on a level ground or on the downgrade, carry out gear jump like "3rd LOW → 4th HIGH → 5th HIGH → 7th LOW → 8th HIGH" to reach high gear with 4 gear change activities.



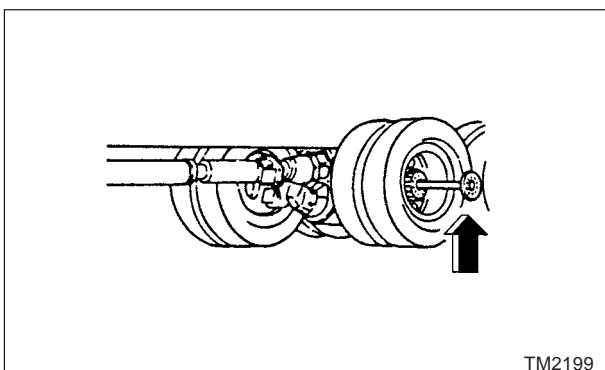
5. How to operate

- When operating the vehicle, be plainly dressed, and make sure of the route in advance keeping busy or smooth traffic sections and obstacles in mind.
- On slopes, gear down appropriately in advance. On the downgrade, use the same change group as that for slopes.
- Namely, if running up a slope with the 5th gear applied, use the 5th gear on the downgrade, too and do not use a high gear(8th gear).

6. Operating of the clutch

The clutch pedal must always be depressed fully for each gear shift movement.

If the clutch is not engaged or disengaged completely, or if the clutch discs have been excessively worn, gearshift problems will occur. In addition, wear on the synchronizers and at the gear teeth and dogs will be greatly increased.

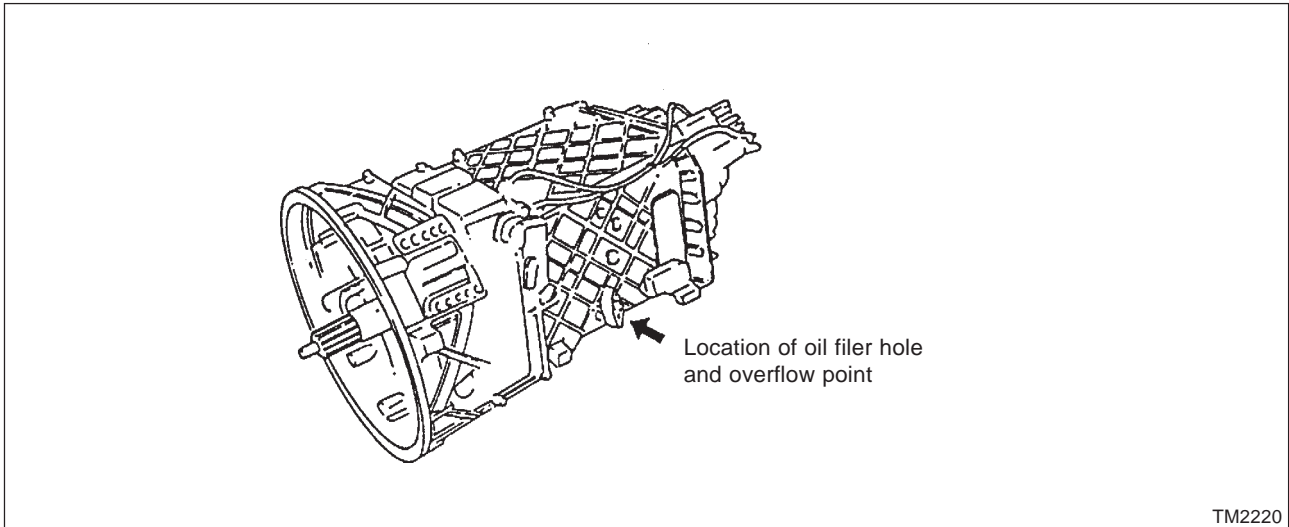


7. Towing away

If the vehicle suffers a breakdown and has to be towed away, note the following precautions.

- If the towing distance is 50km or less
Put the gearshift lever in the neutral position(on the shaft for the 5th and 6th gears) in the HIGH range and keep the towing speed within 60 km per hour. If the gearshift lever would not be put in the neutral position,disconnect the rear axle shaft before having your vehicle towed.
- If the towing distance is more than 50km
Separate the propeller shaft from the rear axle.

9-5-b. GENERAL CARE



1. Oil type and fill capacity

Specifications: Engine oil API CD/CE/CF/SF/SG class (SAE30)

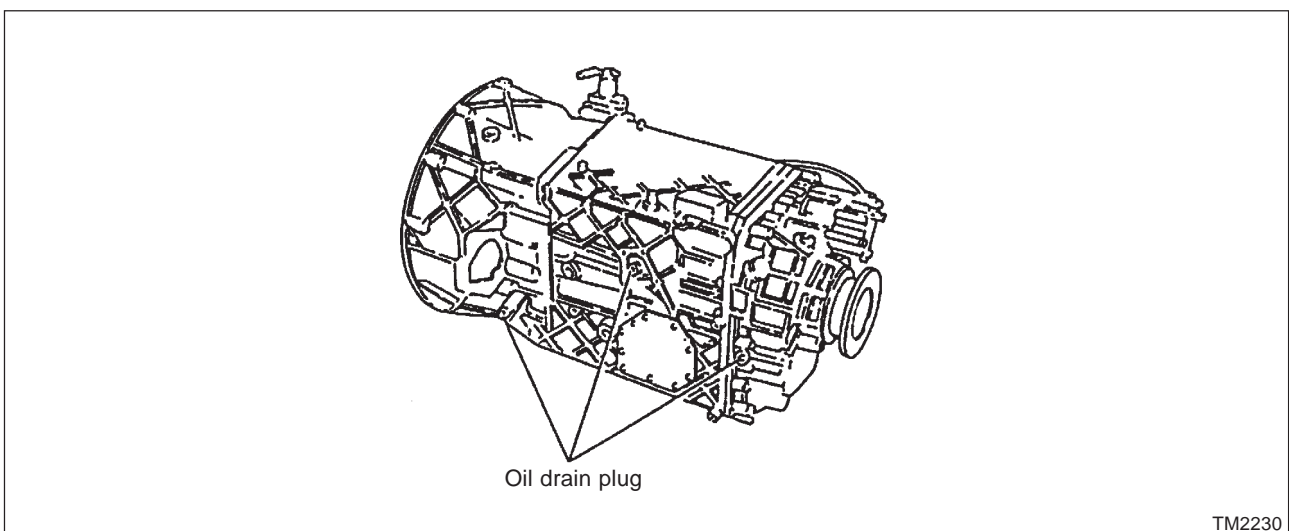
Fill capacity: 11L (ZF16S-151), 13L (ZF16S-221)

2. Oil level check

1) Check oil level at end of first 500km operation and thereafter every 4,000km. Park the vehicle on a level ground and allow some length of time to pass, then open the level plug for check and fill the tank as required.

2) Oil change

Change oil at end of first 5,000km and thereafter every 45,000km. Oil should be changed once or more a year.



- 3) There are 3 oil drain plugs. When draining oil, use the drain plug located on the 4-speed section. When you want to drain the tank quickly or you cannot unscrew the plug located on the 4-speed section, open the plugs located on range change section and splitter section to drain oil.

3. Breather

The breather installed on the upper side of transmission is designed to relieve the pressure generated inside the transmission during the operation of the vehicle. Therefore, it is desirable to always keep the breather clean so that it can perform satisfactorily all the time.

4. Inspection of air system

Compressed air condenses into moisture in some degree depending on changes in atmospheric temperature and atmospheric pressure.

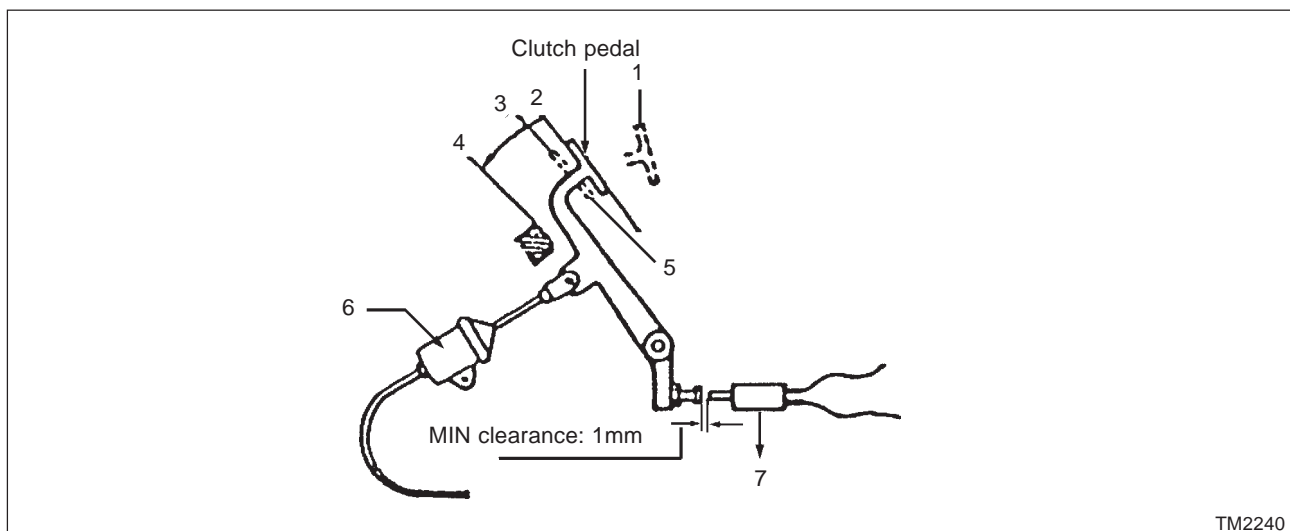
Compressed air in the air tank should be relieved once or more a week. Especially, in cold weather, relieve the air every day so that rust, foreign substances, or moisture may not enter the air pipe.

The entry of foreign substances into the air pipe will cause not only damage or malfunction to the range change and splitter cylinder seal but also harm to the brake system.

5. Adjustment of HI-LO switch on clutch pedal

For the trouble-free shifting of the splitter group, it is absolutely necessary that the HI-LO electrical switch on the clutch pedal is correctly adjusted.

If HIGH-LOW gears are used when the clutch discs are not disengaged completely or the HI-LO electrical switch clearance is not correctly adjusted, the synchronizer may suffer damage.



- | | |
|---------------------------------------|---------------------------------------|
| 1. Position "clutch fully engaged". | 5. Operating position of HI-LO switch |
| 2. Position "clutch fully disengaged" | 6. Clutch master cylinder |
| 3. Excess travel range of clutch | 7. HI-LO electrical switch |
| 4. Final stop | |

6. Inspection to the clearance of HI-LO switch

The HI-LO electrical switch must be operated between the position "2" and "4" as shown. Namely, it should be operated at the position "5".

1) How to identify the location where the clutch is completely disengaged

With the engine on and the vehicle being stationary, apply the reverse gear until a "bawl" is heard. (The reverse gear is not of synchronizer type.) Then depress the clutch until the "bawl" is not heard any longer. The very point is the location where the clutch is completely disengaged.

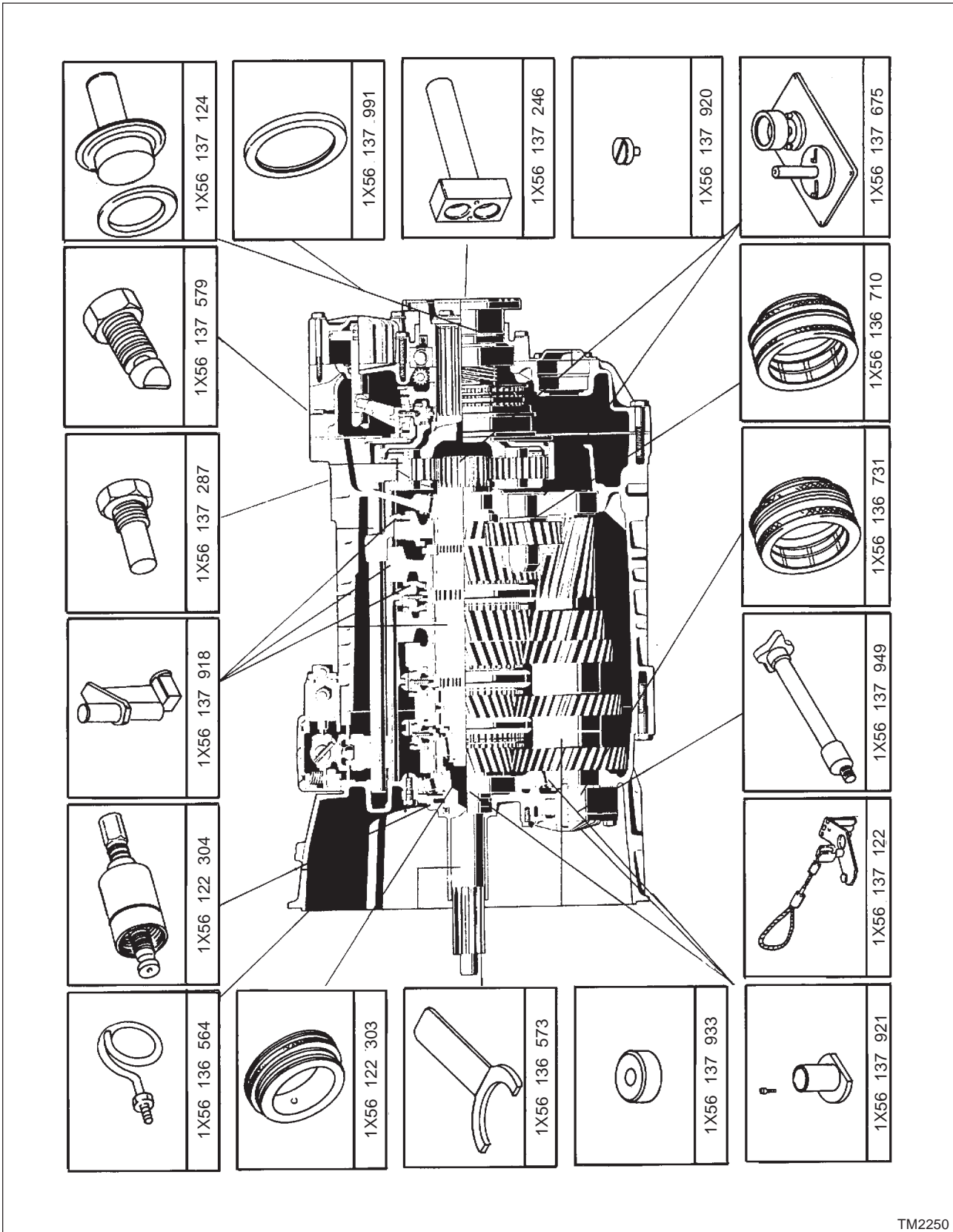
2) Adjustment of HI-LO switch clearance

The HI-LO switch should be operated when the clutch pedal is depressed slightly deeper (by about 5mm) from the location where the clutch is completely disengaged. Namely, it should be operated at the position "5".

3) Therefore, the clearance between the stopper interlocked with the clutch pedal and HI-LO electrical switch "2" should be 1mm at a minimum.

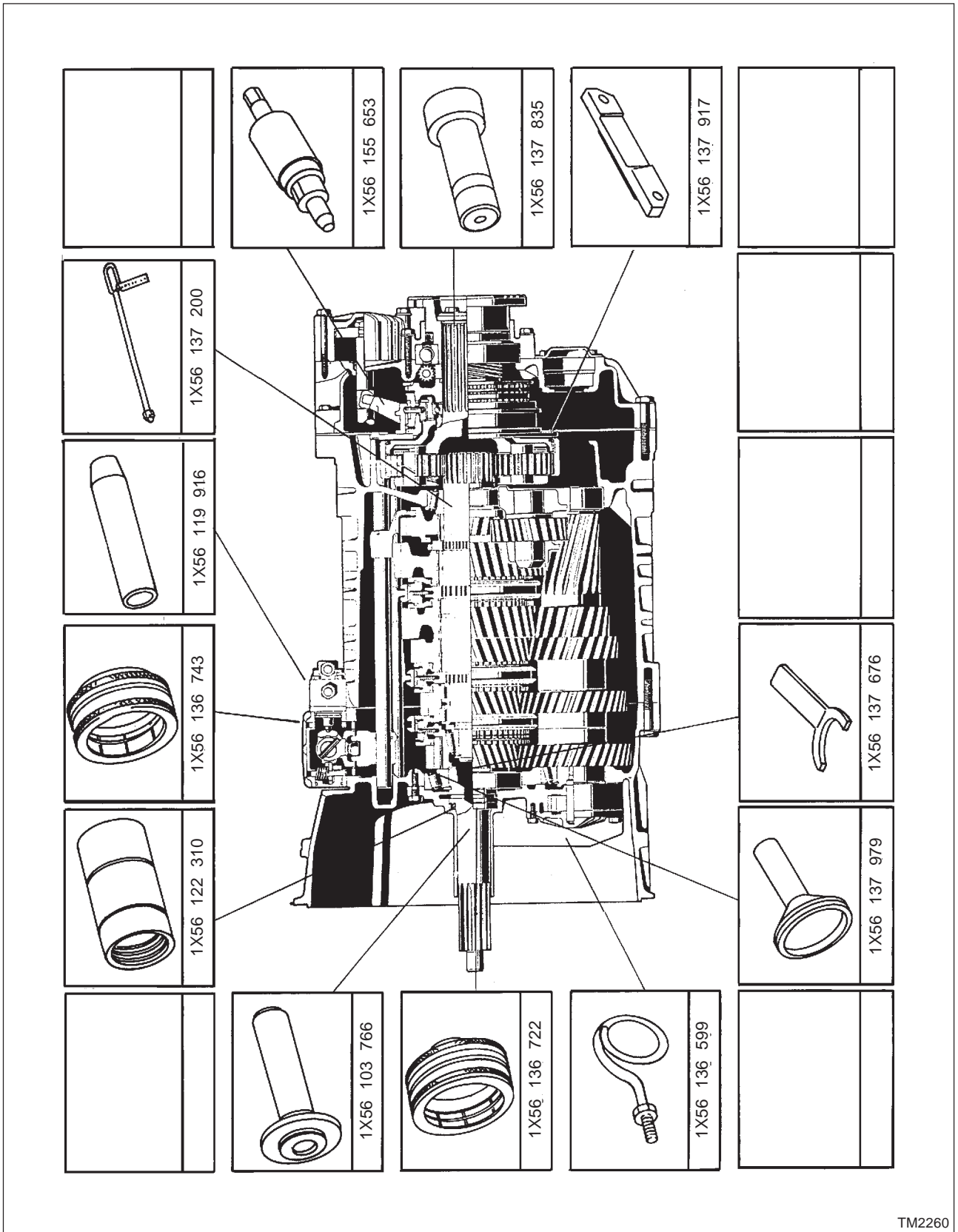
4) The clearance of the HI-LO switch should be checked periodically and each time the clutch is adjusted.

9-6. ZF SPECIAL TOOLS



TM2250

3. TRANSMISSION

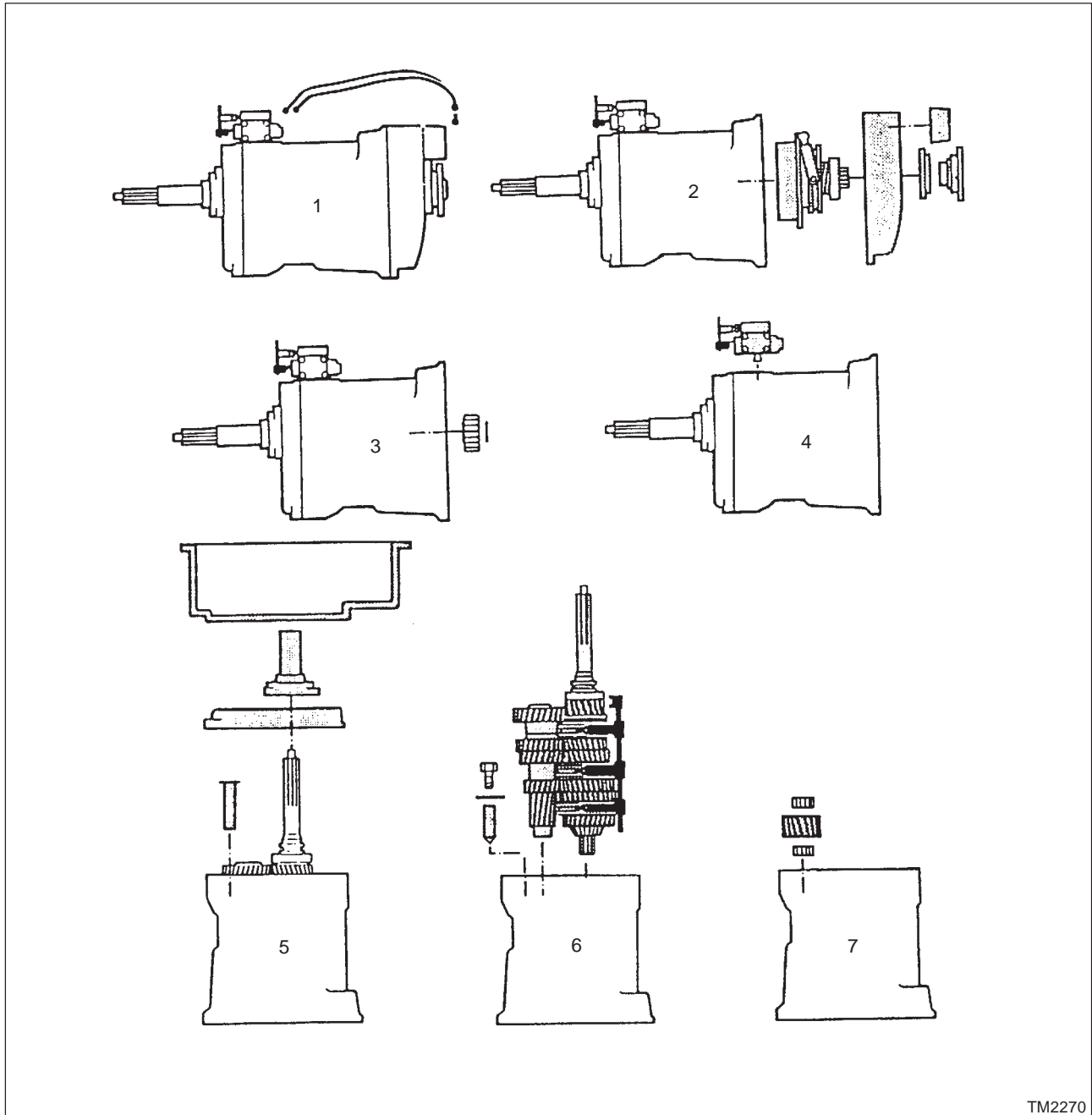


TM2260

9-7. DISASSEMBLY AND REASSEMBLY

9-7-a. DISASSEMBLY AND REASSEMBLY STEPS

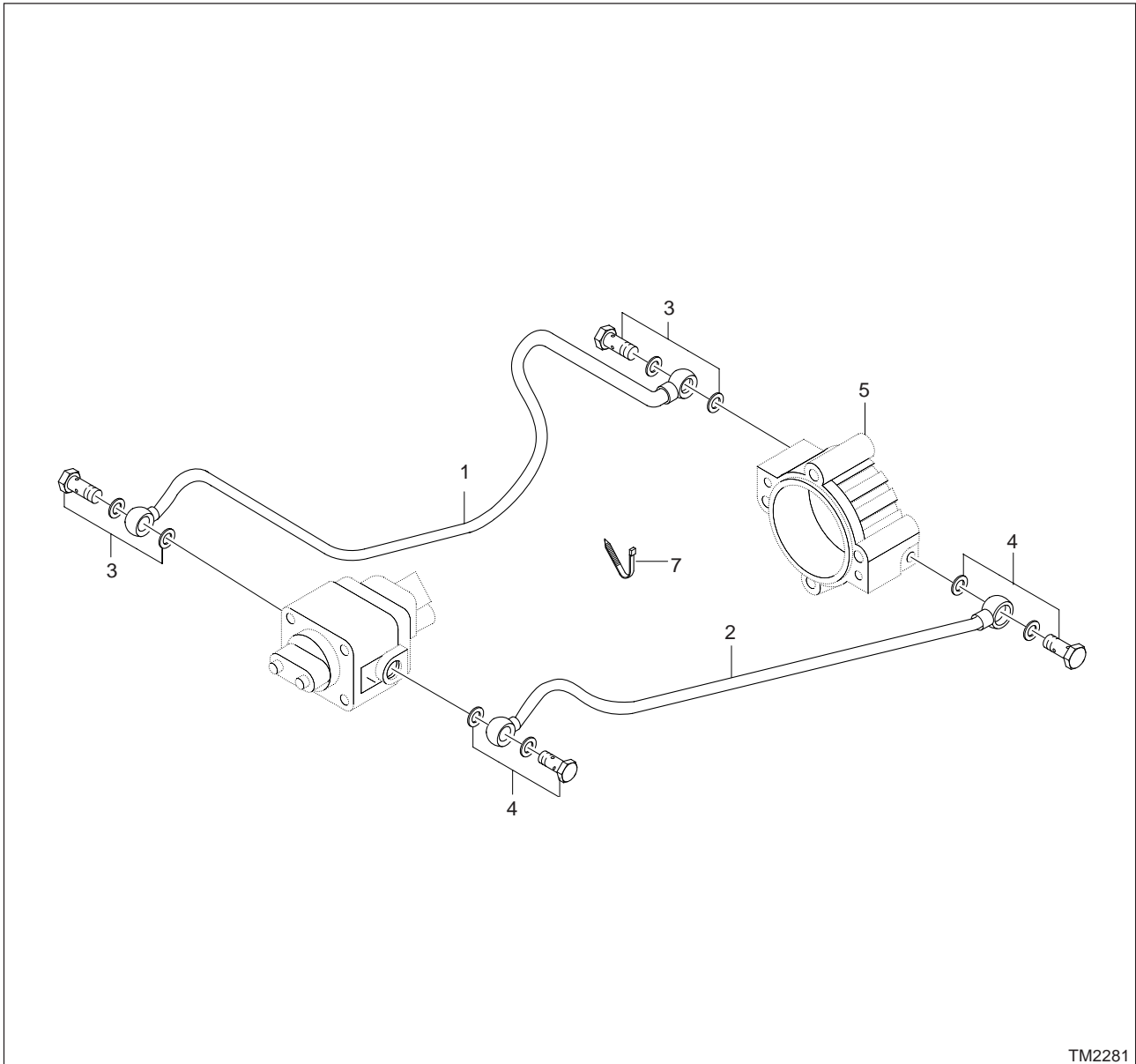
As shown below, the disassembly sequence for major overhaul starts from No. "1" and ends with No. "7" for assembly operation, reverse this sequence.



TM2270

- | | |
|---|---|
| 1. Tecalan pipes | 5. Adaptor plate, Splitter housing,
Clutch bell and oil screen |
| 2. Range change group with shift
cylinders | 6. Shafts with selector rails and Return |
| 3. Sun gear | 7. Housing(major parts) |
| 4. Gear change unit | |

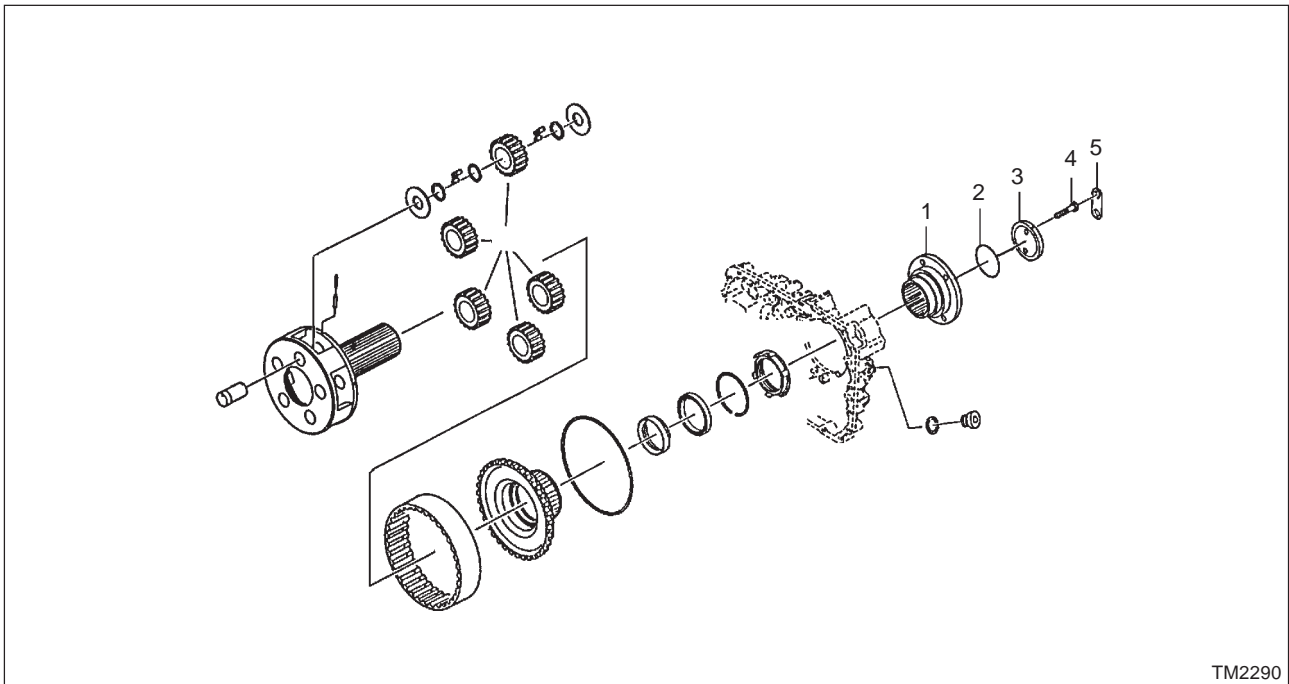
9-7-b. TECALAN PIPES FOR RANGE CHANGE GROUPS



Unscrew and remove banjo bolts 3 and 4 from cut-off valve 6 and range change group cylinder 5. Loosen and remove both tecalan pipes 1 and 2 from the housing. For reassembly, reverse the disassembly steps and fix the pipes with pipe clamp 7.

Caution

– M14x1.5 tightening torque=3.8kgf.m
Use new seals. Fit tecalan pipes 1 and 2 in the right-hand direction.

9-7-c. DISASSEMBLY AND REASSEMBLY OF OUTPUT FLANGE

TM2290

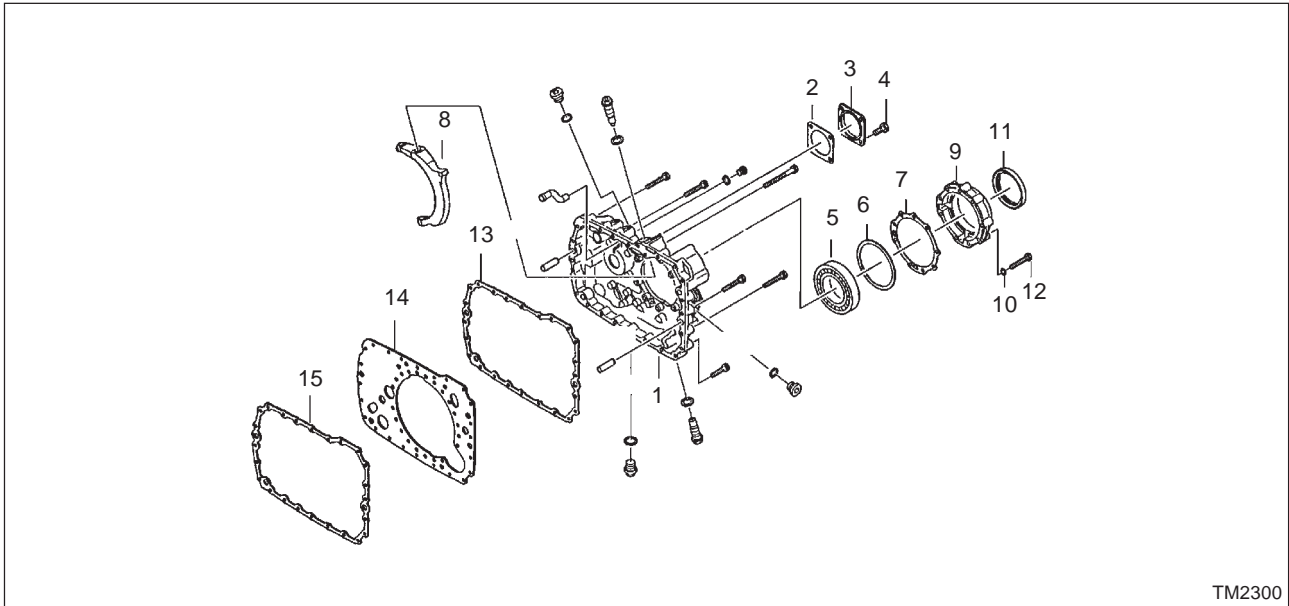
1. Disassembly

- 1) Remove locking plate 5 from output flange.
- 2) Use the standard flange retainer to Prevent output flange 1 from turning.
- 3) Unscrew and remove hex bolts 4 and thrust washer 3.
- 4) Remove output flange 1 using standard 2 or 3-arm puller.
- 5) Remove O-ring 2.

2. Reassembly

- 1) Lightly coat radial seal 11 in bearing cover 9 with oil.
- 2) Heat output flange 1 to max. 70°C and slide it as far as possible onto planetary carrier (shaft).
Use thrust washer 3 and two standard M12x75 hex bolts to tighten the output flange firmly into place.
Remove both hex bolts and thrust washer.
- 3) Press O-ring 2 into recess between output flange 1 and planetary carrier (shaft).
- 4) Secure output flange 1 with standard retaining device to prevent flange from misaligning.
- 5) Insert thrust washer 3 into output flange with hex bolts 4 and tighten into place toward planetary carrier (shaft).
– M12x75 tightening torque=(6kgf.m)
- 6) Drive new retaining plate 5 fully home over bolt heads using special tool.

Disassembly and reassembly of output cover



TM2300

3. Disassembly

- 1) Unscrew hex bolts 4 in plate cover 3 and remove cover together with gasket 2.
- 2) Unscrew and remove hex. bolts 12 and hex. nuts 10 from cover 9.
- 3) Release cover 9 with light blows of plastic hammer.
- 4) Remove cover 9 with gasket 7, grooved ball bearing 5, shim 6 and radial seal.
- 5) Using a hammer, drive grooved ball bearing 5 out of cover 9 with plastic drift and remove shim 6.
- 6) Using a hammer, drive radial seal 11 out of cover 9 with drift.

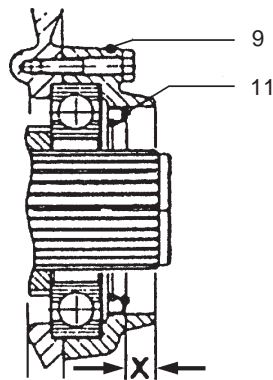
4. Reassembly

- 1) Fit new gasket 2 to plate cover 3, locate cover firmly on housing 1 and screw in hex bolts.
 - M12 tightening torque=(8.7kgf/m)
- 2) Set endfloat of grooved ball bearing 4 with shim 6.
 - The desired clearance is 0.00mm.
 - Tolerance for endfloat 0.00 to 0.10mm

Example)

Depth of bearing seat in housing 1	7.40mm
Depth of bearing seat in cover 9 with gasket 7 fitted	+23.00mm
1.Initial overall dimension	30.40mm
Setting of gasket	-0.05mm
2. Overall dimension	30.35mm
Mean value of clearance(0 to 0.1mm)	-0.05mm
3. Overall dimension	30.30mm
Width of grooved ball bearing	-30.00mm
Thickness of shim 6	=0.30mm

- 3) Heat cover 9 and firmly locate grooved ball bearing 5 to shim 6 of correct thickness.



TM2310

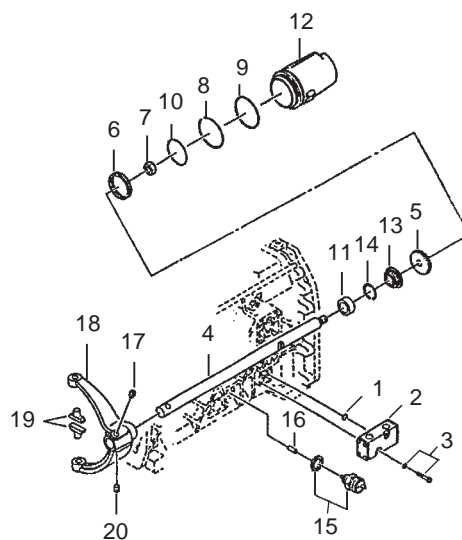
- 4) Insert radial seal 11 with tool(1x56, 137, 124).

Caution

Only use tool with 12.5mm ring.
 Installation dimension $X = 13.5^{+1.0}mm$
 Apply light coating of sealing compound to outer steel face of radial seal.
 Apply anti-friction coating, e.g. liquid soap to outer rubber face of radial seal.

- 5) Fit new gasket 7 to bearing cover 9.
 6) Fit new spring discs with hex bolts 12 and hex nuts 10 and tighten into place.
 – M10 tightening torque=(4.9kgf.m)

Disassembly and reassembly of 5/2-way valve



TM2320

5. Disassembly

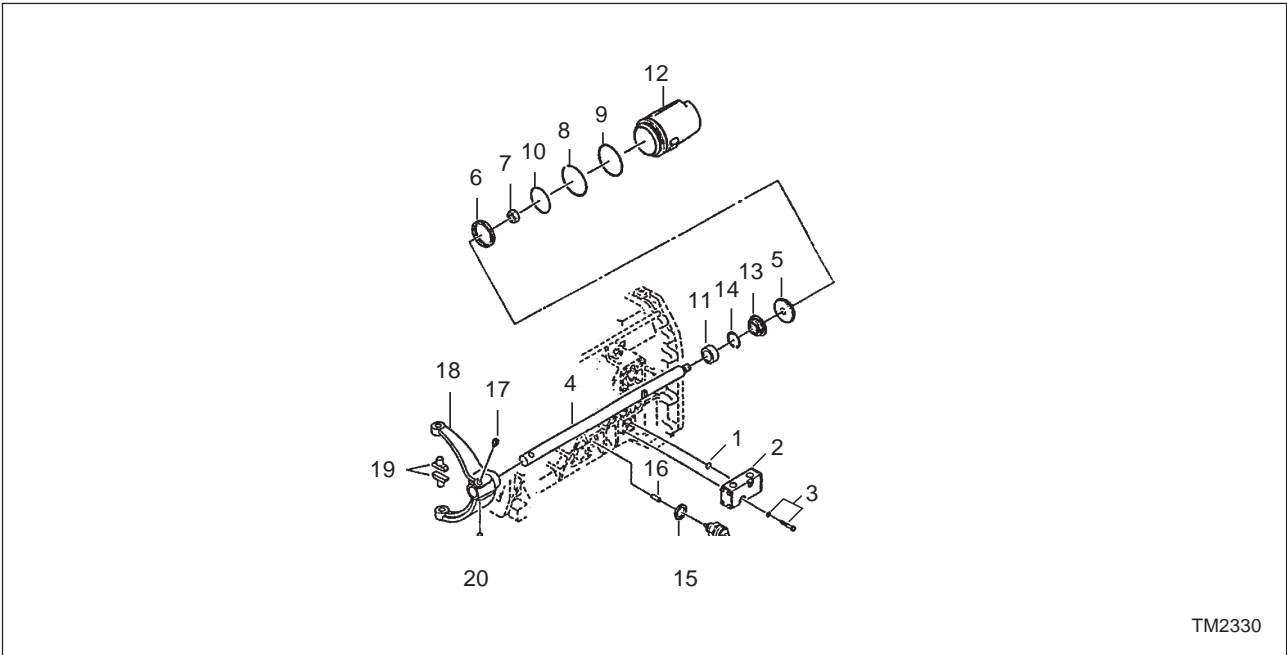
Unscrew and remove hex bolts 3 from spring discs and remove 5/2-way valve 2.

Caution

5/2-way valve 2 is an integrated unit: do not dismantle it.

6. Reassembly

- 1) Wet O-rings 1 with grease and fit to 5/2-way valve 2.
- 2) Fit 5/2-way valve 2 onto housing, carefully aligning the compressed air bores. Screw in hex bolts to fix spring discs 3.
 - M6 tightening torque=(1.7kgf.m)



7. Disassembly

- 1) Remove 5/2-way valve 2 as described in para. 5 above.
- 2) Unscrew retaining nut 7.
- 3) Remove spring ring 8 from housing with light blows of plastic hammer.
- 4) Remove piston 5 from selector rod 4.
- 5) Remove twin-grooved ring 6 from piston.
- 6) Remove two O-rings 9 and 10 from cylinder.



8. Reassembly.

- 1) Coat outer face of new protective sleeve 11 with an anti-friction coating such as liquid soap, and press and drive firmly home in cylinder 12 using suitable drift.

- 2) Coat entire internal bore of cylinder 12 with Aero Grease 22C.
- 3) Grease O-ring 9 and fit in annular groove of cylinder 12.
- 4) Drive cylinder 3 firmly home. (Check alignment. Oil supply bores must match.)