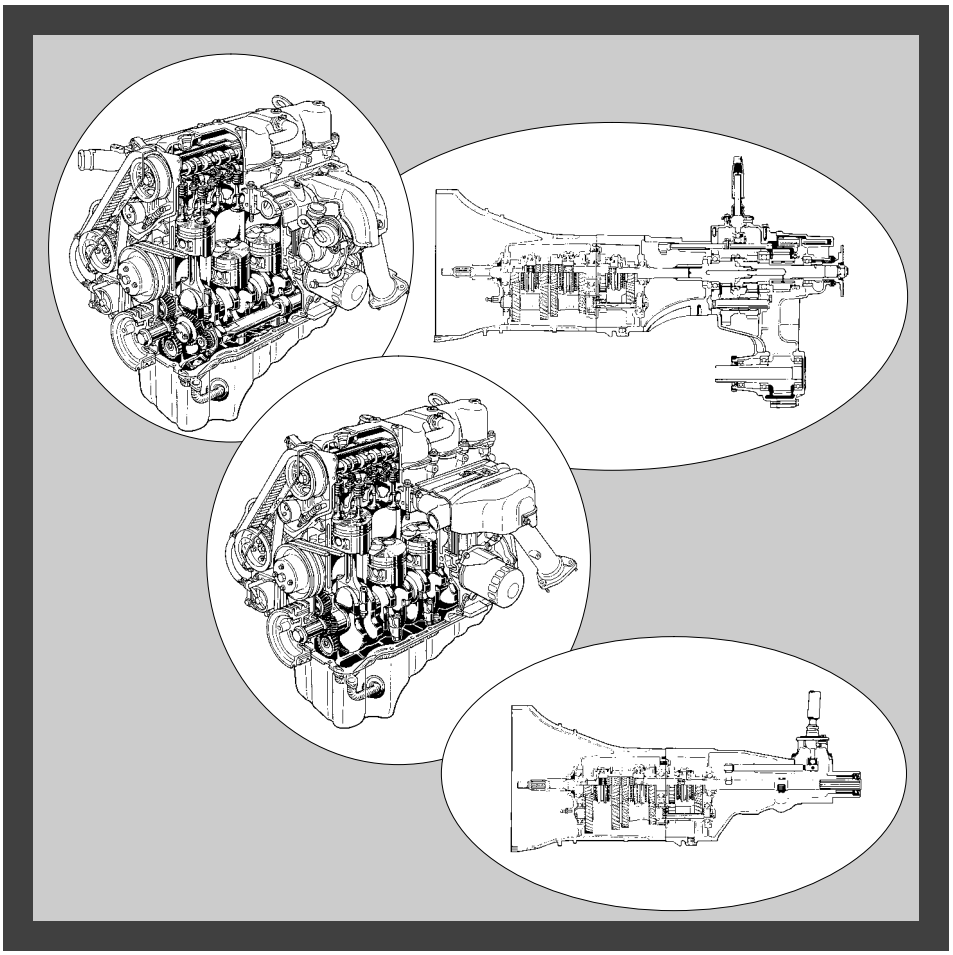
Technical Service Training

FORD RANGER

New Product Introduction TN7002083H

Powertrain



Student Information

CG 7817/S en 04/1999

With the 2000 model year a new commercial vehicle, the Ford “RANGER” is introduced. This new pick-up truck is added to Ford’s four-wheel drive vehicle line, but is also available as a two-wheel drive version.
The object of the Ford “RANGER” course is to present the vehicle and familiarize you with the vehicle components and systems. To this end, the training literature has been split into the following publications based on the main areas:

- New Product Introduction TN7002080H (00/295) “FORD RANGER”, CG 7807/S
- **New Product Introduction TN7002083H (00/295) “FORD RANGER – Powertrain”, CG 7817/S**

This New Product Introduction is designed to give an overview of the entire powertrain of the Ford “RANGER”.

The WL/WL-T engines are dealt with in detail. There are descriptions of the design and operation of the mechanical components and the engine management system. In addition, notes are provided on diagnosis and testing.

Descriptions are also given of the R15M-D and R15MX-D manual transmissions as well as the transfer case.

Further, the drive shafts, differentials and the freewheel mechanism are dealt with. Additionally, important instructions for use are to be found in the appropriate section.

Detailed information about the vehicle’s chassis and electrical and electronic systems as well as the heating, ventilation and air conditioning system is provided in the corresponding Student Information publication.

Please remember that our training literature has been prepared solely for FORD TRAINING PURPOSES. Repair and adjustment operations **MUST** always be carried out according to the instructions and specifications in the workshop literature.
Please make extensive use of the training courses offered by Ford Technical Training Centers to gain extensive knowledge in both theory and practice.

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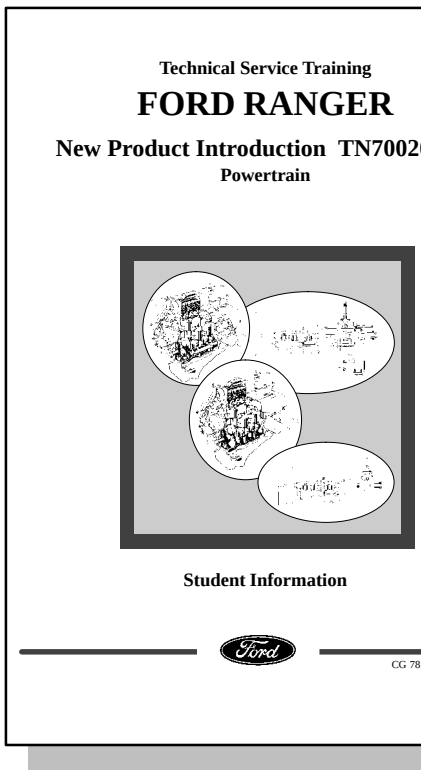
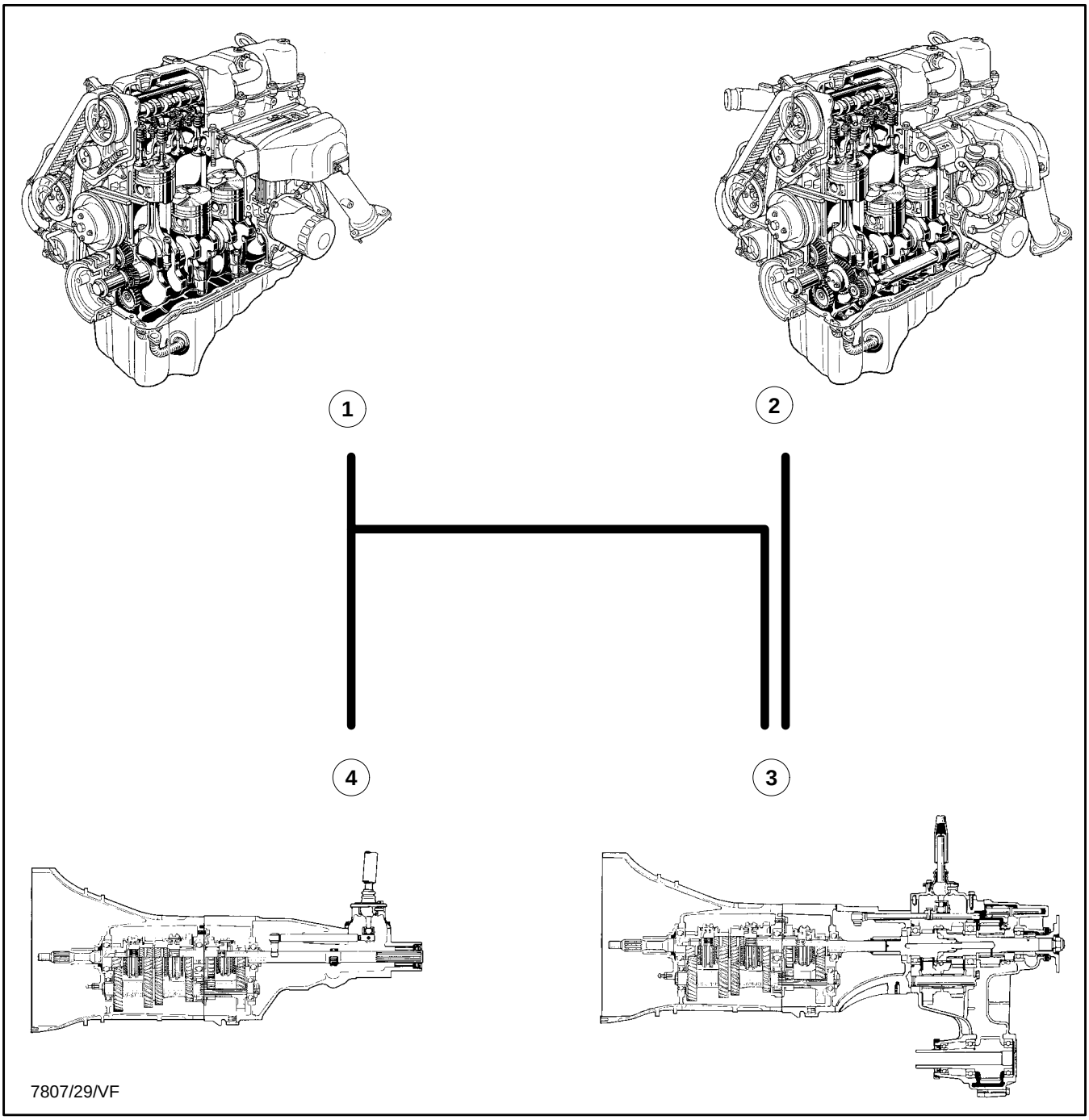


New Product Introduction CG 7807/S
"FORD RANGER TN7002080H"

Wiring diagrams

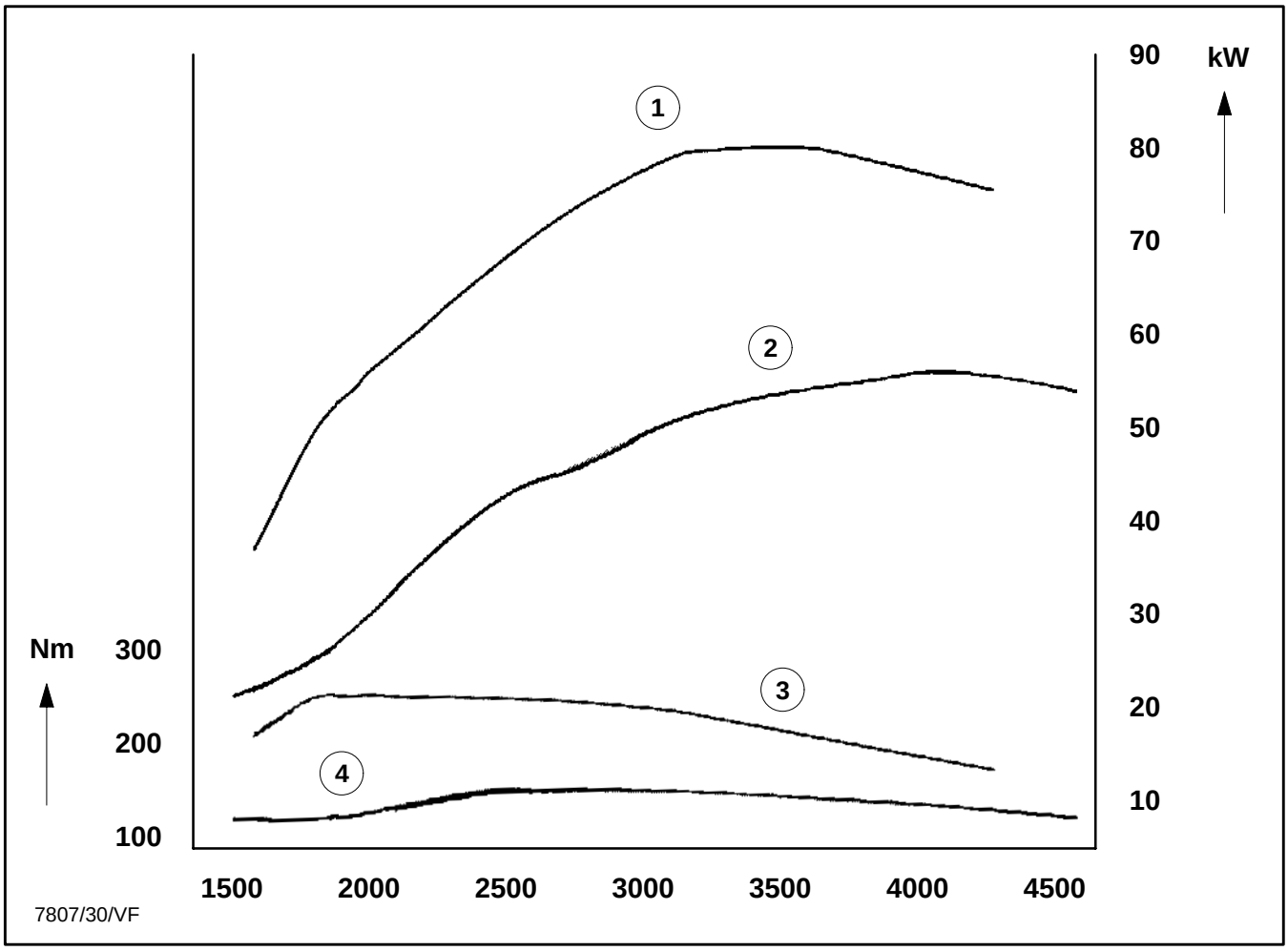
Workshop manual

Diagnosis and test manual



1 2.5L WL naturally aspirated diesel engine
2 2.5L WL-T turbocharged diesel
3 R15MX-D transmission for 4WD
4 R15M-D transmission for 2WD

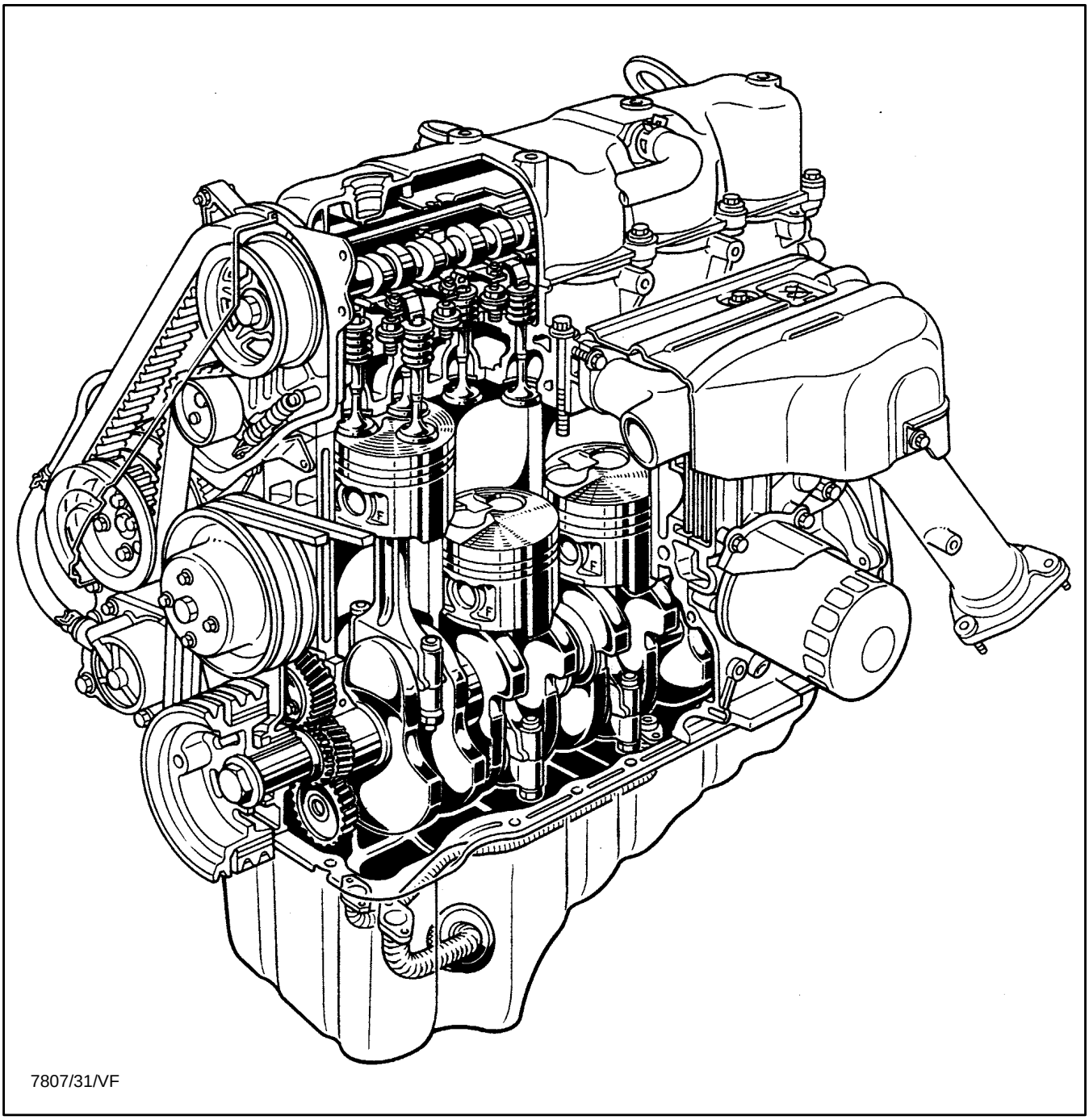
Engine power output and torque



1 Power output – 2.5L WL-T turbocharged diesel
2 Power output – 2.5L WL diesel
3 Torque – 2.5L WL-T turbocharged diesel
4 Torque – 2.5L WL diesel

Technical data

	2.5L WL	**2.5L WL-T**
Cubic capacity	2,499 cc	2,499 cc
Stroke	92.0 mm	92.0 mm
Bore	93.0 mm	93.0 mm
Compression ratio	21.6 : 1	19.8 : 1
Max. power output	57 kW (78 PS) at 4,100 rpm	80 kW (109 PS) at 3,500 rpm
Max. torque	168 Nm at 2,500 rpm	266 Nm at 2,000 rpm



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Engine

- 2.5L naturally aspirated diesel (57 kW or 78 PS at 4,100 rpm/168 Nm at 2,500 rpm)
- Cast iron cylinder block
- Aluminium alloy cylinder head with swirl chamber
- 3 valves per cylinder (1 exhaust valve and 2 intake valves)

Engine management

- Mechanical fuel injection by distributor type fuel injection pump
- PCM controlled glow plug operation, idle speed, fuel injection timing and A/C cut-off

Emission control

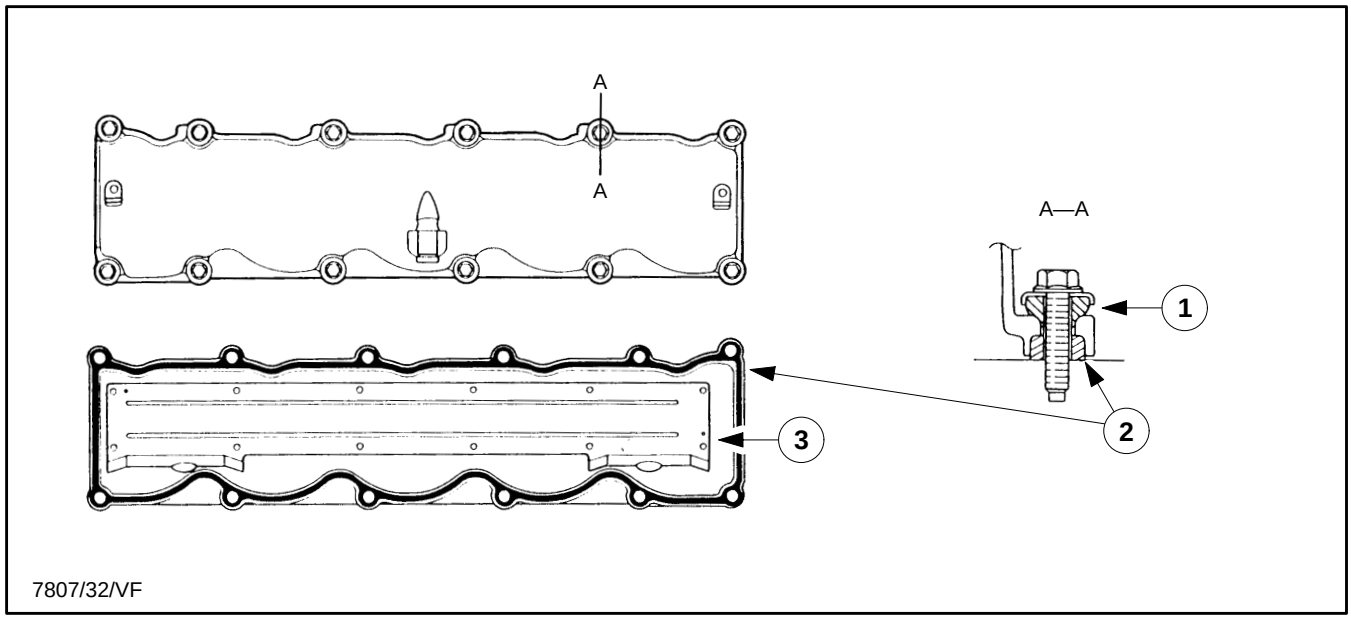
- Emission standard EC Step 2
- Oxidation catalytic converter (OC)

Diagnosis and testing

- Diagnosis and testing through the data link connector (DLC) in the engine compartment

General

Cylinder head cover

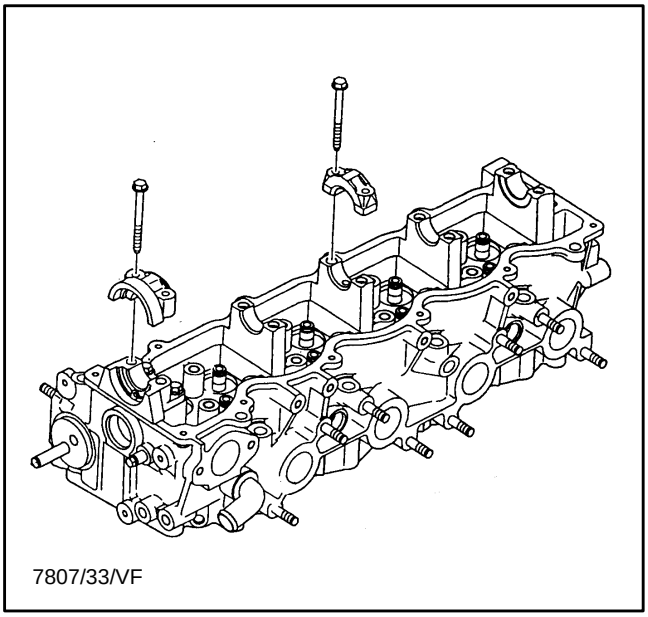


1 Rubber grommet
2 Cylinder head cover gasket
3 Oil baffle

- The cylinder head cover is made of aluminium alloy.
- To reduce noise and vibration, the cylinder head cover features full-floating mounting to the cylinder head through a rubber gasket.

Cylinder head

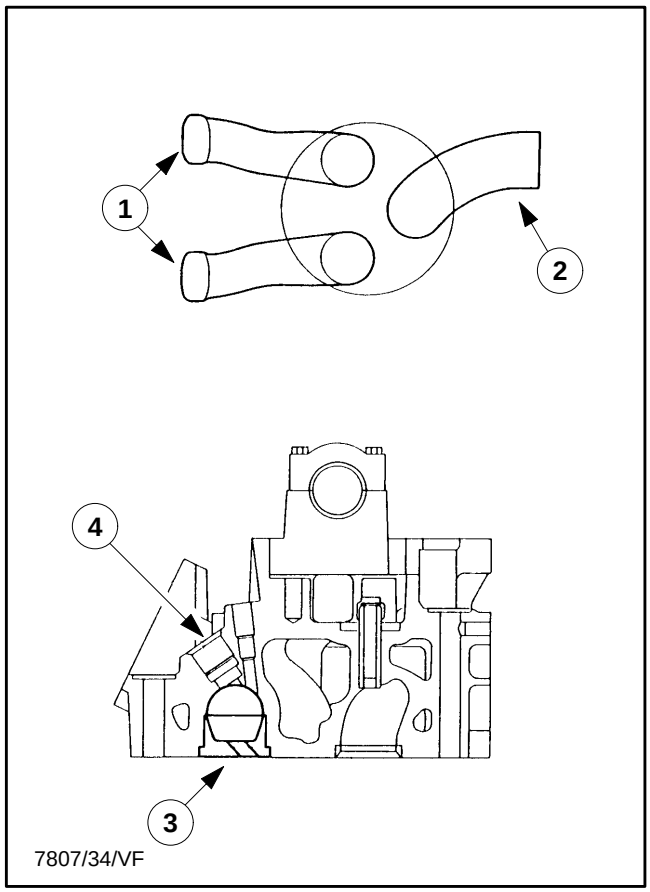
- The cylinder head is made of aluminium alloy.



Cylinder head (continued)

- The port layout is a cross-flow type with two intake valves and one exhaust valve per cylinder.
- The swirl type combustion chamber is integrated in the cylinder head.

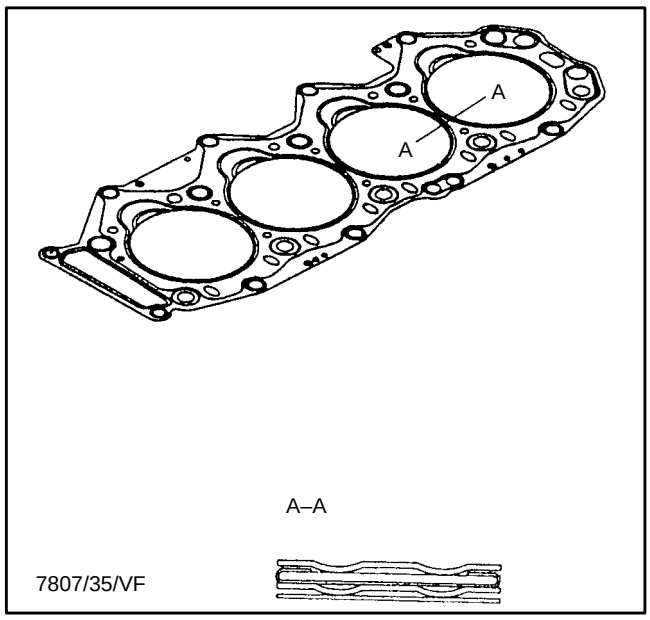
NOTE: The combustion chamber insert must not be changed.



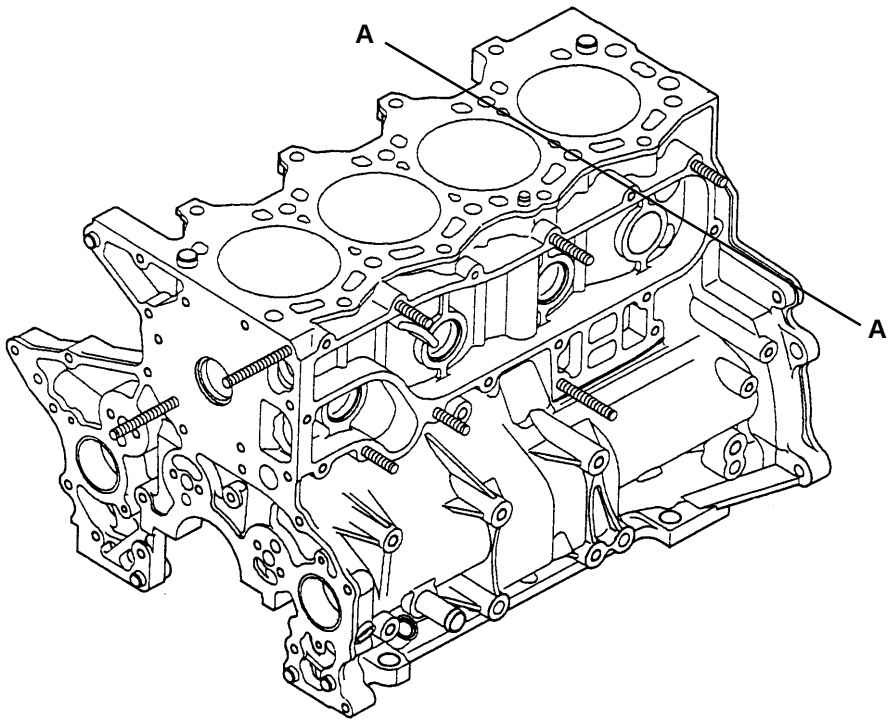
1 Intake port
2 Exhaust port
3 Combustion chamber insert
4 Fuel injection nozzle assembly port

Cylinder head gasket

- The cylinder head gasket is made of five laminated layers of stainless steel.



Cylinder block



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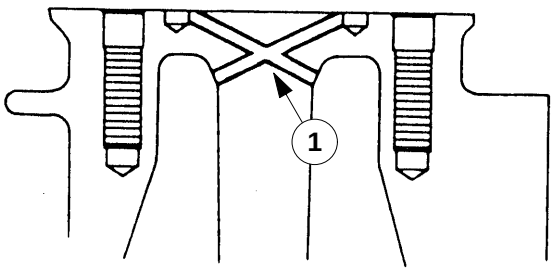
- The cylinder block is made of cast iron.
- The cross-drilled coolant passages improve cooling between the cylinder bores.



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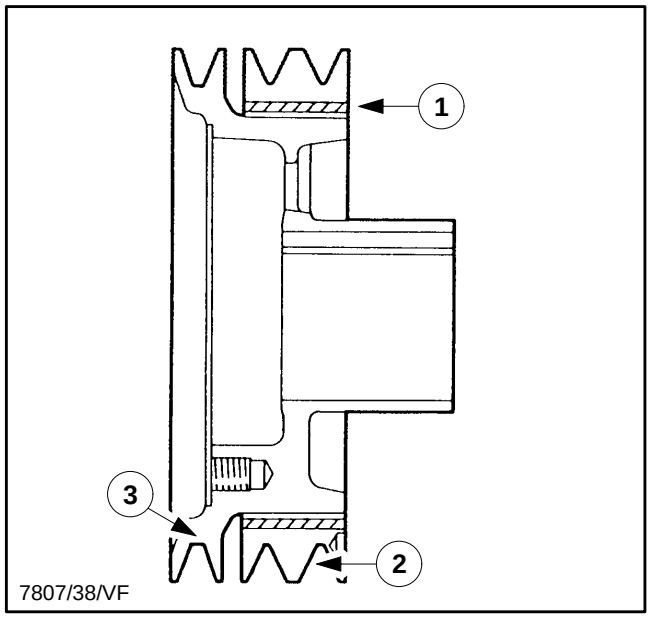
Section A – A

1 Cross-drilled holes

Crankshaft pulley

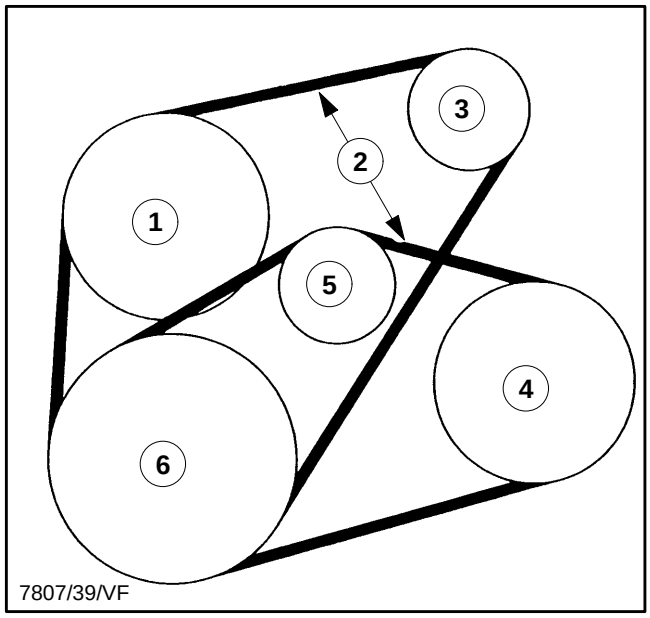
- A torsional damper pulley is used for the crankshaft pulley to reduce noise and torsional vibration during high speed rotation of the crankshaft.



1 Torsional (rubber) damper
2 Generator and water pump pulley
3 A/C compressor pulley

Drive belts

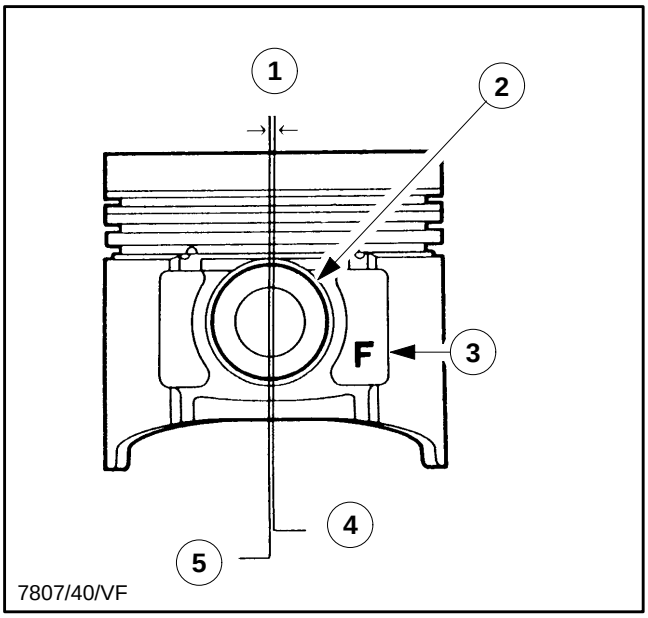
- Water pump and generator are driven by a pair of V-belts.



1 Water pump
2 Drive belts (V-belts)
3 Generator
4 A/C compressor
5 Tensioner pulley
6 Crankshaft pulley

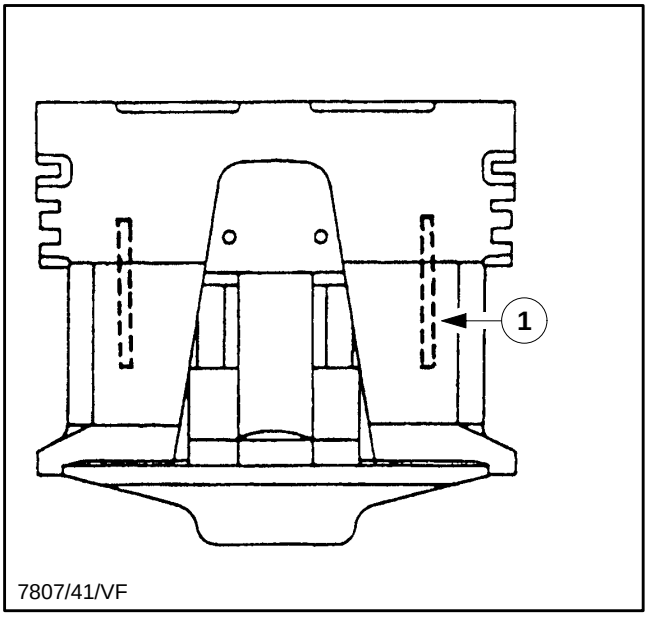
Pistons

- Offset pistons are used to reduce piston slapping noise.
- The fitting of the piston, connecting rod and piston pin is full-floating.



1 Offset
2 Piston pin
3 Front mark
4 Cylinder bore center
5 Piston pin center

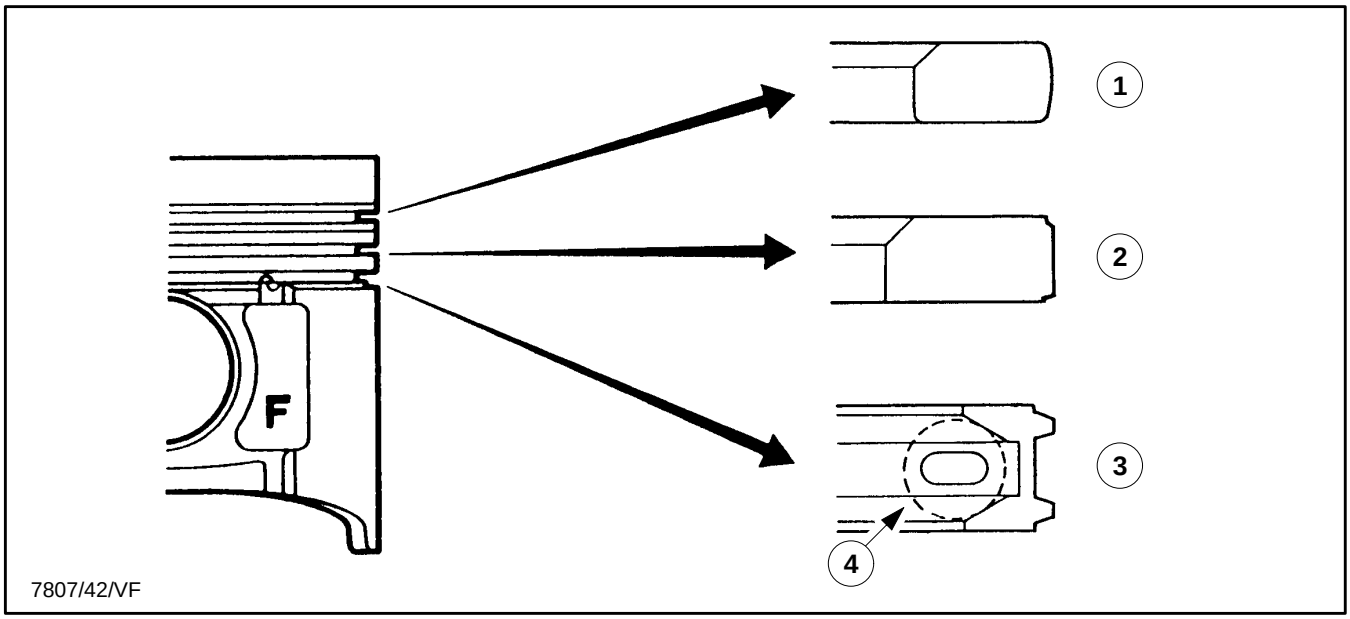
- Steel struts are cast into the boss to curb thermal expansion. This minimizes the change in piston clearance by temperature and optimizing offset volume.



1 Steel strut

Piston rings

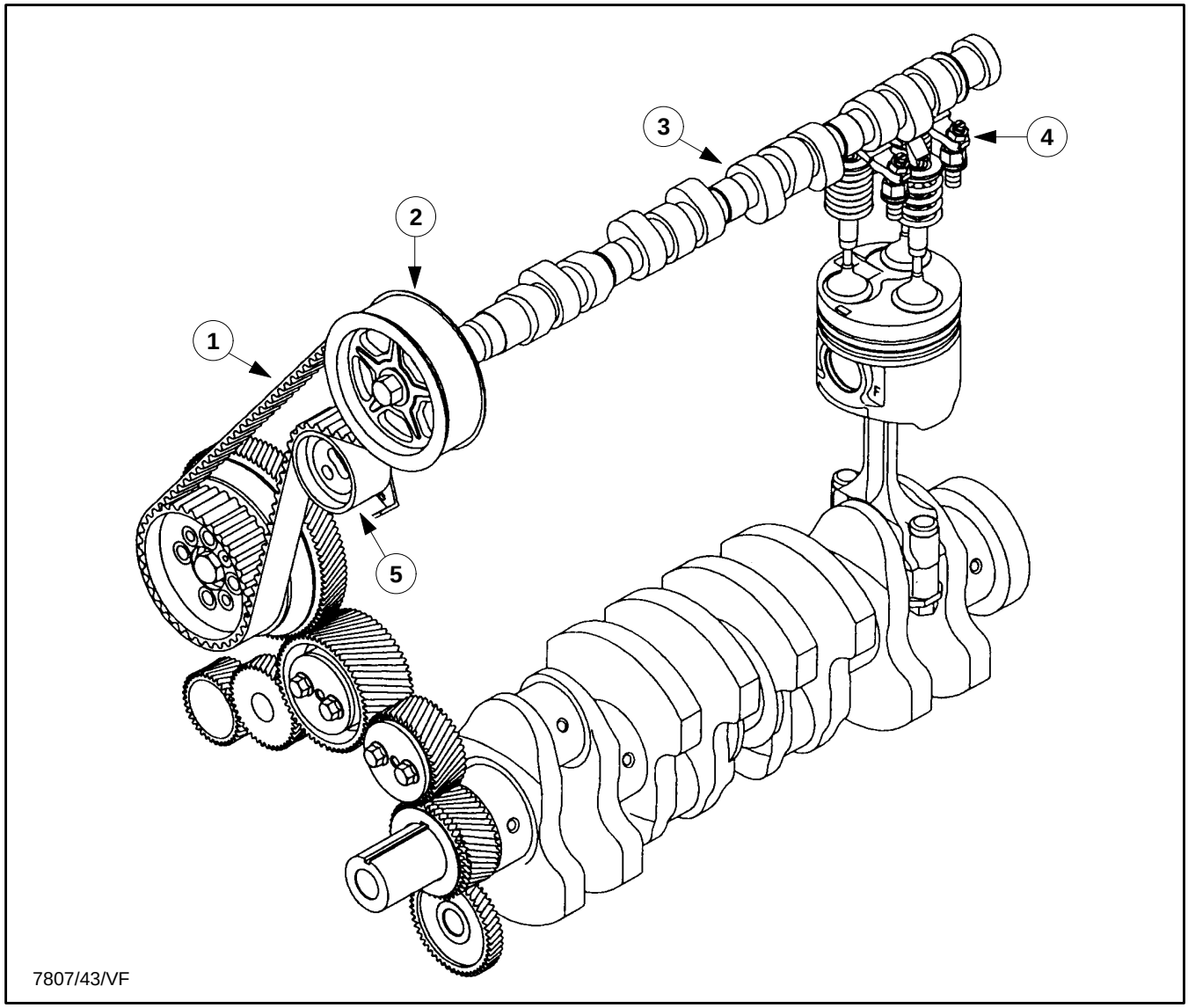
- Top and second rings are inner bevel rings.
- The oil ring is a bevel oil control ring with an expander.



1 Top ring
2 Second ring
3 Oil ring
4 Expander

Valve mechanism

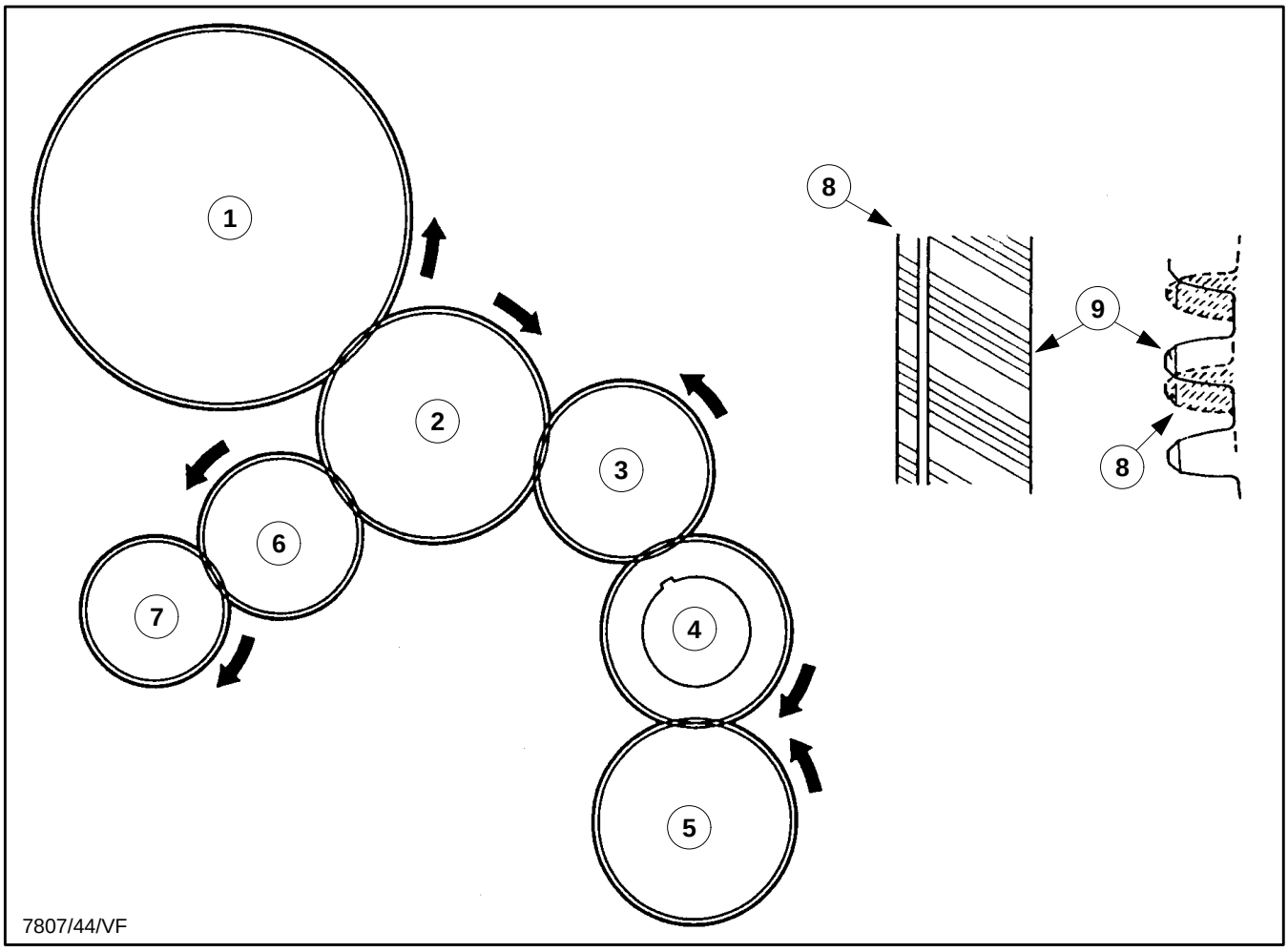
Structural view



1 Timing belt
2 Camshaft pulley
3 Camshaft
4 Rocker arm
5 Tensioner

Valve mechanism (continued)

Drive train



1 Fuel injection pump gear
2 No. 2 idler gear
3 No. 1 idler gear
4 Timing gear
5 Oil pump gear
6 Vacuum pump gear
7 Power steering pump gear
8 Friction gear
9 Helical gear

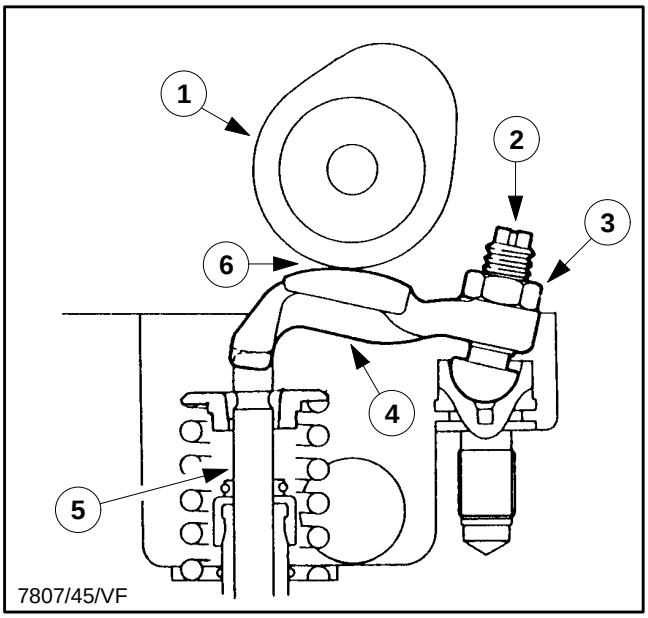
- The gears are helical. The fuel injection pump gear and timing gear are combined with a friction gear.
- The friction gears are equipped for noise reduction. They have one tooth less than the appropriate gear they are fitted to.
- The friction gears are fitted to their main gears by using spring washers in between.
- When the engine is running, the friction gears rotate a little bit faster than the main gears and cause friction that counteracts the play between the teeth of the main gears.

NOTE: The gears are marked for production and service. Refer to the current service literature.

Valve mechanism (continued)

Valve actuation

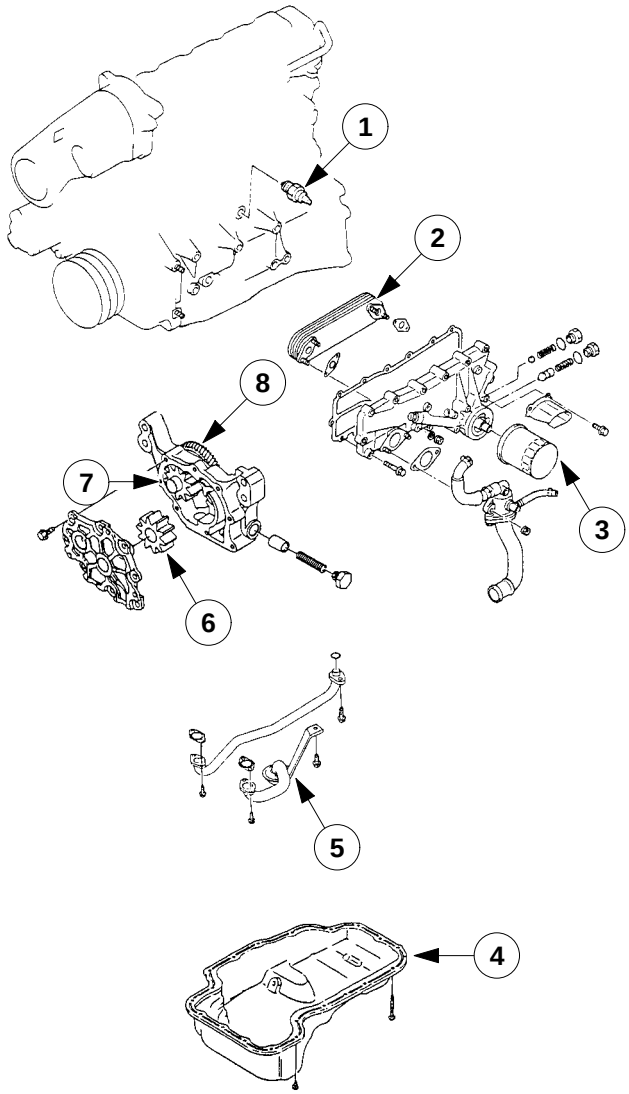
- The valves are operated by rocker arms.
- Valve clearance is adjusted by the adjustment bolt and nut of the rocker arm.



1 Camshaft
2 Adjustment bolt
3 Nut
4 Rocker arm
5 Valve stem
6 Valve clearance measuring point

Lubrication system

Structural view



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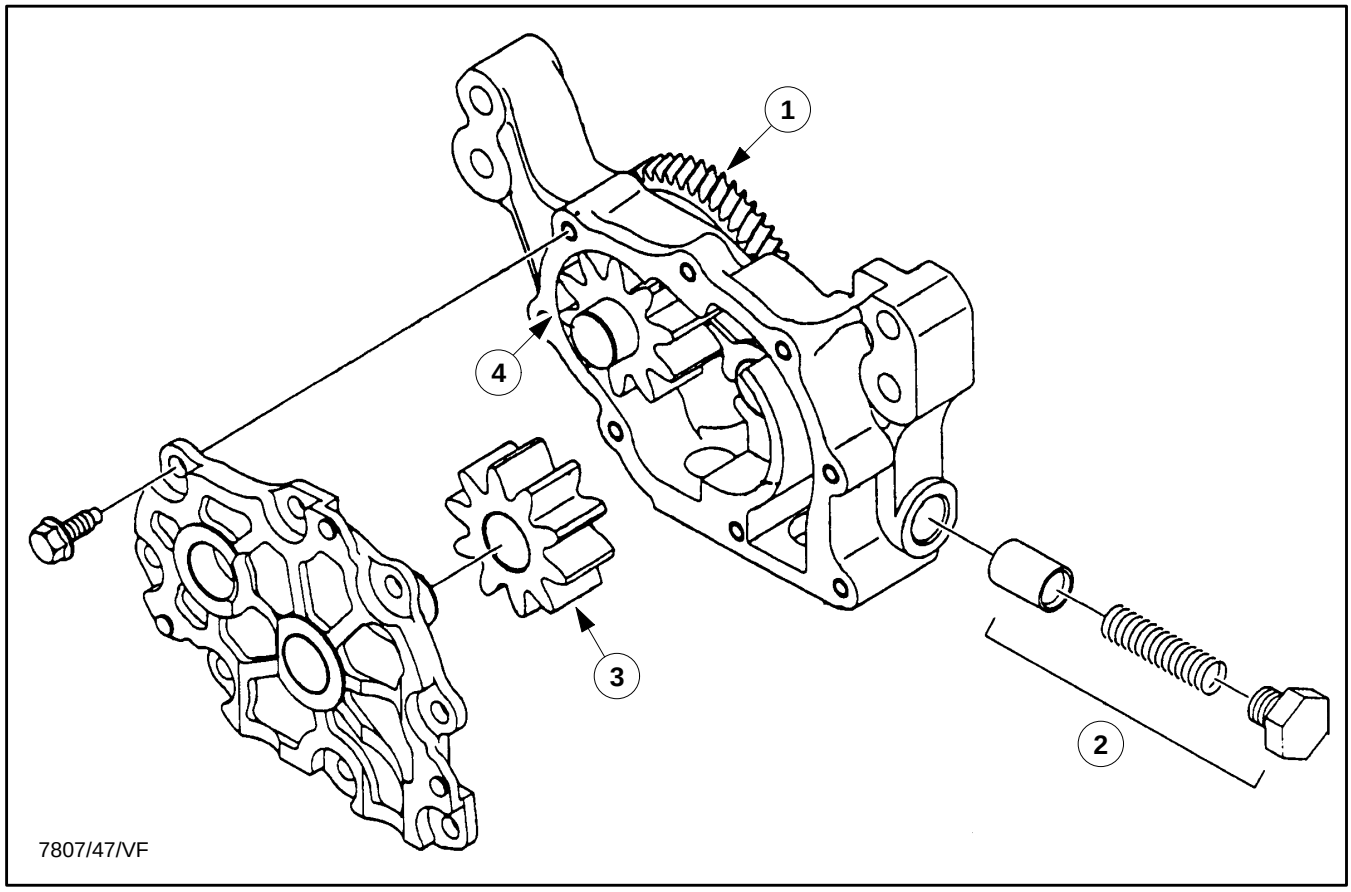
1 Oil pressure switch
2 Oil cooler
3 Oil filter
4 Oil pan
5 Oil strainer
6 Oil pump driven gear
7 Oil pump driving gear
8 Oil pump drive gear

Lubrication system (continued)

Oil pump

- The oil pump used in the Ford Ranger diesel engines is a gear type.
- The drive gear of the oil pump is driven by the timing gear.
- The oil pressure relief valve is integrated in the oil pump housing.

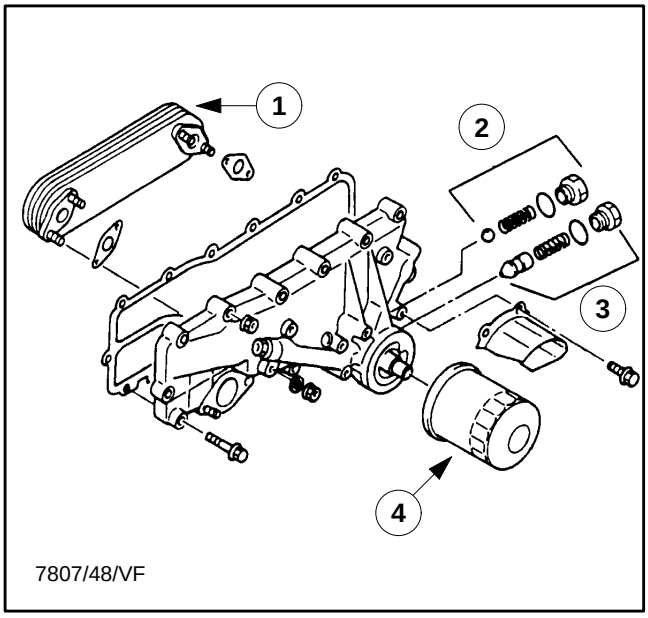


1 Drive gear
2 Oil pressure relief valve
3 Driven gear
4 Driving gear

Lubrication system (continued)

Oil cooler

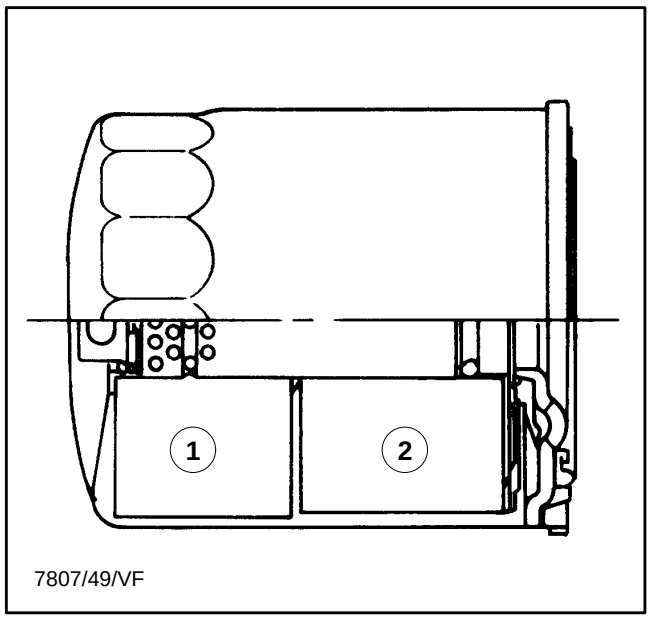
- The oil cooler is a water cooled type.
- The oil cooler integrates the oil cooler bypass valve and the oil pressure control valve.



1 Oil cooler
2 Oil cooler bypass valve
3 Oil pressure control valve
4 Oil filter

Oil filter

- The oil filter consists of two filter elements. The full-flow element is used for cleaning the oil which is forced into the lubrication system. The bypass element is used to clean the oil which is fed back into the oil pan.

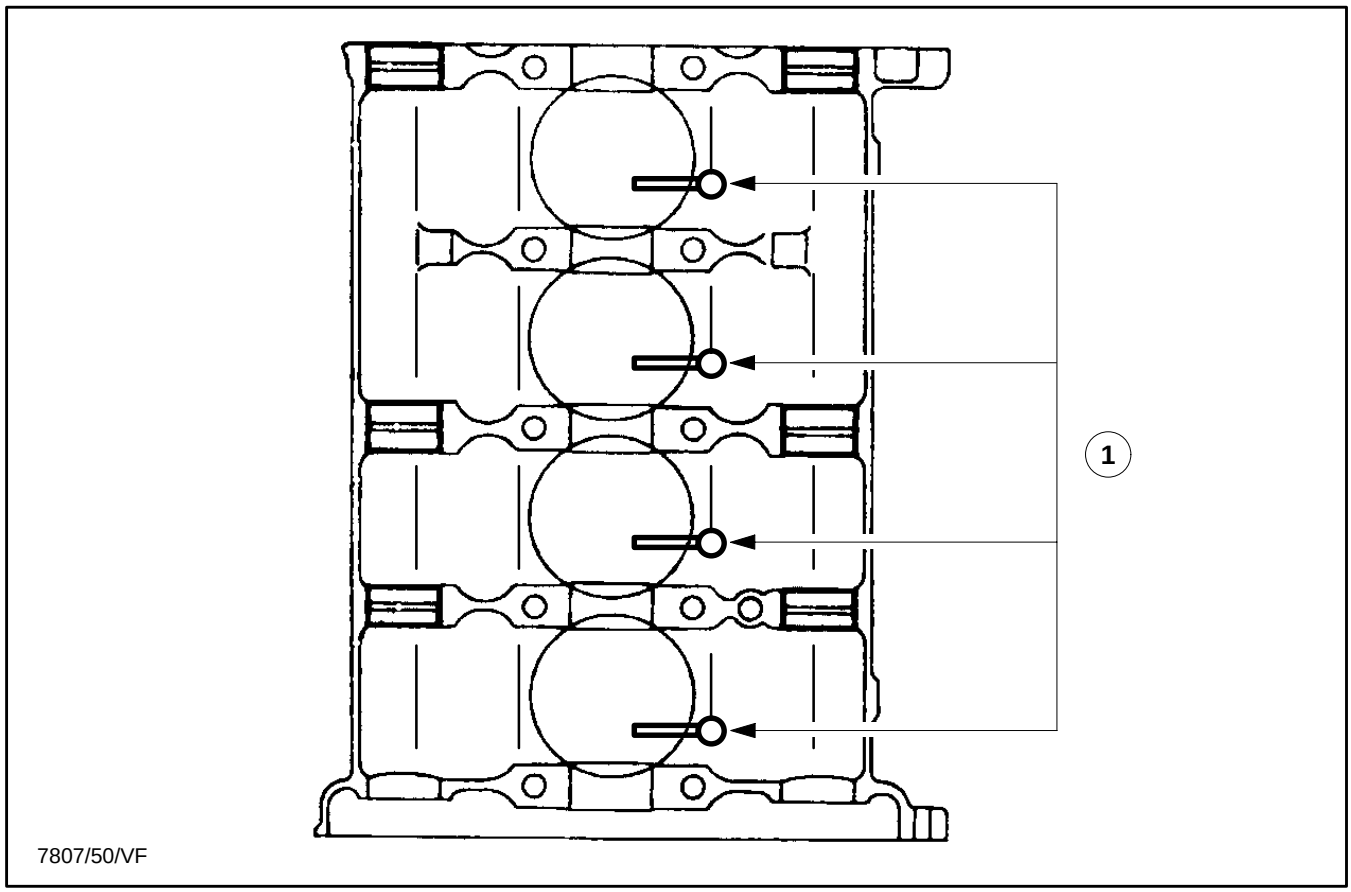


1 Full-flow element
2 Bypass element

Lubrication system

Oil spray tubes

- For each cylinder an oil spray tube is mounted in the lower part of the cylinder block.
- The oil spray tubes continously spray oil under the pistons to cool the piston crown.

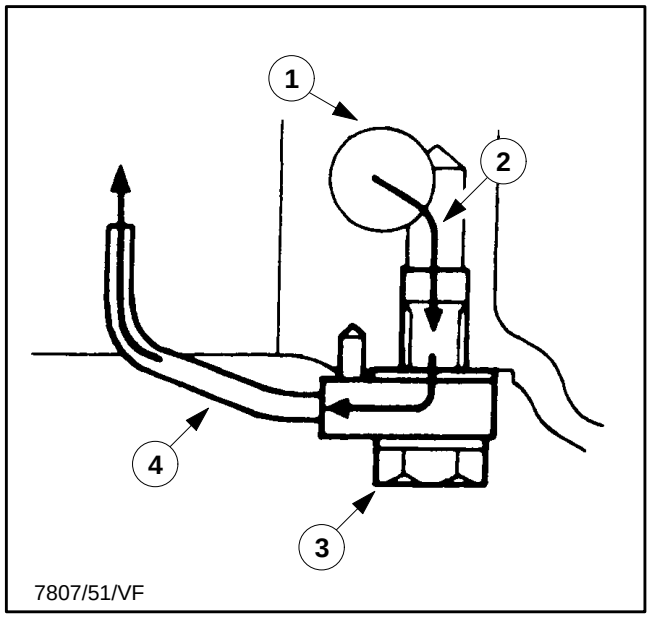


1 Oil spray tubes

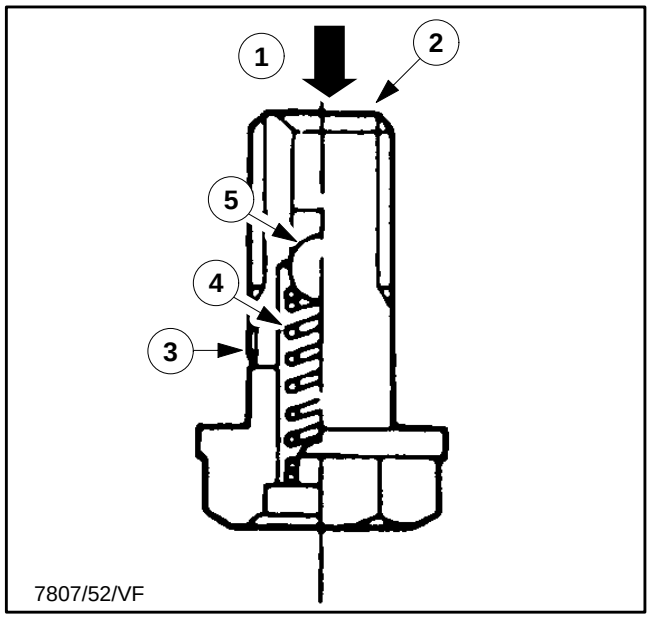
Lubrication system (continued)

Check valve

- If the oil pressure is below 1.4 – 2.0 bar, a check valve stops the oil supply to the spray tubes to maintain sufficient oil pressure for engine lubrication.



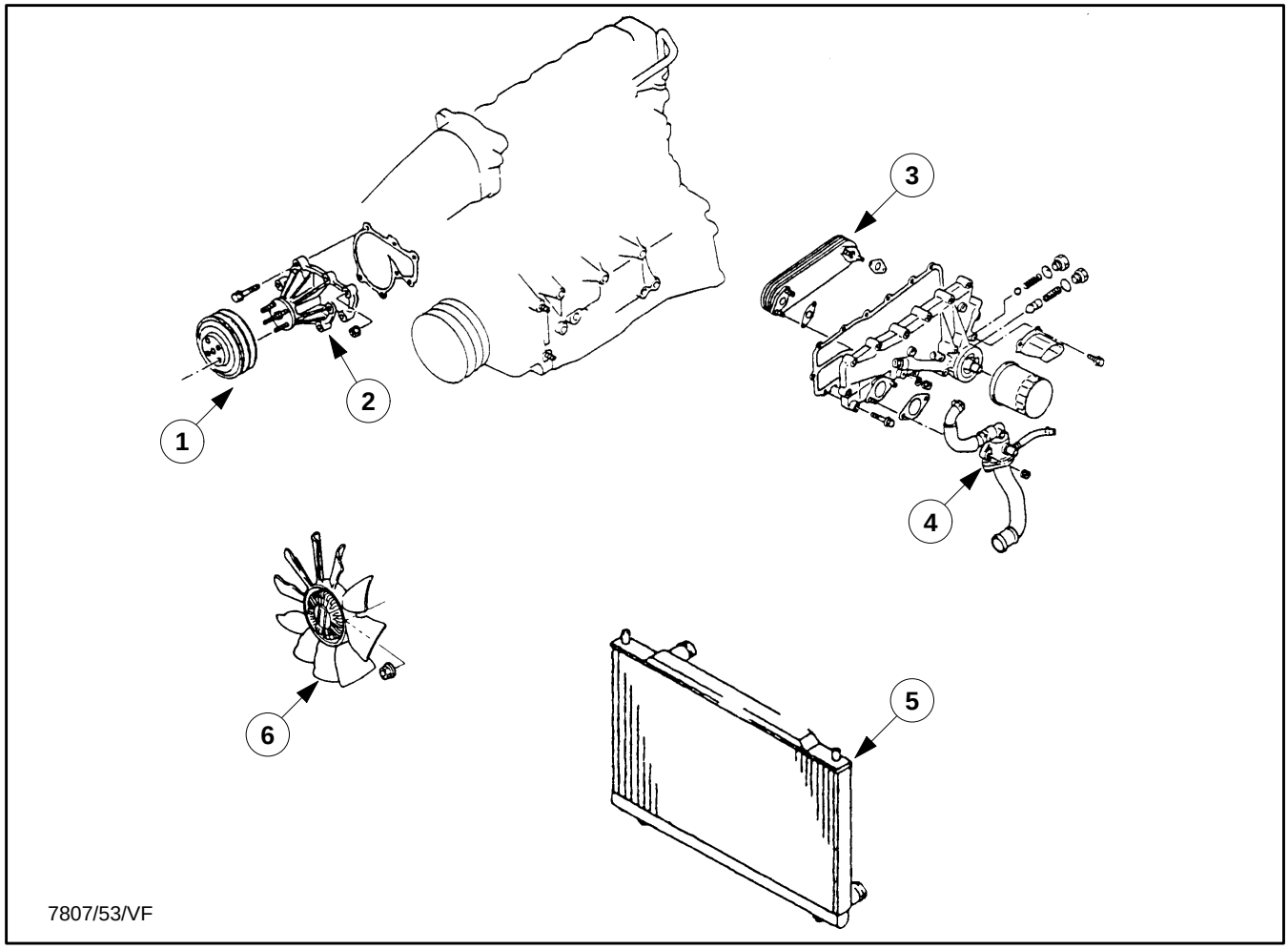
1 Cylinder block main oil gallery
2 Engine oil
3 Check valve
4 Oil spray tube



1 Oil pressure
2 Oil channel
3 Oil hole to spray tube
4 Check ball spring
5 Check ball

Cooling system

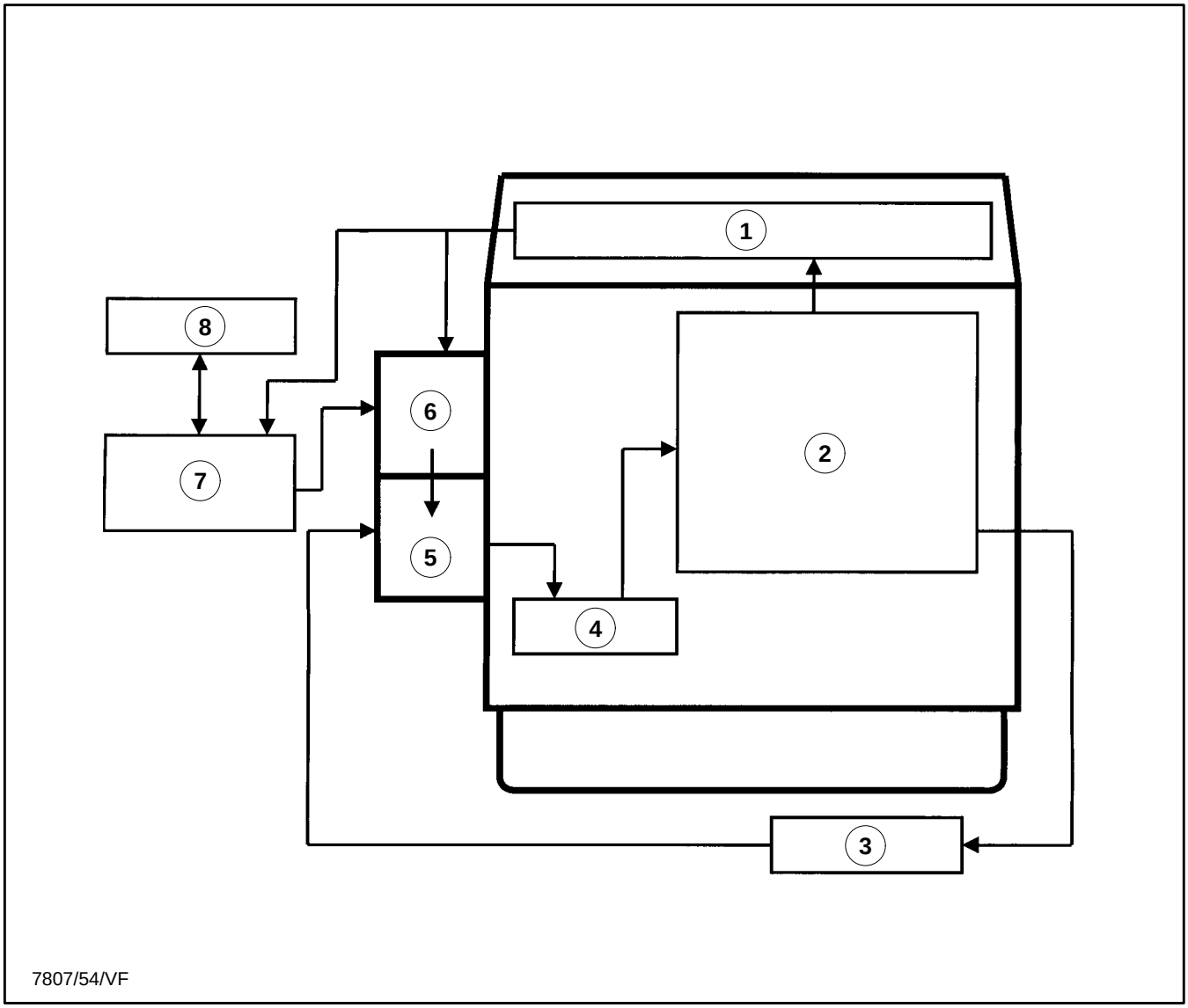
- The water pump is integrated in the cylinder block.
- The cooling fan is connected to the water pump pulley by a thermomodulated coupling and driven by a V-belt.



1 Water pump pulley
2 Water pump
3 Oil cooler
4 Thermostat
5 Radiator
6 Cooling fan

Cooling system (continued)

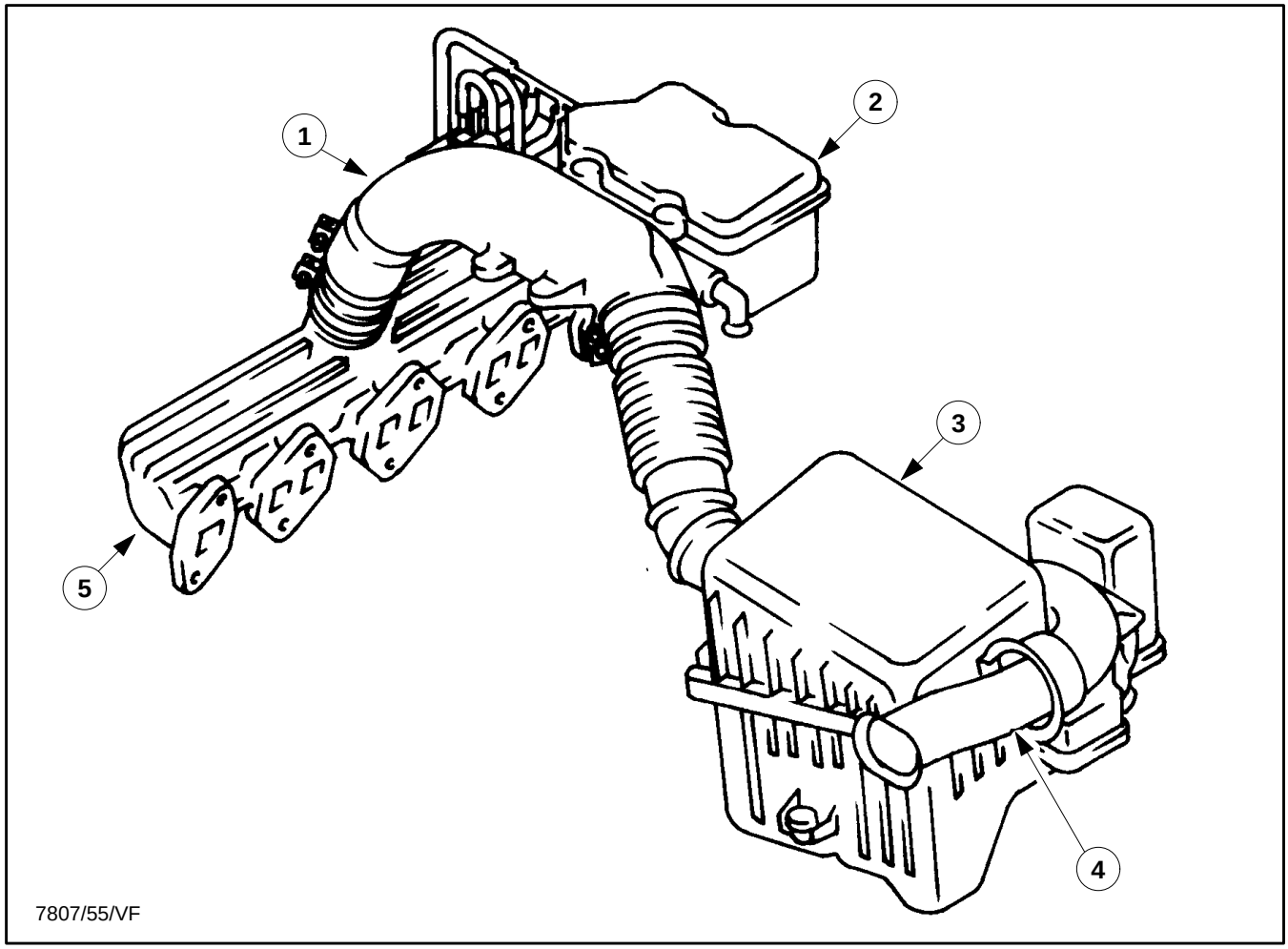
Coolant flow diagram



1 Cylinder head
2 Cylinder block
3 Heater core
4 Oil cooler
5 Water pump
6 Thermostat
7 Radiator
8 Coolant expansion tank

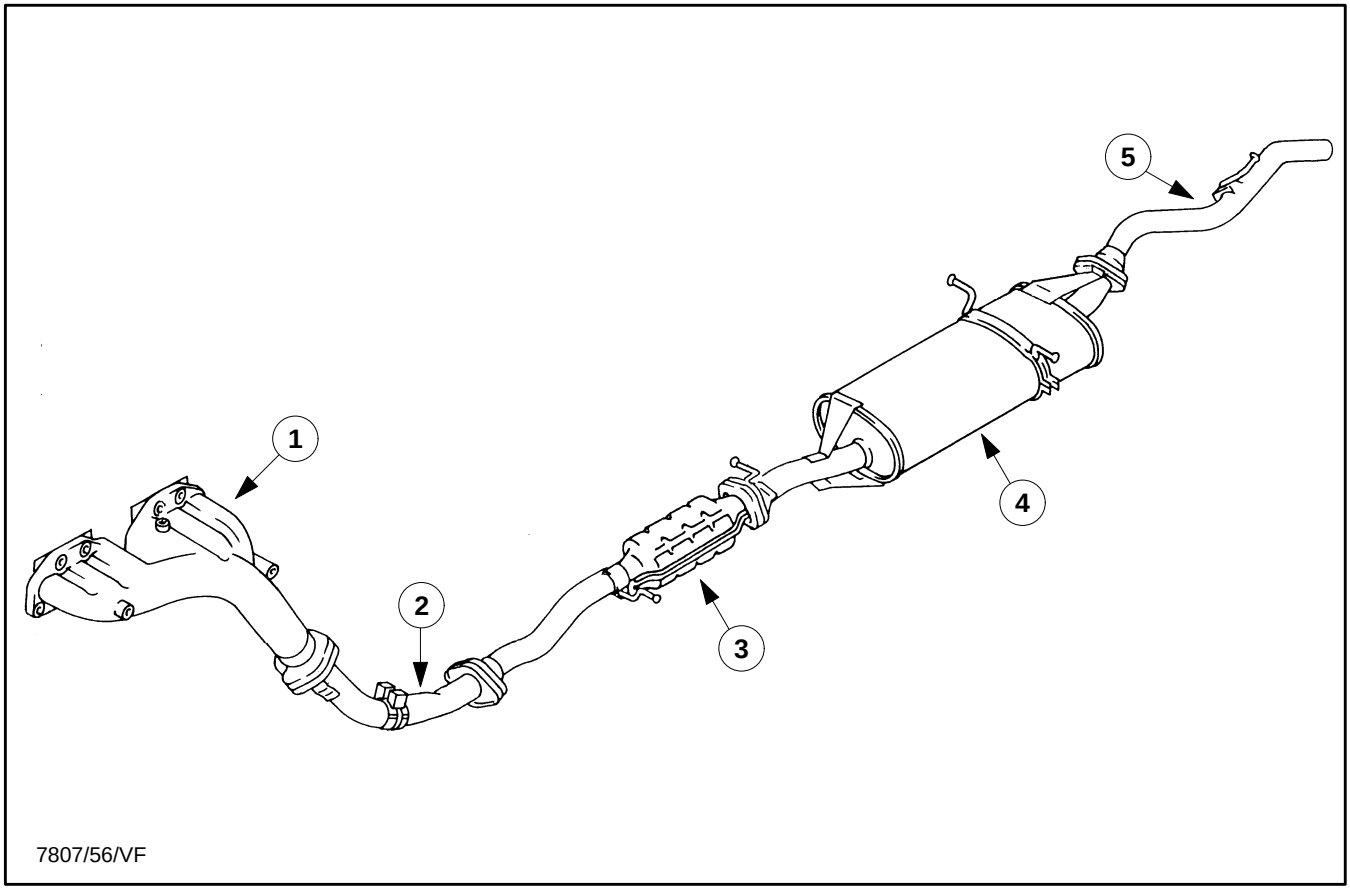
Air intake system

- Intake air from the fresh air duct is filtered by the air cleaner and passed through the intake manifold to the combustion chambers.
- A resonator is fitted for optimal noise control.

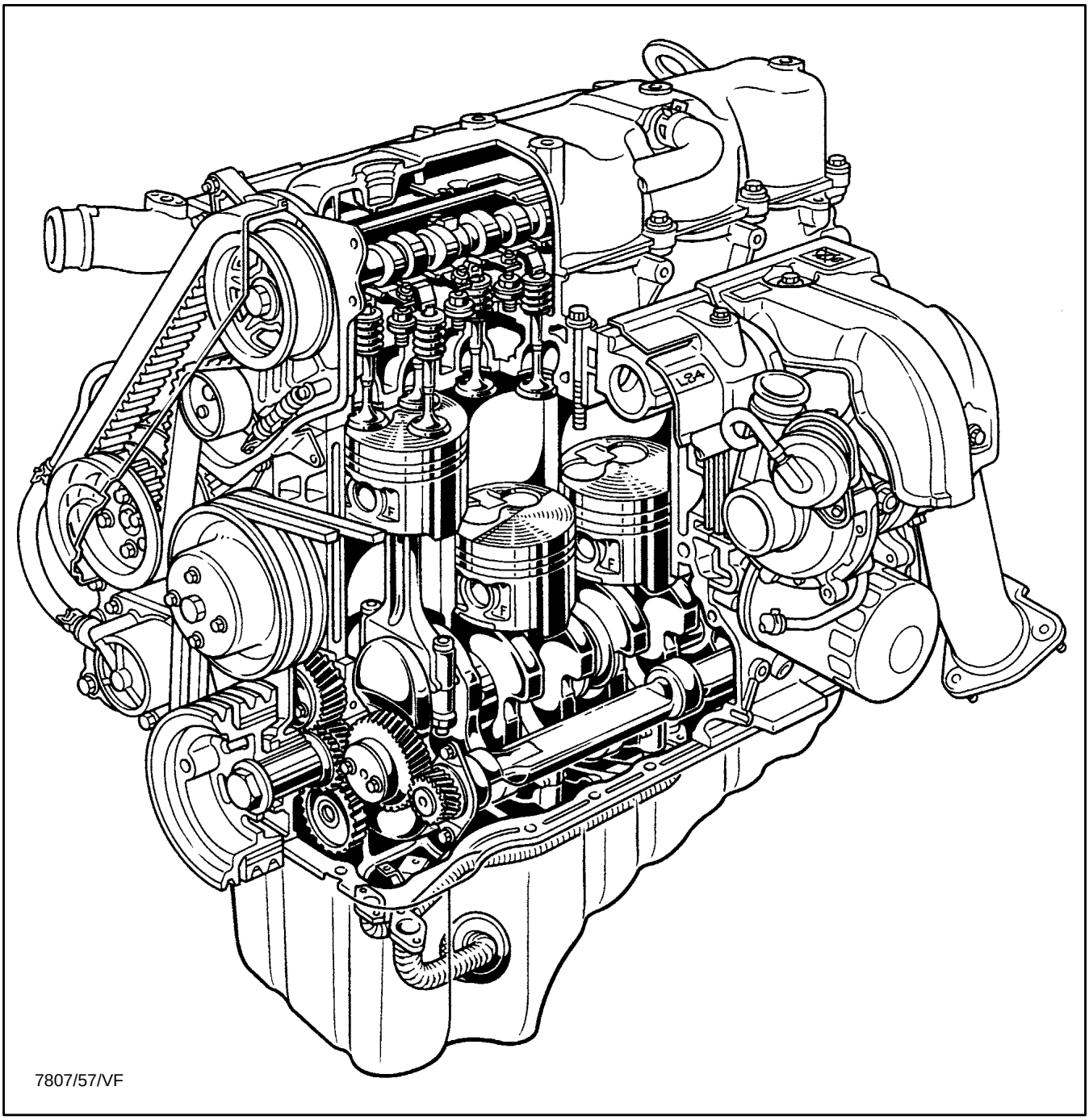


1 Intake air pipe
2 Intake air resonator
3 Air cleaner
4 Fresh-air duct
5 Intake manifold

Exhaust system



1 Exhaust manifold
2 Front pipe
3 Oxidation catalytic converter (OC)
4 Muffler
5 Tailpipe



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Engine

- 2.5L turbocharged diesel (80 kW or 109 PS at 3,500 rpm/266 Nm at 2,000 rpm)
- Intercooler
- Cast iron cylinder block
- Aluminium alloy cylinder head with swirl chamber
- 3 valves per cylinder (1 exhaust valve and 2 intake valves)
- 2 balance shafts

Engine management

- Mechanical fuel injection by distributor type fuel injection pump
- PCM controlled glow plug operation, idle speed, fuel injection timing, EGR operation and A/C cut-off

Emission control

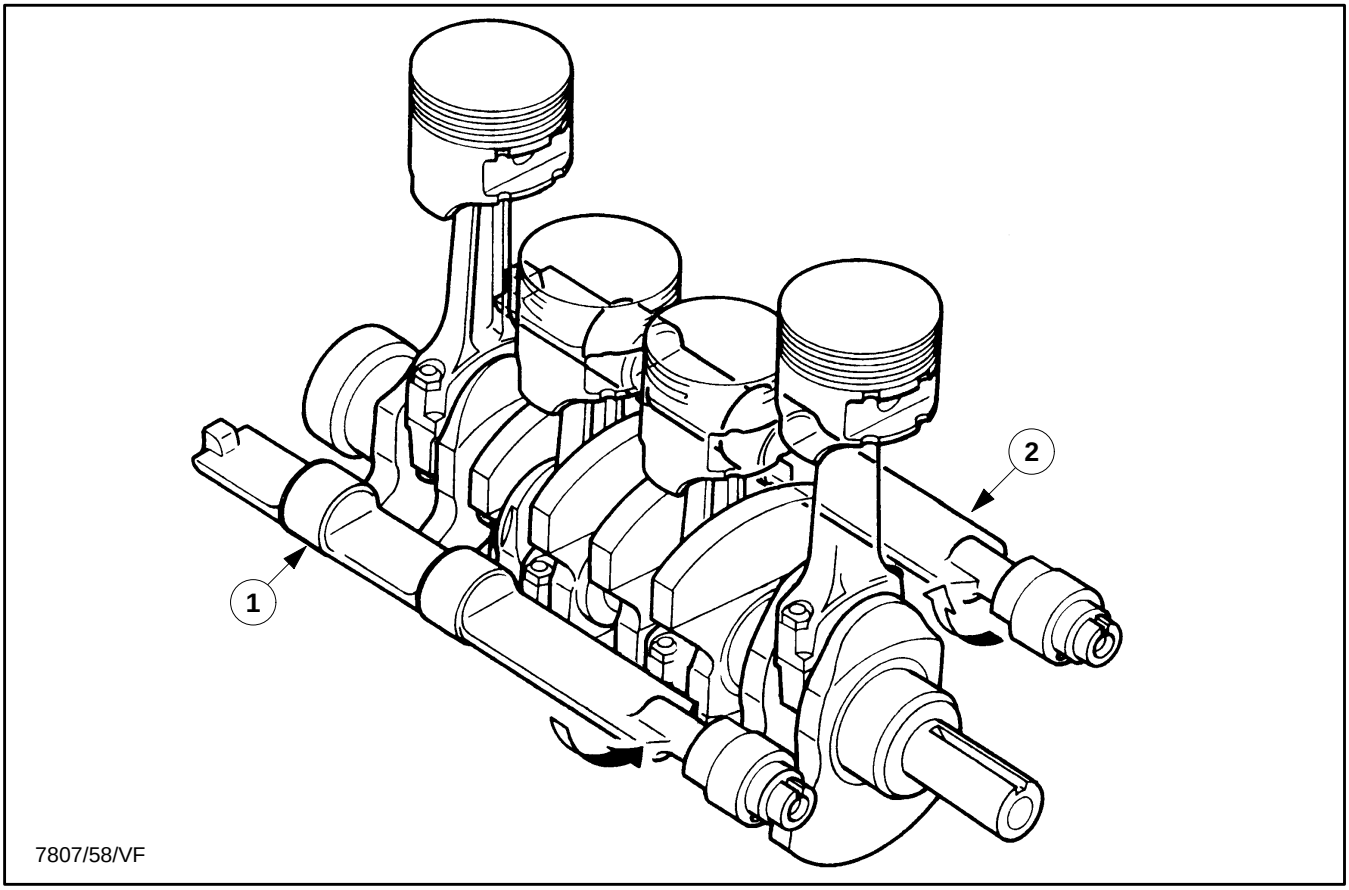
- Emission standard EC Step 2
- Oxidation catalytic converter (OC)
- Exhaust gas recirculation (EGR)

Diagnosis and testing

- Diagnosis and testing through the data link connector (DLC) in the engine compartment

NOTE: The WL-T engine is based on the WL engine and therefore shares several features with the WL engine. For that reason the following chapters only highlight the different/additional components of the WL-T engine.

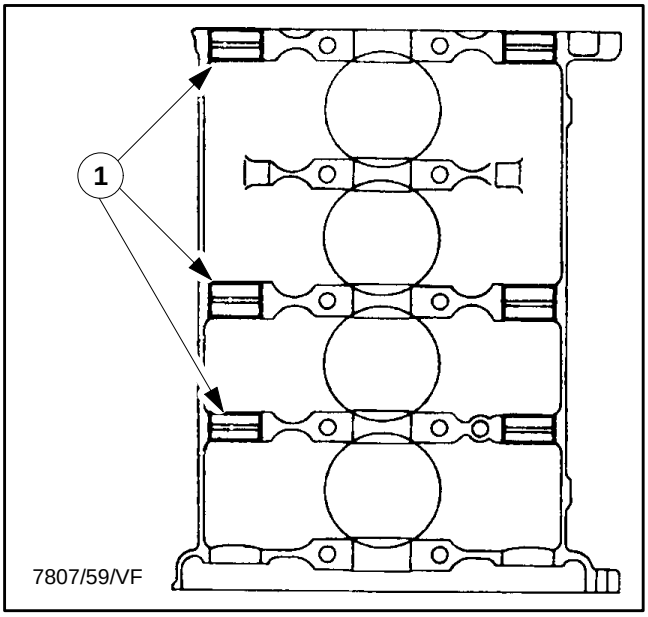
Balance shafts



1 Right-hand balance shaft

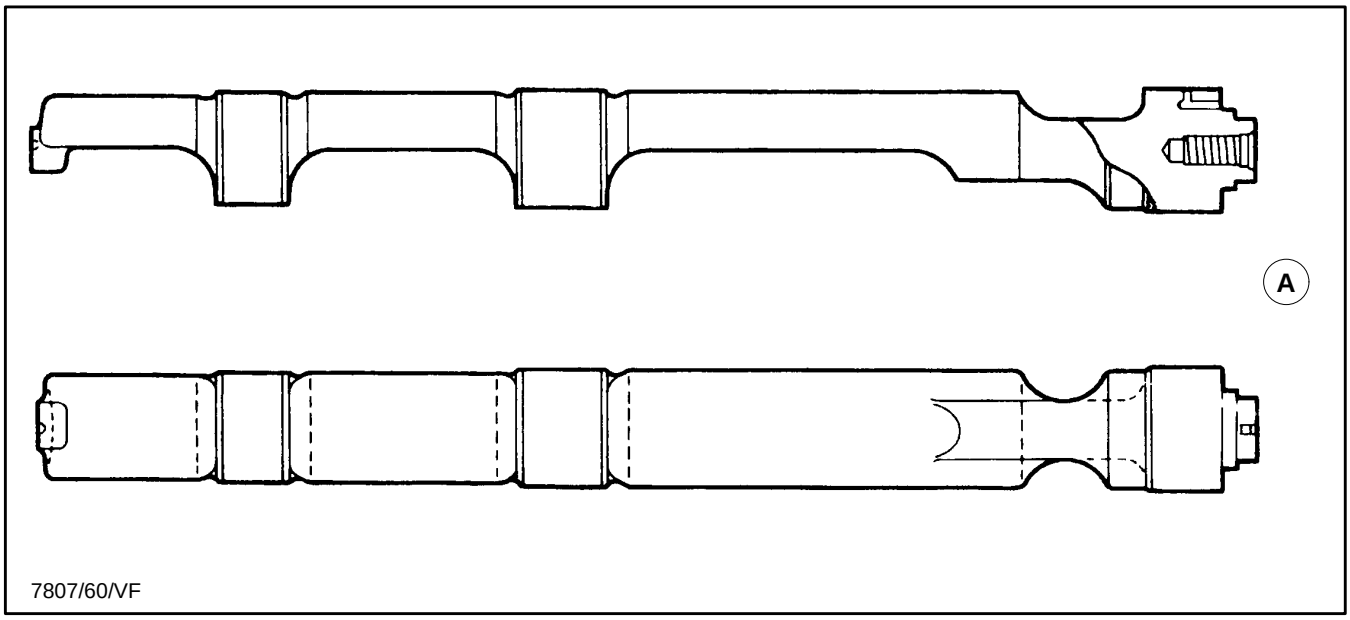
2 Left-hand balance shaft

- Two balance shafts are fitted to the WL-T engine to reduce secondary vertical vibration.
- The bearings of the balance shafts are not renewable.



1 Bearings for balance shafts

Balance shafts (continued)

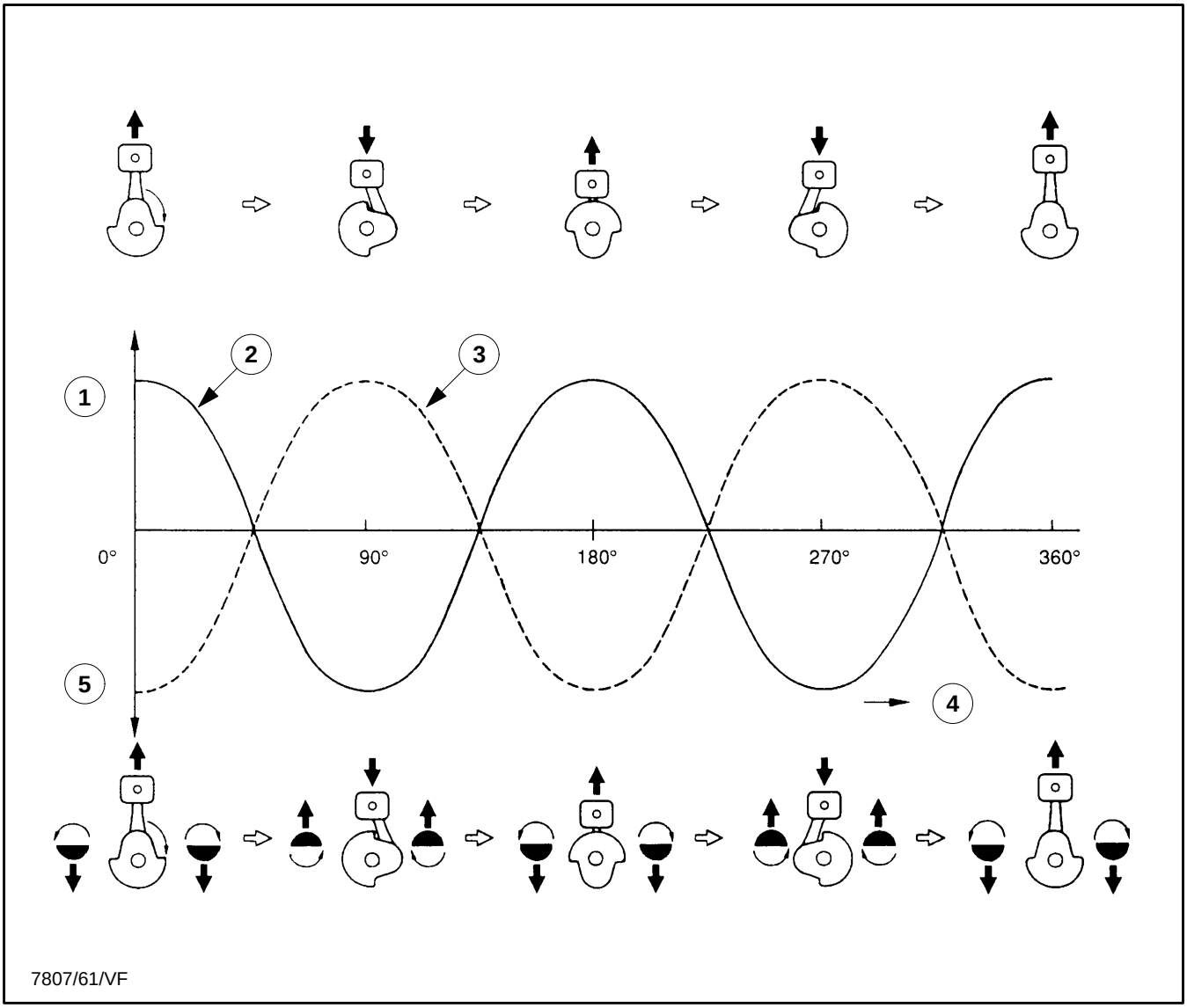


A Front of engine

Operation

- In-line four-cylinder engines are normally constructed to have the pistons of the No. 1 and No. 4 cylinders moving in the opposite direction of those of the inner No. 2 and No. 3 cylinders.
- Therefore the force generated by pistons No. 1 and No. 4 offsets the force generated by pistons No. 2 and No. 3.
- Due to the inertial weight of the piston/rod assemblies, however, different upward and downward force is generated.
- Upward force is generated when the pistons are at top dead center (TDC) and bottom dead center (BDC). Downward force is generated when the pistons are at the 90º and 270º crank angle position, which results in four vertical forces (two upwards and two downwards) during each combustion cycle.
- This is known as secondary vertical vibration and can be quite severe at high engine speeds.
- The balance shafts offset this secondary vertical vibration by creating vibration of the same magnitude (as indicated by the dotted line in the illustration on the next page) in the opposite direction.

Balance shafts (continued)

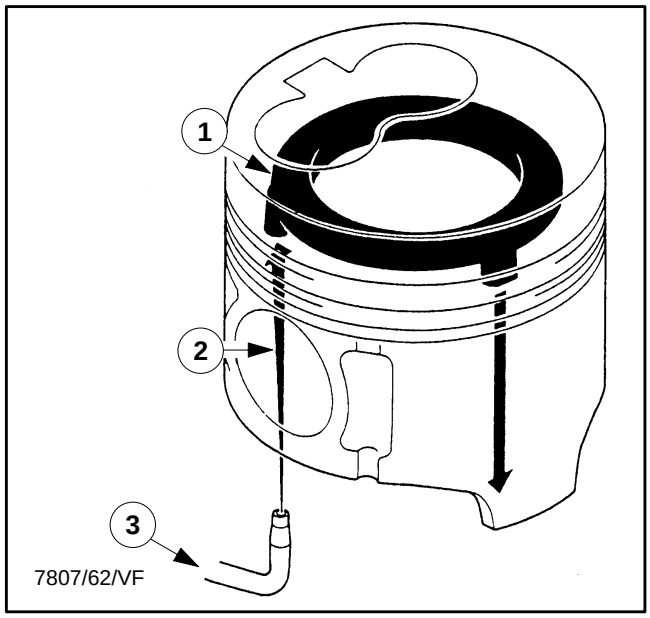


Piston position and secondary vertical vibration

1 Upward force
2 Secondary vertical vibration
3 Vertical vibration by balance shafts
4 Crank angle
5 Downward force

Pistons

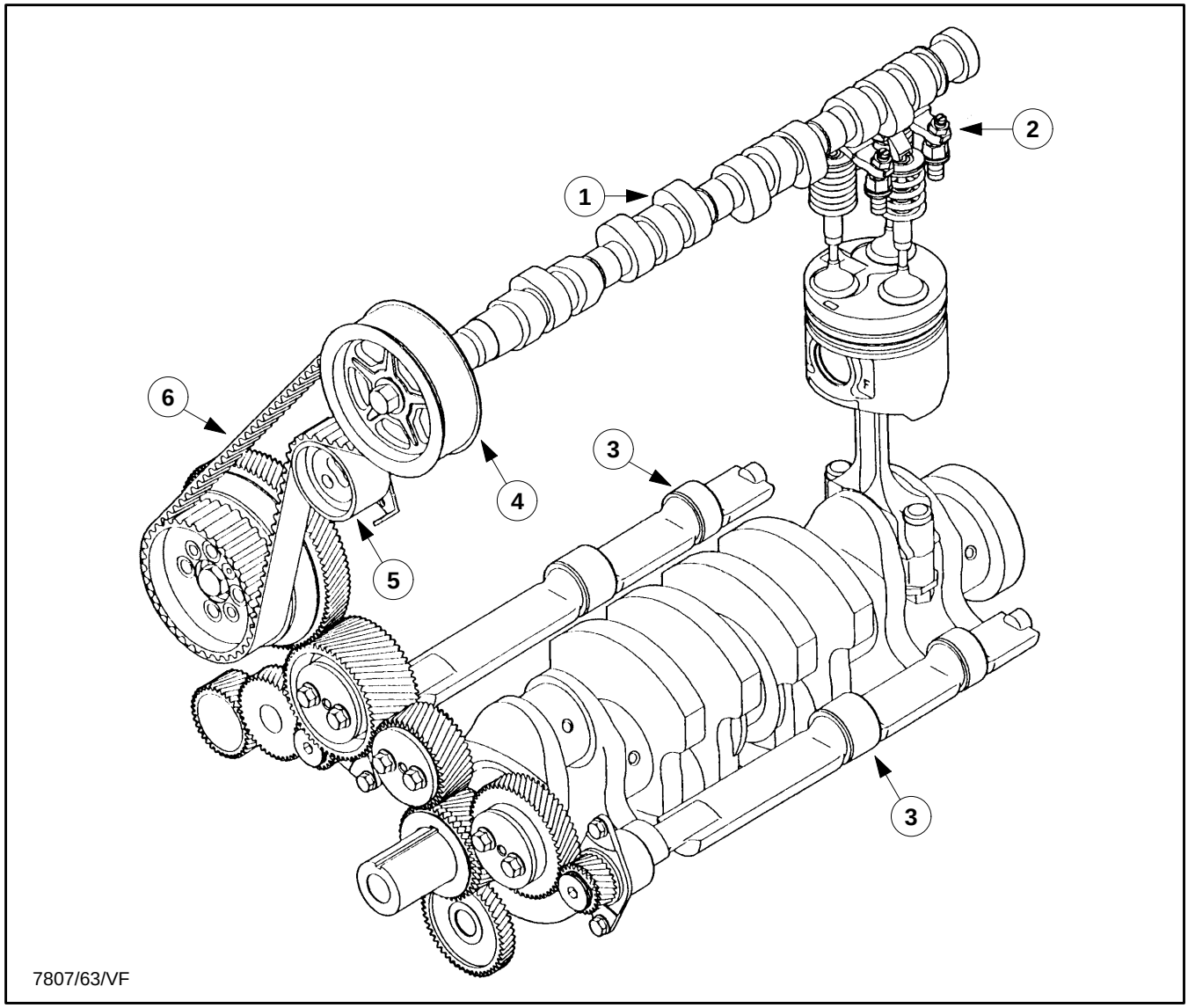
- The piston body has a cooling channel. The oil spray tubes squirt oil into this cooling channel.
- The oil absorbs heat from around the rings and reduces piston ring and cylinder wall wear.



1 Cooling channel
2 Engine oil
3 Oil spray tube

Valve mechanism

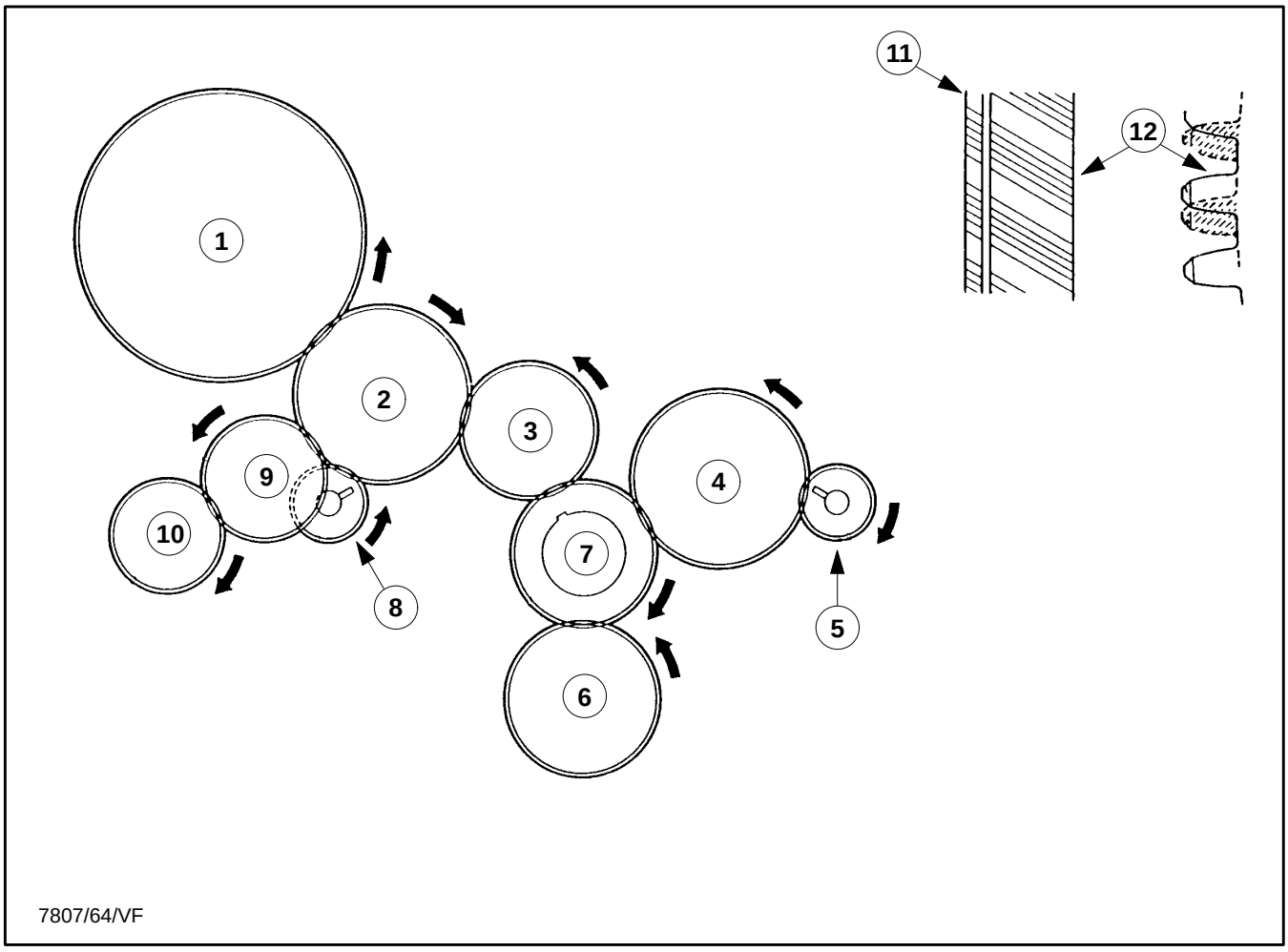
Structural view



1 Camshaft
2 Rocker arm
3 Balance shaft
4 Camshaft pulley
5 Tensioner
6 Timing belt

Valve mechanism (continued)

Drive train



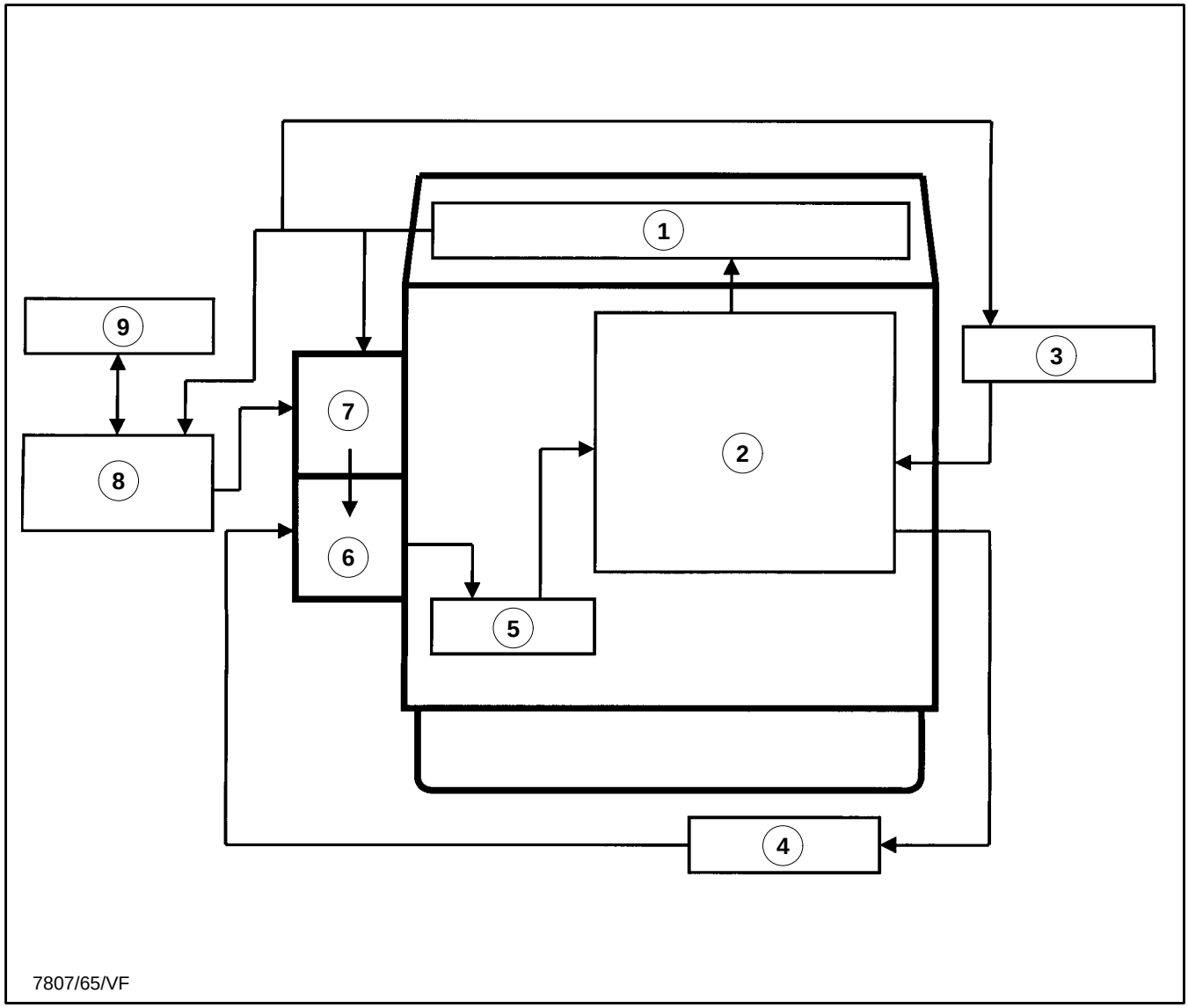
1 Fuel injection pump gear
2 No. 2 idler gear
3 No. 1 idler gear
4 No. 3 idler gear
5 Left-hand balance shaft
6 Oil pump gear
7 Timing gear
8 Right-hand balance shaft
9 Vacuum pump gear
10 Power steering pump gear

- The gears are helical. The fuel injection pump gear, balance shaft gears and timing gear are combined with a friction gear.
- The balance shaft gears and No. 3 idler gear are equipped for the WL-T engine only.

NOTE: The gears are marked for production and service. Refer to the current service literature.

Cooling system

Coolant flow diagram

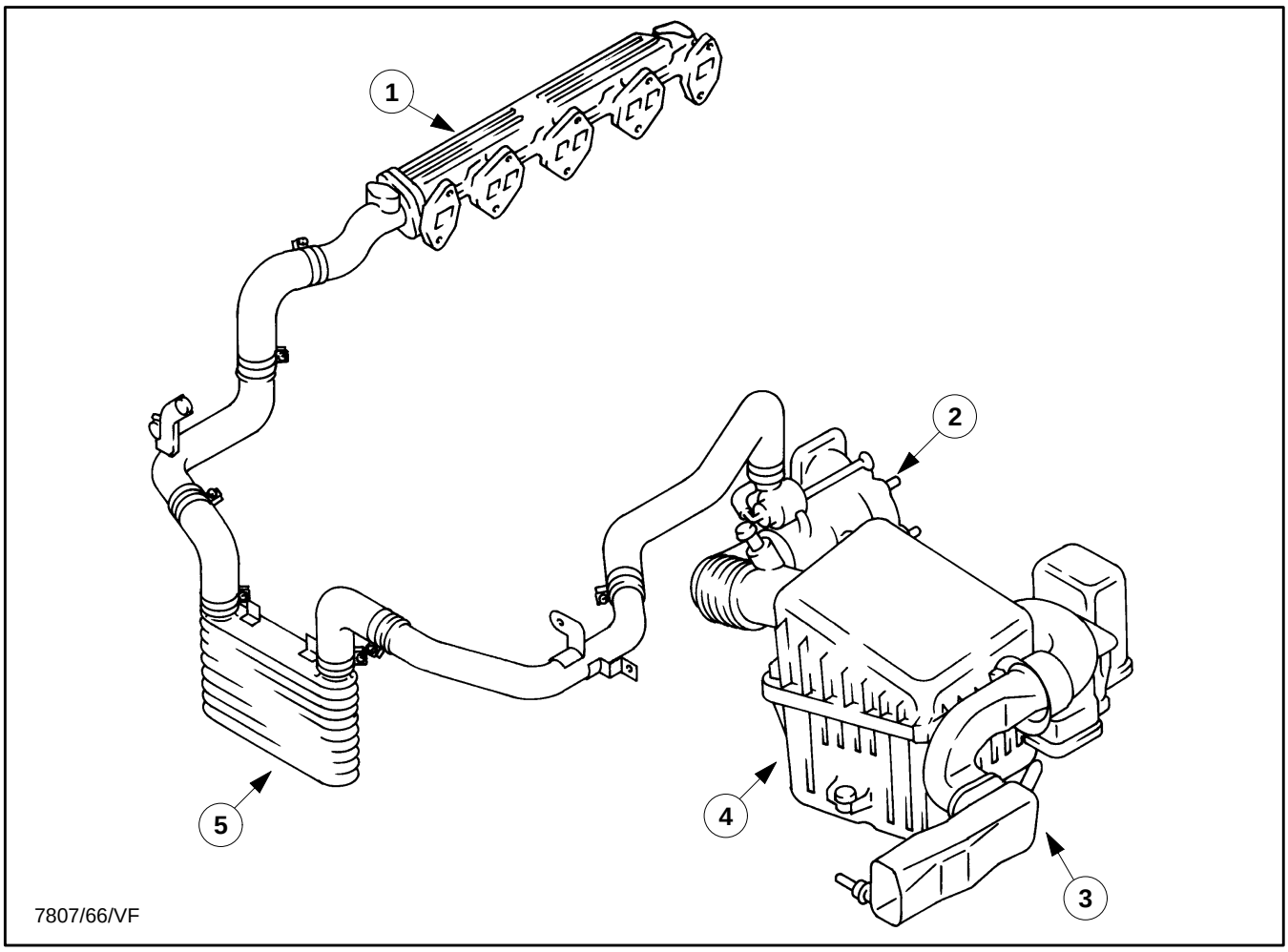


1 Cylinder head
2 Cylinder block
3 Turbocharger
4 Heater core
5 Oil cooler
6 Water pump
7 Thermostat
8 Radiator
9 Coolant expansion tank

Air intake system

General

- Intake air from the fresh air duct is filtered by the air cleaner and forced by the turbocharger through the intercooler and then through the intake manifold into the combustion chambers.
- A turbocharger is fitted to the WL-T engine to improve mid-range engine torque.

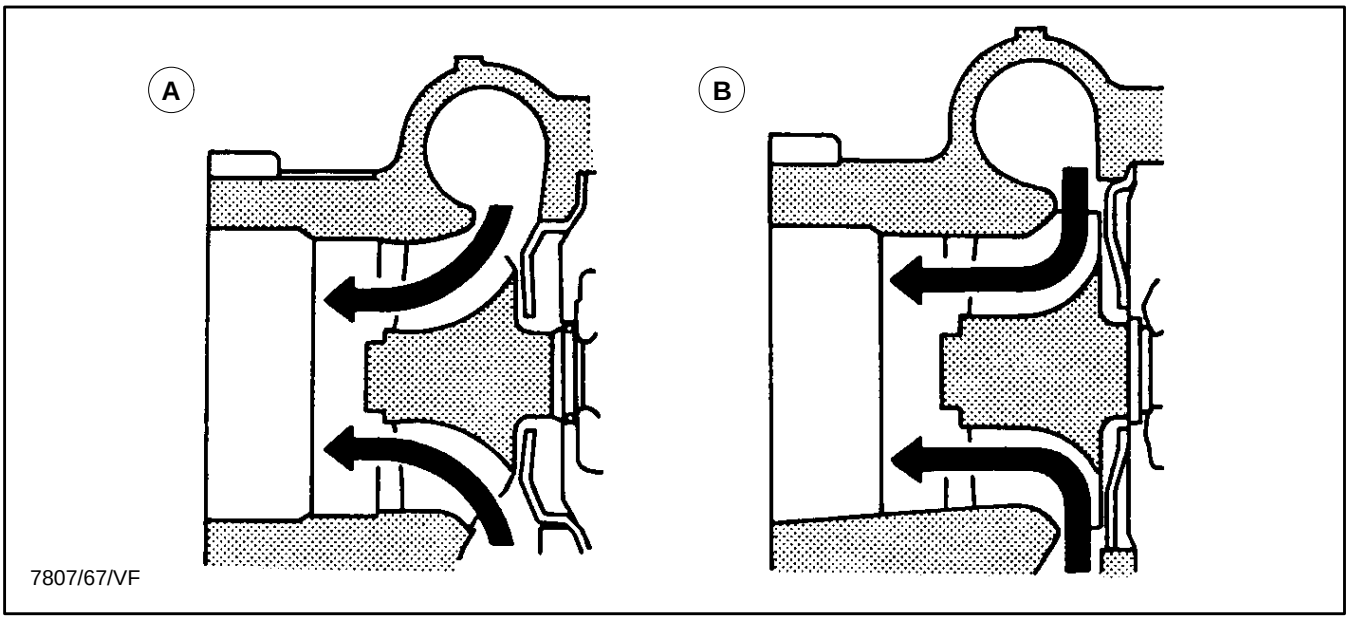


1 Intake manifold
2 Turbocharger
3 Fresh air duct
4 Air cleaner
5 Intercooler

Air intake system (continued)

Turbocharger

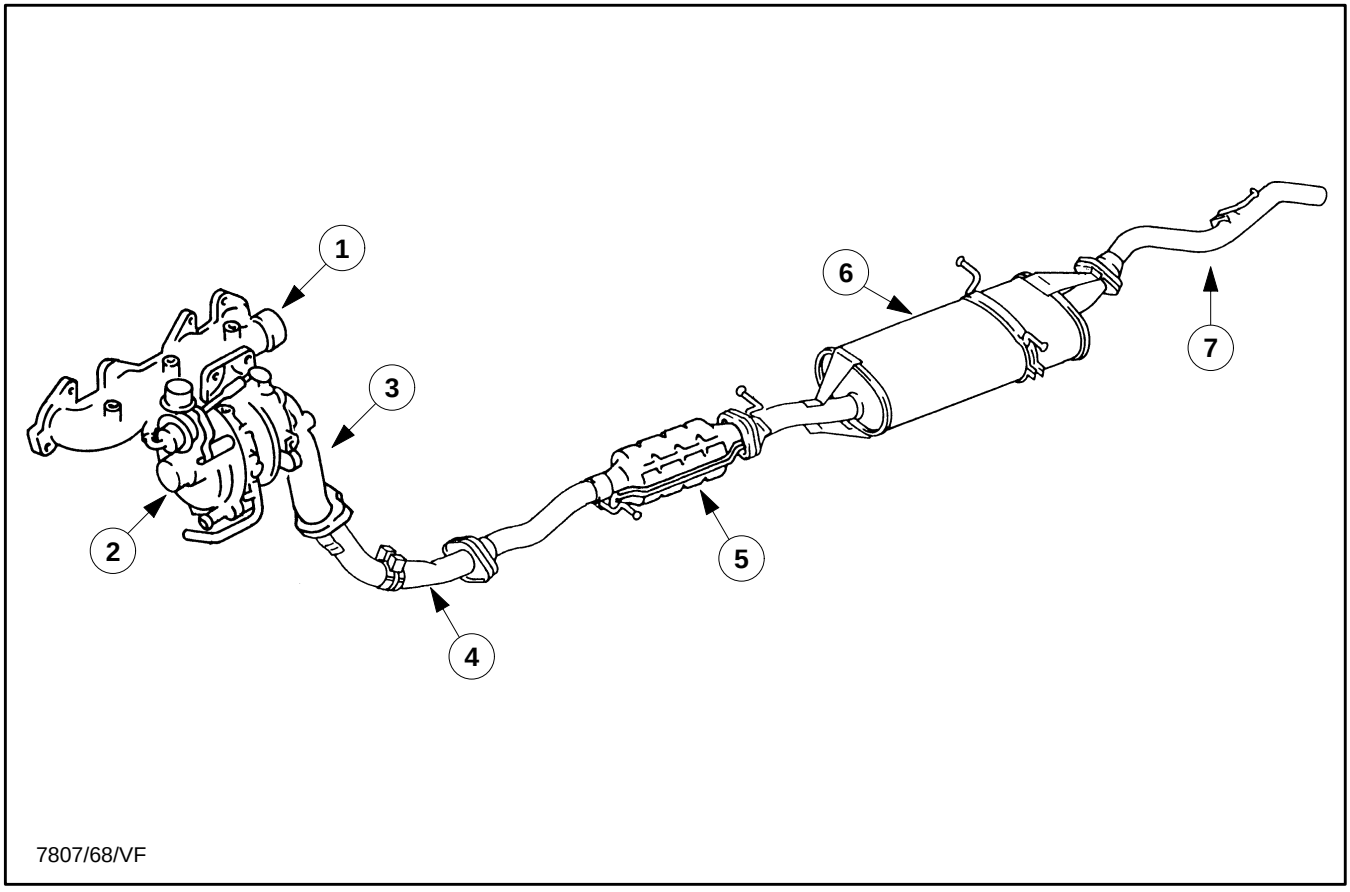
- The turbocharger used in the Ford Ranger is a mixed flow type turbocharger. That means that the exhaust gas flows diagonally into the turbine.
- This makes the flow of the exhaust gas smoother, reducing its resistance. In this way the charging efficiency is improved in comparison to a conventional radial turbocharger.
- The mixed flow turbocharger also has a turbine of reduced size and weight for improved charging response.
- With these features the mixed flow turbocharger improves engine response to the accelerator operation while providing adequate torque at low and middle engine speeds.



A Mixed flow turbocharger

B Radial turbocharger

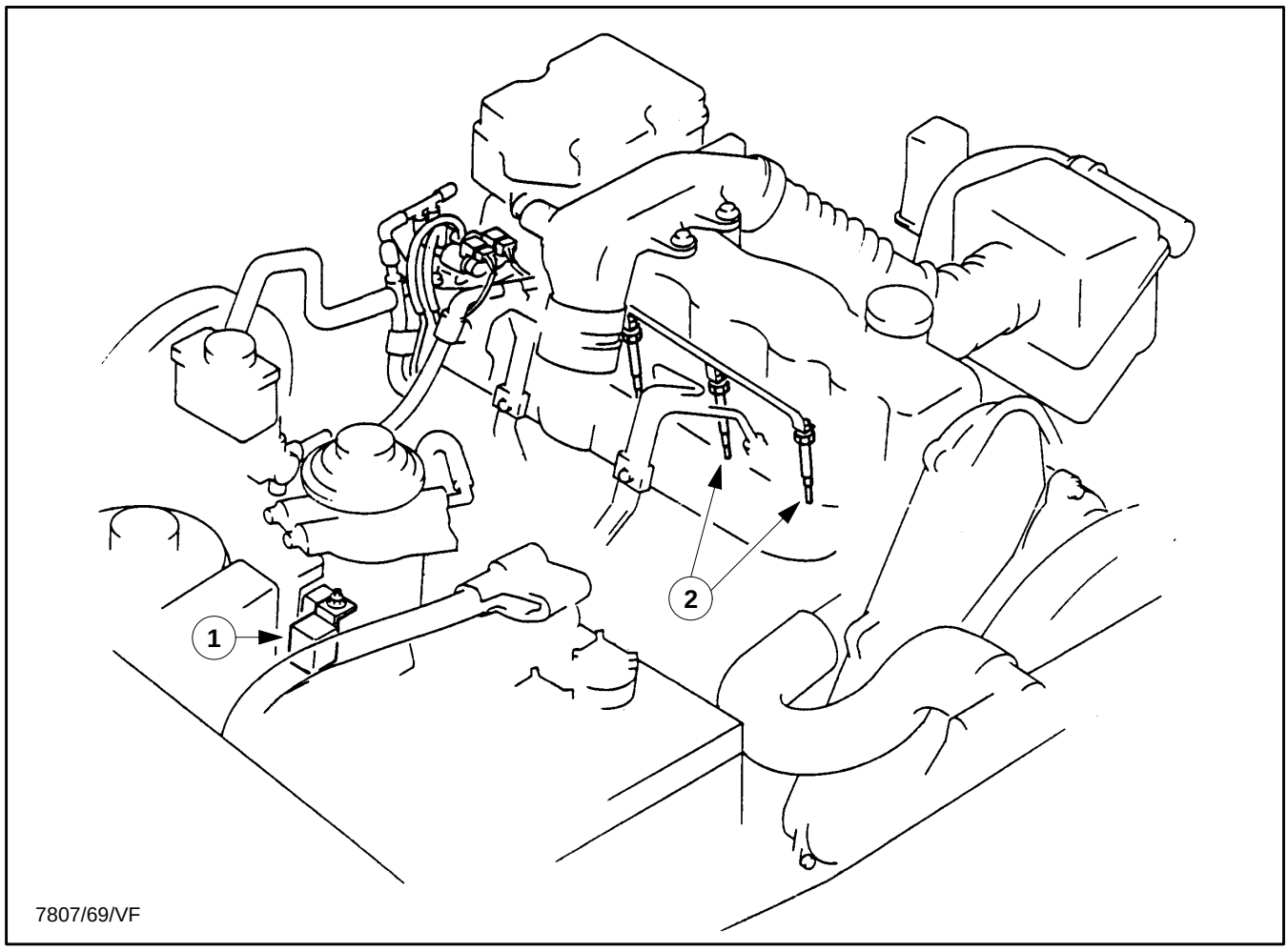
Exhaust system



1 Exhaust manifold
2 Turbocharger
3 Joint pipe
4 Front pipe
5 Oxidation catalytic converter (OC)
6 Muffler
7 Tailpipe

General

- The glow plug system heats the glow plugs, which are installed in the swirl combustion chamber, and raises the temperature in the swirl combustion chamber. This improves ignitability at engine start.
- The glow plug system consists of 4 glow plugs, a glow plug relay and a glow plug indicator.
- The glow plug relay and the glow plug indicator are controlled by the PCM.

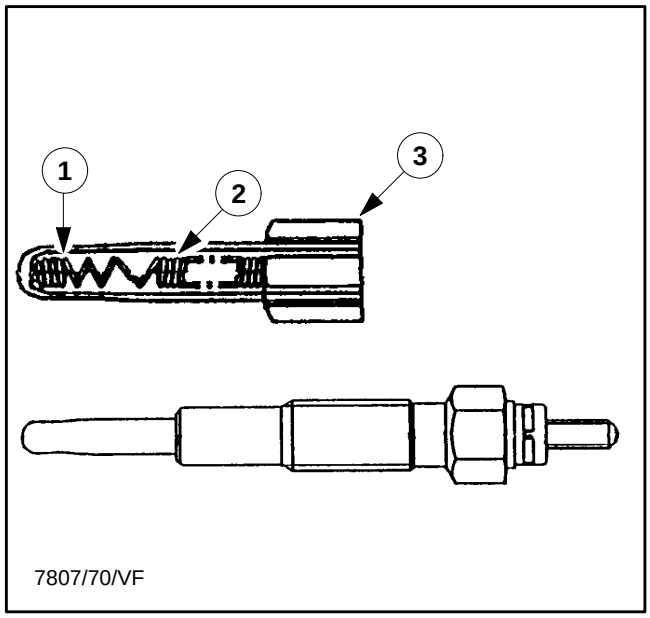


1 Glow plug relay

2 Glow plugs

Glow plugs

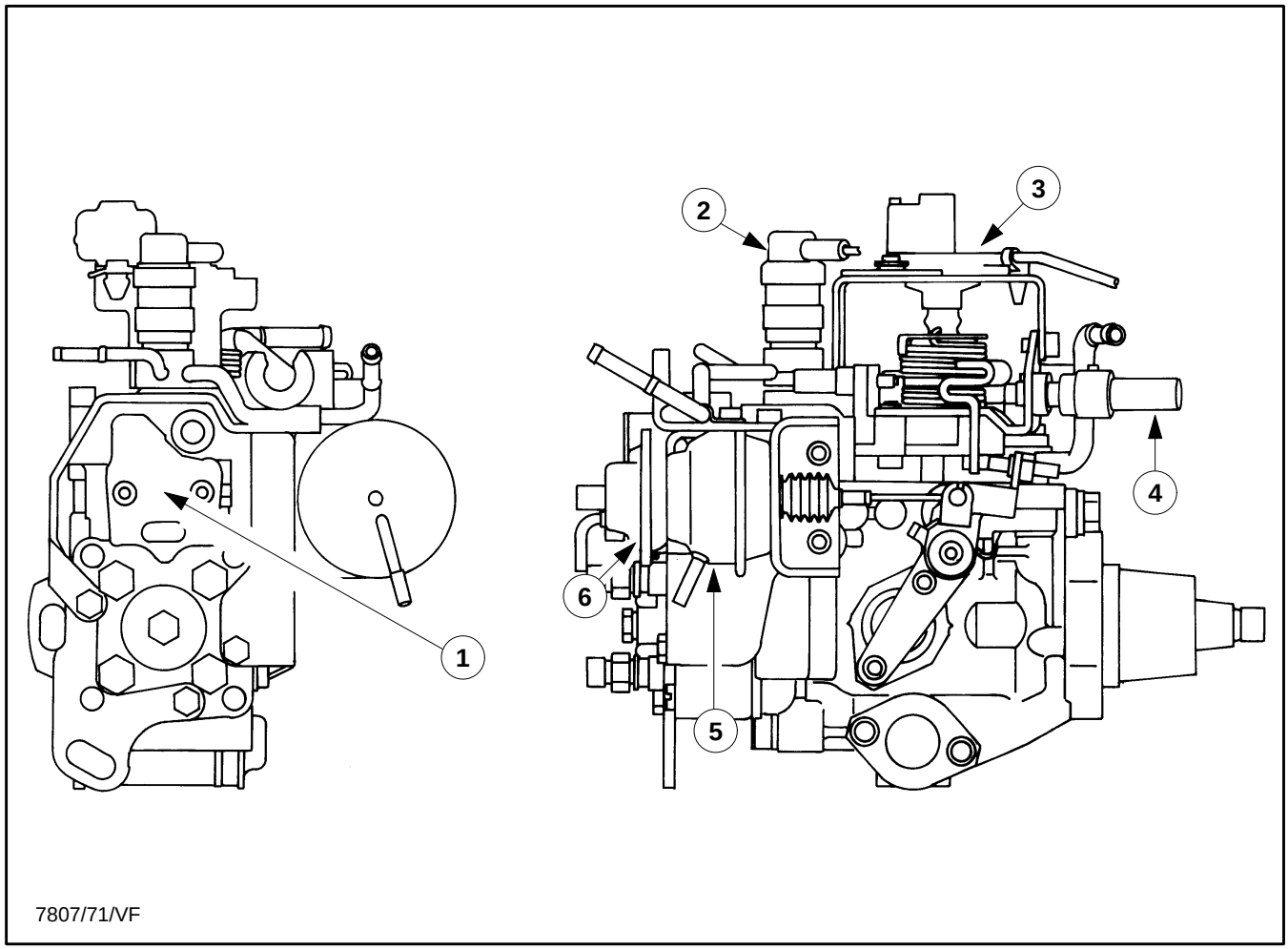
- Each glow plug has a heating coil and a regulator coil inside.
- When voltage is applied to the glow plug, the heating coil heats up the tip of the glow plug and the air temperature in the combustion chamber rises.
- The regulator coil is a PTC thermistor. If it heats up too, its electrical resistance increases, restricting the power supply for the heating coil.
- In this way, the glow plug temperature does not exceed a certain temperature.



1 Heating coil
2 Regulator coil
3 Metal shell

Fuel injection pump for WL engines

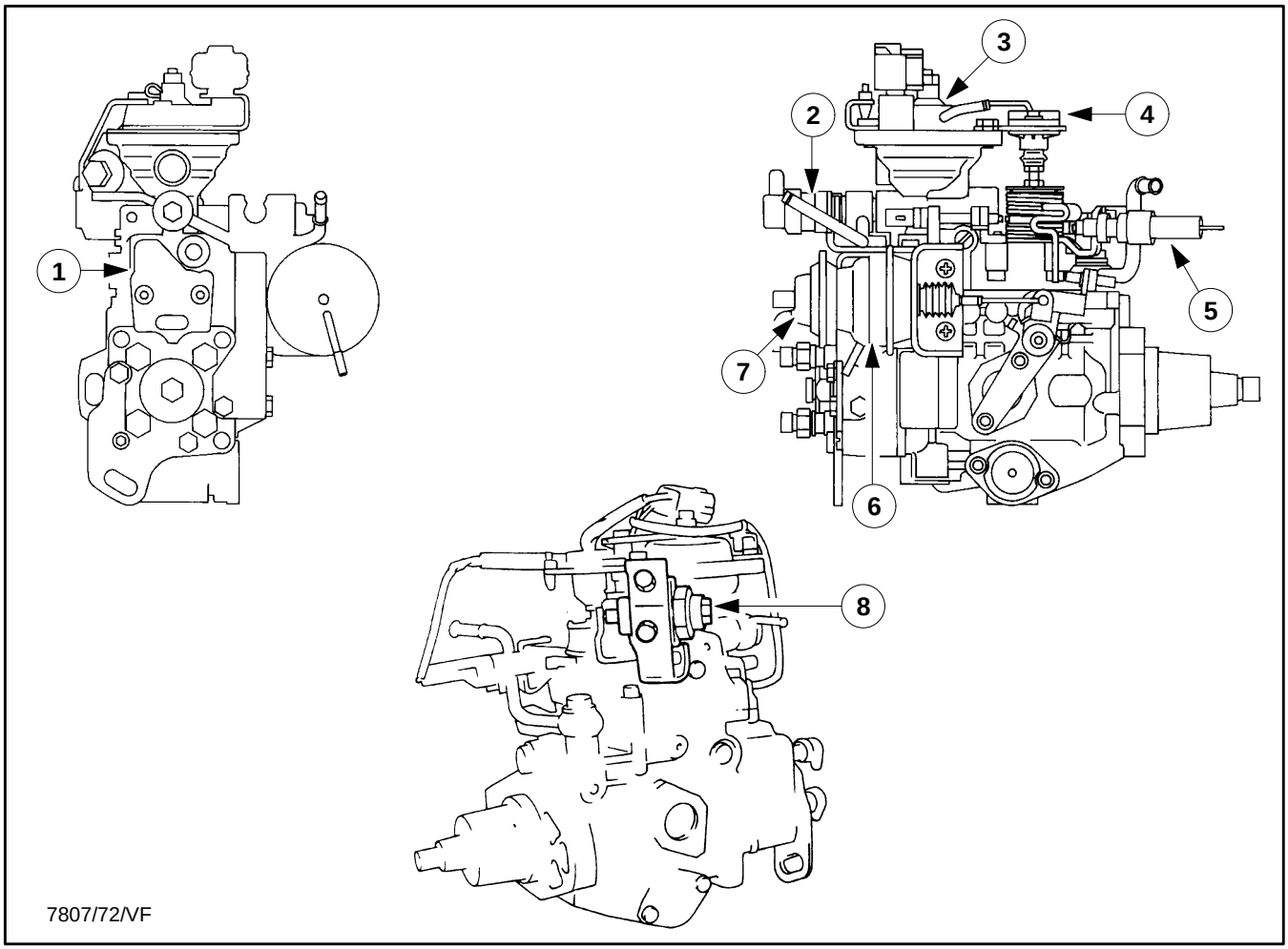
- The fuel injection pump is a distributor-type fuel injection pump. It was originally designed by Bosch and is now produced under licence by Zexel Co. Ltd. in Japan.



1 Diesel smart module
2 Timer control valve (TCV)
3 Control lever position sensor
4 Idle switch
5 Fast idle control device (FICD) actuator No. 1
6 Fast idle control device (FICD) actuator No. 2

Fuel injection pump for WL-T engines

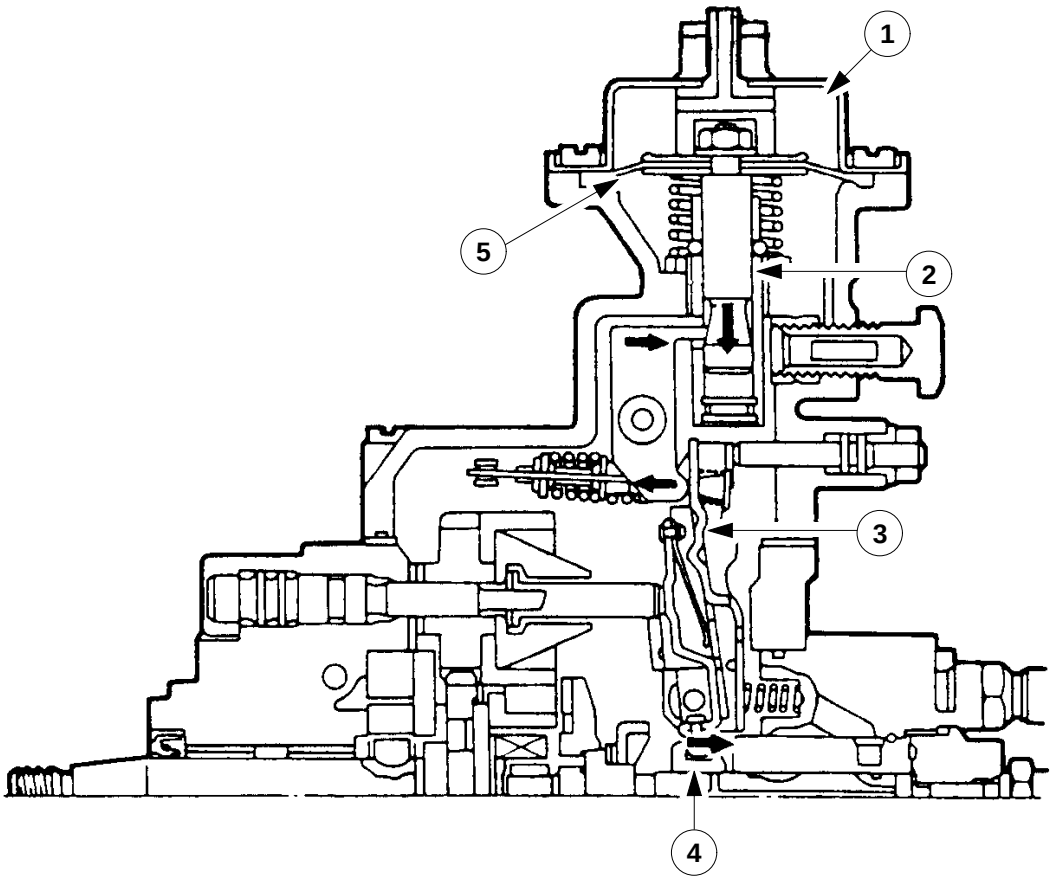
- Fuel injection pumps used for the WL-T engine are equipped with a boost compensator which controls the fuel injection amount according to the charging pressure.
- Vehicles with WL-T engines and vehicles with air conditioning system have a fast idle control device (FICD) to maintain smooth and stable idle speed.



1 Diesel smart module
2 Timer control valve (TCV)
3 Boost compensator (WL-T only)
4 Control lever position sensor
5 Idle switch
6 Fast idle control device (FICD) actuator No. 1
7 Fast idle control device (FICD) actuator No. 2
8 Dashpot

Boost compensator (WL-T engines only)

- The boost compensator adjusts the fuel injection amount according to the charging pressure, independently of the governor.
- Charging pressure from the intake manifold is fed into the pressurizing chamber of the boost compensator. When the pressure exceeds the set load of the spring, the diaphragm is pressed down and the adjusting rod moves down.
- As the adjusting rod moves down, a lever, which is in contact with the tapered section of the rod, moves in the direction shown in the illustration below.
- According to this movement, the tension lever moves to cause a sliding motion of the control sleeve to increase fuel flow.

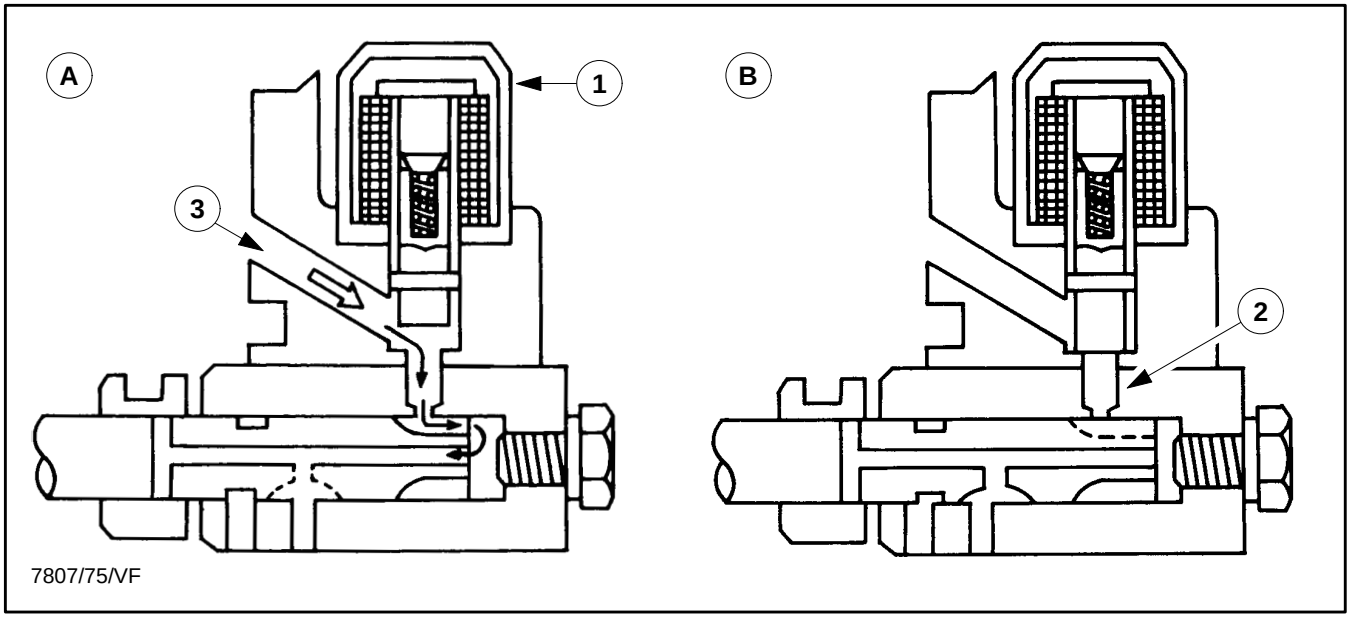


7807/74/VF

1 Pressurizing chamber
2 Adjusting rod
3 Tension lever
4 Control sleeve
5 Diaphragm

Fuel shutoff valve (vehicles without PATS)

- The fuel shutoff valve opens and closes the fuel passage to the plunger intake port in accordance with the ignition switch condition (ON/OFF).
- When the ignition switch is ON (engine running), the fuel shutoff valve is energized and the fuel passage is open.
- When the ignition switch is OFF (engine stopped), power supply to the fuel shutoff valve is cut and the fuel passage is closed.

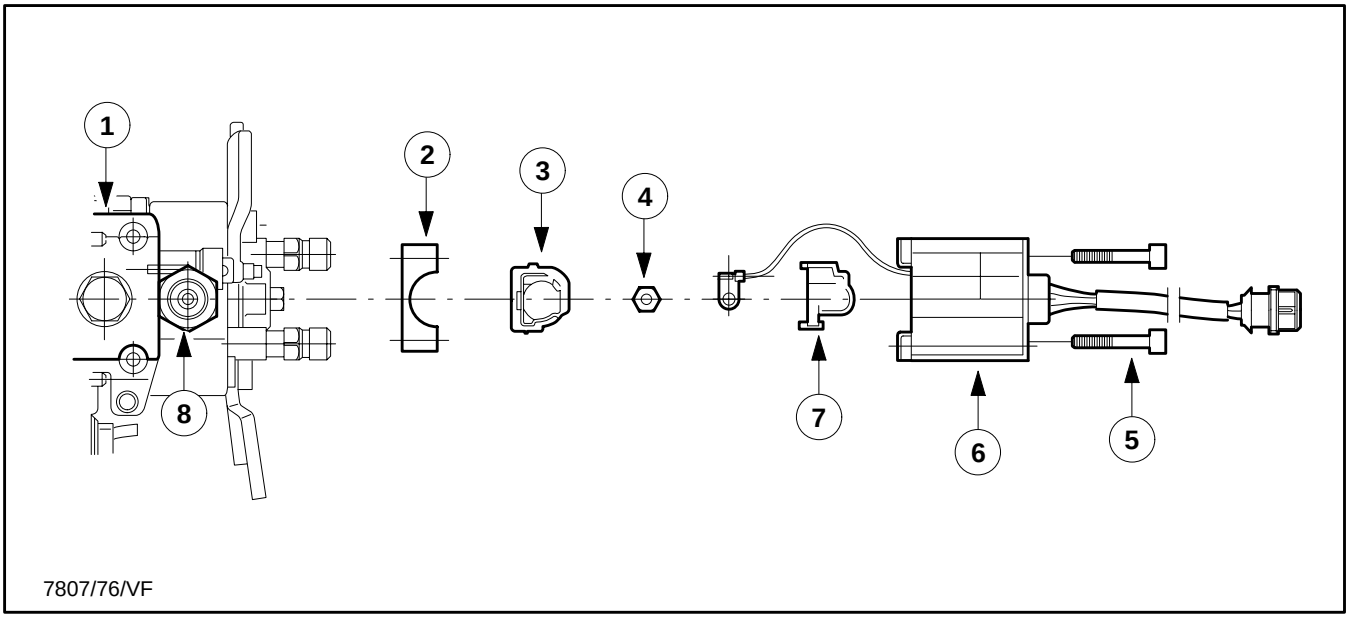


A Engine running
B Engine stopped

1 Fuel shutoff valve
2 Intake port
3 Fuel passage

Diesel smart module (vehicles with PATS)

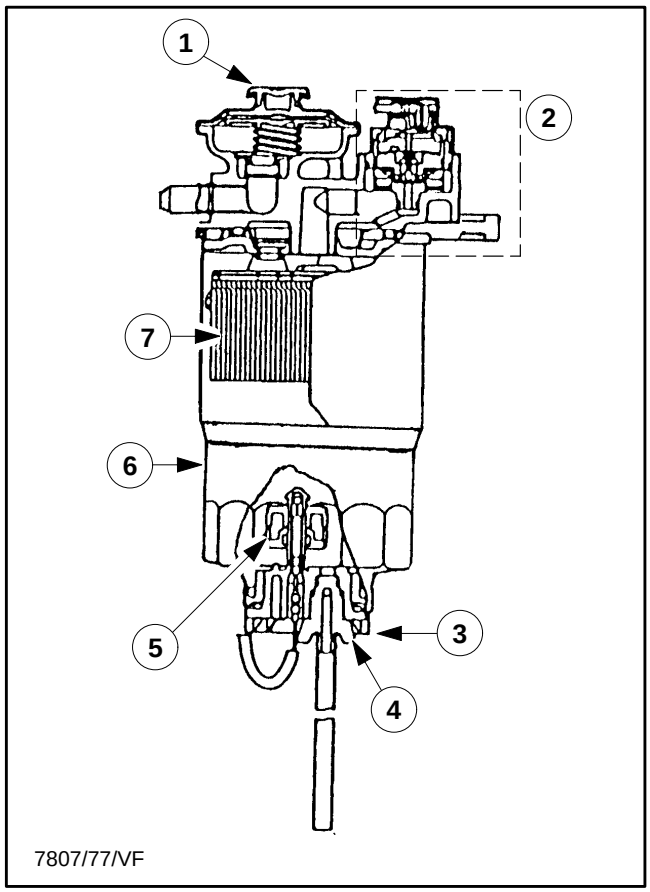
- On vehicles with PATS, the fuel shutoff valve is operated by means of the diesel smart module.
- An electronic signal from the PCM makes the diesel smart module switching the fuel shutoff valve on and off.
- For reasons of safety the diesel smart module is covered by a protection frame.
- The diesel smart module is controlled by the PCM. The diesel smart module compares a code word coming from the PCM with that registered in the diesel smart module.
- If the received code word is valid, the diesel smart module activates the fuel shutoff valve and the fuel passage is open.



1 Fuel injection pump
2 Clamp
3 Fixture
4 Flanged nut
5 Fastening screws
6 Diesel smart module
7 Protective cap
8 Fuel shutoff valve

Fuel filter

- The cartridge type fuel filter has an integral sedimentor.
- When a certain volume of water has been accumulated in the sedimentor, the sedimentor switch is turned on and the sedimentor warning indicator in the instrument cluster illuminates to indicate that the water should be drained soon.
- A priming pump is equipped to drain the water easily from the sedimentor.

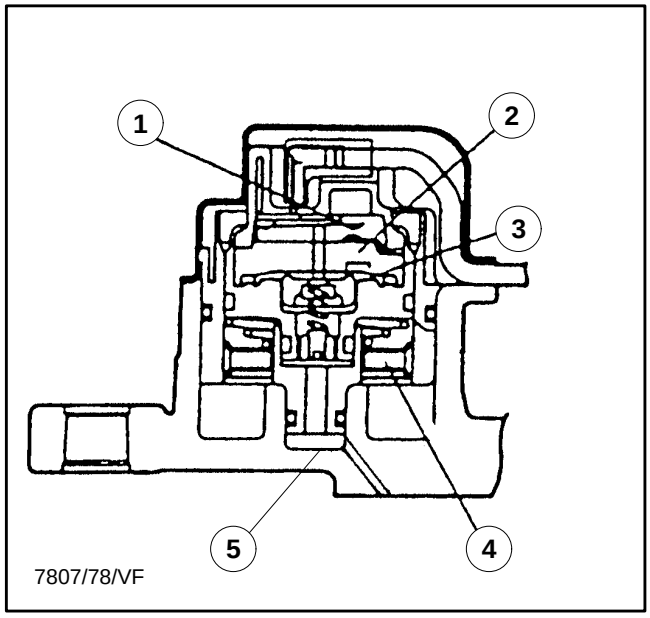


1 Priming pump
2 Fuel heater
3 Sedimentor switch
4 Drain
5 Float
6 Sedimentor
7 Filter

Fuel heater

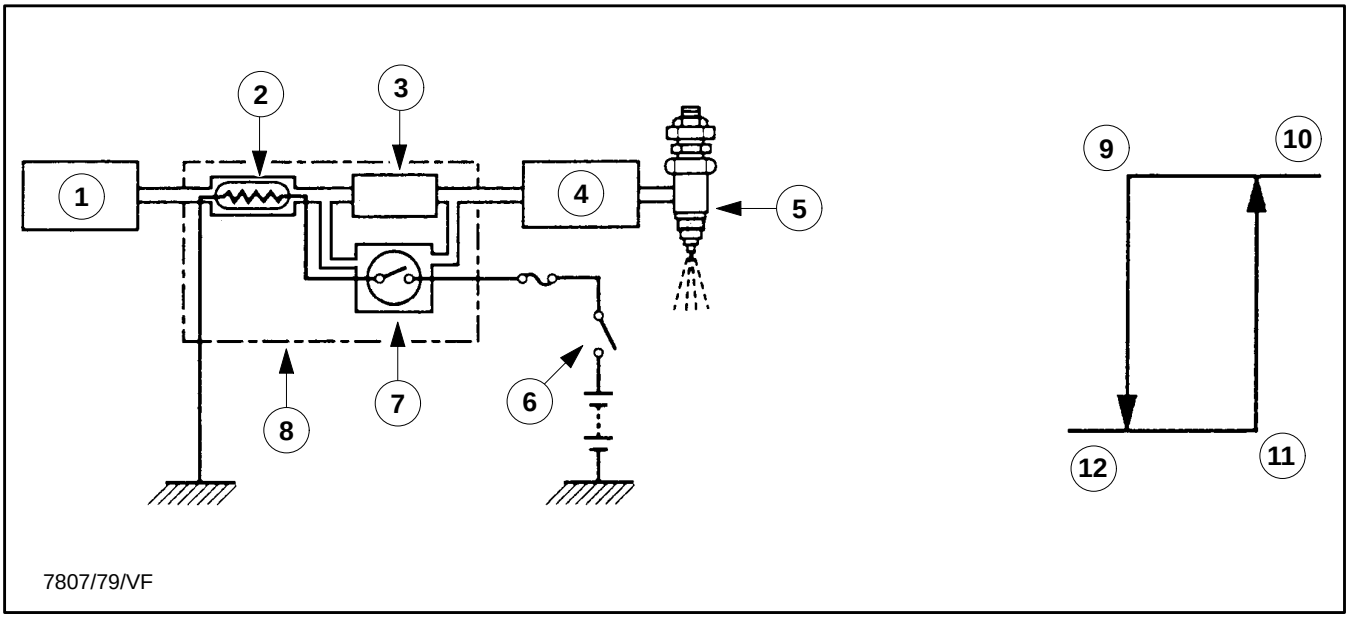
- A fuel heater is integrated to prevent the diesel fuel from waxing to block the fuel filter when the outside air temperature is low.

1 Switch
2 Atmospheric pressure
3 Diaphragm
4 Heater element
5 Filter outlet pressure



Fuel heater (continued)

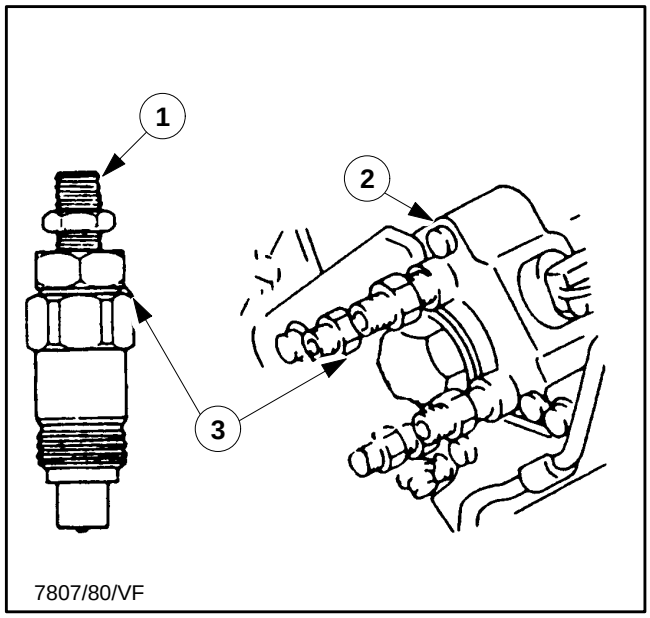
- A heater element and a vacuum switch for fuel pressure detection, to operate the heater element, are integrated in the filter cap.
- When driving while the engine is cold, the diesel fuel waxes to block the fuel filter and the fuel negative pressure after passing the filter is increased.
- When the negative pressure reaches –34.7 kPa (–260 mmHg, –10.2 inHg), the vacuum switch for fuel pressure detection is turned on and the heater element is energized.
- As a result, the heat is generated in the heater element to dissolve the wax. When the wax is dissolved and the negative pressure drops below –22.0 kPa (–165 mmHg, –6.50 inHg), the switch for fuel pressure detection is turned off, stopping the electrical current to the heater element.



1 Fuel tank
2 Heater element
3 Filter element
4 Fuel injection pump
5 Injection nozzle
6 Ignition switch
7 Vacuum switch
8 Fuel filter assembly
9 Vacuum switch operating pressure –22.0 kPa (–165 mmHg, –6.50 inHg)
10 Vacuum switch ON
11 Vacuum switch operating pressure –34.7 kPa (–260 mmHg, –10.2 inHg)
12 Vacuum switch OFF

Injection nozzles

- To achieve smooth engine idling, the injection nozzles are adjusted and assigned to the appropriate pressure valves and therefore marked with colored rings.



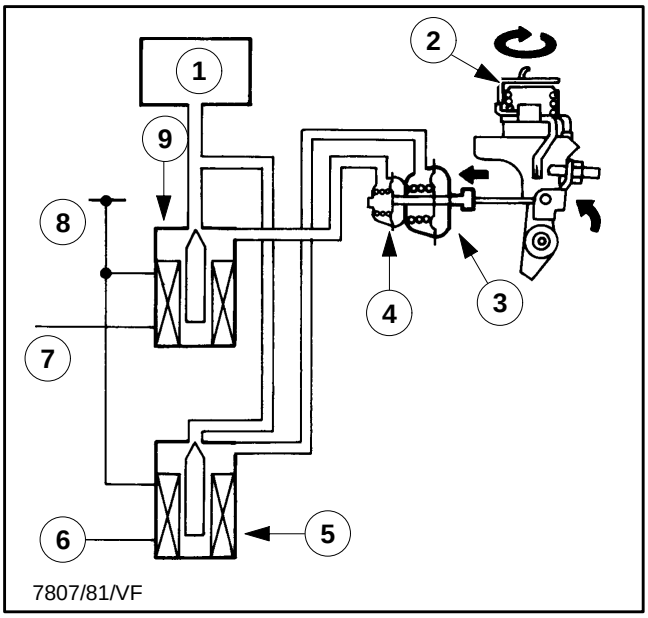
1 Injection nozzle
2 Fuel injection pump
3 Colored rings

Fast idle control device (FICD)

- The fast idle control device (FICD) controls the amount of the injected fuel according to engine temperature and load. In this way the idle speed stability is maintained.
- The fuel quantity is controlled by using FICD actuators to operate the control lever.
- The FICD actuators each have one pneumatic chamber. They are operated by vacuum, which is produced by the vacuum pump, and controlled by two solenoid valves.
- If the FICD solenoid valves open, vacuum is applied to the servo diaphragms.
- The diaphragms pull the rod and the control lever is moved to increase fuel quantity and thus idle speed.

FICD solenoid valves No. 1 and No. 2

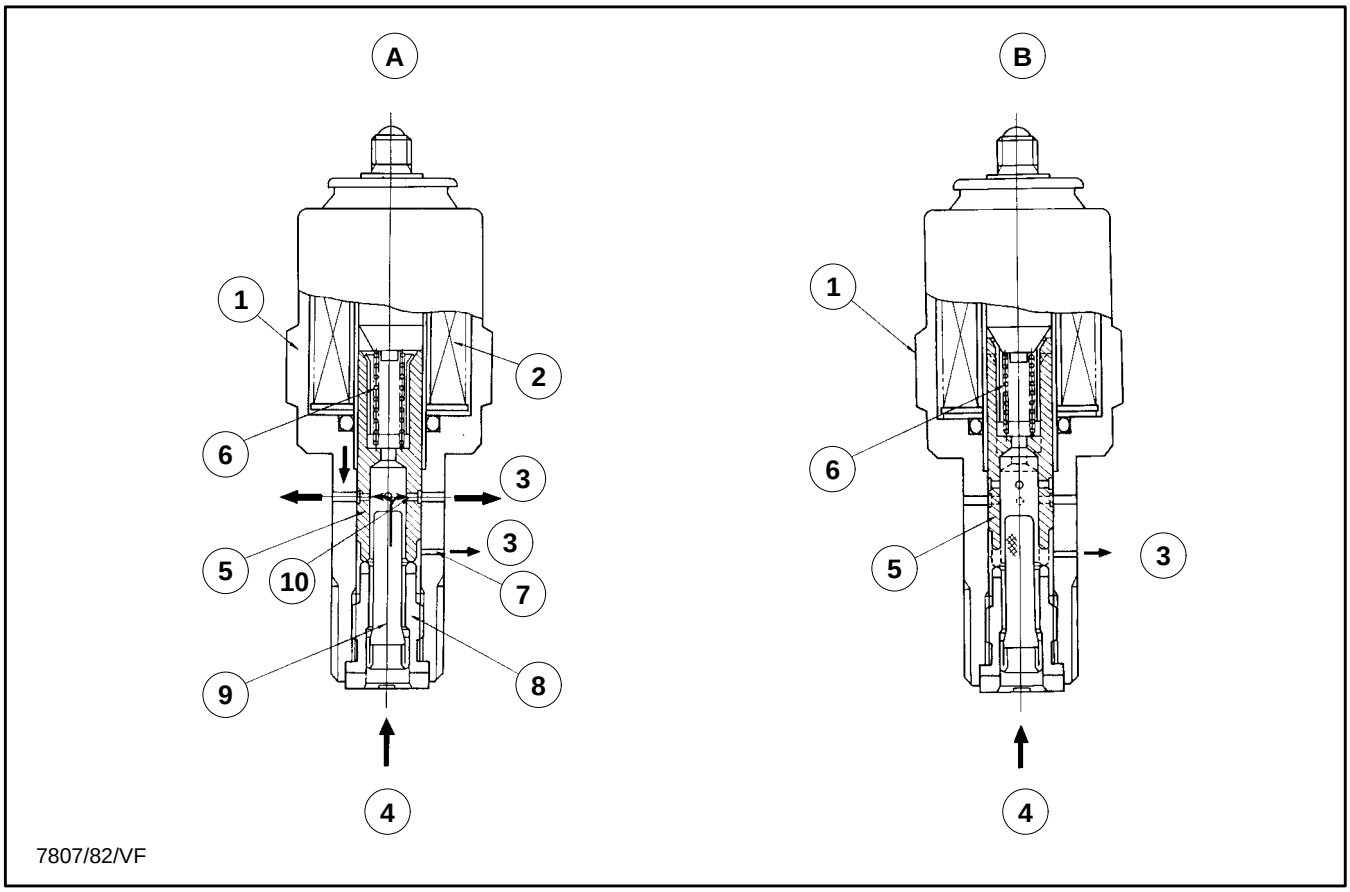
- FICD solenoid No. 1 and No. 2 operate according to control signals from the PCM. They control the vacuum which is led to the FICD actuators.
- FICD actuator No. 1 is used for increasing the idle speed when the engine is cold.
- FICD actuator No. 2 is used for increasing the idle speed when the engine is cold or engine load is applied, for example by switching on the air conditioning system.
- The solenoids are controlled by the PCM. For detailed information on the FICD control refer to the section “PCM controlled systems – idle speed control”.



1 Vacuum pump
2 Control lever
3 FICD actuator No. 1
4 FICD actuator No. 2
5 FICD solenoid valve No. 1
6 From PCM, terminal C
7 From PCM, terminal P
8 Power supply
9 FICD solenoid valve No. 2

Timer control valve (TCV)

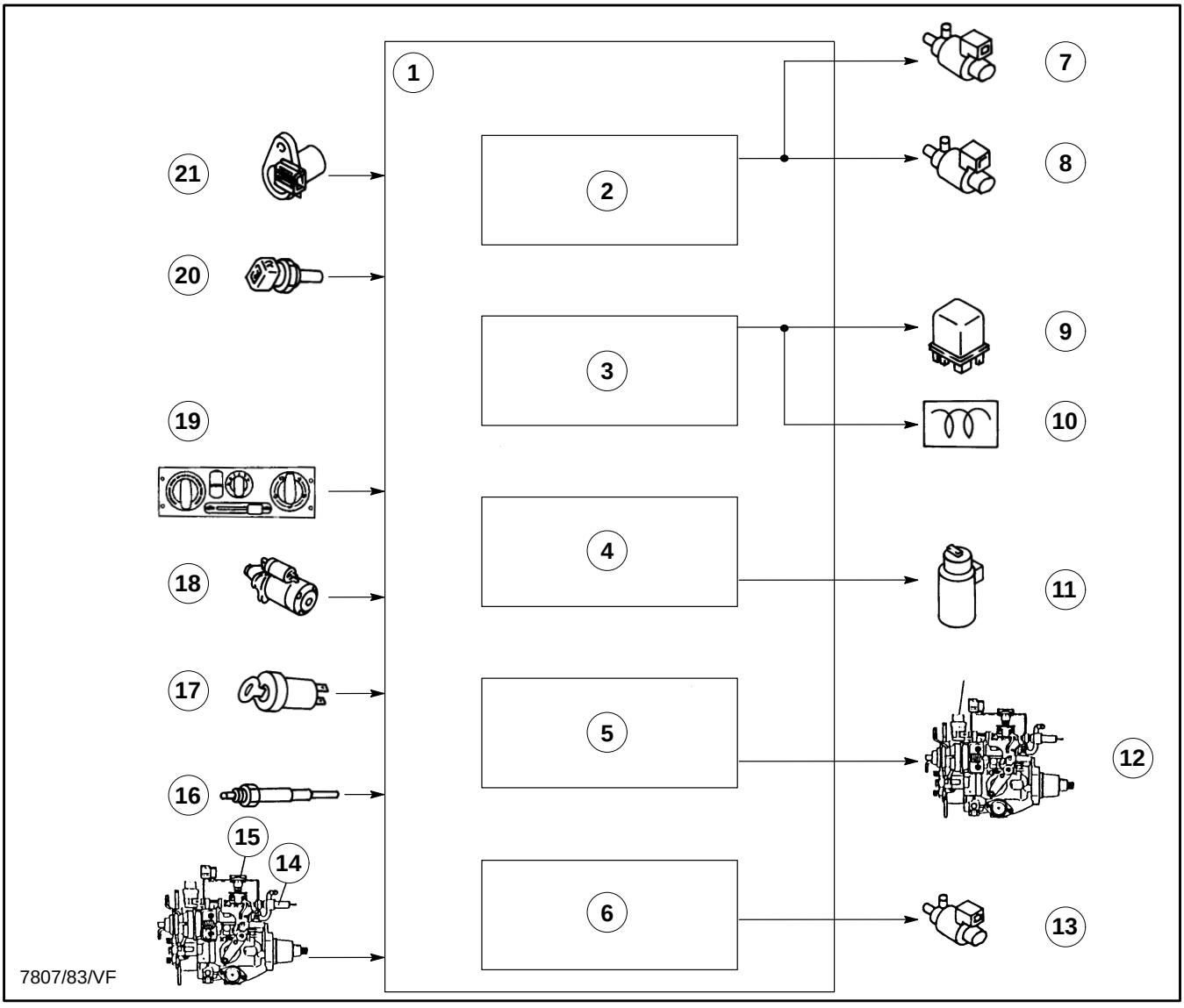
- The TCV is located on the upper part of the fuel injection pump and controls the fuel injection timing by changing the pump internal pressure.
- The TCV is made up of a solenoid coil, a spring, and a piston and an orifice.
- The piston will be pushed downwards (in the direction of retarded injecting) by the spring force and the fuel outlet hole and housing hole passage will be opened. Therefore the pump internal fuel will be returned through the return pipe to the fuel tank.
- This maintains normal condition of advanced injection. The orifice will constantly be opened and the overflow fuel will be returned to the fuel tank through the orifice and return pipe.
- Excitation current is sent to the solenoid coil according to a signal from the PCM, and as a result the spring force decreases and the piston is pulled upwards. Then the fuel outlet hole and housing hole passages are shut and the pump internal fuel will only return through the orifice.
- At this point, the pump internal pressure will suddenly rise and the timer piston will be further pushed to the direction of advanced injection.



A De-energized
B Energized
1 Housing
2 Solenoid coil
3 To fuel tank
4 Pump chamber pressure
5 Piston
6 Spring
7 Orifice
8 Stopper
9 Filter
10 Fuel outlet hole

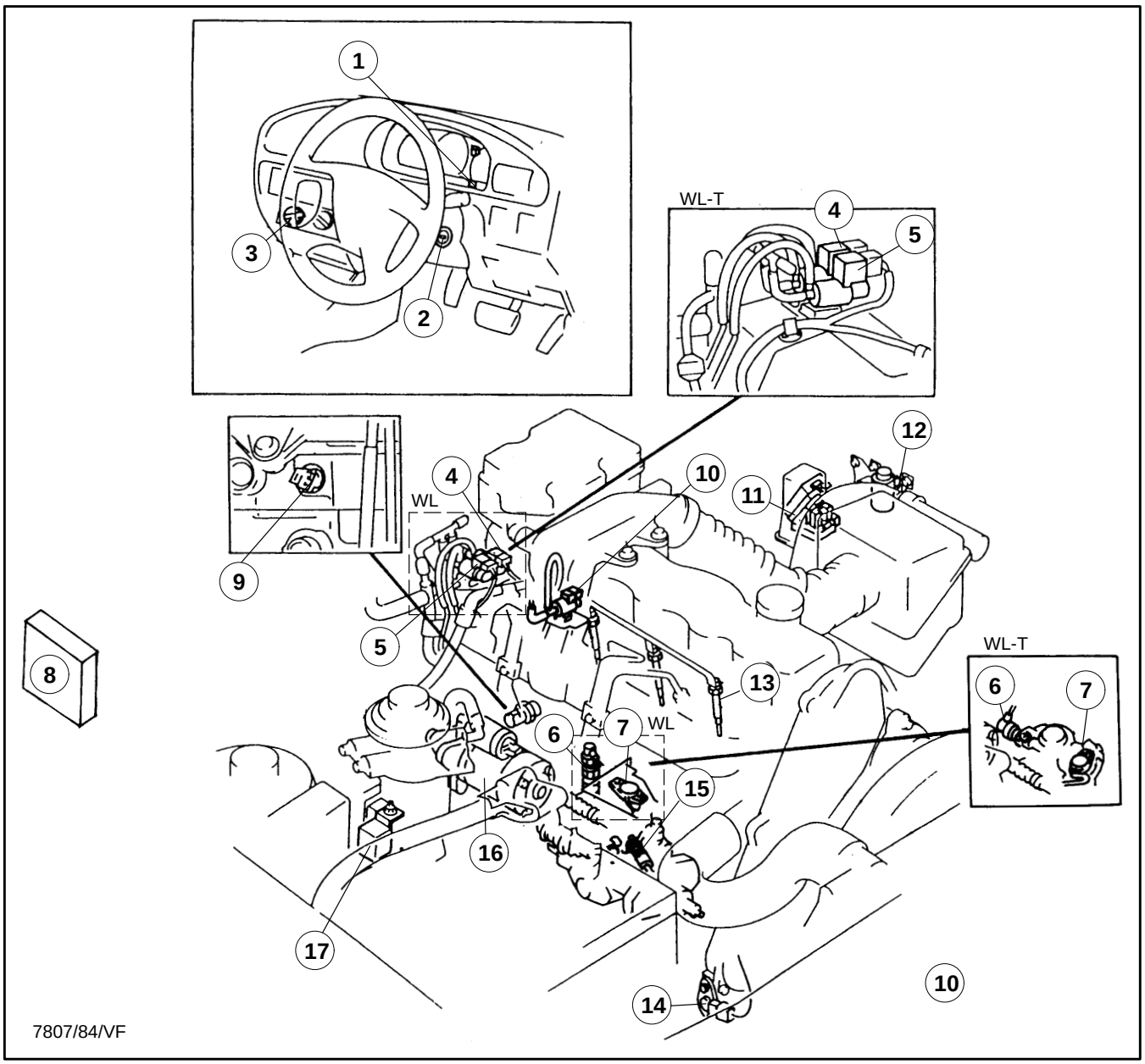
Overview

- The powertrain control module (PCM) controls the idle speed, the glow plug system, the operation of the air conditioning system, the fuel injection timing and the EGR control (WL-T).



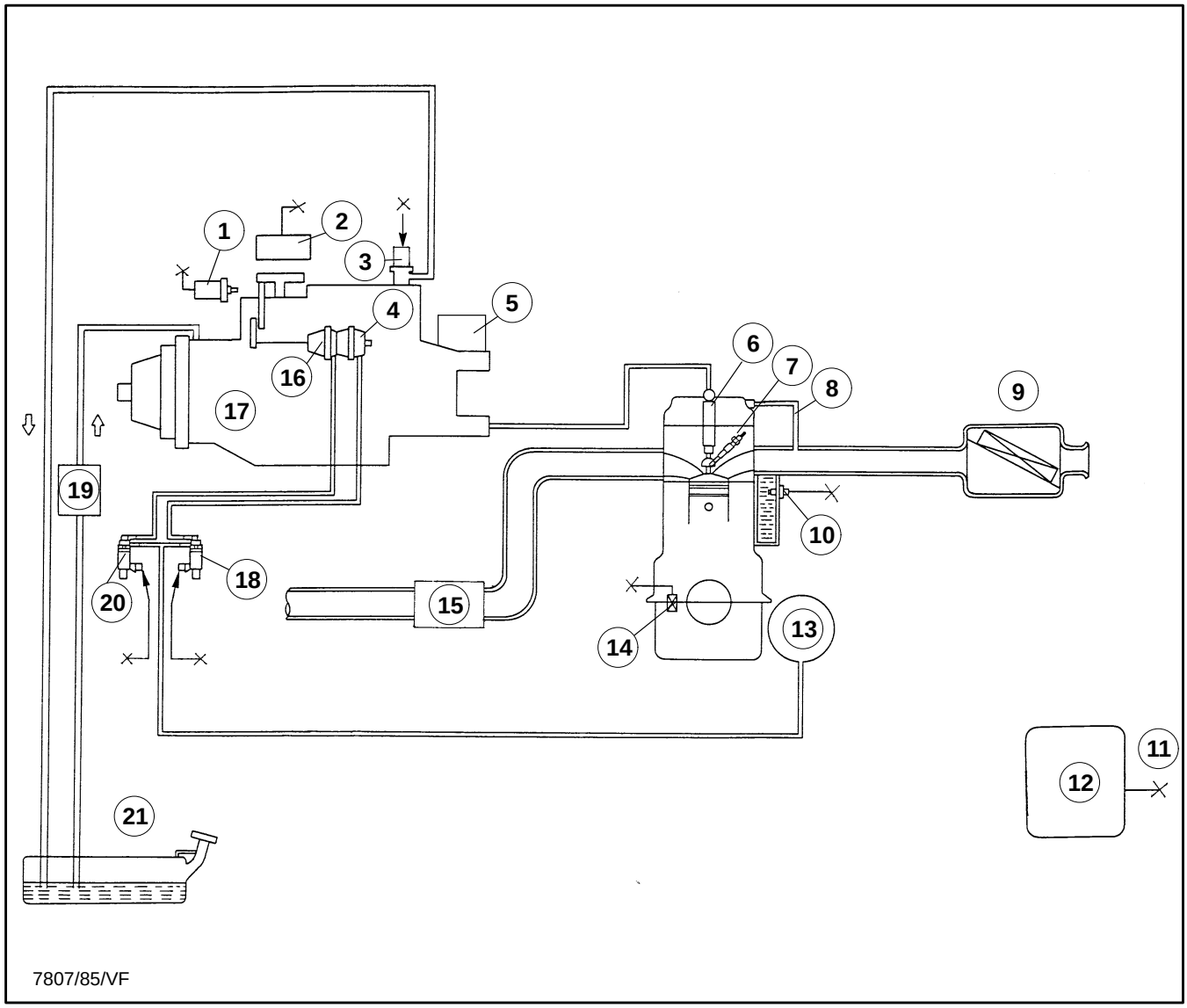
1 Powertrain control module (PCM)
2 Idle speed control
3 Glow plug control
4 A/C cut-off control
5 Fuel injection timing control
6 EGR control (WL-T)
7 FICD solenoid valve No. 1
8 FICD solenoid valve No. 2
9 Glow plug relay
10 Glow plug indicator
11 A/C relay
12 Timer control valve (TCV)
13 EGR solenoid valve
14 Idle switch
15 Control lever position sensor
16 Glow plugs (glow voltage signal)
17 Ignition switch
18 Starter motor (engine start signal)
19 A/C switch
20 Engine coolant temperature (ECT) sensor
21 NE sensor

Locations of engine management components (RHD shown)



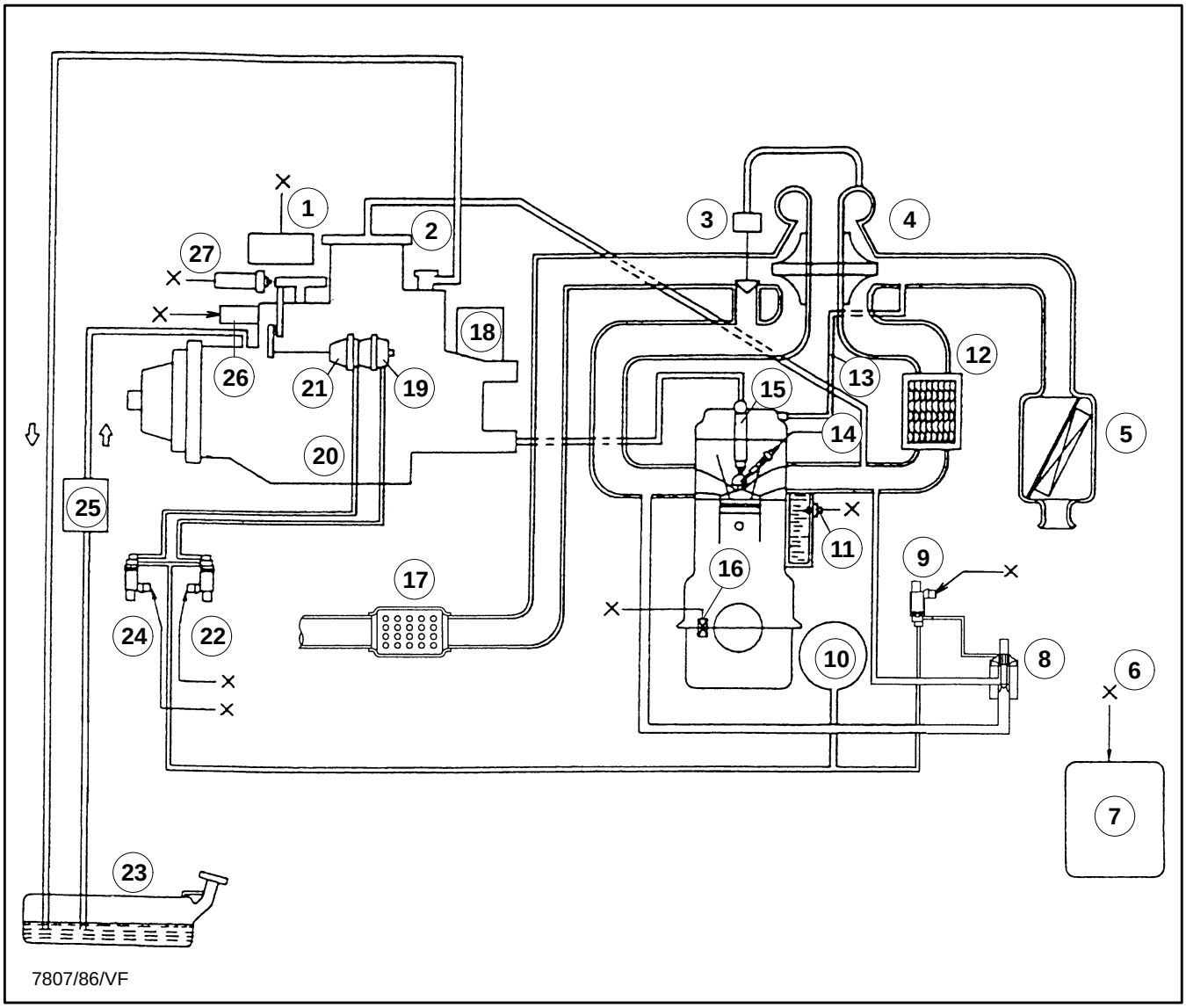
1 Glow plug indicator
2 Ignition switch
3 A/C switch
4 FICD solenoid valve No. 2
5 FICD solenoid valve No. 1
6 Timer control valve (TCV)
7 Control lever position sensor
8 Powertrain control module (PCM)
9 Engine coolant temperature (ECT) sensor
10 EGR solenoid valve
11 Data link connector (DLC)
12 A/C relay
13 Glow plugs
14 NE sensor
15 Idle switch
16 Starter motor
17 Glow plug relay

WL engine



1 Idle switch
2 Control lever position sensor
3 Timer control valve (TCV)
4 Fast idle control device (FICD) actuator No. 2
5 Fuel shutoff valve
6 Injection nozzle
7 Glow plug
8 Crankcase ventilation hose
9 Air cleaner
10 Engine coolant temperature (ECT) sensor
11 To powertrain control module (PCM)
12 Powertrain control module (PCM)
13 Vacuum pump
14 NE sensor
15 Oxidation catalytic converter (OC)
16 Fast idle control device (FICD) actuator No. 1
17 Fuel injection pump
18 Fast idle control device (FICD) solenoid No. 2
19 Fuel filter
20 Fast idle control device (FICD) solenoid No. 1
21 Fuel tank

WL-T engine



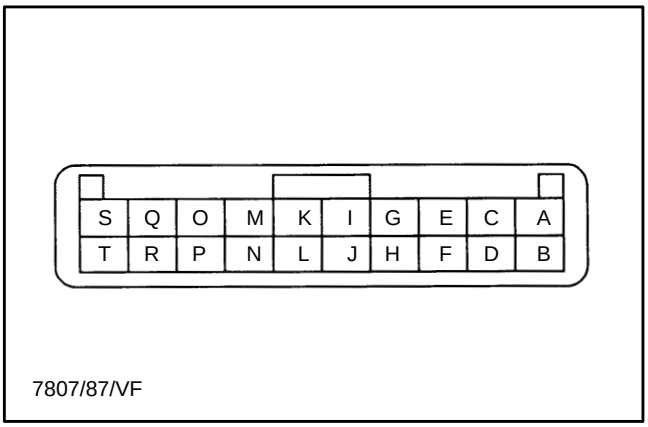
1 Control lever position sensor
2 Boost compensator
3 Wastegate valve
4 Turbocharger
5 Air cleaner
6 To powertrain control module (PCM)
7 Powertrain control module (PCM)
8 EGR valve
9 EGR solenoid valve
10 Vacuum pump
11 Engine coolant temperature (ECT) sensor
12 Intercooler
13 Crankcase ventilation hose
14 Glow plug
15 Injection nozzle
16 NE sensor
17 Oxidation catalytic converter (OC)
18 Fuel shutoff valve
19 Fast idle control device (FICD) actuator No. 2
20 Fuel injection pump
21 Fast idle control device (FICD) actuator No. 1
22 Fast idle control device (FICD) solenoid No. 2
23 Fuel tank
24 Fast idle control device (FICD) solenoid No. 1
25 Fuel filter
26 Timer control valve (TCV)
27 Idle switch

Overview of operation

Device		Control Item				
		Idle speed control	**Glow plug control**	**A/C cut-off control**	**Fuel injection timing control**	**EGR control**
Input	NE sensor		●		●	●
	ECT sensor	●	●	●	●	●
	A/C switch	●		●		
	Starter motor (engine start signal)		●			
	Ignition switch (power supply to the PCM)		●			
	Glow plugs (glow plug voltage signal)		●			
	Idle switch				●	●
	Control lever position sensor		●		●	●
Output	FICD solenoid valve No. 1	●				
	FICD solenoid valve No. 2	●				
	Glow plug relay		●			
	Glow plug indicator		●			
	A/C relay			●		
	Timer control valve (TCV)				●	
	EGR solenoid valve					●

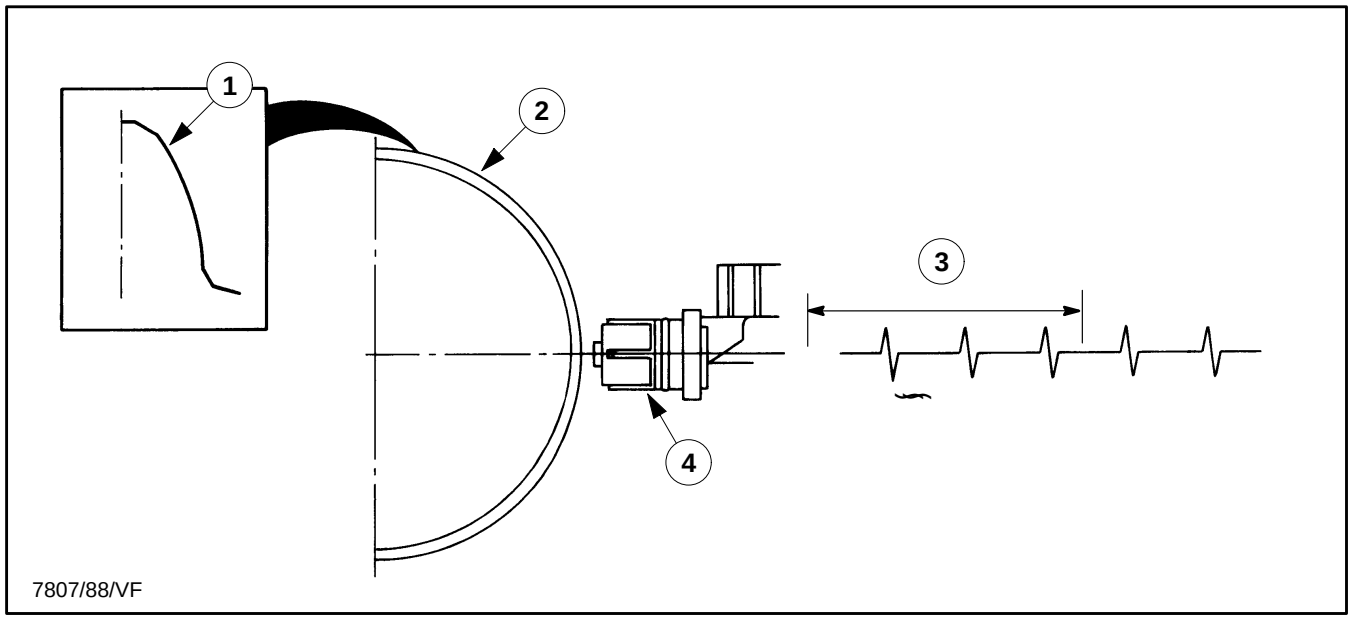
Powertrain control module (PCM)

- The powertrain control module (PCM) sends the signals to each actuator according to the input signals of the sensors.
- The PCM is located at the A-pillar in the footwell on the driver side.
- The PCM has a 20-pin connector.



PCM 20-pin connector

Engine speed (NE) sensor

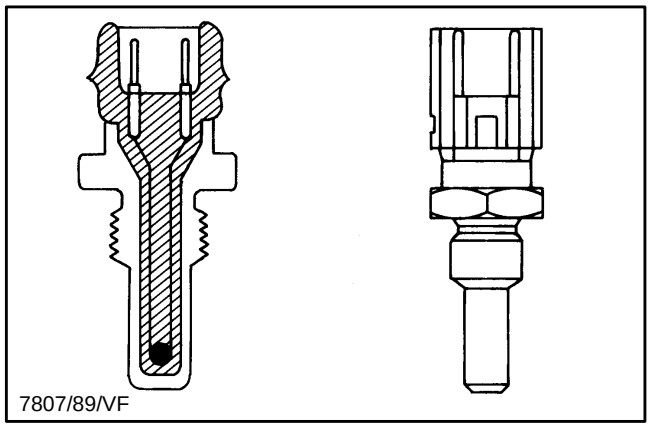


1 Teeth shape
2 Fuel injection pump gear
3 96 pulses per 2 crankshaft revolutions
4 NE sensor

- The engine speed (NE) sensor detects the rotation speed of the fuel injection pump gear, which is used by the PCM as an engine speed signal.
- The NE sensor is an inductive sensor. It is located in the timing gear housing.
- Because the fuel injection pump gear has 96 teeth, the NE sensor sends 96 pulses per 2 crankshaft revolutions to the PCM.

Engine coolant temperature (ECT) sensor

- The engine coolant temperature (ECT) sensor is an NTC thermistor type. It is installed in the cylinder head.
- The ECT sensor inputs the thermistor resistance, which changes according to the engine coolant temperature, to the PCM as a voltage.



A/C signal

- The A/C signal indicates the condition of the A/C switch operated by the driver to the PCM.

Engine start signal

- The engine start signal is used by the PCM to recognize when the engine is cranking.

Ignition switch

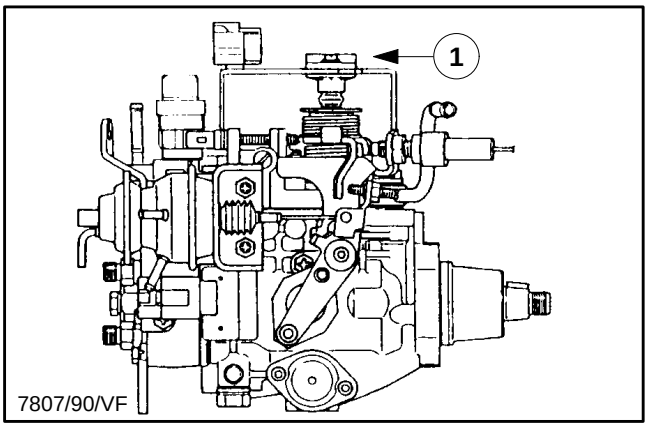
- The power supply for the PCM is engaged by the ignition switch.

Glow plug voltage signal

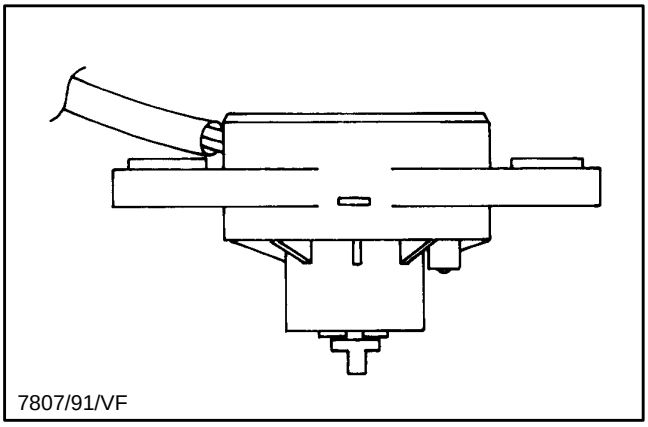
- The glow plug voltage signal inputs the voltage aplied to the glow plugs to the PCM.
- The PCM controls the power supply to the glow plug relay.

Control lever position sensor

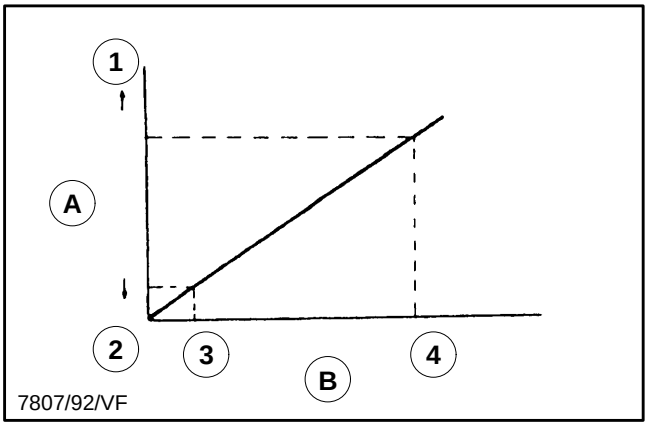
- The control lever position sensor inputs the depression amount of the accelerator pedal to the PCM. The PCM detects the signal from the control lever position sensor as a fuel injection pump control lever opening signal.
- The control lever position sensor is a potentiometer that cannot be adjusted.
- The control lever position sensor is installed on the fuel injection pump control lever, and the voltage from the sensor to the PCM changes according to the control lever movement.
- The input voltage to the PCM increases when the depression amount of the accelerator pedal is increased and decreases when the depression amount of the accelerator pedal is reduced.



1 Control lever position sensor



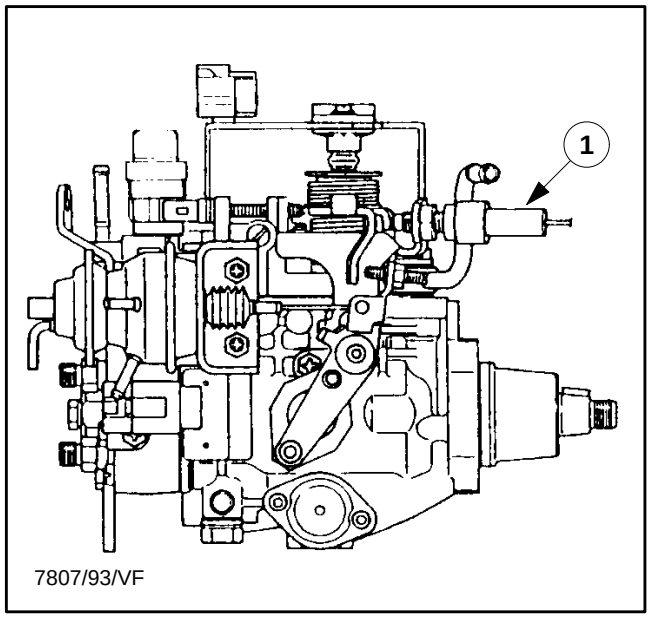
Control lever position sensor



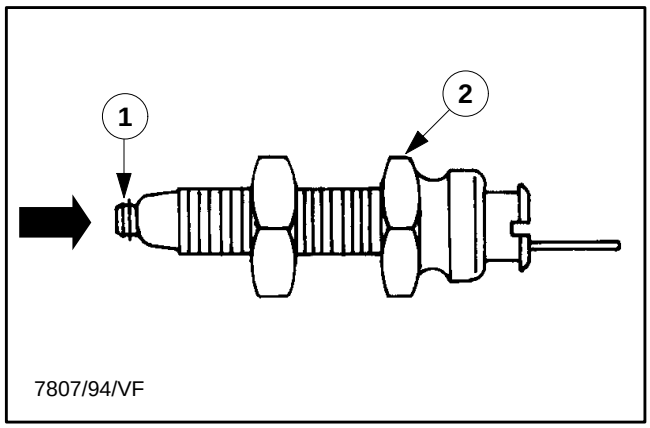
A Input voltage
1 High
2 Low
B Control lever opening
3 Fully closed
4 Fully open

Idle switch

- The idle switch inputs the accelerator pedal condition (depressed or not) to the PCM. The PCM detects the signal from the idle switch as an idle judgement signal.
- The idle switch is installed on the fuel injection pump and its contact point is turned ON/OFF according to the control lever movement. The control lever and the accelerator pedal are interlocked with the accelerator cable.
- The contact point of the idle switch closes (ON) when the push rod is pushed a fixed amount, and the PCM judges that the engine is idling. When the contact point of the idle switch is open (OFF), the PCM judges that the engine is not idling.



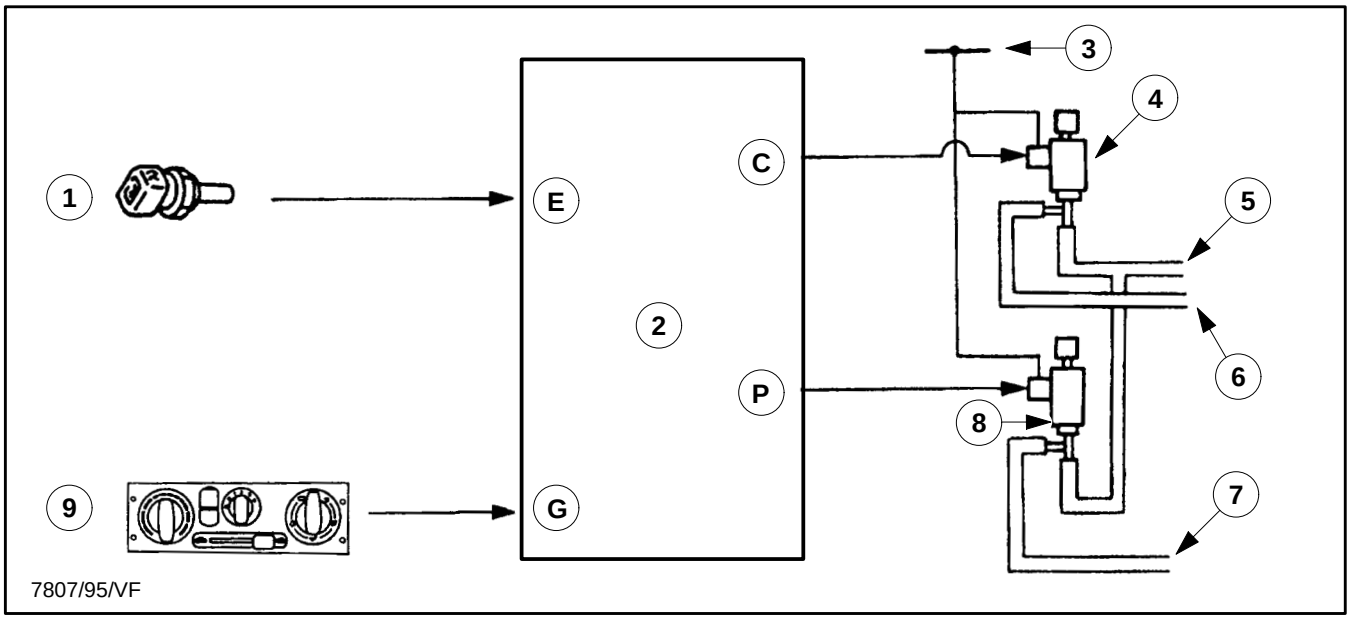
1 Idle switch



1 Push rod
2 Idle switch

Notes

Idle speed control



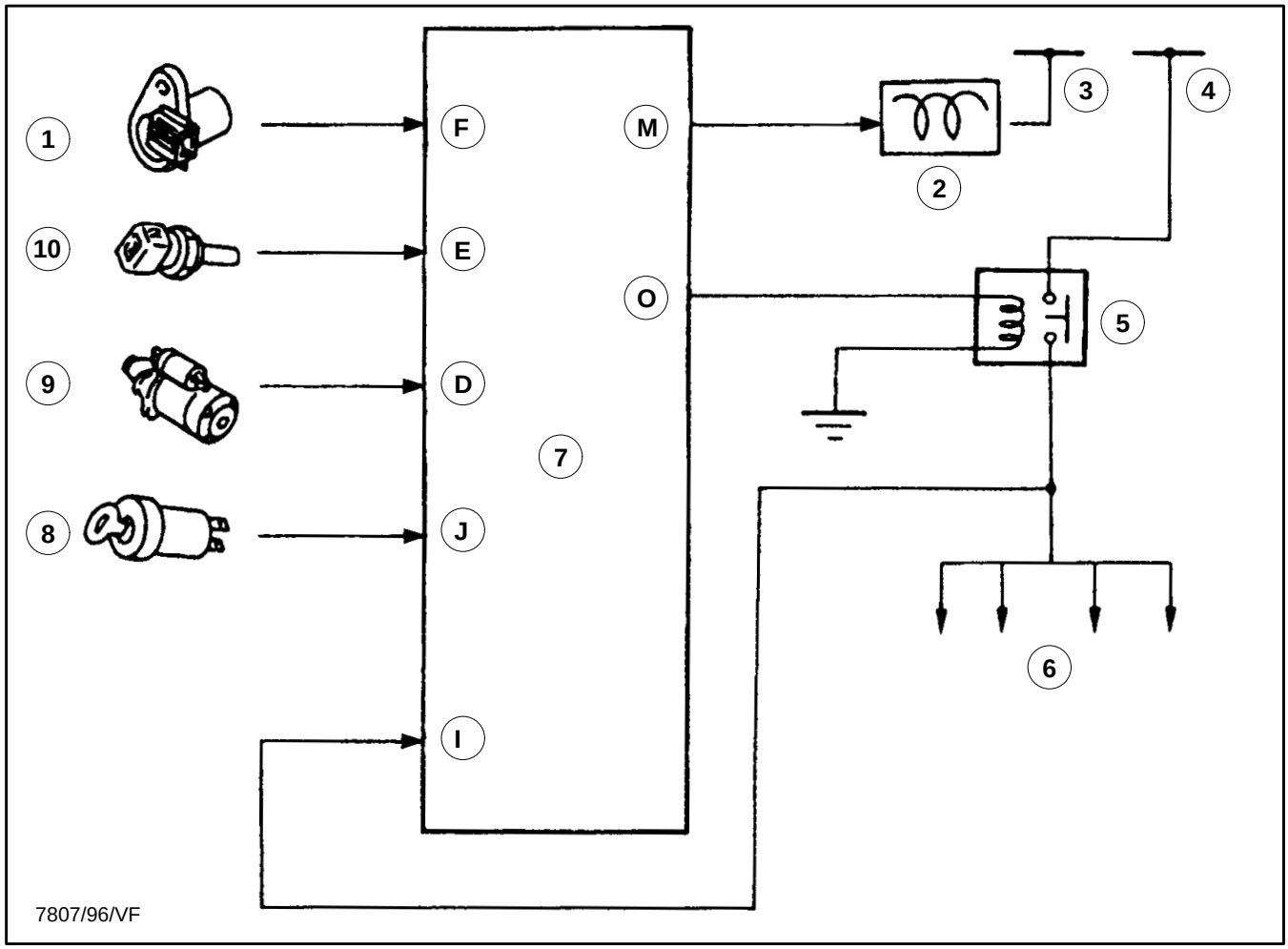
1 Engine coolant temperature (ECT) sensor
2 Powertrain control module (PCM)
3 Ignition switch
4 FICD solenoid valve No. 1
5 To vacuum pump
6 To FICD actuator No. 1
7 To FICD actuator No. 2
8 FICD solenoid valve No. 2
9 A/C switch

- By activating fast idle control device (FICD) No. 1 and No. 2, the fuel injection amount and idle speed stability are controlled.
- The actuation of FICD solenoid No. 1 and/or No. 2 depends on the engine load and temperature.
- The PCM actuates the solenoids as shown below. For detailed information on the FICD design and operation refer to the section “Fuel system – fast idle control device (FICD)”.

Engine condition	Condition		FICD solenoid valve operation	
			FICD solenoid valve No. 1	FICD solenoid valve No. 2
Warm-up condition	Engine coolant temperature	below 20°C (68°F)	ON	ON
		20-60°C (68-140°F)	OFF	ON
		above 60°C (140°F)	OFF	OFF
Load condition	A/C compressor clutch	engaged	OFF	ON
		disengaged	OFF	OFF

Glow plug control

- The glow plug system is controlled by the PCM. The PCM actuates the glow plug relay according to the input signals of the ECT sensor, NE sensor, ignition switch and starter motor.
- The system operation is basically the pre-glow control, temperature-hold control and long-afterglow control.
- For detailed information on the glow plug system components refer to the section “Glow plug system”.



1 NE sensor
2 Glow plug indicator
3 From ignition switch
4 From battery
5 Glow plug relay
6 Glow plugs
7 Powertrain control module (PCM)
8 Ignition switch
9 Starter
10 Engine coolant temperature (ECT) sensor

Operation of glow plug control

- The glow plug relay will be activated in any of the following conditions:
  - during the pre-glow phase
  - while the engine is cranking
  - during the temperature-hold phase when the engine coolant temperature is below 60°C (140°F)
  - during the long-afterglow phase when the engine coolant temperature is below 60°C (140°F)
- The operational timing schedule of the glow plug system is designed according to the conditions of the engine coolant temperature.

Pre-glow phase

- After the ignition switch is turned on, the pre-glow function is to preheat the swirl combustion chamber by activating the glow plug relay for several seconds according to the engine coolant temperature.
- The duration of the pre-glow phase gets longer as the engine temperature decreases.
- During the pre-glow phase the glow plug indicator illuminates.

Temperature-hold phase

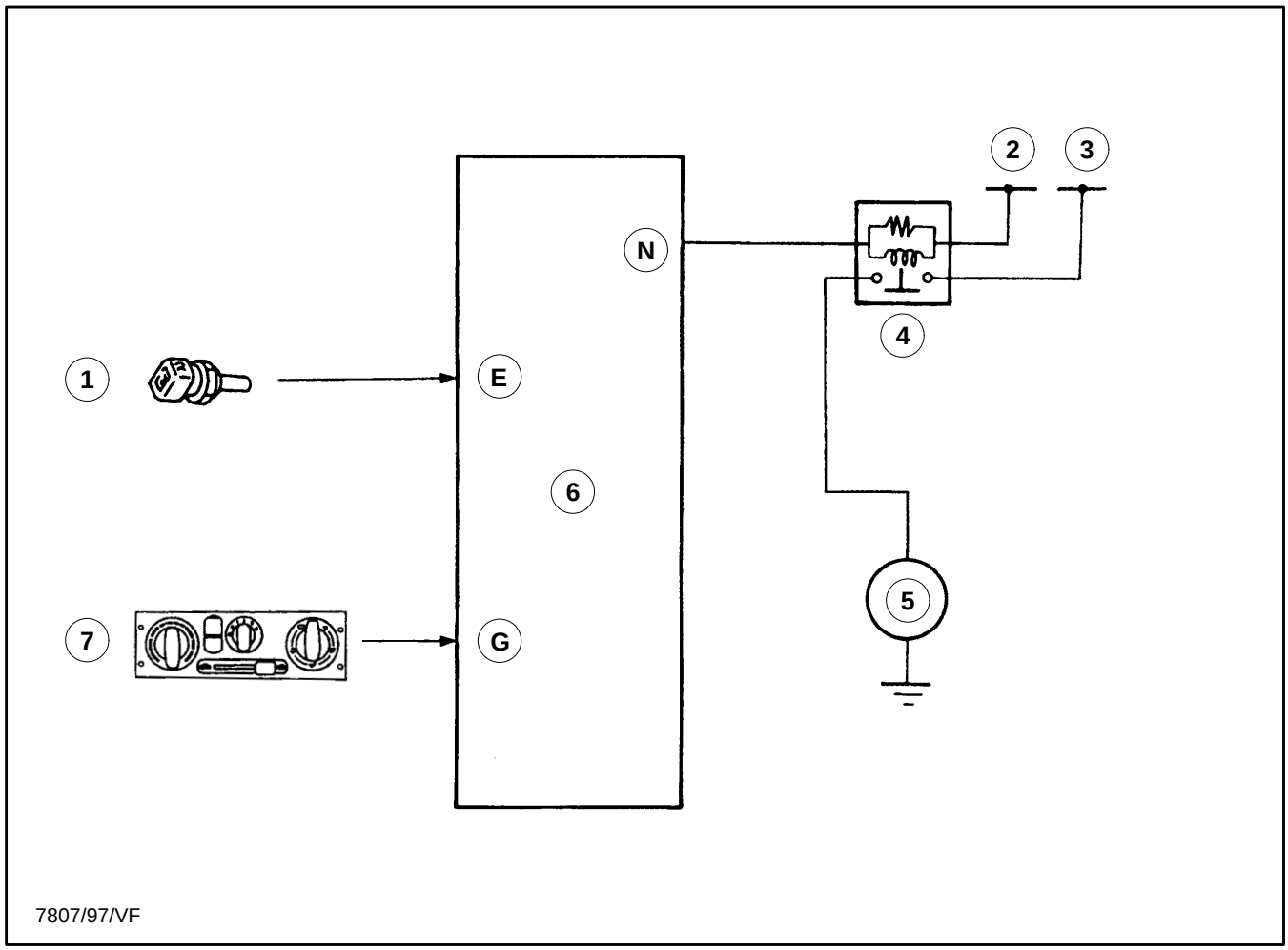
- When, after the pre-glow phase, the ignition switch is kept in the ON position (not cranking/starting the engine) with the engine cold, the PCM still activates the glow plug relay for approximately 15 seconds (temperature-hold phase).
- This keeps the engine's combustion chamber temperature ready for starting.

Long-afterglow phase

- The long-afterglow feature activates the glow plugs for approximately 10 minutes after engine start when the engine is cold.
- This improves ignition and combustion stability and reduces engine noise.
- The PCM aborts the long-afterglow function under the following conditions:
  - engine coolant temperature rises over 60°C (140°F)
  - glow plug voltage exceeds 16 volts
  - malfunction of glow plug relay or ECT sensor

A/C cut-off control

- For improving the reliability of the engine, the PCM stops the power supply to the A/C relay when the engine coolant exceeds a certain temperature.
- The A/C relay is activated again when the engine coolant temperature decreases.



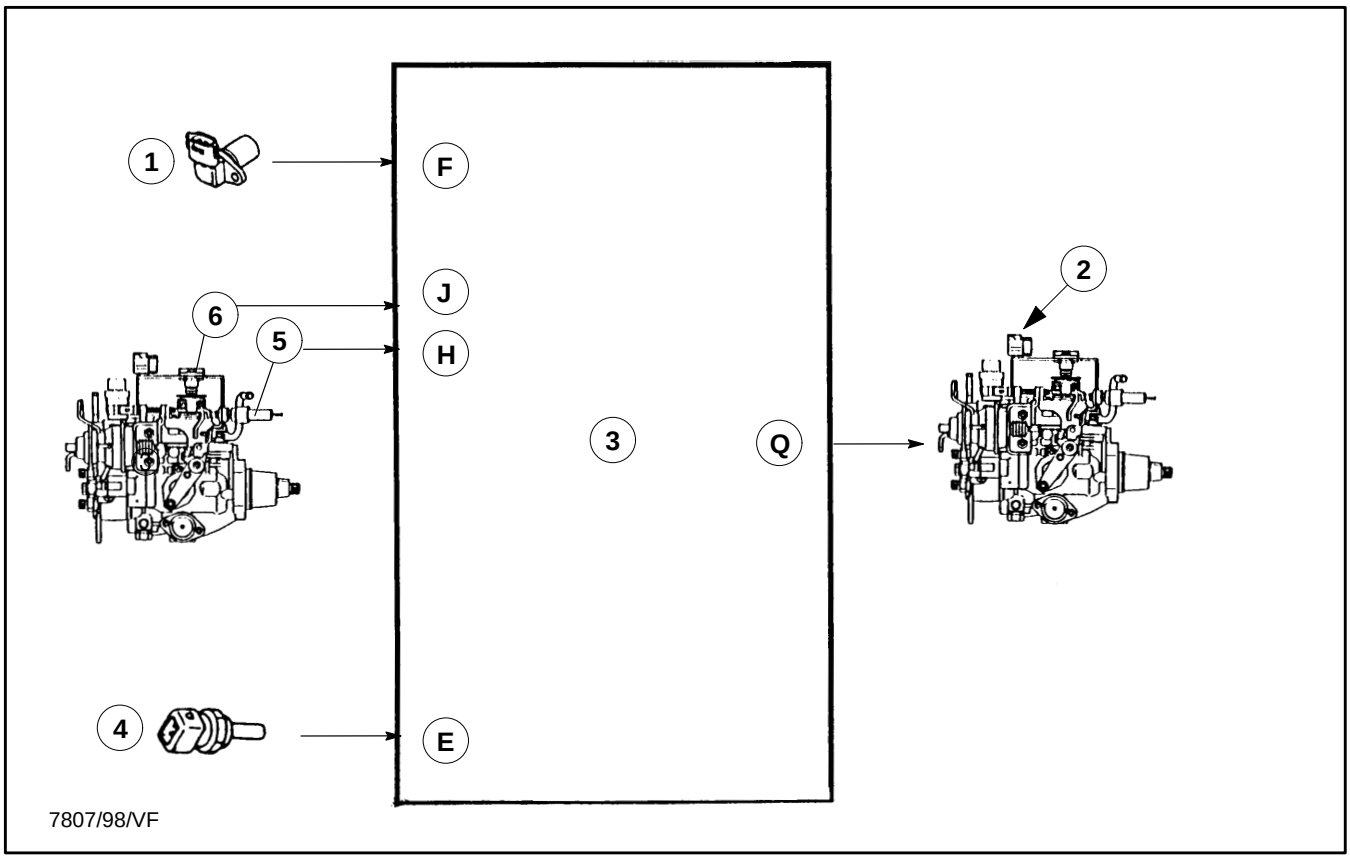
1 ECT sensor
2 Battery (+) terminal
3 Ignition switch
4 A/C relay
5 A/C compressor clutch
6 Powertrain control module (PCM)
7 A/C switch

- The PCM stops the power supply to the A/C relay under the following conditions:

A/C cut-off condition	A/C cut-off time	Purpose
ECT is above 115°C (239°F)	Until ECT falls below 112°C (234°F)	Engine reliability improvement

Fuel injection timing control

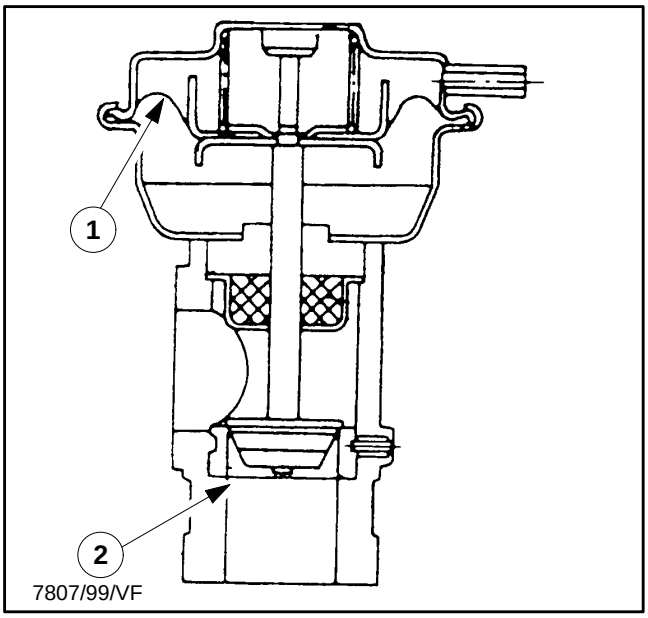
- The fuel injection timing control determines the optimal fuel injection timing according to the engine driving condition. The PCM judges the engine driving condition based on the signals from the input sensors shown in the figure below, and calculates the control signals of the fuel injection timing to drive the timer control valve (TCV).
- The PCM controls the fuel injection timing by driving the TCV installed to the fuel injection pump to change the fuel pressure on the timer piston and move the timer piston position.
- The PCM determines the optimal injection timing based on each input signal, and then determines the opening angle of the TCV according to the injection timing.
- The TCV is driven by the injection timing signal (ON/OFF signal) from the PCM. When the injection timing signal is ON, the injection timing is retarded under any of the following conditions:
  1. While cranking
  2. When the engine speed is low with the ECT below 70°C (158°F)
  3. When the engine speed is high



1 NE sensor
2 Timer control valve (TCV)
3 Powertrain control module (PCM)
4 Engine coolant temperature (ECT) sensor
5 Idle switch
6 Control lever position sensor

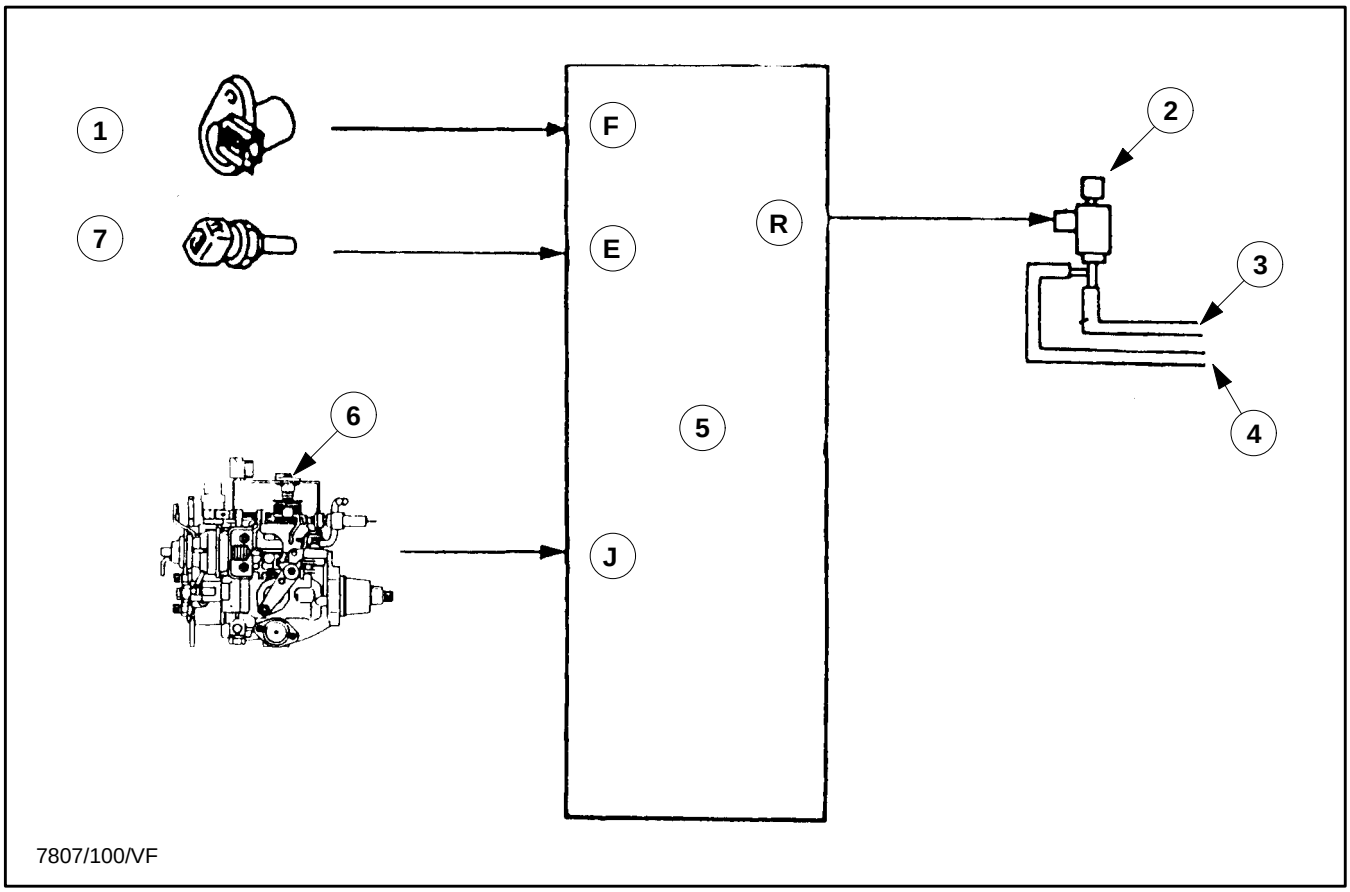
EGR control (WL-T only)

- Ford Ranger vehicles with the turbocharged WL-T engine are equipped with an exhaust gas recirculation (EGR) system.
- The EGR valve recirculates a small amount of exhaust gas into the intake manifold to reduce the combustion temperature in the cylinder and reduce oxides of nitrogen (NOx) emissions.
- The EGR valve opens/closes according to the vacuum amount that operates on the EGR diaphragm.
- The EGR solenoid valve operates according to the control signal from PCM and controls vacuum ON/OFF to EGR valve.



1 Diaphragm 2 Valve

EGR control (continued)



1 NE sensor
2 EGR solenoid valve
3 To vacuum pump
4 To EGR valve
5 Powertrain control module (PCM)
6 Control lever position sensor
7 ECT sensor

- By activating the EGR solenoid valve, the EGR valve is opened and recirculates exhaust gas.
- The time that electricity flows to the EGR solenoid valve is determined according to the engine condition.
- The EGR control is operated when the ECT is between 65°C (149°F) and 110°C (230°F) to ensure drivability and low level emission.

General

- The data link connector (DLC) has the “FEN” (“from engine”) terminal for diagnostic trouble code (DTC) output, and the “TEN” (“test engine”) terminal for setting the engine condition suitable for the test mode.
- The DLC is located in the engine compartment.
- The diagnostic system has a failure detection function that detects input/output signal malfunctions.
- The diagnostic system can be used by connecting test equipment to the data link connector. It is possible to read only the DTCs using the circuit tester.

Failure detection function

- The failure detection function detects malfunctions in the input/output system (when the ignition switch is ON or while driving).
- When a failure is detected, the DTCs are output through the failure indication function to the FEN terminal in the data link connector. At the same time, the detection results are also sent to the memory and to the fail-safe function.

Fail-safe function

- The fail-safe function ensures the minimum vehicle driveability by switching the signal judged as a failure in the failure detection function to the preset value and limiting the PCM control.

Memory function

- The memory function memorizes the signal systems judged to be abnormal in the failure detection function. The memory cannot be erased when the ignition switch is turned off (LOCK position) or after recovering from the failure.
- To erase the failure information, disconnect the battery ground cable.

DTC table

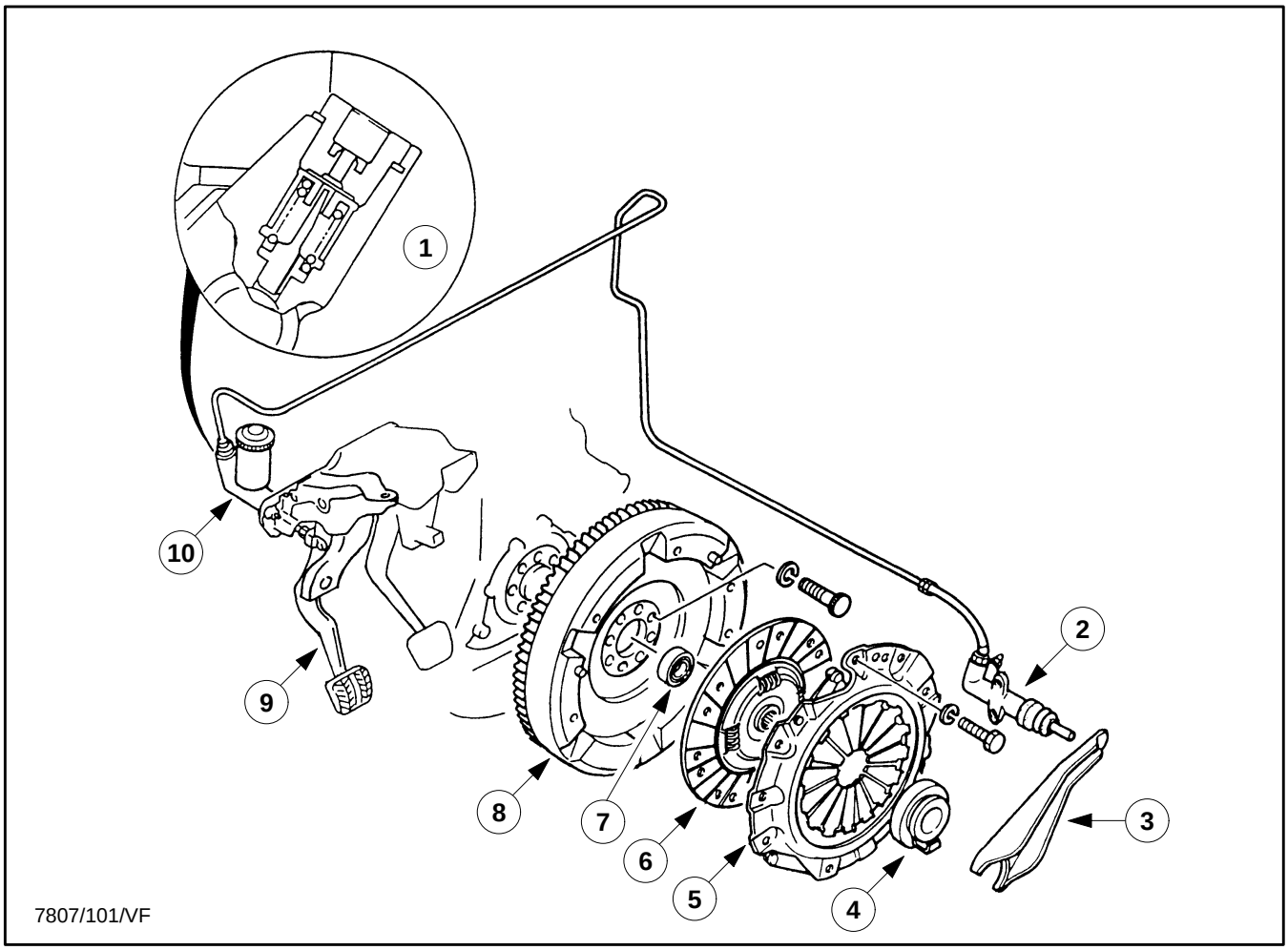
- The following DTCs have been set to improve serviceability:

DTC No.	Output pattern	Diagnosed circuit	Detection condition	Fail-safe	Memory function
09		engine coolant temperature signal circuit	input value to PCM is excessively high or low for more than 2.0 sec	– fixes ECT at 80ºC (176ºF) – inhibits after glow control – turns EGR solenoid valve off *	●
12		control lever position signal circuit	input voltage from control lever position sensor is below 0.10 V or above 4.75 V when continued for 1.0 sec	– fixes control lever position at 0% – turns EGR solenoid valve off *	●
			when idle switch is on, input voltage from control lever position sensor is below 0.35 V or above 1.39 V	– fixes input voltage from control lever position sensor at 0.87 V	
36		glow plug relay signal circuit	when glow plug relay is on, current voltage signal of the relay below 1.0 V or above 4.0 V is inputted to the PCM continuously for more than 1.0 sec	– turns glow plug relay off	●

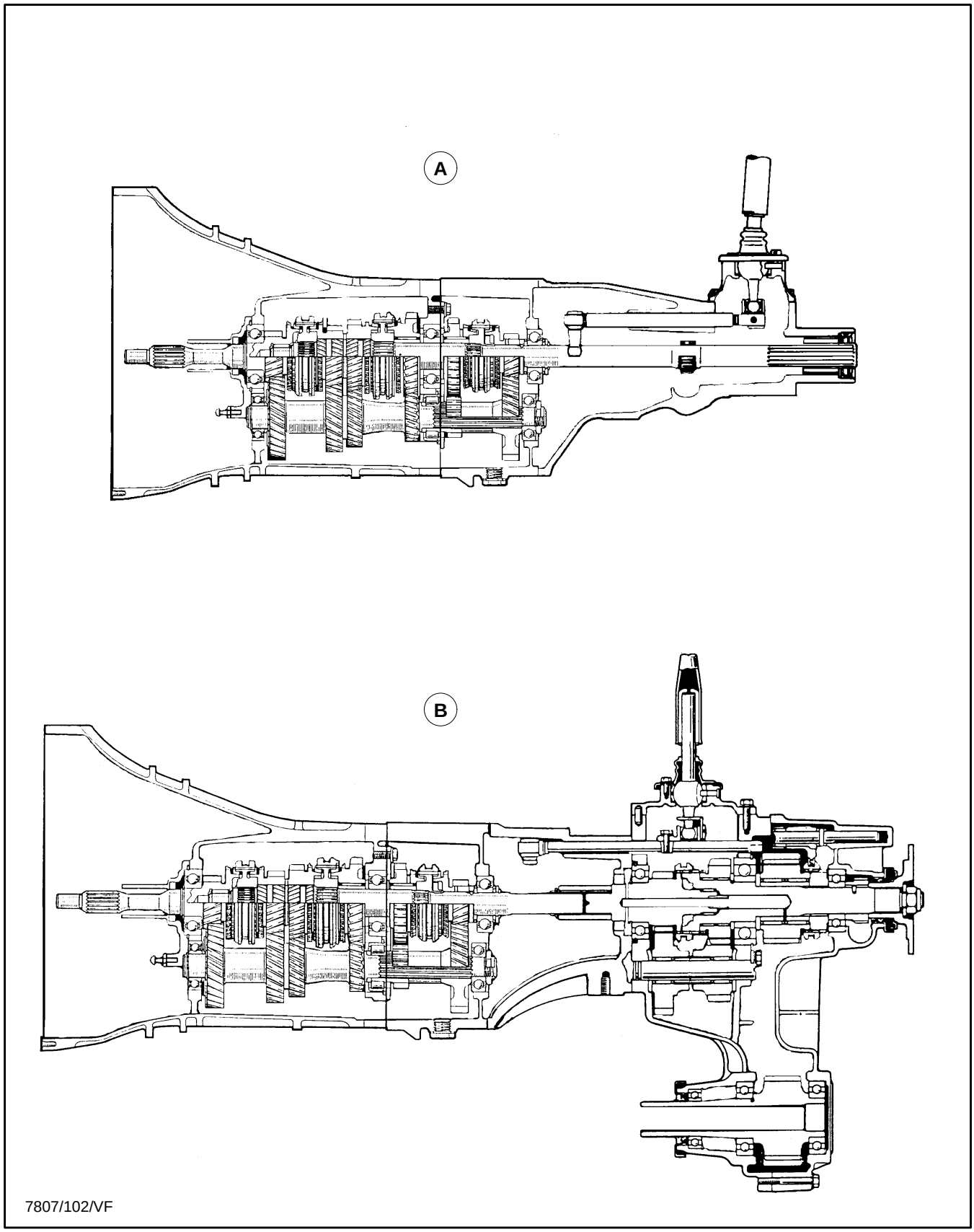
* WL Turbo
● Applied

Notes

- The clutch is a single plate, dry-friction disc with a diaphragm-style spring clutch pressure plate.
- The clutch master cylinder transmits fluid pressure to the clutch slave cylinder, which in turn moves the clutch release fork and the clutch release bearing.
- The clutch pedal has a turn-over type assist spring to reduce the force required to operate the clutch pedal.
- On LHD vehicles, the clutch pedal is mounted on an integrated bracket with the brake pedal.
- On RHD vehicles, the clutch pedal is mounted on an integrated bracket with the brake pedal and accelerator pedal.
- The clutch master cylinder has an integrated return restrictor valve to obtain smooth clutch engagement.
- The clutch slave cylinder contains a conical spring to maintain the push rod end free play at zero for maintenance-free operation.



1 Return restrictor valve
2 Clutch slave cylinder
3 Clutch release fork
4 Clutch release bearing
5 Clutch pressure plate
6 Clutch disc
7 Pilot bearing
8 Flywheel
9 Clutch pedal
10 Clutch master cylinder



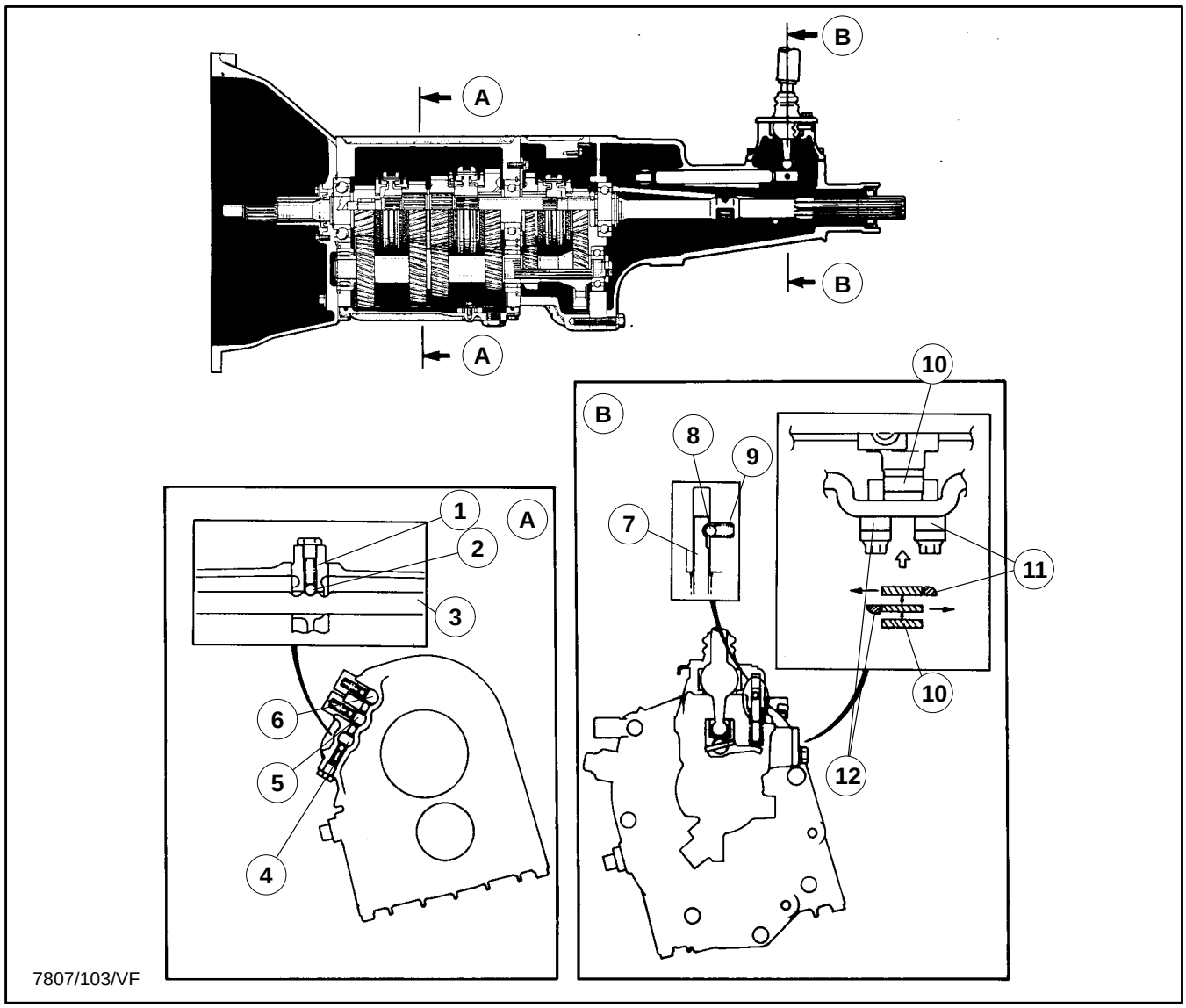
A R15M-D manual transmission (2WD)

B R15MX-D manual transmission (4WD)

General

- The R15M-D manual transmission is used for 2WD models and the R15MX-D manual transmission is used for 4WD models. The R15M-D and R15MX-D are top-shift, fully synchronized, five-speed transmissions, equipped with an overdrive 5th gear ratio.
- All gears, including reverse, are selected by a synchronizer mechanism. The clutch housing, transmission housing, center housing, bearing housing and extension housing are constructed of aluminium alloy.
- A detent mechanism device, in which a spring pushes a steel ball into grooves designed in each shift rod, is used to improve shift feel and to fix the shift rod to the correct position.
- A select lock spindle and a stopper pin on the shift lever section of the extension housing prevent unintentional shifts into 5th and reverse gear. The select lock spindle is designed with steps on to which a steel ball is pushed by a spring.
- The change in load that is created when the steel ball overcomes each step of the select lock spindle results in improved shifting into 5th or reverse gear. By controlling movement of the control lever end, the stopper pin prevents unintentional shifts into 5th or reverse gear when shifting in the direction of these gears.
- Each gear is lubricated with oil that is splashed by the counter shaft gear, and the extension housing section is lubricated with splashed oil that is guided to each section by the oil pass.
- The 2nd gear has a double cone synchronizer mechanism.

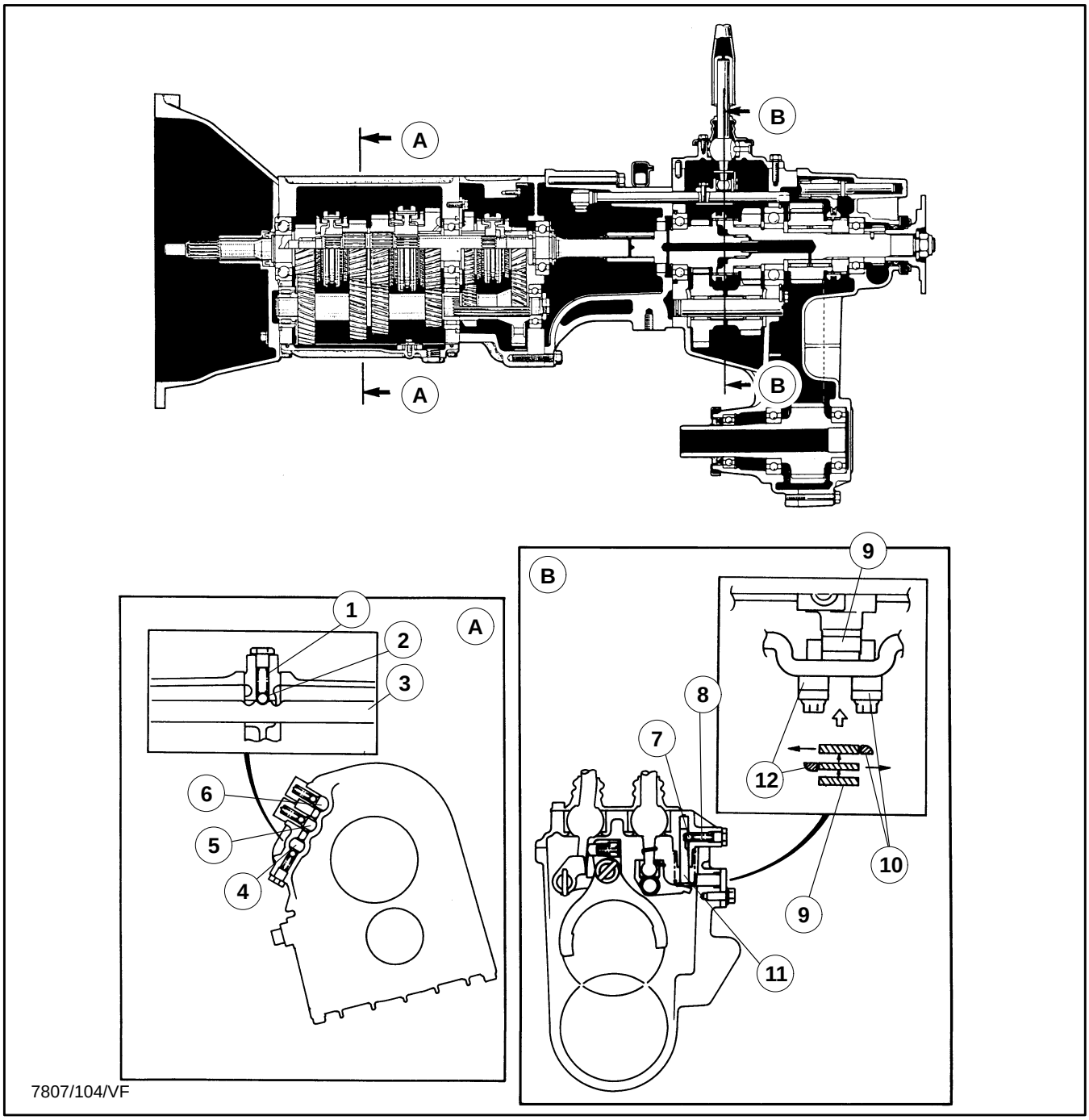
R15M-D manual transmission (2WD)



A Section A – A
1 Spring
2 Steel ball
3 Shift rod
4 5th/reverse shift rod
5 3rd/4th shift rod
6 1st/2nd shift rod

B Section B – B
7 Select lock spindle
8 Steel ball
9 Spring
10 Control lever end
11 Reverse stopper pin
12 5th stopper pin

R15MX-D manual transmission (4WD)

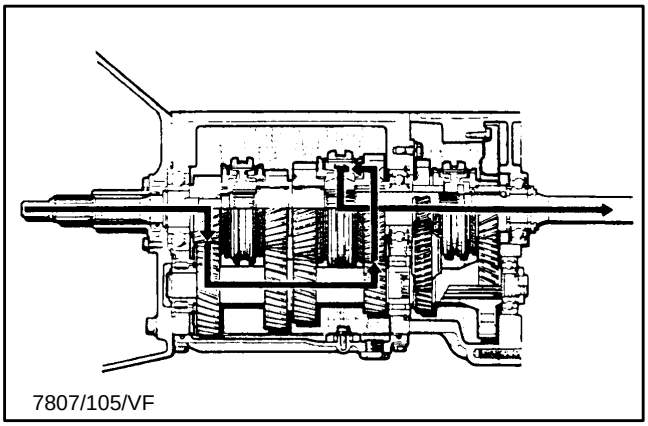


A Section A – A
1 Spring
2 Steel ball
3 Shift rod
4 5th/reverse shift rod
5 3rd/4th shift rod
6 1st/2nd shift rod

B Section B – B
7 Steel ball
8 Spring
9 Control lever end
10 Reverse stopper pin
11 Select lock spindle
12 5th stopper pin

Power flow in the various gears

1st gear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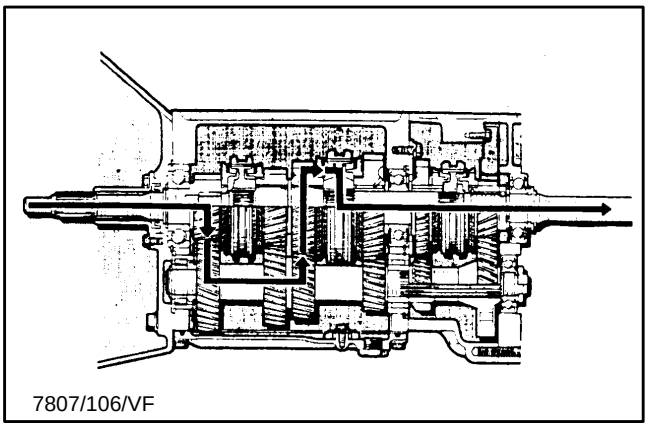
2nd gear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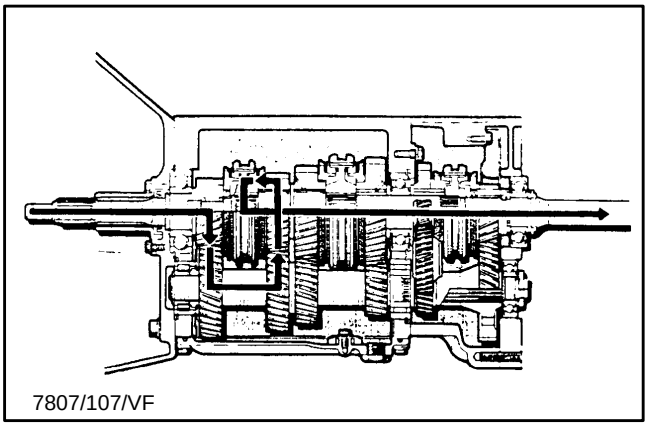
3rd gear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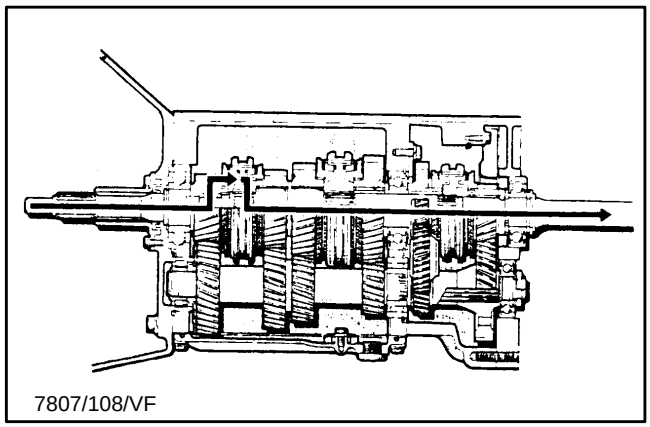
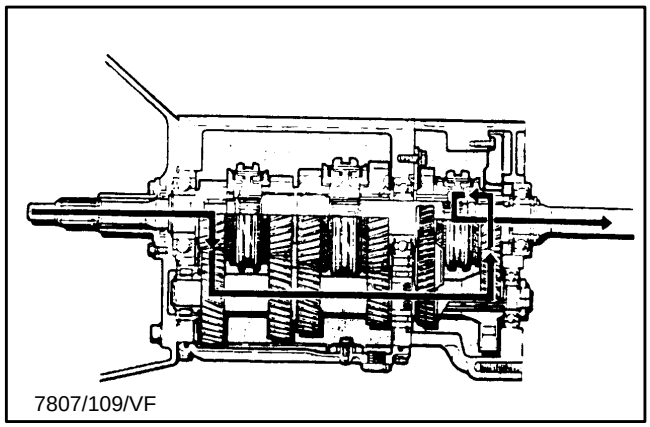
Power flow in the various gears (continued)

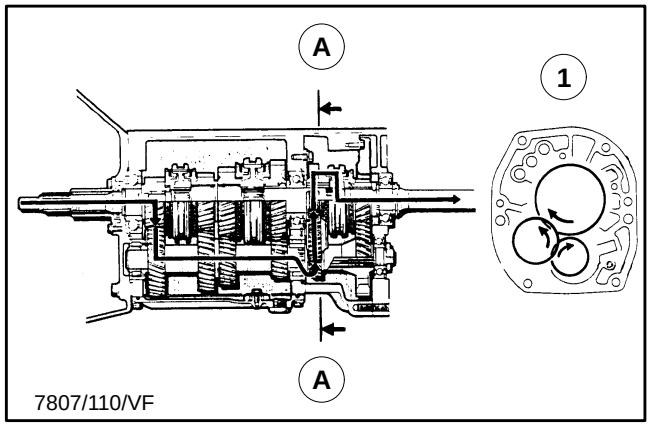
4th gear



5th gear



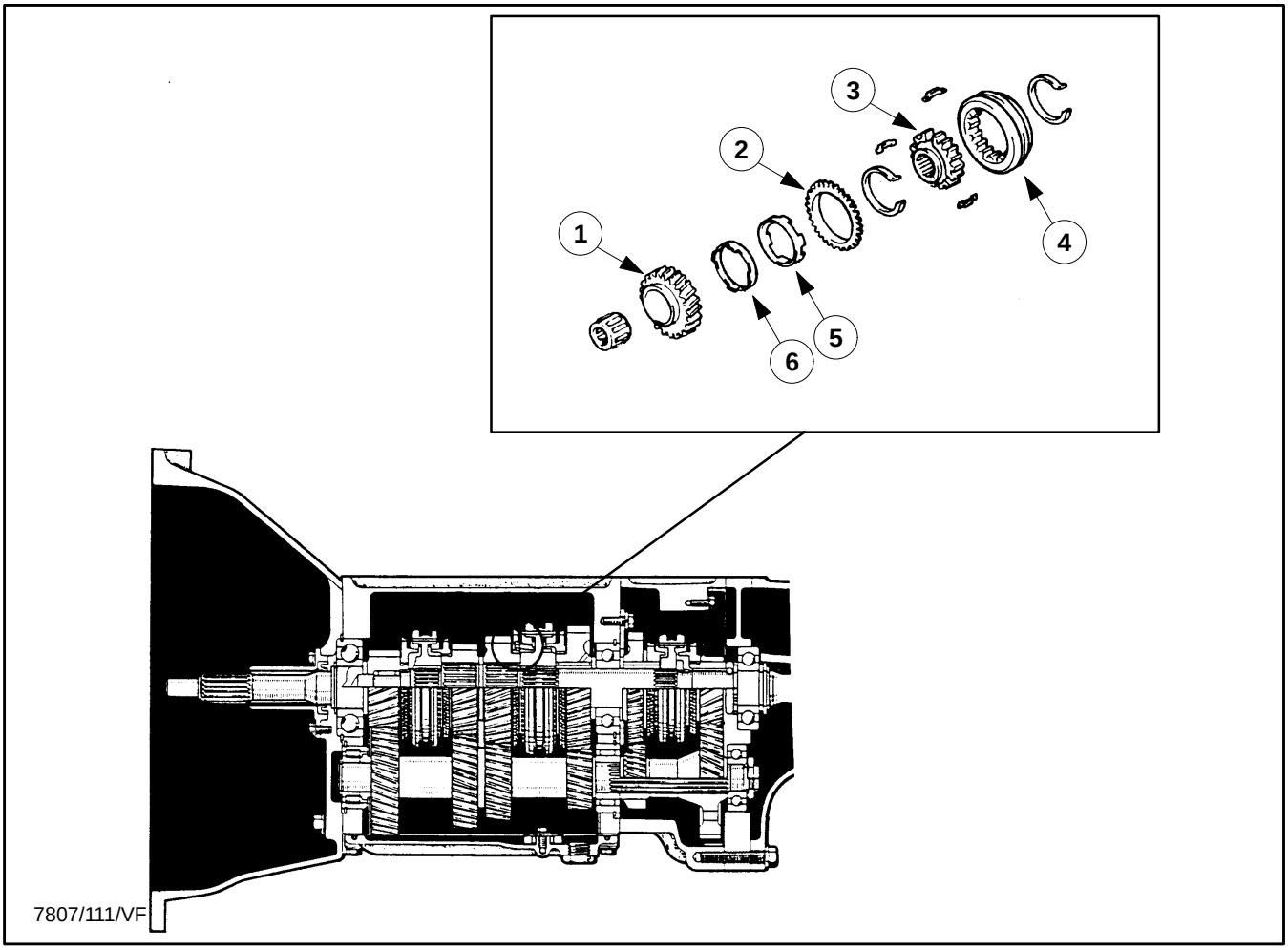
Reverse gear



1 Section A – A

Double cone synchronizer mechanism for 2nd gear

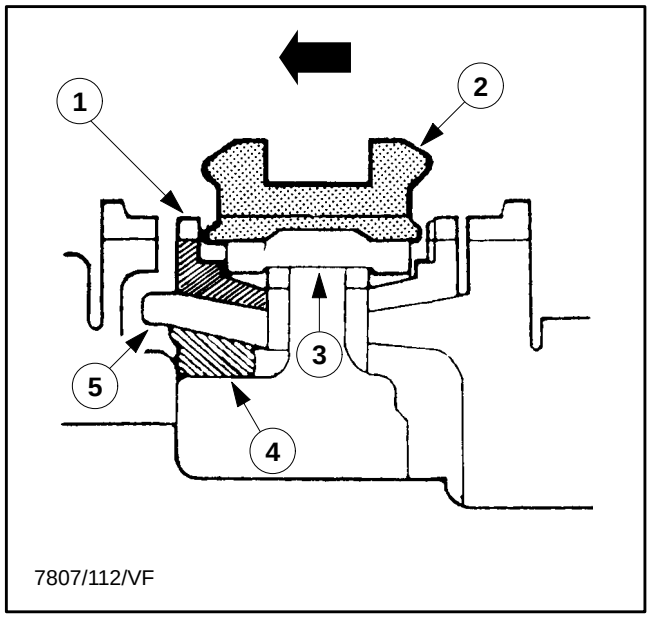
- The double cone synchronizer mechanism is a compact device capable of heavy duty meshing.
- The synchronizer mechanism reduces meshing time and improves operation.
- The double cone synchronizer mechanism includes a synchronizer ring, a double cone, and an inner cone.



1 2nd gear
2 Synchronizer ring
3 Clutch hub
4 Clutch hub sleeve
5 Double cone
6 Inner cone

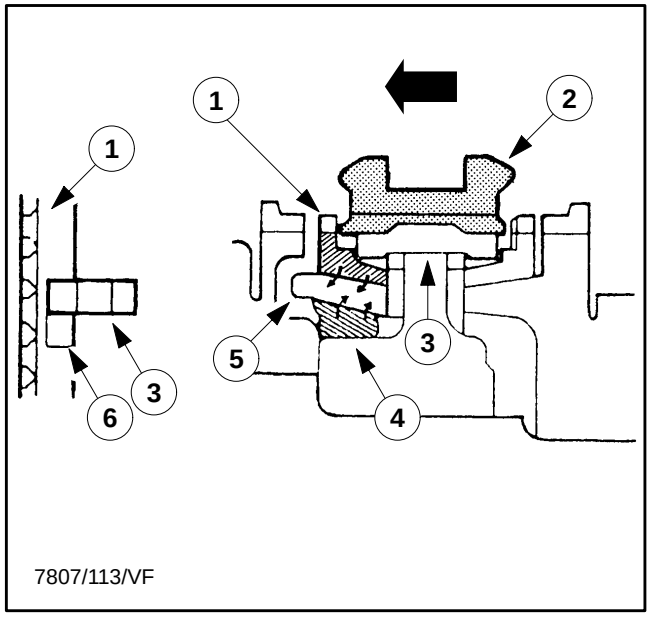
Operation of double cone synchronizer mechanism

- When the hub sleeve moves to the left (in the direction of the arrow), the synchronizer key presses against the synchronizer ring.
- The synchronizer ring is pressed onto the double cone, and the double cone is pressed onto the inner cone.



1 Synchronizer ring
2 Hub sleeve
3 Synchronizer key
4 Inner cone
5 Double cone

- As the hub sleeve continues moving to the left, the key causes friction between the synchronizer ring, double cone, and inner cone.
- The synchronizer ring turns only the distance that the key channel gap allows, aligning the teeth of the hub sleeve and the synchronizer ring.
- As the hub sleeve continues moving, the friction between the cones becomes greater, and the difference between the rotational speeds of the synchronizer ring, inner cone, and double cone (unified with gear) gradually disappears.

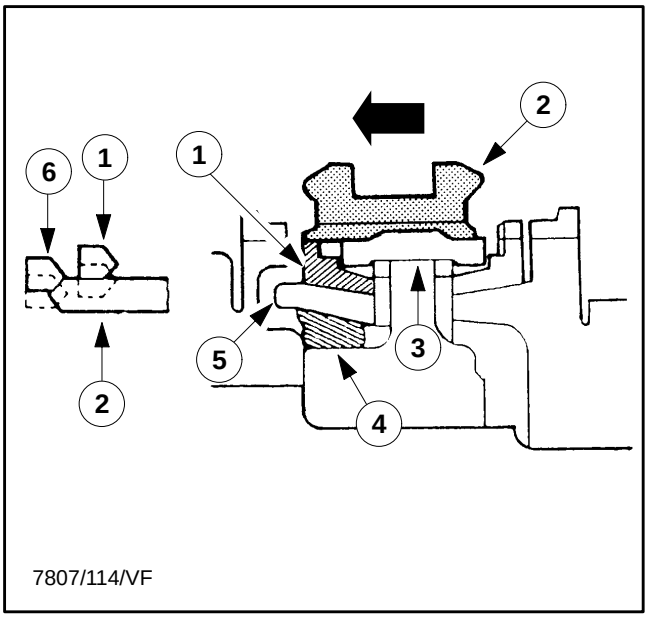


1 Synchronizer ring
2 Hub sleeve
3 Synchronizer key
4 Inner cone
5 Double cone
6 Key channel gap

Operation of double cone synchronizer mechanism (continued)

- The hub sleeve then moves up onto the synchronizer key and engages the synchronizer ring.

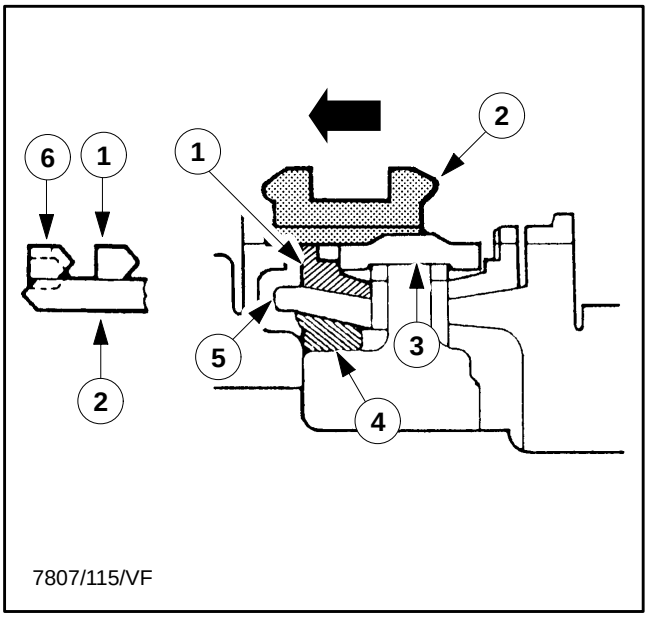
1 Synchronizer ring
2 Hub sleeve
3 Synchronizer key
4 Inner cone
5 Double cone
6 Synchronizer teeth



7807/114/VF

- The hub sleeve then engages the synchronizer teeth of the gear to complete the shift.
- An interlock pin prevents double engaging.

1 Synchronizer ring
2 Hub sleeve
3 Synchronizer key
4 Inner cone
5 Double cone
6 Synchronizer teeth



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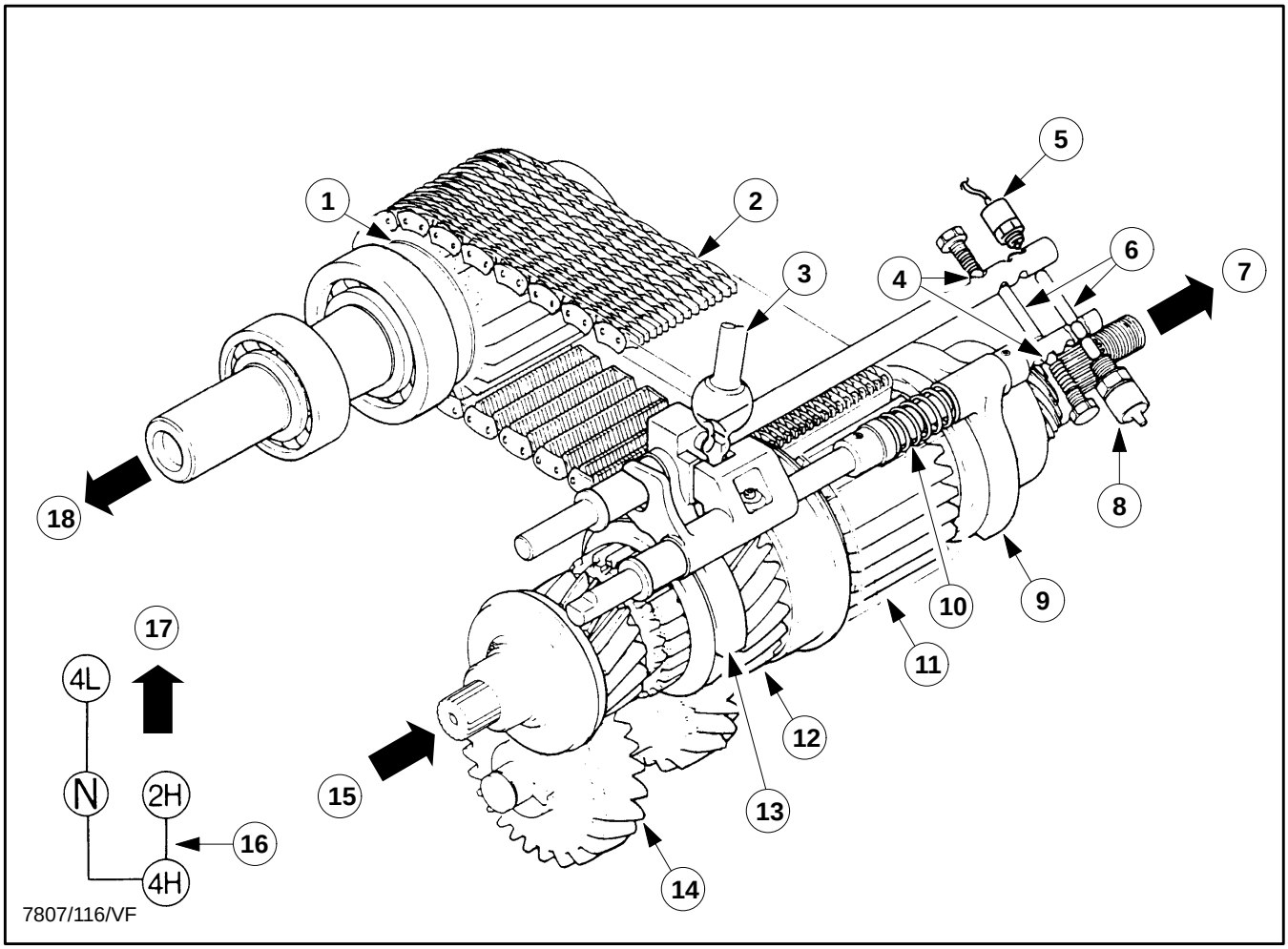
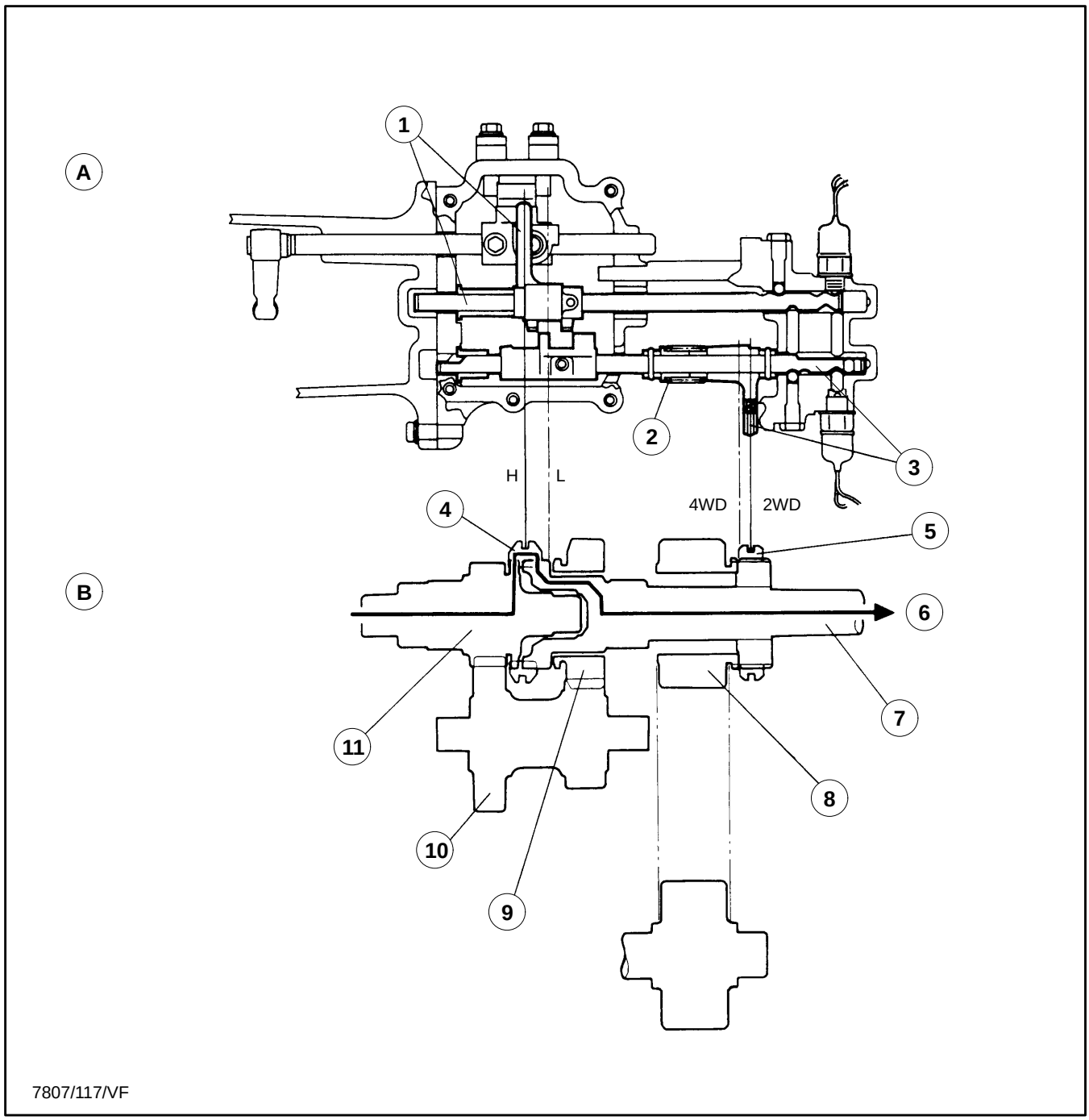
General

- The transfer case of the R15MX-D manual transmission is a chain-drive part-time transfer in which the shift is engaged mechanically. The speed selection is controlled by a single-lever shift mechanism that provides N, 2H, 4H and 4L.
- The purpose of the transfer case is for transmission of driving force to either the rear differential only or to the front and rear differentials simultaneously.
- The power is transmitted to the front differential by a maintenance free chain, requiring no tension adjustment.
- The transfer is a non-synchro type transmission.



1 Front drive sprocket
2 Chain
3 Select lever
4 Detent balls
5 Transfer neutral switch (with RFW only)
6 Interlock pins
7 To rear driveshaft
8 4WD indicator switch
9 2WD-4WD shift fork
10 Spring
11 Drive sprocket
12 Low gear
13 H-L shift fork
14 Counter gear
15 From transmission
16 Shift pattern
17 Front
18 To front driveshaft

2H (2WD-high)



A Shift control
B Power flow
1 H-L shift rod and fork
2 Spring
3 2WD-4WD shift rod and fork
4 H-L hub sleeve
5 2WD-4WD hub sleeve
6 To rear driveshaft
7 Output shaft
8 Drive sprocket
9 Input shaft gear
10 Counter gear
11 Low gear

2H (2WD-high)

Shift control

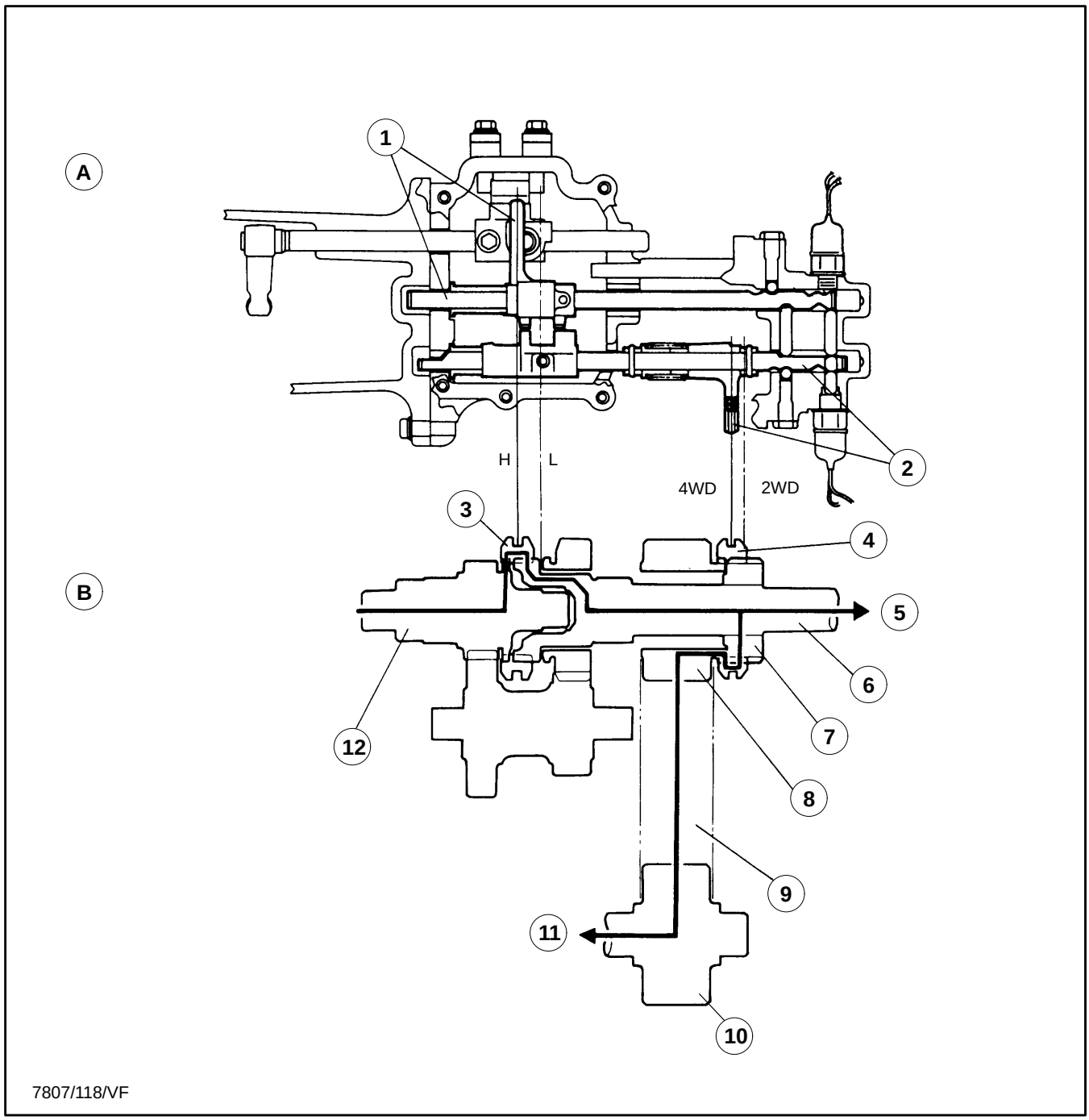
- When shifting the transfer select lever to the “2H” position, the 2WD-4WD shift rod and fork are pushed back by the spring, and the 2WD-4WD hub sleeve and the drive sprocket do not mesh. The H-L shift rod and fork remain in the high range position.

Power flow

- Power from the transmission passes from the input shaft to the H-L hub sleeve, through the output shaft, and out to the rear driveshaft.

NOTE: The transfer select lever directly moves the shift rods. The input shaft gear, counter gear and low gear are always meshed with one another.

4H (4WD-high)



A Shift control
B Power flow
1 H-L shift rod and fork
2 2WD-4WD shift rod and fork
3 H-L hub sleeve
4 2WD-4WD hub sleeve
5 To rear driveshaft
6 Output shaft
7 2WD-4WD clutch hub
8 Drive sprocket
9 Chain
10 Front drive sprocket
11 To front driveshaft
12 Input shaft gear

4H (4WD-high)

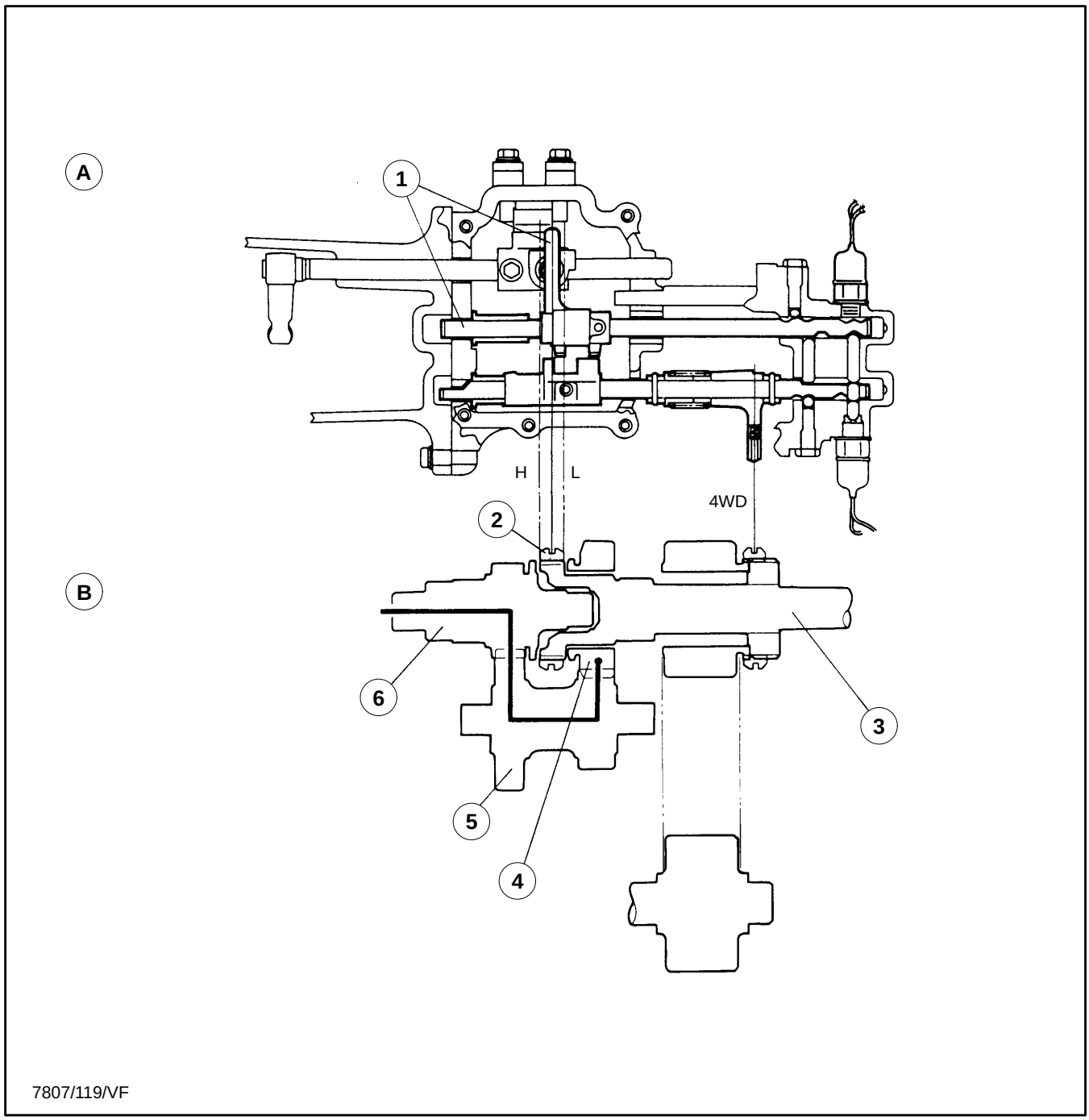
Shift control

- When shifting the transfer select lever to the “4H” position, the 2WD-4WD shift rod and fork are pushed forward and the 2WD-4WD hub sleeve meshes with the drive sprocket to turn the chain and front drive sprocket. The H-L shift rod and fork remain in the high range position.

Power flow

- Power from the transmission passes from the input shaft to the H-L hub sleeve, through the output shaft to the rear driveshaft. Power also flows from the 2WD-4WD hub sleeve through the drive sprocket, chain, and front drive sprocket, to the front driveshaft.

N (neutral)



A Shift control
B Power flow
1 H-L shift rod and fork
2 H-L hub sleeve
3 Output shaft
4 Low gear
5 Counter gear
6 Input shaft gear

N (neutral)

Shift control

- When shifting the transfer select lever to the “N” position, the H-L shift rod and fork are pushed to a position between High and Low. Therefore, the H-L hub sleeve does not mesh with the input shaft or low gear.

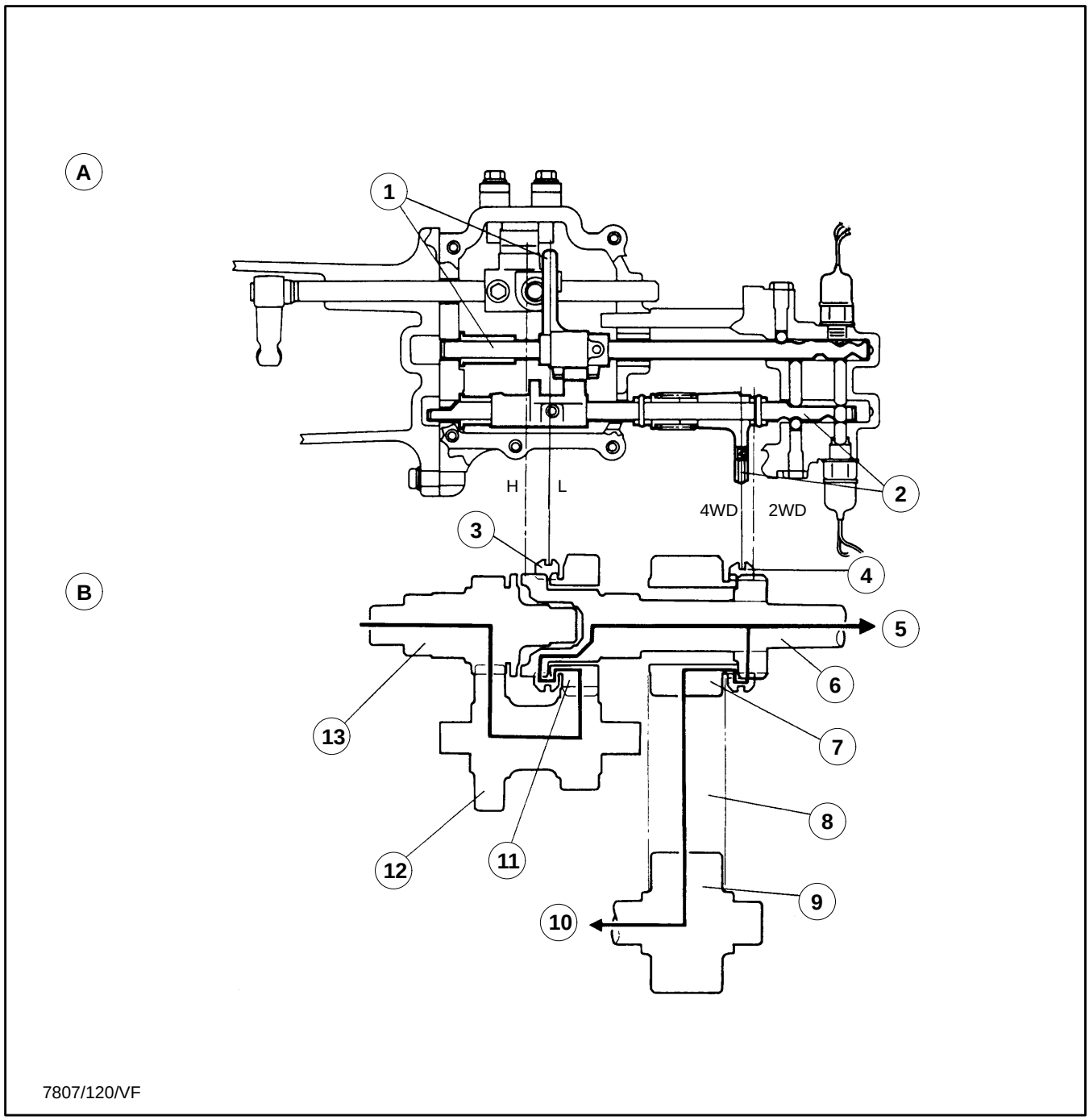
Power flow

- Power from the transmission is transmitted from the input shaft to the counter gear and the low gear, which is not connected to the output shaft. In this way, power flow stops.

NOTE: Usually, there is no need for the selector lever to be left in this position.

⚠ **CAUTION:** Never park the vehicle with the transfer in the “N” position without setting the parking brake. Even if the transmission is in gear there is the possibility that the vehicle might move because the front and rear differentials are not engaged.

4L (4WD-low)



A Shift control
B Power flow
1 H-L shift rod and fork
2 2WD-4WD shift rod and fork
3 H-L hub sleeve
4 2WD-4WD hub sleeve
5 To rear driveshaft
6 Output shaft
7 Drive sprocket
8 Chain
9 Front drive sprocket
10 To front driveshaft
11 Low gear
12 Counter gear
13 Input shaft gear

4L (4WD-low)

Shift control

- When shifting the transfer select lever to the “4L” position, the H-L shift rod is pushed back, and the H-L hub sleeve meshes with the low gear. The 2WD-4WD shift rod and fork remain in the 4WD position.

Power flow

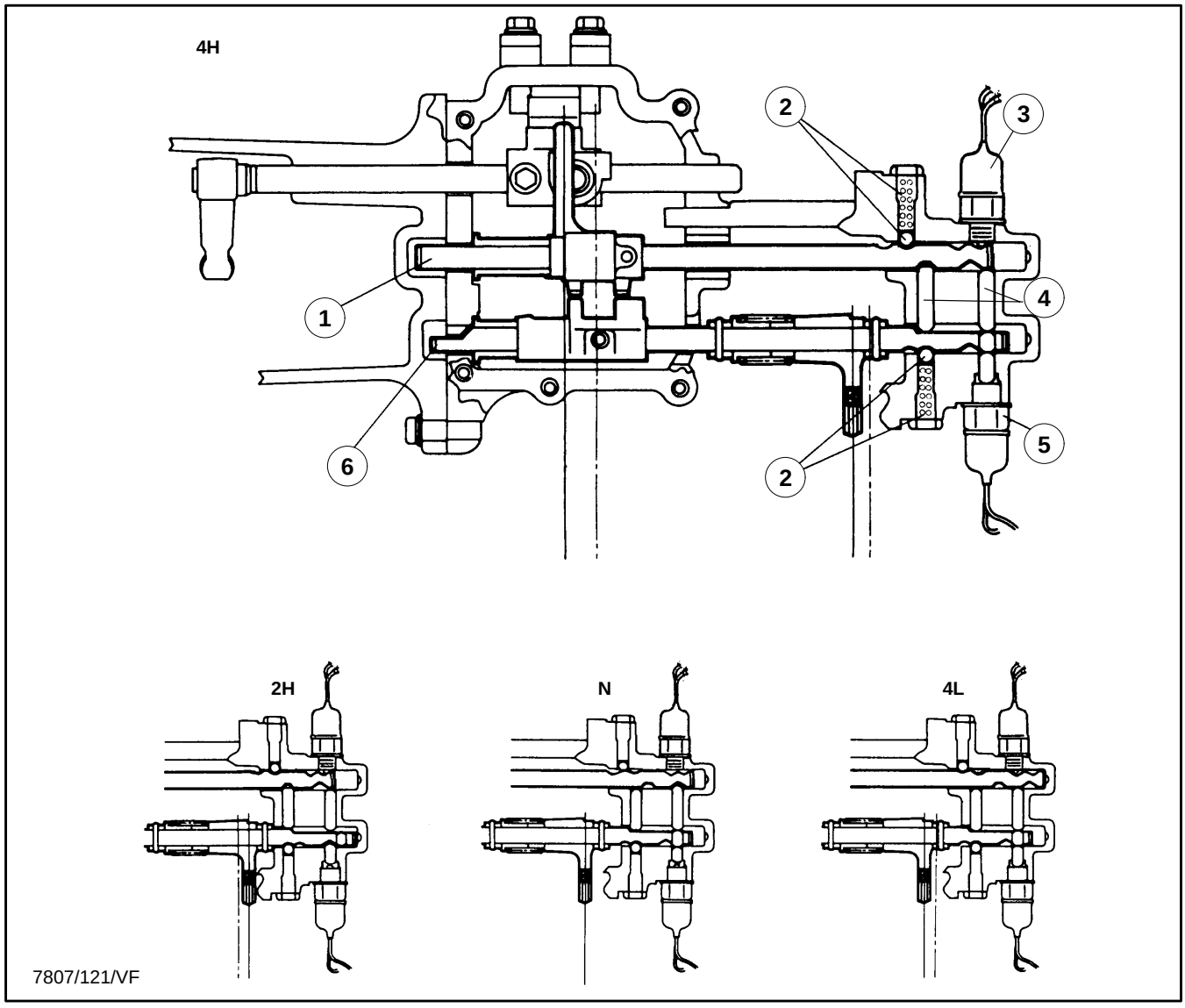
- Power from the transmission flows from the input shaft, counter gear, and low gear, and passes through the H-L hub sleeve, and flows to the output shaft. Power flows to the rear driveshaft, and from the 2WD-4WD hub sleeve through the drive sprocket, chain, and front drive sprocket to the front driveshaft. At this time, the gear ratio is 2.21 : 1.

⚠ **CAUTION:** Because there is no synchronizing mechanism between “4H” and “4L”, to shift from “4H” to “4L” the vehicle must be completely stopped.

Shift mechanism

Outline

- The 4WD-2WD shift mechanism and the high range-low range shift mechanism are separated and controlled individually. Accordingly, the 2H, 4H, N and 4L positions can be selected.



1 H-L shift rod
2 Detent ball and spring
3 Transfer neutral switch (with RFW only)
4 Interlock pins
5 4WD indicator switch
6 2WD-4WD shift rod

Shift mechanism (continued)

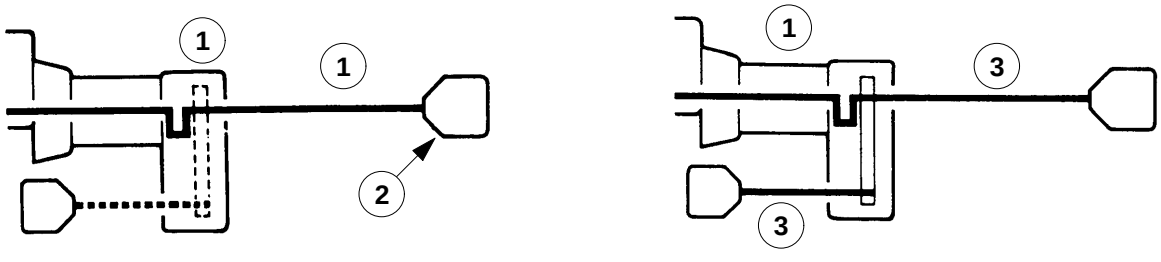
Interlock Pin

- The purpose of the interlock pin is to prevent the transfer case from going into a “2L” (2WD-low) condition.
- If it were possible to shift to “2L”, the torque (T) from the transmission would become 2.21 × T inside the transfer. If this were to happen, severe damage to the transfer and rear differential would result.
- The interlock pin prevents this from happening by allowing only one rod to move at a time. Thus the H-L shift rod can be moved only when the 2WD-4WD shift rod is in the 4WD position.

NOTE: With the transfer in “4L”, the torque inside the transfer becomes 2.21 × T just as in the case of unwanted “2L”, but the power is transmitted to the front and rear powertrains. Thus, each powertrain only receives 2.21 × T/2=1.1 × T, as it is designed.

Detent Ball and Spring

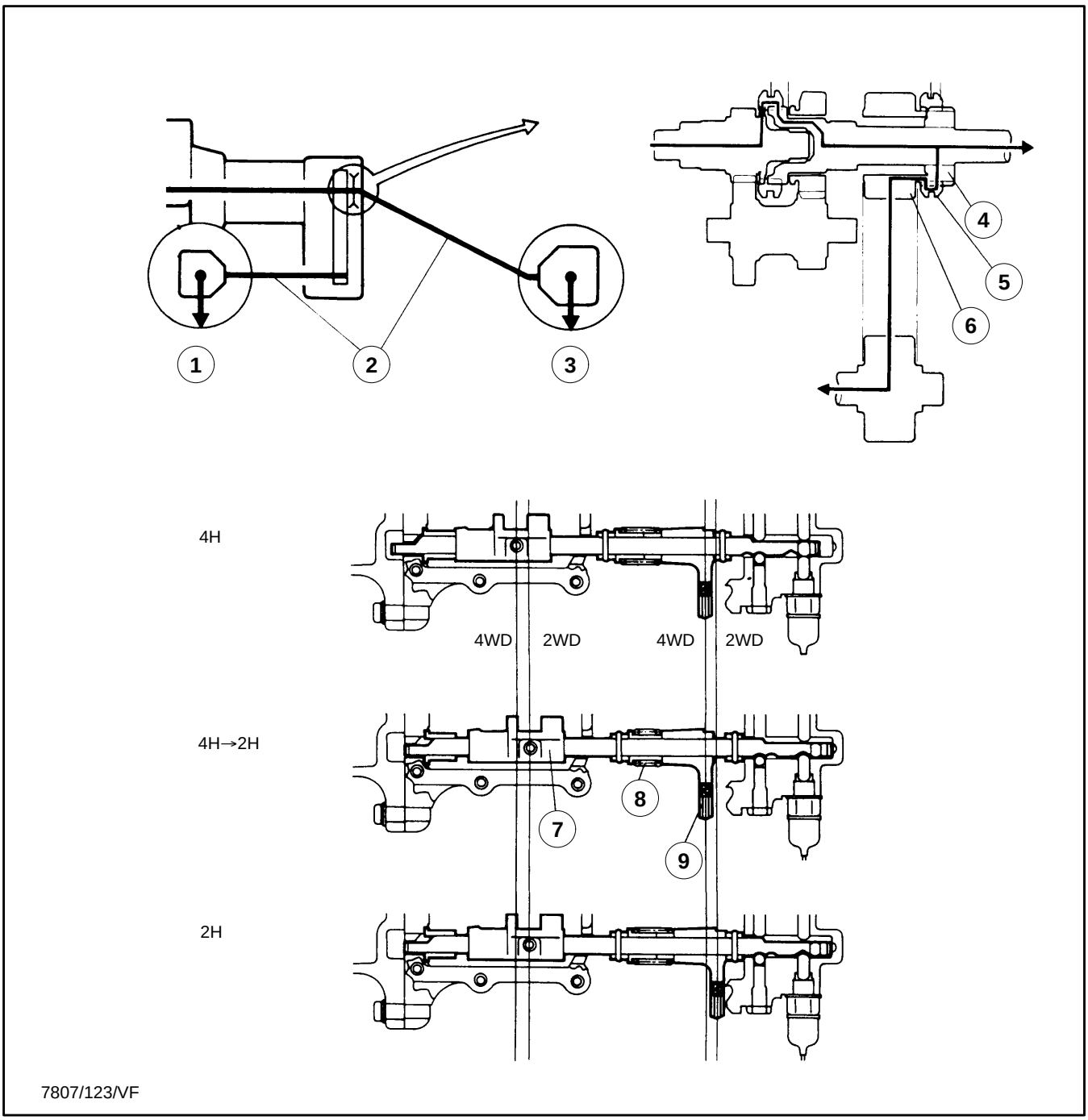
- There are detents in the H-L shift rod for selection of “4H”, “N”, and “4L” positions. On the 2WD-4WD shift rod there are detents for the “4H” and “2H” positions.
- The detent balls and springs are used to ensure that the transfer stays in the selected gear.
- The detent ball and spring installed on the H-L shift rod are larger than those on the 2WD-4WD shift rod. The reason for this is that it is very important that the transfer does not jump out of gear while in 4WD. (Imagine, for example, the transfer jumping into neutral when climbing a steep grade.)



7807/122/VF

1 2.21 x T 2 Rear differential 3 1.1 x T

Shift mechanism (continued)



1 Front wheel
2 Driveshafts
3 Rear wheel
4 2WD-4WD clutch hub
5 2WD-4WD hub sleeve
6 Drive sprocket
7 2WD position
8 Pushing
9 Still remains in 4H position

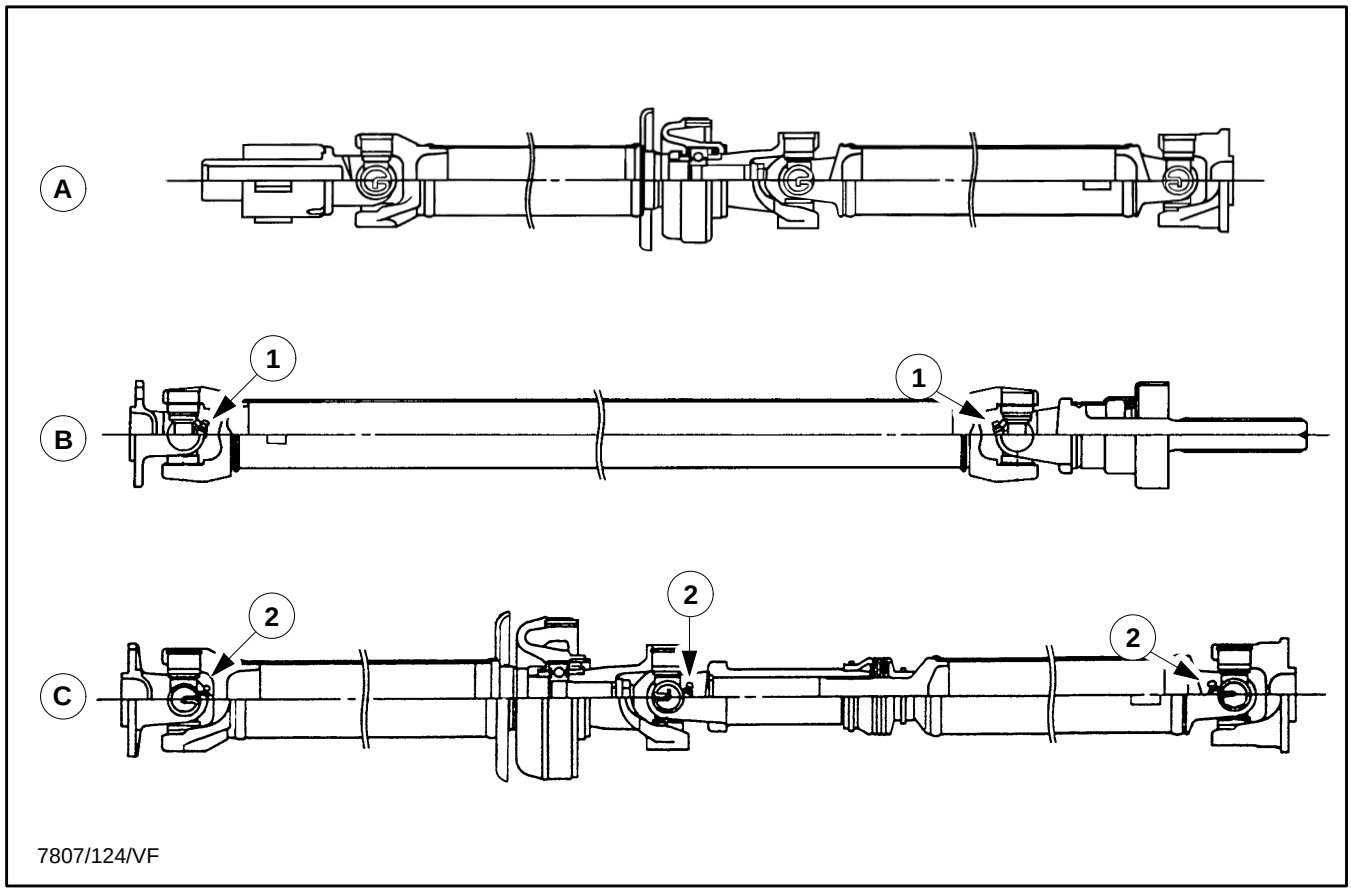
Shift mechanism (continued)

Smooth shift mechanism

- The smooth shift mechanism ensures a smooth shift from “4H” to “2H”, especially when the vehicle is stopped.
- When the vehicle is traveling in 4WD, the front and rear wheel speeds differ according to the vehicle’s load, the road surface, tire wear, etc. The driveshaft speeds are therefore different.
- Because of the speed difference between the drive sprocket and the 2WD-4WD clutch hub, it is difficult for the hub sleeve to disengage when shifted.
- First, the 2WD-4WD shift rod moves to the 2WD position. At this time, the shift fork, which cannot disengage the hub sleeve, compresses the spring. (The transfer remains in “4H”.)
- When the speeds of the front and rear differentials equalize, the hub sleeve becomes free to move and the spring pushes the shift fork and clutch hub into the “2H” positions.

- The driveshaft of the 2WD version is a two-piece, three-joint type with a center bearing support.
- The driveshaft (2WD) is maintenance free.
- The front driveshaft of the 4WD version is a one-piece type.
- The rear driveshaft is a two-piece, three-joint type with a center bearing support.
- Both driveshafts of the 4WD version need lubrication during service.

NOTE: A different type of grease is used for points 1 and 2 of the universal joints as shown below.



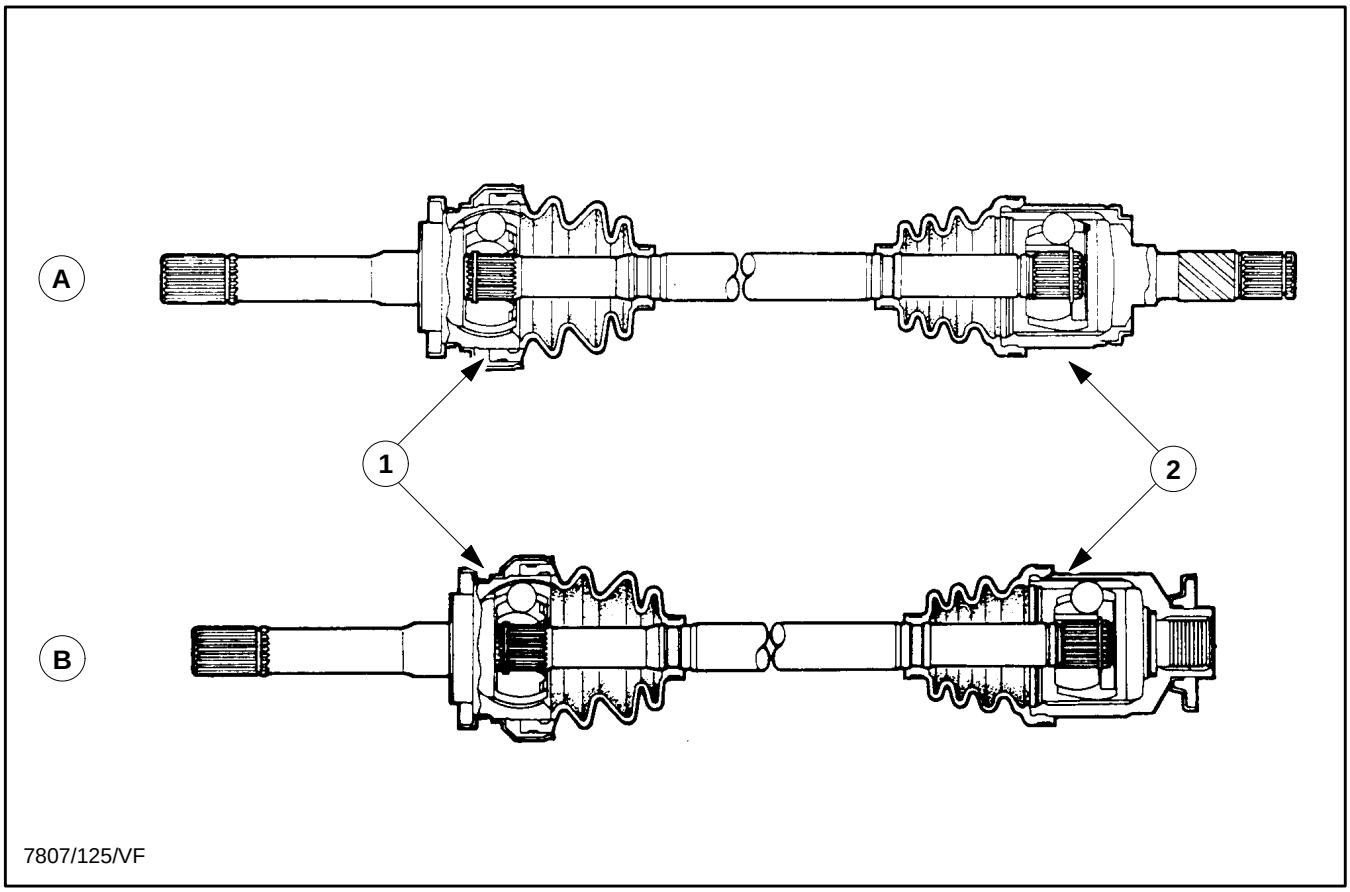
7807/124/VF

A 2WD
B 4WD front
C 4WD rear

1 Disulfide molybdenum grease
2 NLGI No.2 (lithium base)

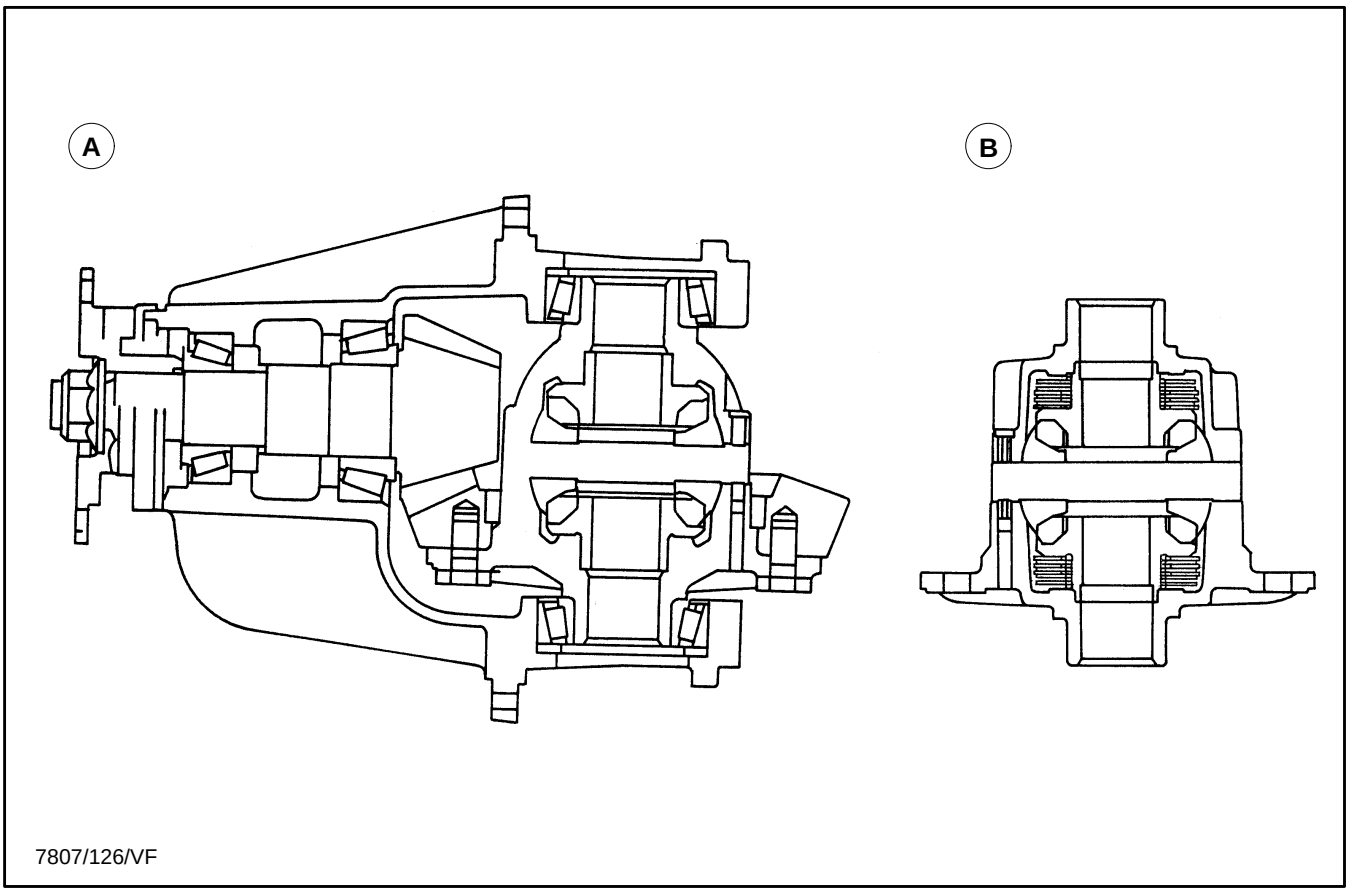
Front wheel halfshafts (4WD models)

- The halfshafts for the front wheels have maintenance-free constant velocity (CV) joints.
- The inner joints provide length compensation of the halfshaft during suspension movement.



A Right hand side halfshaft
B Left hand side halfshaft
1 Outer joint
2 Inner joint with length compensation

- There are two types of differentials available, a standard differential and a limited-slip differential.
- The purpose of the limited-slip differential is to provide driving force to both wheels by preventing either wheel from spinning.
- With a standard differential, if a wheel starts spinning due to poor traction such as mud or snow, the driving force is exerted on that wheel by the action of the differential.
- With the limited-slip differential, the differential action is automatically limited and driving force is exerted on both wheels.



A Standard differential

B Limited-slip differential

- The remote freewheel mechanism (RFW) disengages the front wheels from the front power train to prevent the front power train from being turned by the front wheels during 2WD operation.
- This in turn prevents the loss of fuel economy and excessive noise during 2WD operation.
- The RFW system consists of the following components:
  - RFW control module
  - transfer neutral switch
  - 4WD indicator switch
  - RFW switch
  - RFW main switch
  - RFW LOCK solenoid
  - RFW FREE solenoid
  - 4WD indicator
  - RFW indicator
  - selector lever
  - RFW unit
  - RFW actuator
  - one-way check valve
- The RFW control module receives signals from the different switches. It accordingly activates one of the two solenoids, causing a vacuum from the vacuum pump to be applied to the RFW actuator, and switching the RFW unit to LOCK or FREE.
- The RFW control module operates the 4WD and RFW indicator according to the system's condition.
- To prevent reduced performance of the actuator as a result of a decrease in vacuum pump performance, such as during low engine speed or at high altitude operation, the actuation system includes a one-way check valve.

Principle of operation

Component		Operation
RFW control module		sends ON/OFF signals to LOCK and FREE solenoids and indicators according to signals from various switches
Input	transfer neutral switch	detects selector lever N positon
	4WD indicator switch	detects selector lever 2H position
	RFW switch	detects RFW unit "LOCK"
	RFW main switch	cancels RFW unit "LOCK"
	selector lever	sets transfer case operation mode (2H, 4H, N, or 4L)
Output	RFW solenoids (LOCK and FREE)	switched ON/OFF by electrical signals from RFW control module, regulates RFW unit "LOCK" or "FREE"
	RFW LOCK solenoid	switched ON when locked
	RFW FREE solenoid	switched ON when free
	4WD indicator	illuminates when 4H or 4L is selected
	RFW indicator	illuminates when RFW unit is locked
	RFW unit	transmits front driveshaft rotation to front wheels
	RFW actuator	locks or frees RFW unit
	one-way check valve	prevents loss of vacuum

Instructions for use

2H (free) to 4H selection

- The RFW unit is automatically locked when the selector lever is moved from 2H to 4H while the vehicle is stopped. At this time, the 4WD indicator and the RFW LOCK indicator illuminate to inform the driver that the vehicle is in four-wheel drive mode and that the RFW unit is locked.

NOTE: The changeover from 2H (free) to 4H (locked) MUST NOT be made while the vehicle is moving because it may result in damage to the front differential and RFW components.
If such a shift is made by mistake, a ratching noise may be heard. In this case return the selector lever to 2H and press the RFW main switch.

4H to 2H (free) selection

- The RFW unit will be automatically freed when the RFW main switch is pressed once after the selector lever is moved (while the vehicle is moving or while the vehicle is stopped) from 4H to 2H. At this time, the 4WD indicator and the LOCK indicator go off to inform the driver that the vehicle is in 2WD mode and that the RFW unit has been freed.

NOTE: The RFW unit will remain locked only if the RFW main switch is pressed while the vehicle is operating in 4H or 4L.

2H (lock) to 4H, or 4H to 2H (lock) selection

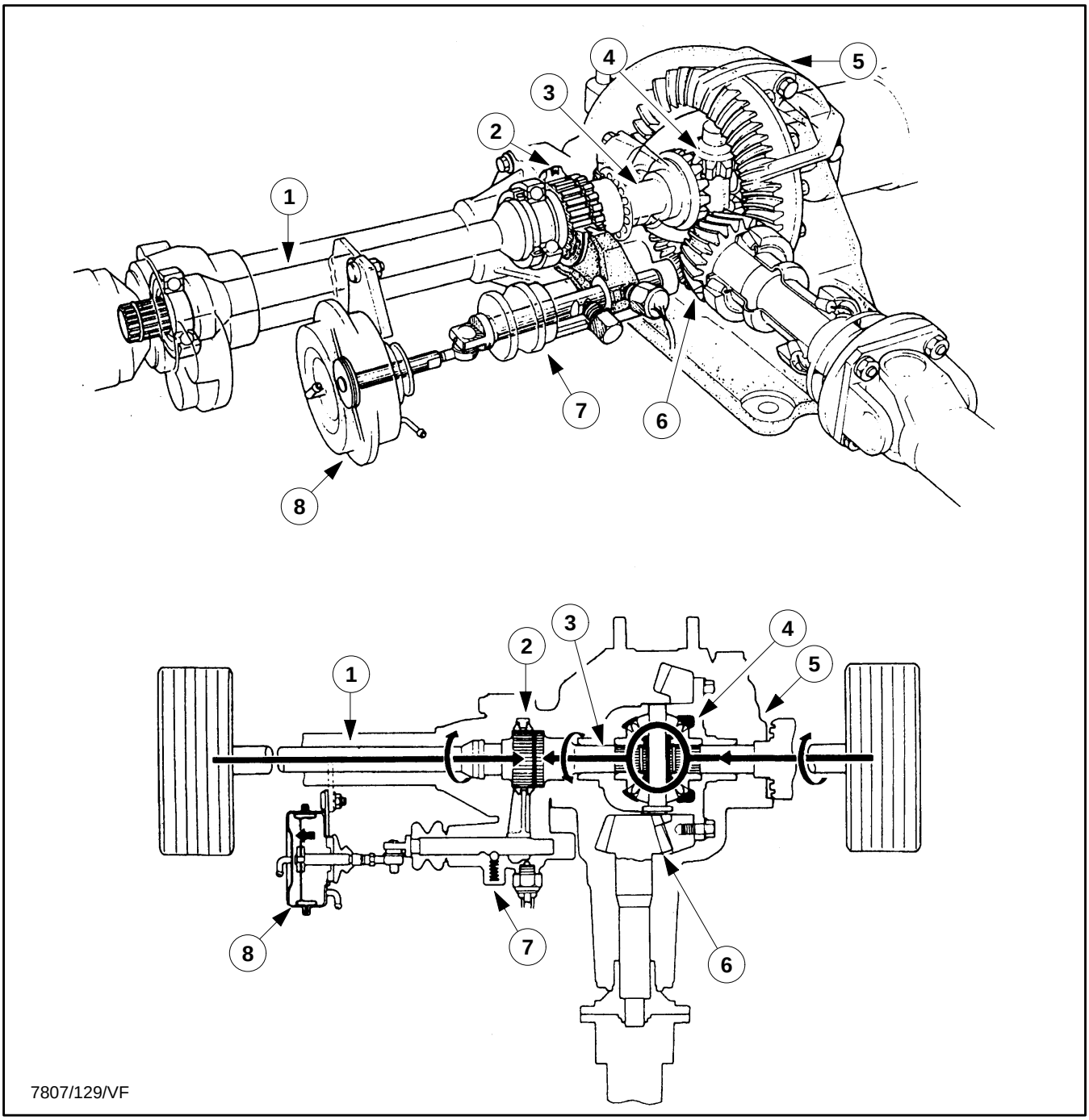
- If the RFW unit is locked, the transfer case can be changed from 2H to 4H or vice versa while the vehicle is running. At this time, the LOCK indicator remains illuminated to inform the driver that the RFW unit remains locked.

4H to 4L, or 4L to 4H selection

- As with a conventional 4WD, the transfer case can be shifted from 4H to 4L or vice versa when depressing the clutch while the vehicle is stopped and the engine is running. At this time, the RFW unit remains locked, and the 4WD and LOCK indicators remain illuminated.

Remote freewheel unit: FREE

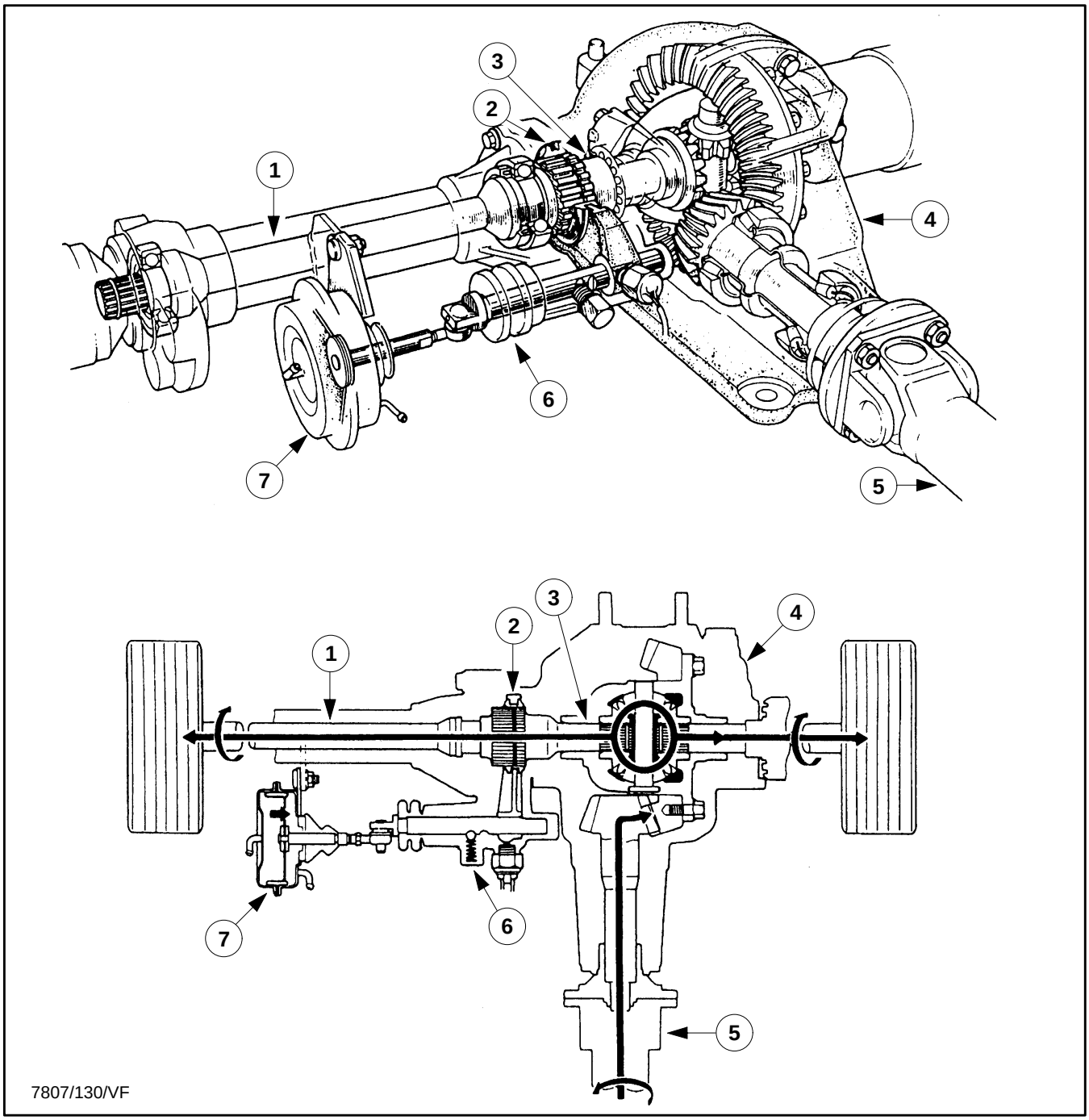
- The switching mechanism of the RFW unit is a mechanical dog clutch on the left side of the front differential.
- The RFW unit actuator pulls the sleeve away from the front differential output shaft, allowing the front differential to rotate freely.
- The rotation of the right front wheel is absorbed by the front differential straight bevel gears, with the result that the ring gear, drive pinion gear, and front driveshaft do not turn.



1 Intermediate shaft
2 Sleeve
3 Output shaft
4 Straight bevel gear
5 Front differential
6 Drive pinion gear
7 RFW unit
8 RFW actuator

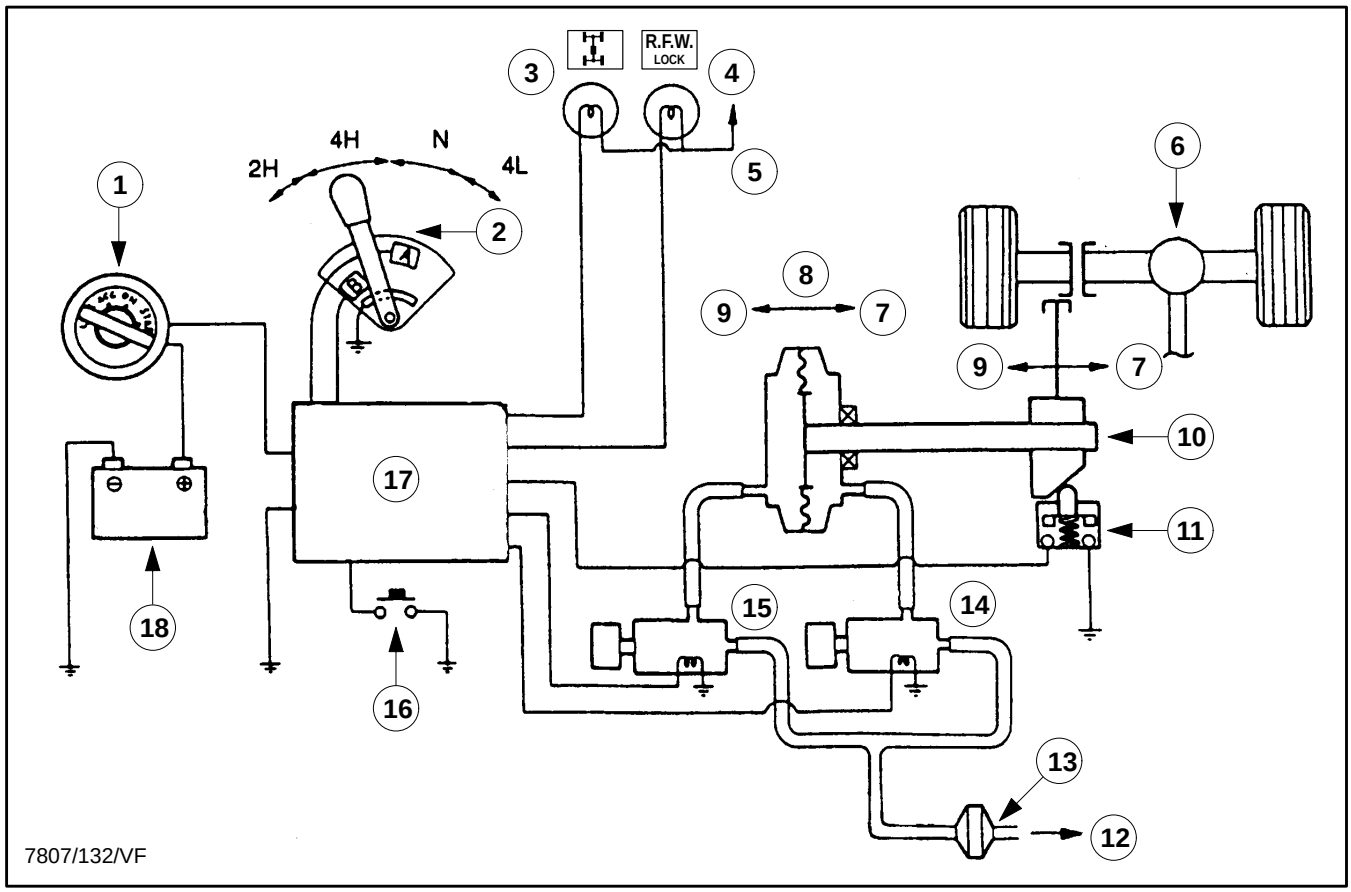
Remote freewheel unit: LOCK

- The RFW actuator pushes the sleeve over the output shaft, and the front differential output shaft and intermediate shaft are coupled together.
- If the sleeve and the output shaft are not aligned when actuated, the RFW actuator applies pressure to the sleeve until it can slide into place.
- The rotation of the front driveshaft is then transferred, through the front differential, to the front wheels, and four-wheel drive operation is possible.



1 Intermediate shaft
2 Sleeve
3 Output shaft
4 Front differential
5 Front driveshaft
6 RFW unit
7 RFW actuator

System overview



A Transfer neutral switch
B 4WD indicator switch
1 Ignition switch
2 Selector lever
3 4WD indicator
4 Lock indicator
5 To battery
6 Front differential
7 Lock
8 RFW actuator
9 Free
10 RFW unit
11 RFW switch
12 To vacuum pump
13 One-way check valve
14 Lock solenoid
15 Free solenoid
16 RFW main switch
17 RFW control module (on driver side A-pillar)
18 Vehicle battery

2H (free) to 4H selection

- When the selector lever is moved from 2H (2H-F in control module) to 4H, the 4WD indicator switch (in the transfer case switch) changes from ON to OFF.
- As a result, the RFW control module establishes a condition known as 4H-L_1, and the lock solenoid is switched ON, causing the actuator to move towards the lock side. At the same time, the 4WD indicator is illuminated.
- When the RFW unit is fully locked, the RFW switch is switched ON, and condition 4H-L is established in the control module. The RFW LOCK indicator illuminates to show the driver that the RFW unit is locked.

4H to 2H (lock) selection

- When the selector lever is moved from 4H (4H-L condition) to 2H, the 4WD indicator switch (in the transfer case switch) changes from OFF to ON.
- If the RFW main switch is in the OFF position, condition 2H-L is established, the lock solenoid remains ON, and the RFW actuator is held at the lock position. At this time, the 4WD indicator is switched OFF.

2H (lock) to 2H (free) selection

- When in the above condition (2H-L) the RFW main switch is pressed once (ON), condition 2H-F_1 is established, the RFW LOCK indicator is switched OFF and, at the same time, the free solenoid is switched ON, and the actuator is pulled to the free side. When the RFW unit becomes fully free, the RFW switch is turned OFF, and 2H-F condition is established.

4H to 4L or 4L to 4H selection

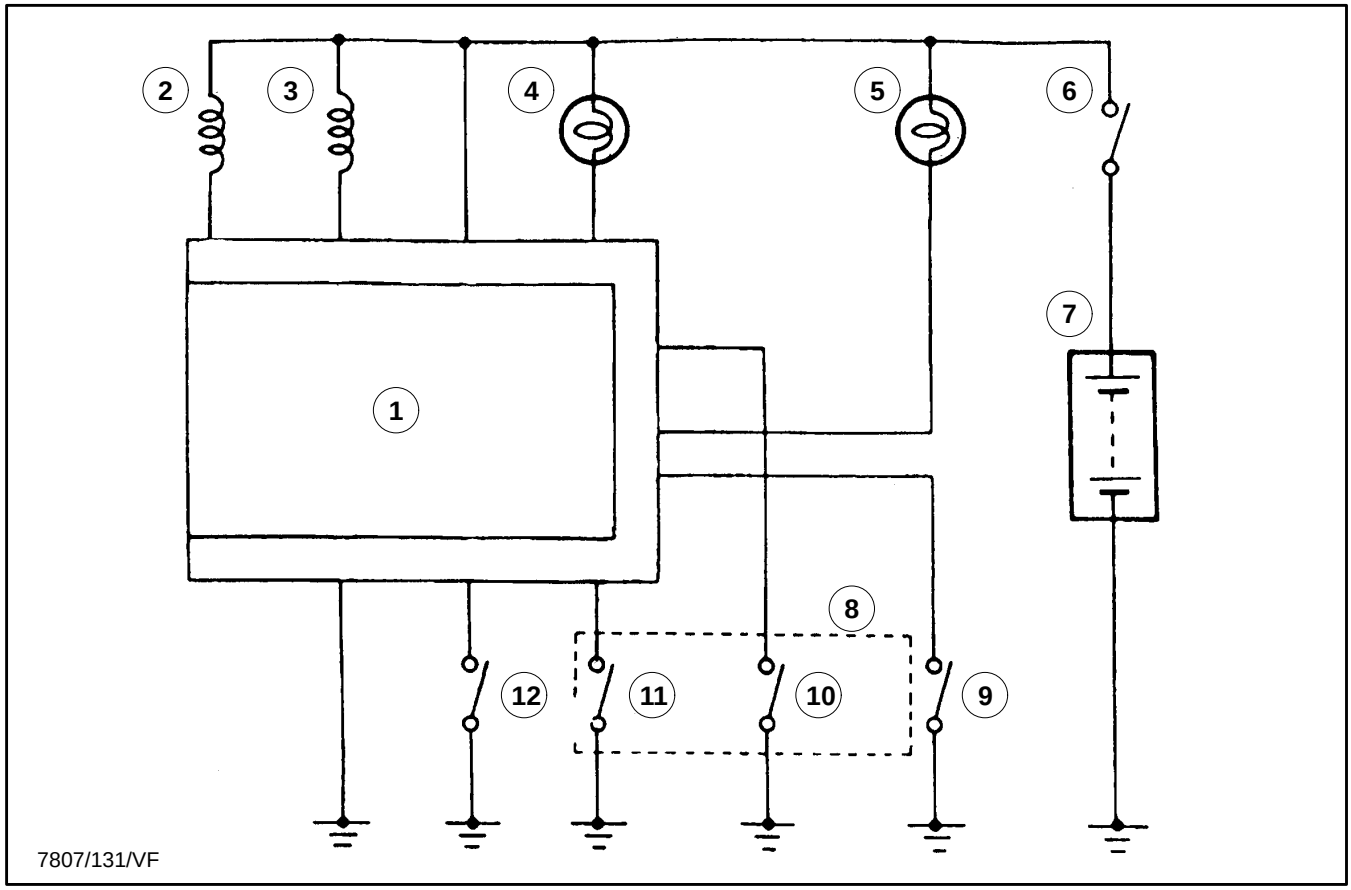
- When the selector lever is moved from 4H to 4L (both 4H-L in the control module) or vice versa, there is a change to the neutral condition midway through the changeover, thereby momentarily switching ON the transfer neutral switch (in the transfer case switch), and switching OFF the 4WD indicator.
- During 4H or 4L operation, the lock solenoid is ON (as a result of 4H-L condition), and the RFW actuator is held in the lock position. If the RFW main switch is pressed at this time, there is no effect upon the RFW actuator.

Ignition switch turned from OFF to ON

- When the ignition switch is turned from OFF to ON, the switches and solenoids are activated to provide the same RFW condition as when it was turned off.

Electronic control

Electric circuit



1 RFW control module (on driver side A-pillar)
2 Lock solenoid
3 Free solenoid
4 4WD indicator
5 Lock indicator
6 Ignition switch
7 Battery
8 Transfer case switch
9 RFW switch
10 Neutral switch
11 4WD indicator switch
12 RFW main switch

The abbreviations conform to standard SAE J1930 with the exception of those marked with an asterisk *.

2WD*	**2 W**heel **D**rive
4WD*	**4 W**heel **D**rive
A/C	**A**ir **c**onditioning
BDC*	**B**ottom **D**ead **C**enter
CV	**C**onstant **v**elocity
DLC	**D**ata **L**ink **C**onnector
DTC	**D**iagnostic **T**rouble **C**ode
ECT	**E**ngine **C**oolant **T**emperature
EGR	**E**xhaust **G**as **R**ecirculation
FEN*	**F**rom **En**gine
FICD*	**F**ast **I**dle **C**ontrol **D**evice
LHD*	**L**eft **H**and **D**rive
NE*	Engine speed
NO_x	**O**xides of **N**itrogen
NTC*	**N**egative **T**emperature **C**oefficient
OC	**O**xidation Catalytic **C**onverter
PATS	**P**assive **A**nti-**T**heft **S**ystem
PCM	**P**owertrain **C**ontrol **M**odule
PTC*	**P**ositive **T**emperature **C**oefficient
RFW*	**R**emote **F**reewheel **M**echanism
RHD*	**R**ight **H**and **D**rive
rpm*	**r**evolutions **p**er **m**inute
SAE*	**S**ociety of **A**utomotive **E**ngineers
TCV*	**T**imer **C**ontrol **V**alve
TDC*	**T**op **D**ead **C**enter
TEN*	**T**est **En**gine

Notes