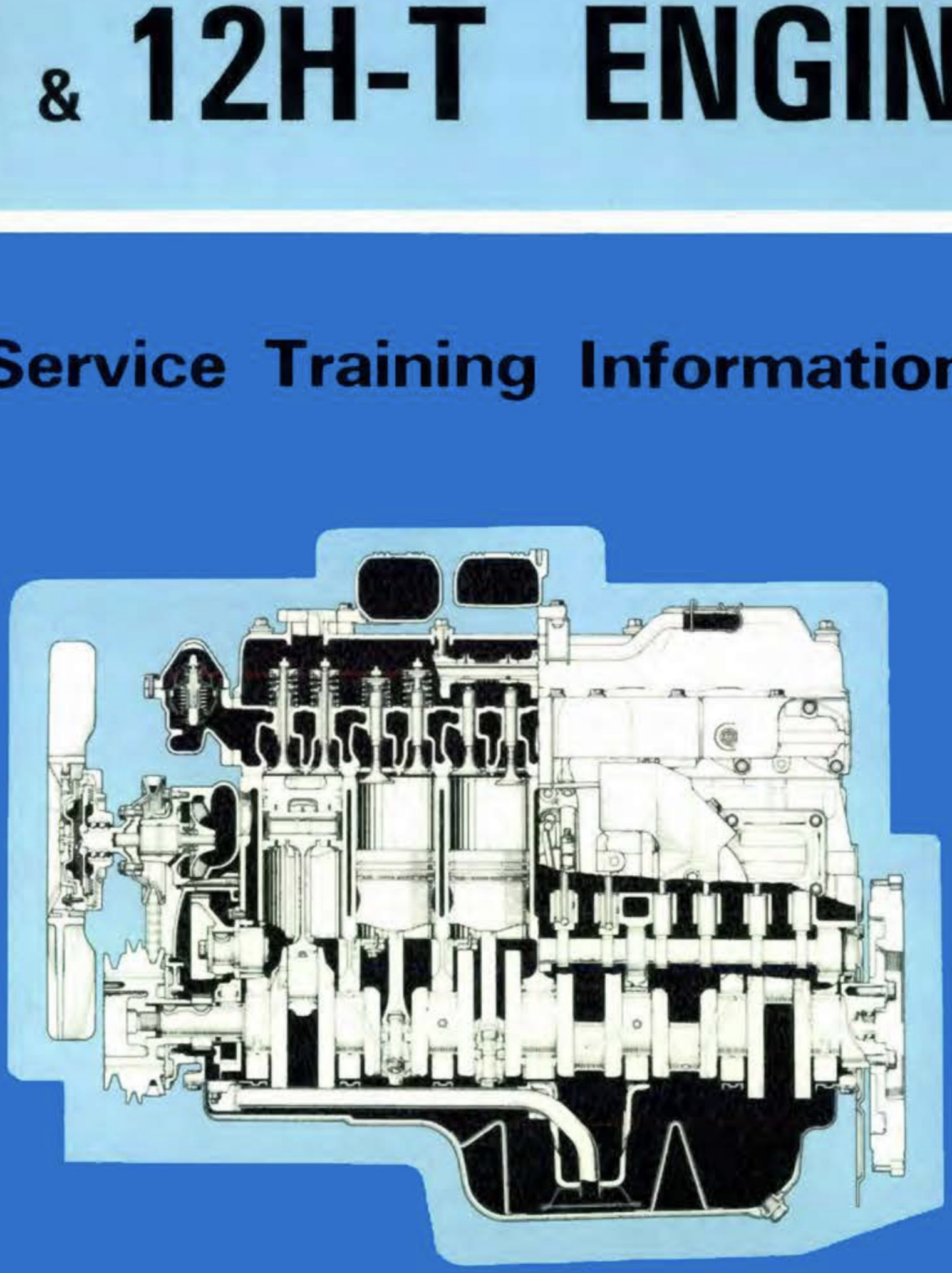
TOYOTA

2H & 12H-T ENGINES

Service Training Information



TOYOTA MOTOR CORPORATION

Pub. No ST1006E

FOREWORD

This Service Training Information has been prepared as a guide for technical service instructors of Toyota overseas distributors and explains the construction and operation of the 2H diesel engine and 12H-T turbocharged diesel engine.

For detailed information on diesel injection pump construction and operation, please also refer to the following STI, which covers those prts not appearing in the present STI

Diesel Injection Pump (In-line type) Pub. No. STI003E

For detailed repair procedures and specifications, refer to the 2H & 12H-T Engine Repair Manual.

All information contained in this manual is the most up-to-date at the time of publication. However, we reserve the right to make changes without prior notice.

TOYOTA MOTOR CORPORATION

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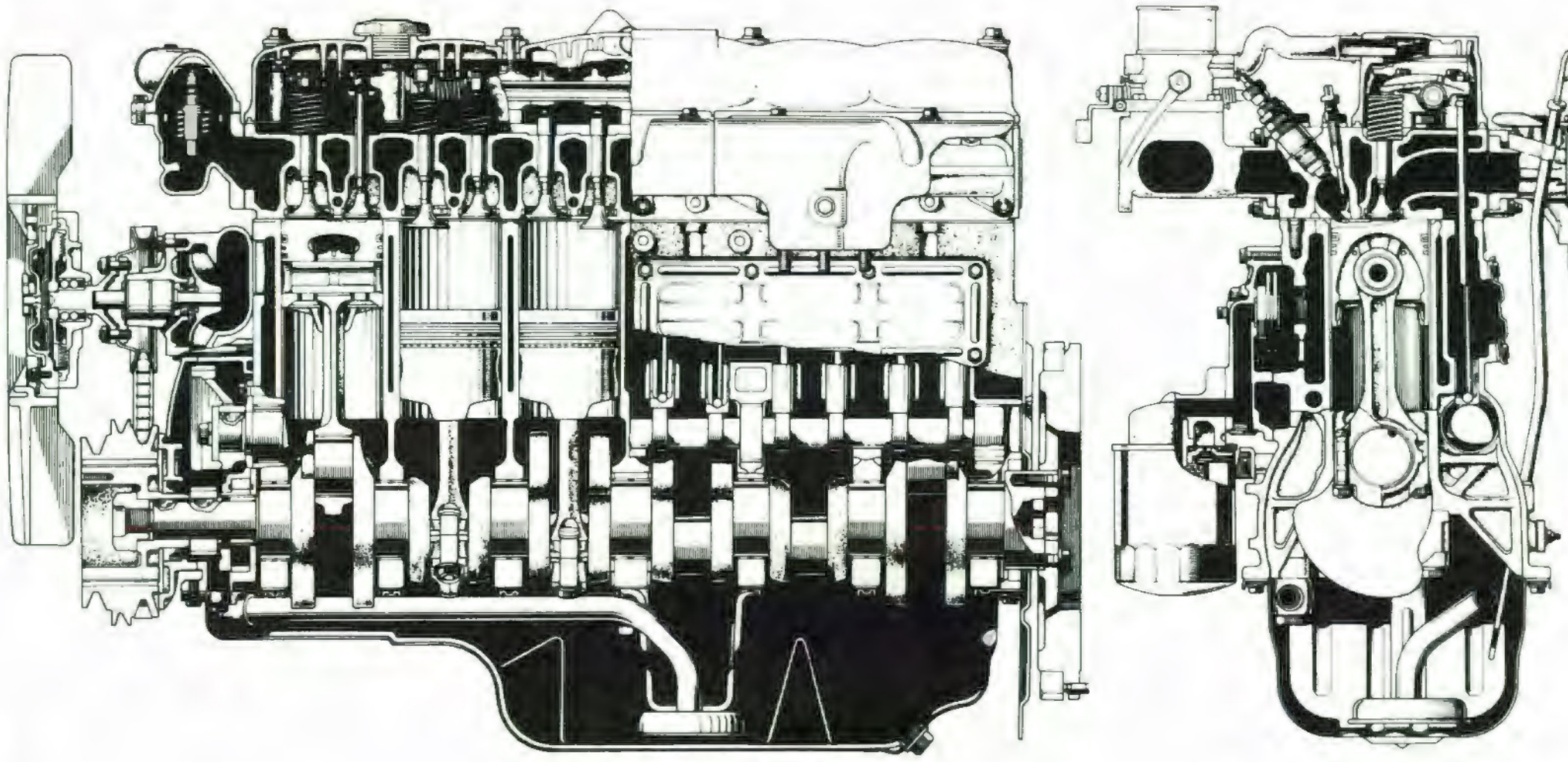
ENGINE GENERAL

2H ENGINE

The 2H engine is a 4-liter, 6-cylinder, 4-cycle indirect injection type diesel engine (i.e., one having an auxiliary [swirl] combustion chamber). This 2H engine almost the same as the 2H engine that has already been in use now for several years, but to coincide with the development of the new 12H-T engine, changes have been made to the cylinder block and oil pump of the 2H engine so that those parts may be used in common by both engines. The 2H engine has an in-line type injection pump, with either a mechanical or combined governor.



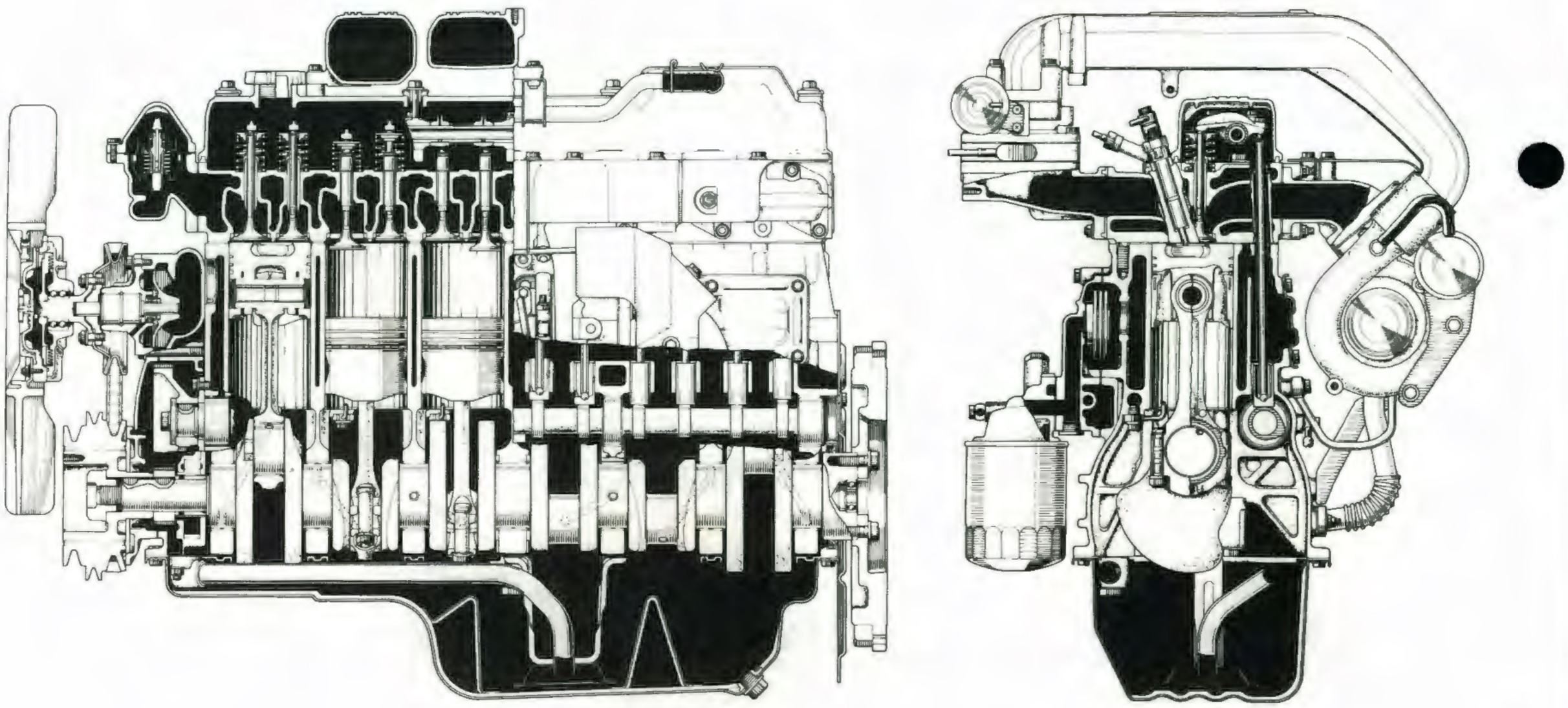
OHP-1

MAJOR SPECIFICATIONS

Engine type		4-cycle diesel
No. of cyls. & arrangement		6, in-line
Valve mechanism		OHV, gear drive
Injection method		Indirect (auxiliary comb. cham.)
Displacement	(cc)	3,980
Bore × stroke	(mm)	91.0 × 102.0
Compression ratio		20.7
Max. power output, SAE net	(Kw/rpm)	79/3500
Max. torque, SAE net	(N·m/rpm)	246/1800

12H-T ENGINE

The 12H-T engine is a 4-liter, turbocharged, direct injection type diesel engine which was developed based on the 2H engine. The fuel efficiency and power output of the new engine have been further improved over those of the 2H engine, through the use of direct combustion and a turbocharger.
As with the 2H engine, the 12H-T engine has an in-line injection pump, but has only the mechanical governor.



OHP-2

MAJOR SPECIFICATIONS

Engine type	4-cycle diesel
No. of cyls. & arrangement	6, in-line
Valve mechanism	OHV, gear drive
Injection method	Direct
Displacement (cc)	3,980
Bore × stroke (mm)	91.0 × 102.0
Compression ratio	18.6
Max. power output, SAE net (Kw/rpm)	103/3500
Max. torque, SAE net (N·m/rpm)	322/1800

COMPARISON OF INJECTION TYPES

The fuel injection type of diesel engine may be divided into the indirect injection type (as, for example, the 2H engine), and the direct injection type (as, for example, the 12H-T engine).

The indirect and direct injection type engines are explained in outline below, together with the unique features of each.

INDIRECT INJECTION ENGINE

An indirect injection engine has an auxiliary combustion chamber in the cylinder, in addition to the main combustion chamber formed by the cylinder head and piston head. In this type of engine, the fuel is first injected into the auxiliary combustion chamber, where most of it burns before going to the main comustion chamber. The main combustion chamber and auxiliary combustion chamber are connected to each other by a connecting passage.

Following are features that are normally associated with swirl-chamber indirect injection type engines:

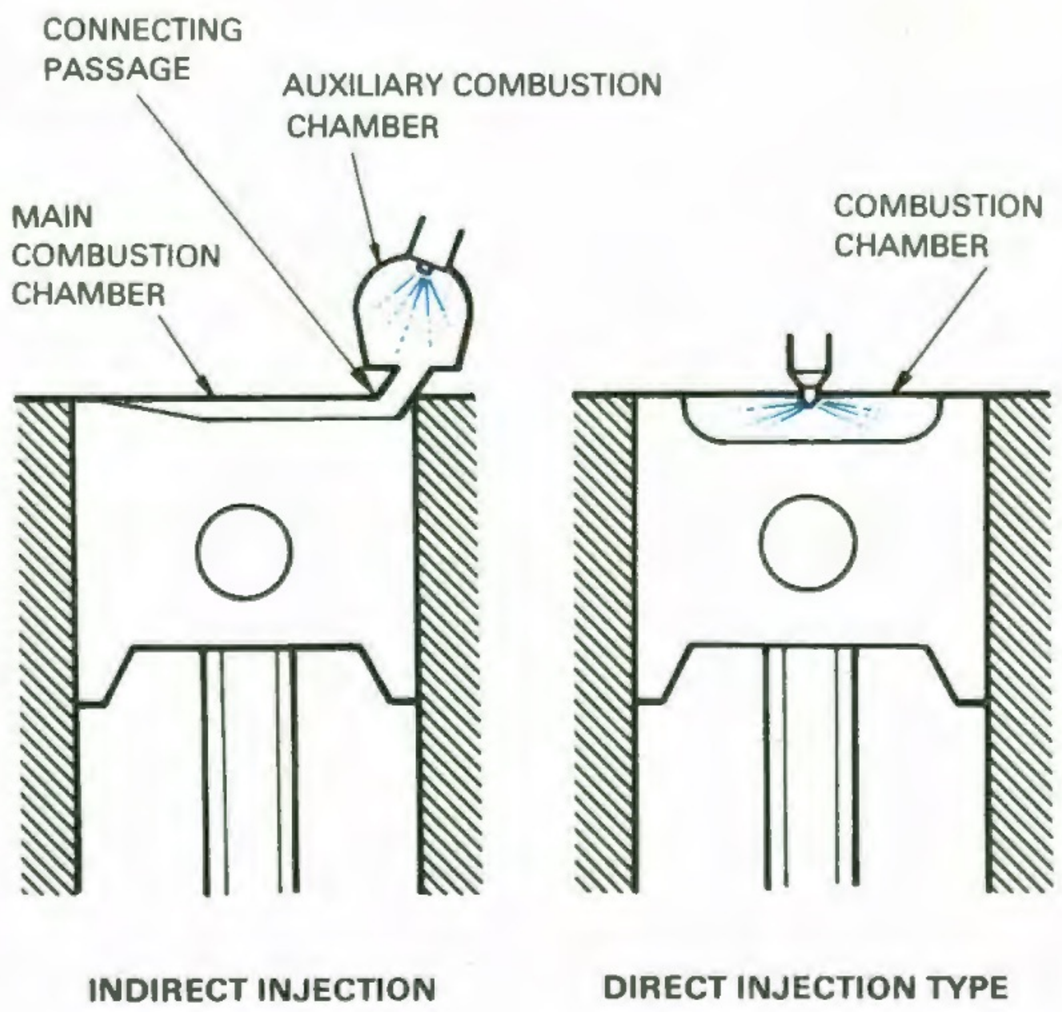
- Air is mixed with the fuel by a strong swirl that is generated in the auxiliary combustion chamber during the compression stroke. This allows very fast combustion of the mixture, leading to high engine speeds and high engine power output.
- Since the connecting passage is much smaller in diameter than either combustion chamber, passage of the combustion gas through it is restricted. Therefore, although pressure is high in the auxiliary combustion chamber immediately after combustion, it rises slowly in the main combustion chamber, thus minimizing combustion noise.
- Because the injection nozzle is of the throttle type, which features less fuel "dribble" after each injection, emission of unburned hydrocarbon (fuel) in the exhaust gas can be minimized.

DIRECT INJECTION ENGINE

The direct injection type engine has only a main combustion chamber, and the fuel is injected directly into it and burnt.

Following are features that are normally associated with direct combustion type engines:

- Since the area of the inside wall of the combustion chamber is smalller, there is less heat loss from the combustion chamber. This both improves fuel efficiency and makes starting easier.
- Since the engine does not have an auxiliary combustion chamber, the combustion gas travels less distance compared to in an indirect injection type engine having two chambers. This reduces heat loss and improves fuel efficiency. On the other hand, however, the rate of pressure increase during combustion is higher, resulting in greater combustion noise.
- To help the fuel swirl more strongly, the combustion chamber is made in a special shape, and the fuel is injected under high pressure through a multi-hole nozzle.



INDIRECT INJECTION

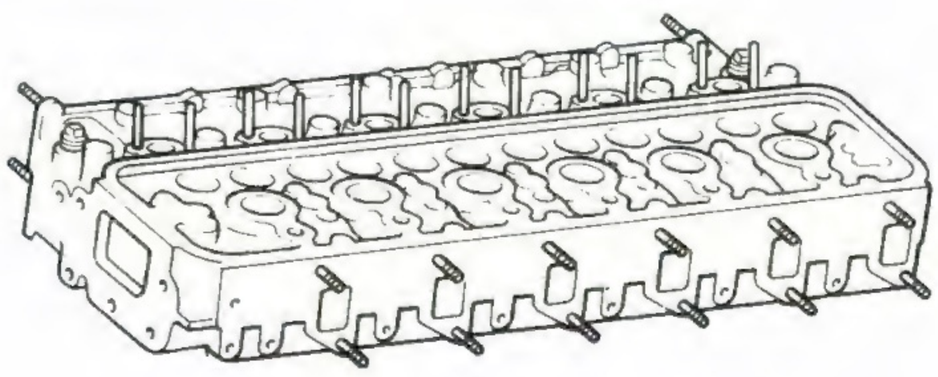
DIRECT INJECTION TYPE

ENGINE PROPER

CYLINDER HEAD

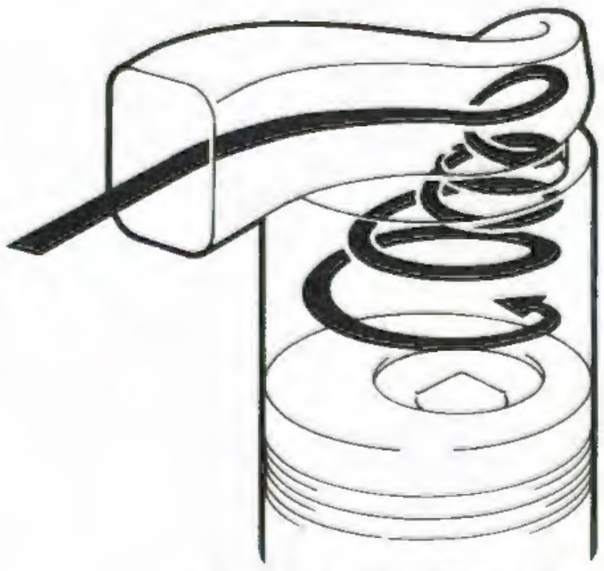
1. DESCRIPTION

a. The intake and exhaust ports are laid out in the cross-flow arrangement to increase intake and exhaust efficiency.
b. The cylinder hed is made of a one-piece cast-iron block.
c. Since the 2H engine employs indirect injection combustion chambers, the cylinder head is provided with auxiliary combustion chambers. Also holes are provided for the fitting of glow plugs.
d. Since the 12H-T engine is of the direct injection combustion type, the cylinder head is of a simple design.



2. INTAKE PORT (FOR 12H-T)

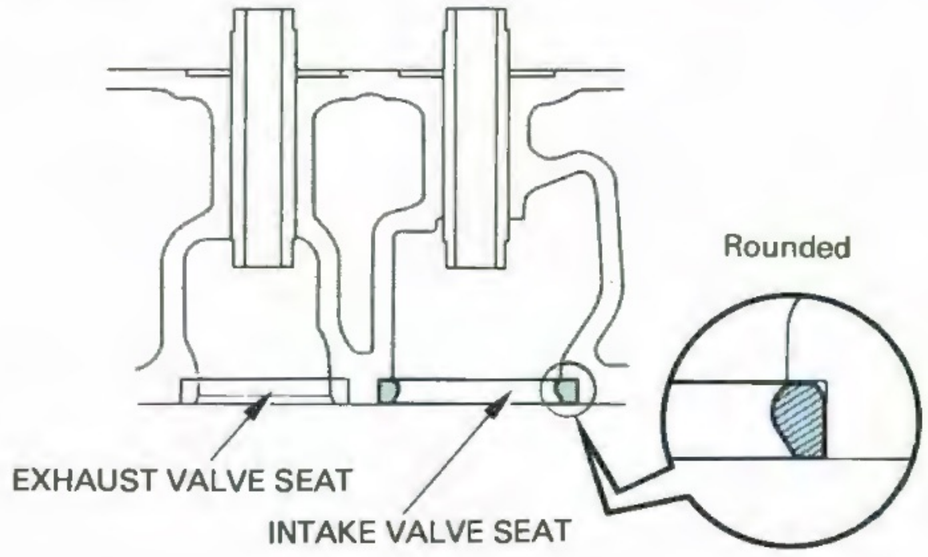
A swirl type intake port has been adopted. The following diagram illustrates how the intake air swirls as it flows into the cylinder via the swirl port. This ensures that the fuel injected into the combustion chamber during the combustion process will mix well with the air to yield greater combustion efficiency while providing quieter operation.



SWIRLING OF INTAKE AIR

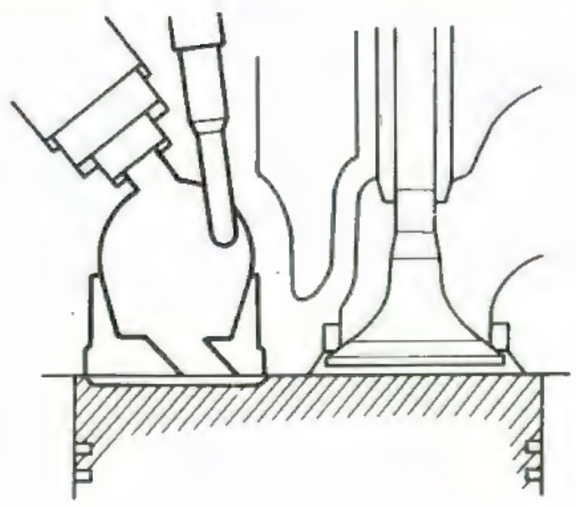
3. VALVE SEAT (FOR 12H-T)

The inside surfce of the intake valve seat is rounded to reduce resistance to air being sucked into the cylinders.

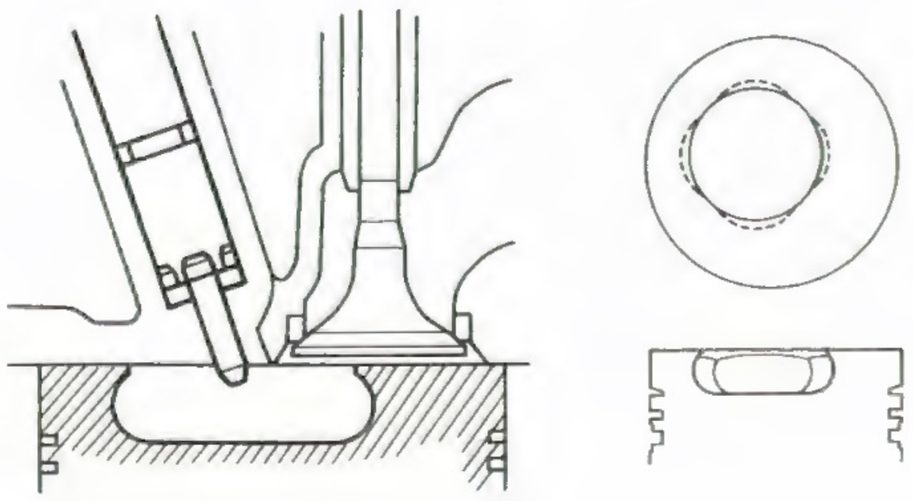


4. COMBUSTION CHAMBERS

a. The 2H engine has swirl type auxiliary combustion chambers in the cylinder head.

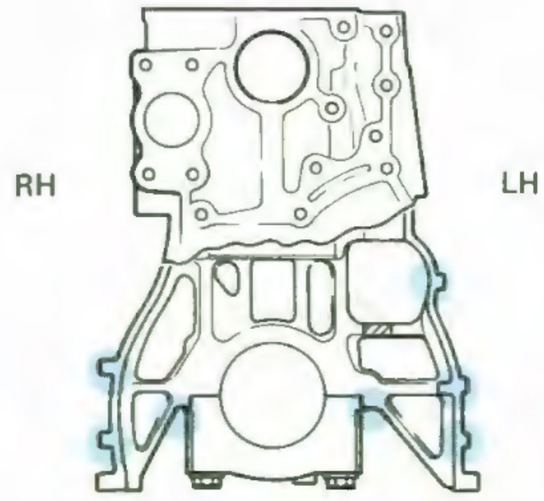


b. In the 12H-T engine, there is a four-lobe type combustion chamber in the cylinder head over each piston head. The combustion chamber is designed in such a way as to create a strong swirl in the air during the compression stroke to enhance combustion efficiency.

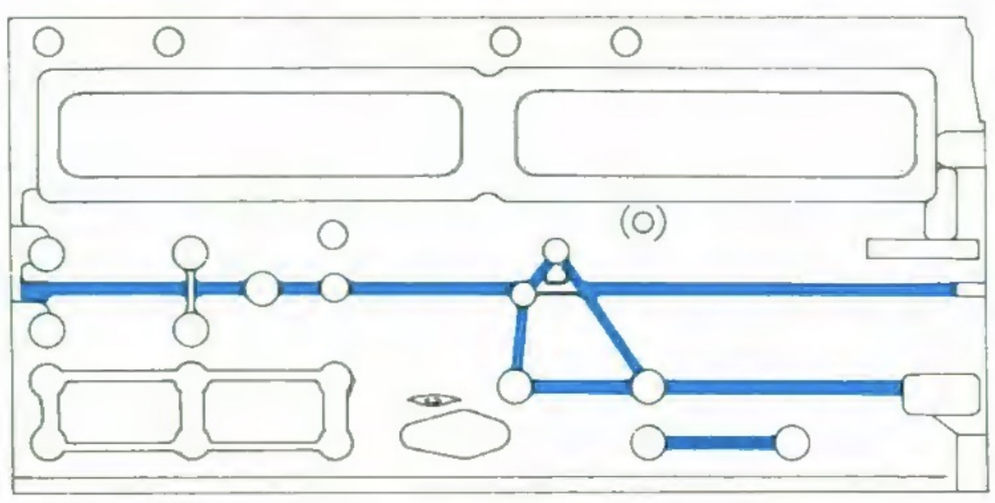


CYLINDER BLOCK

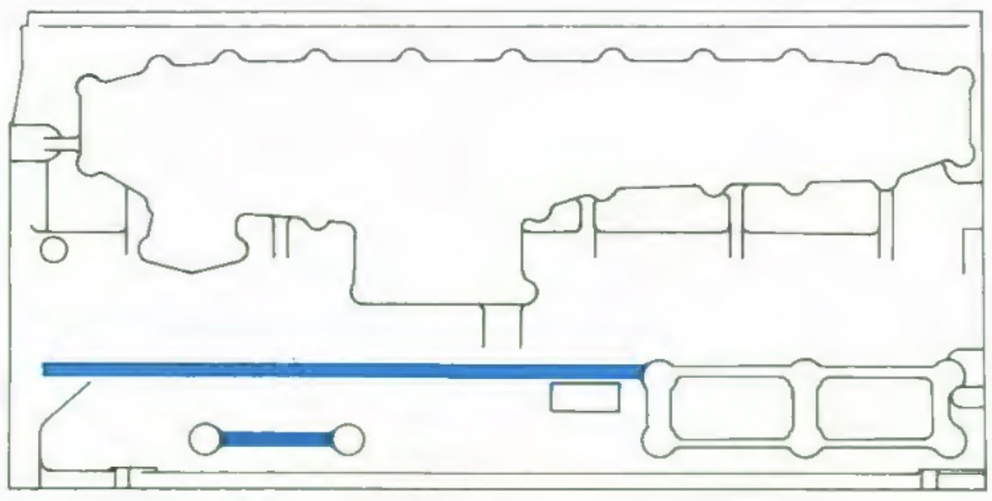
a. The skirt sections on both sides of the cylinder block are ribbed to reduce noise, and the shape of the crankshaft main bearing caps and cylinder block (where it meets the main bearing caps) has been changed to increase rigidity.



FRONT VIEW



LEFT VIEW

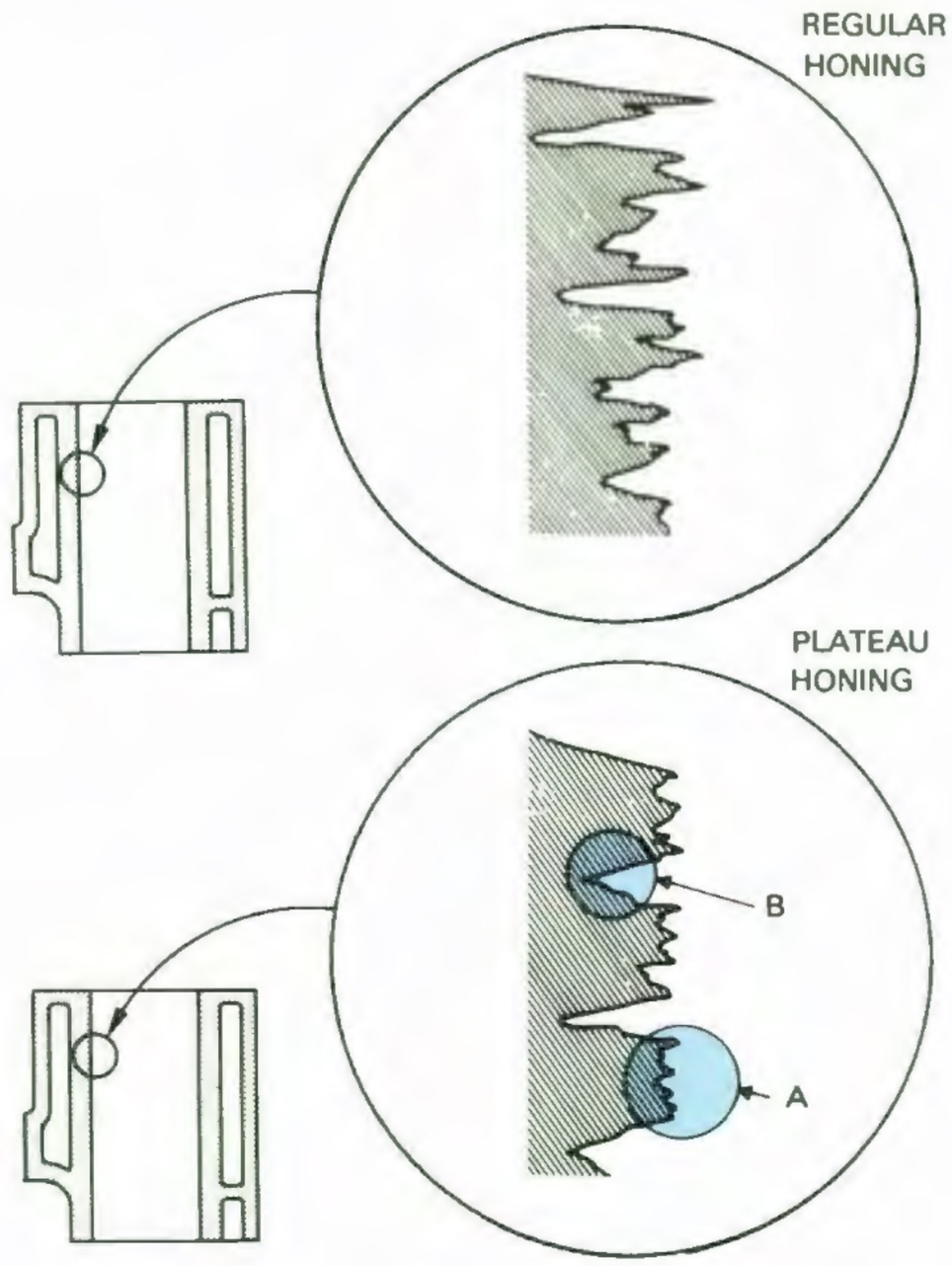


RIGHT VIEW

b. As with most modern gasoline engines, the use of cast iron with good anti-wear features eliminates the need for cylinder liners.
The cylinder walls have been finished with plateau honing* to increase smoothness.

***PLATEAU HONING:**

In regular honing, the surface of the finishing of the bore is comparatively rough, as shown in the illustration below. In plateau honing, however, the cylinder is more finely bored so that microscopic "plateaus" are created, as shown below. These plateaus (one of which is labeled "A" in the illustration) take up the expansive force of the piston rings, while oil accumulates in the grooves ("B") between them. The result of this is less wearing of piston rings and cylinders.



— NOTE —

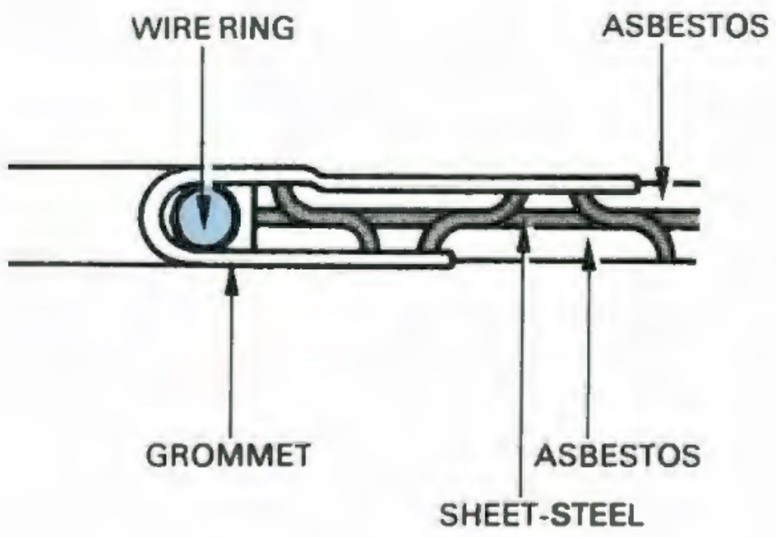
It is recommended that a honing stone of grit #200 or finer be used to hone the cylinder after it is bored out.

CYLINDER HEAD GASKET

The cylinder head gasket is made from asbestos having a sheet-steel core.

A wire ring inside each bore grommet in the cylinder head gasket of the 12H-T engine helps the grommet to withstand the high compressive pressures.

CYLINDER HEAD GASKET FOR 12H-T



CROSS-SECTION A-A'

PISTON

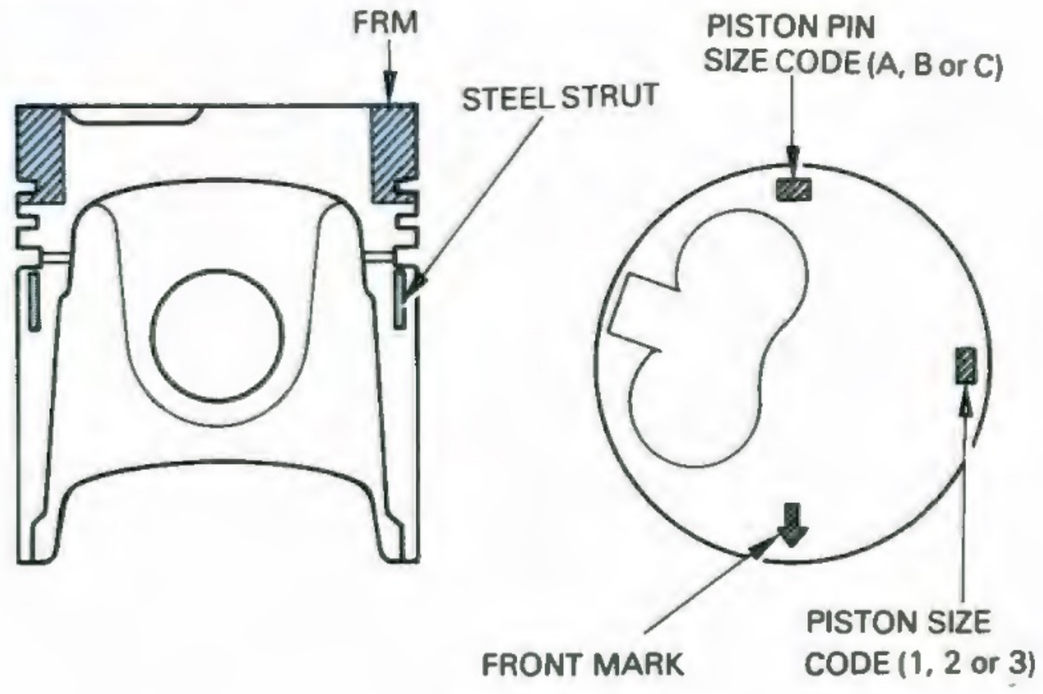
a. The piston head of both the 2H and 12H-T type engine is made from fiber-reinforced metal* for improved cooling and resistance against heating and wearing.

***FIBER-REINFORCED METAL:**
Metal strangthened by the use of ceramic threads.

b. An integral, ring-shaped steel strut is fitted along the entire circumference of each piston skirt.

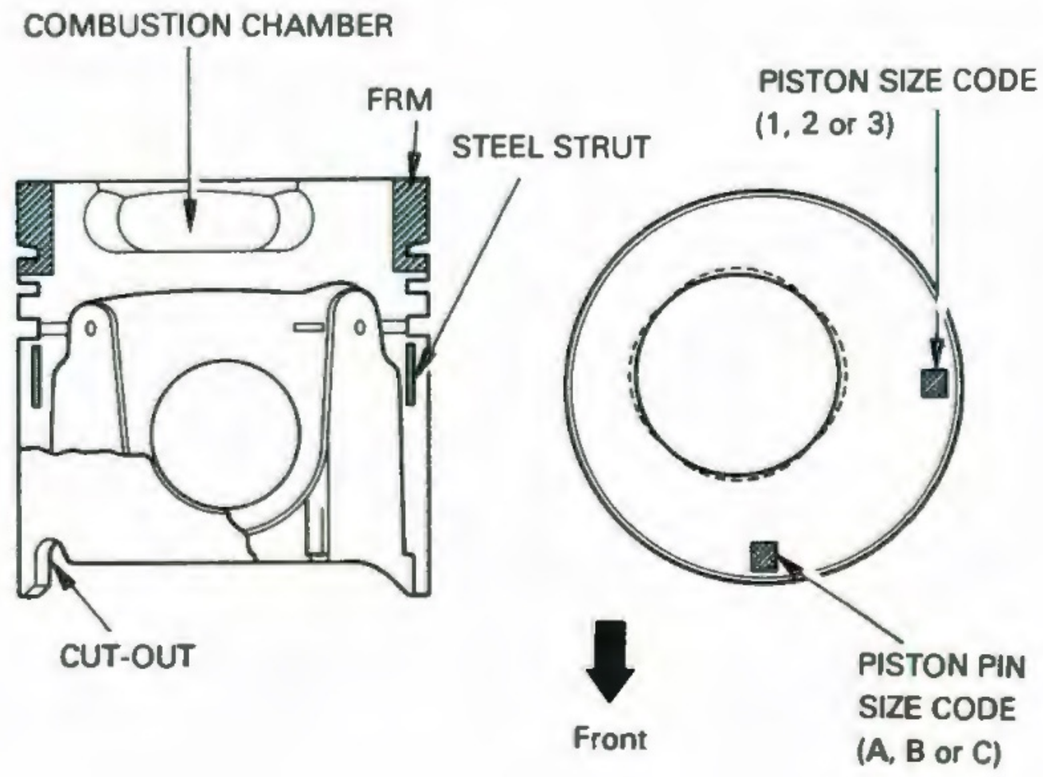
c. In the 12H-T engine, a combustion chamber is provided in the head of each piston. Due to this, the compression height (the distance from the central axis of the piston pin to the piston crown) is greater than that in the 2H type engine. There is also a notch provided in the skirt of each piston to prevent interference with the oil nozzle which is provided to cool the inside of the piston.

FOR 2H



OHP-3

FOR 12H-T



OHP-4

PISTON & PIN SPECIFICATIONS

Engine model		2H	12H-T
Piston outer dia.	(mm)	90.93	90.94
Piston pin outer dia.	(mm)	29.0	32.0
Piston compression height*	(mm)	52.2	56.3

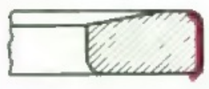
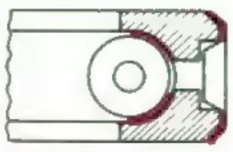
* Distance from central axis of piston pin to crown of piston.

PISTON RINGS

a. There are two compression rings and an oil control ring to each piston.

b. All piston rings of the 2H engine, and the No. 2 compression ring and oil control ring of the 12H-T engine, are made from a special type of cast iron whose surface is plated with a hard chrome. Compression ring No. 1 of the 12H-T engine is made of steel with a gas-nitrided surface, which helps it to withstand the high combustion pressures created due to turbocharging.

c. The oil control ring is of the solid type with coil expander.

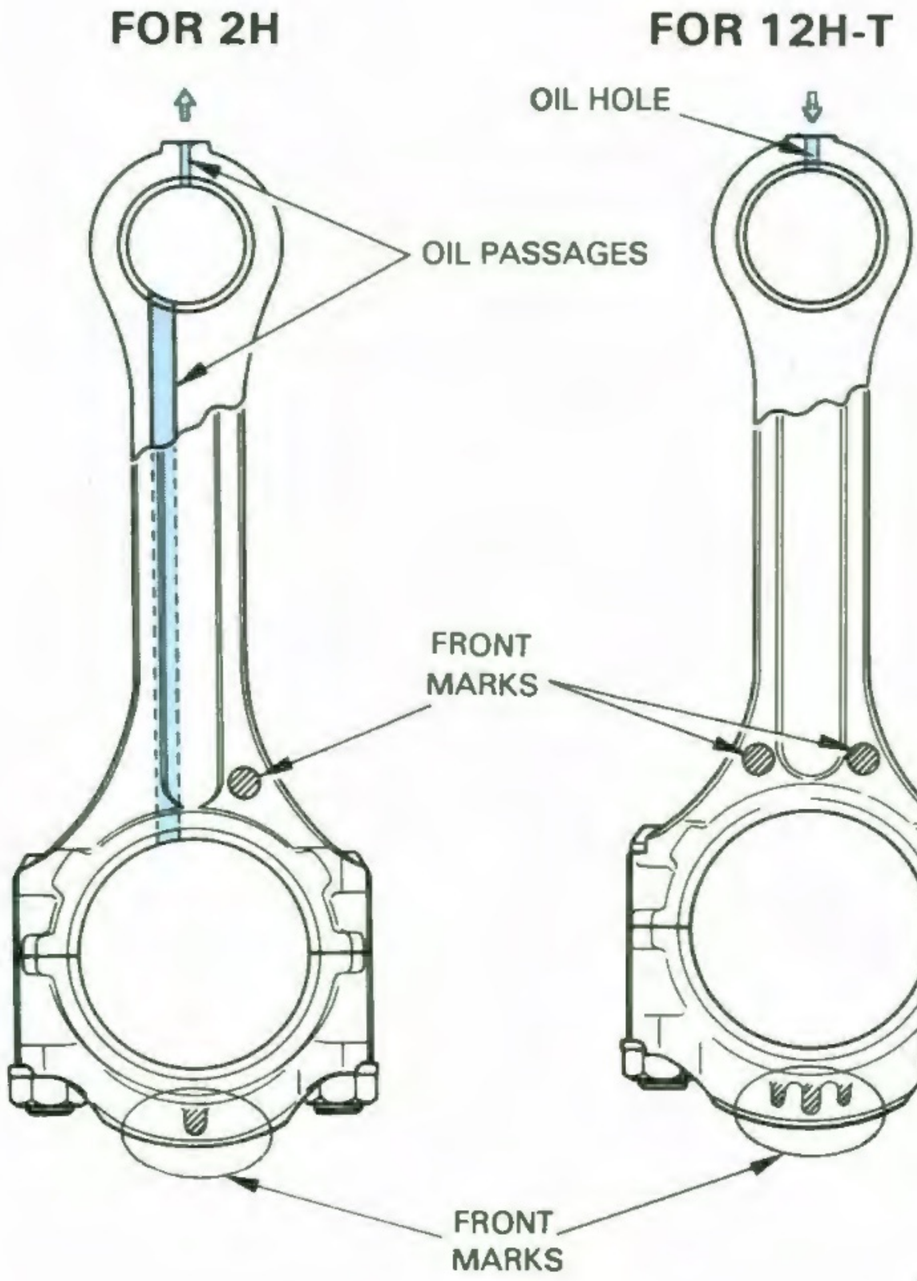
RING	SHAPE/ TYPE	CHROME PLATING	GAS NITRIDING
Compression Ring No. 1	Barrel face semi-keystone	 (For 2H)	 (For 12H-T)
Compression Ring No. 2	Tapered face		
Oil Control Ring	Solid type with coil expander		

OHP-5

CONNECTING ROD

a. The connecting rod of the 2H type engine is provided with an oil passage between the big end and small end for lubricating the piston pin.

b. The connecting rod of the 12H-T type engine has no oil passage between the big end and small end. However, the piston pin is lubricated by oil being sprayed out from the oil nozzle through an oil hole provided in the small end of the connecting rod.



OHP-6

CONNECTING ROD SPECIFICATIONS

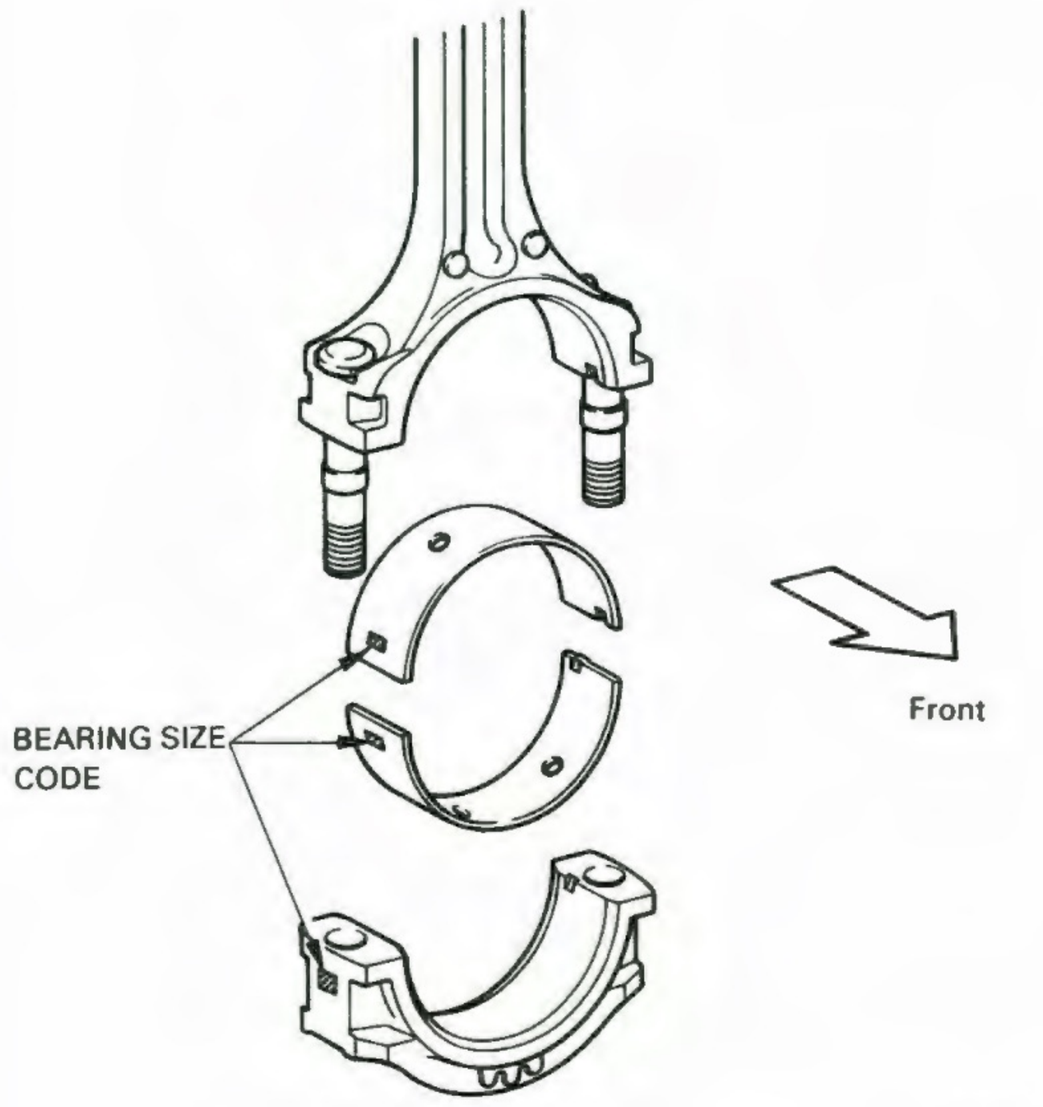
Engine model	2H	12H-T
Span*	174.0	170.0
Big end inner dia. (mm)	58.0	58.0
Small end inner dia. (mm)	29.0	32.0

***Distance from center of piston pin bore (in small end) to center of crankpin hole (in big end).**

CONNECTING ROD BEARINGS

a. Connecting rod bearings are made of aluminum, and can be used in both the 2H and 12H-T engines.

b. There are two standard sizes for connecting rod bearings; each bearing is identified by a code number (1 or 2) printed on the back. Similarly, a big end inner diameter code number (1 or 2) is stamped at the right side of the connecting rod bearing cap. When replacing bearings, use bearings having a code number that corresponds to the code number stamped on the bearing cap. Bearings in combination with bearings caps having the same code number will provide a standard oil clearance.



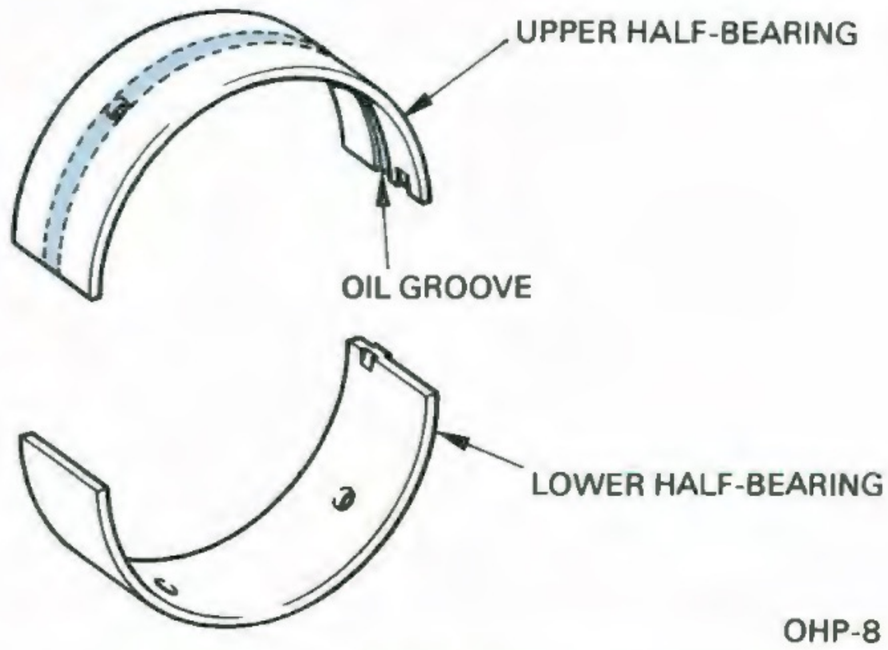
OHP-7

c. If crankpin journals are ground down, use 0.25, 0.50, 0.75 or 1.00 under-size bearings as needed.

CRANKSHAFT MAIN BEARINGS

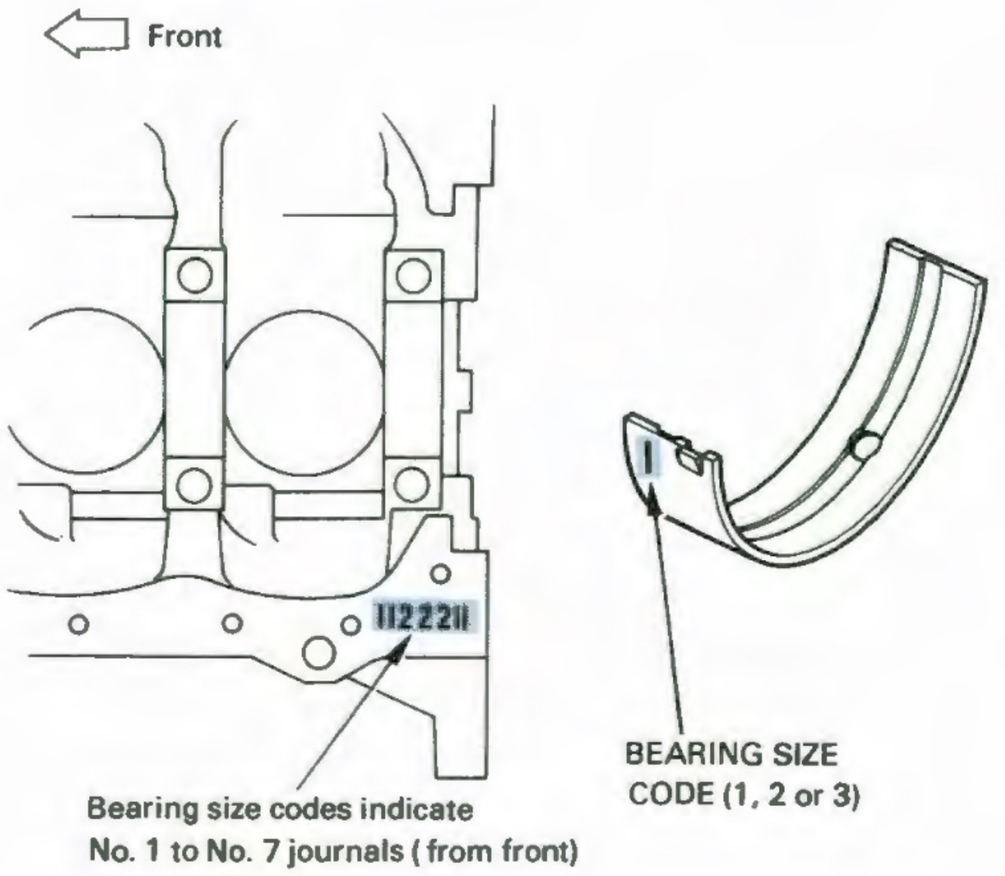
a. Crankshaft bearings are made of aluminum, and can be used in both 2H and 12H-T engines. The width of the crankshaft bearings has been decreased by 2 mm from the conventional size to reduce friction loss. The new bearing width is 29.6 mm for the 4th (center) journal, or 22.6 mm for other journals.

b. The crankshaft upper half-bearing is provided with oil holes and an oil groove to allow oil to be supplied from the cylinder block. However, there is no oil groove in the lower half-bearing.



OHP-8

c. There are three standard sizes of crankshaft main bearings. Each bearing size is identified by a code number (1, 2 or 3) printed on the back of the bearing. Inside diameters of the journal bores are identified by code numbers (1, 2 or 3) stamped onto the right-hand bottom rear of the cylinder block. The code numbers represent the journals in the order 1 through 7 from the front. When replacing bearings, use bearings having the same code number (1, 2 or 3) as the that stamped on the cylinder block. This will provide a standard oil clearance.

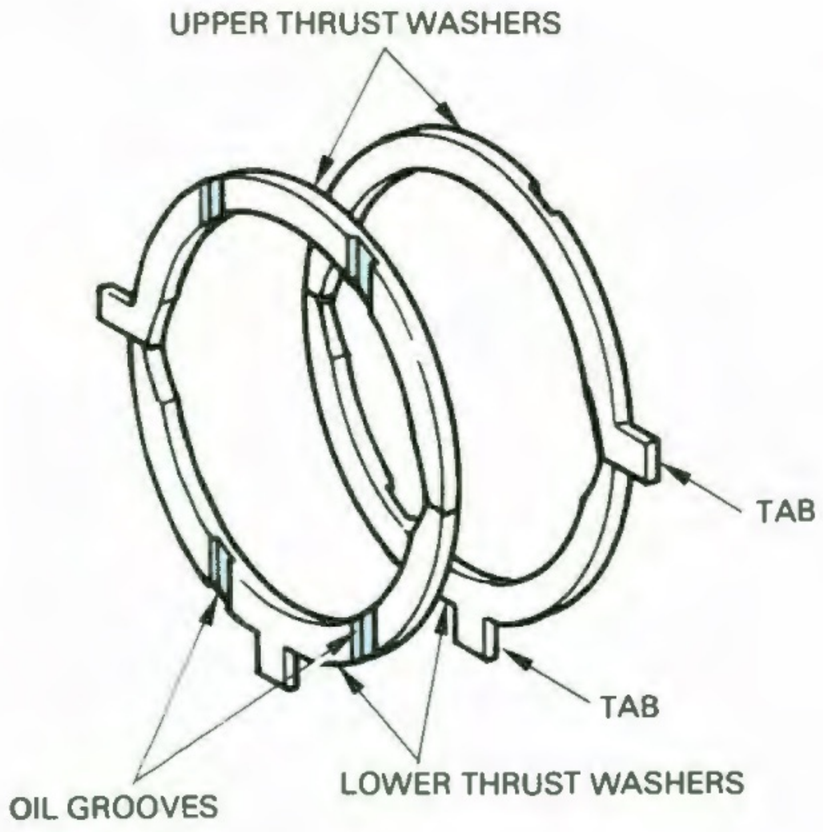


OHP-8

d. If crankshaft main journals are ground down, use 0.25, 0.50, 0.75 or 1.00 under-size bearings as needed.

CRANKSHAFT THRUST WASHERS

a. Crankshaft thrust washers are provided at the 4th (center) journal.
b. There are oil grooves on the side of the thrust washers that contact the crankshaft. Crankshaft thrust washers are provided with tabs both to prevent the bearing from moving and to prevent mis-installation.

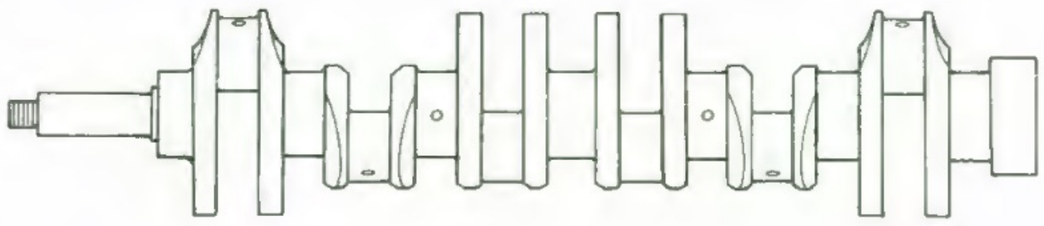


CRANKSHAFT BEARING CAPS

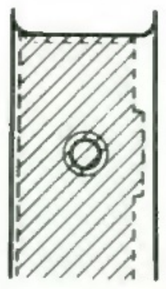
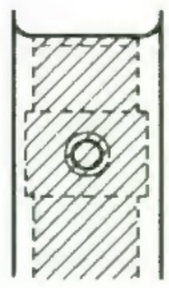
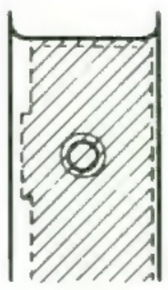
There are two types (No. 1 and No. 2) of bearing caps. No. 1 caps are used with the 1st, 2nd, 3rd, 5th, 6th and 7th journals, and the appropriate number (1, 2, 3, 5, 6, or 7) is stamped on each cap to indicate with which journal it is to be used. The No. 2 cap is used with the 4th (center) journal. The size of bearing cap bolts has been increased from 13 mm to 14 mm.

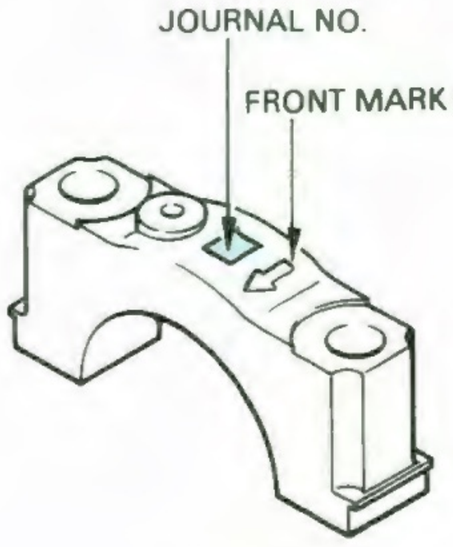
CRANKSHAFT

The crankshaft of the 2H and 12H-T engines are completely identical in shape. However, all journals of the crankshafts of both engines are treated with high-frequency induction hardening. The width of the hardening on the No. 1 and No. 6 crankpins for the 12H-T engine crankshaft is wider than that of the 2H engines. This has been done to increase their rigidity. Therefore, the part number for these crankshafts is different.

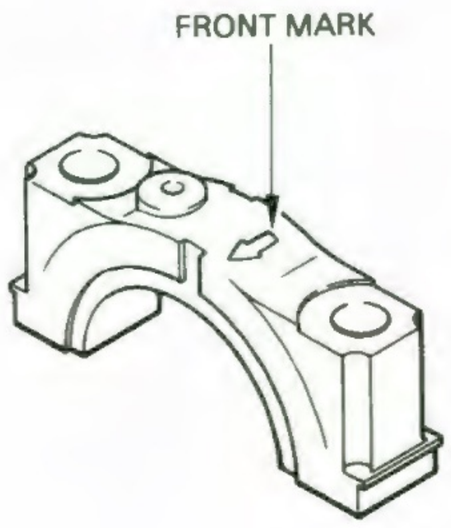


CRANKPIN INDUCTION HARDENING AREA

	BEARING NUMBERS		
2H	—	No. 1 - 6	—
12H-T	No. 1	No. 2 - 5	No. 6
HARDEN -ING AREA			



NO. 1

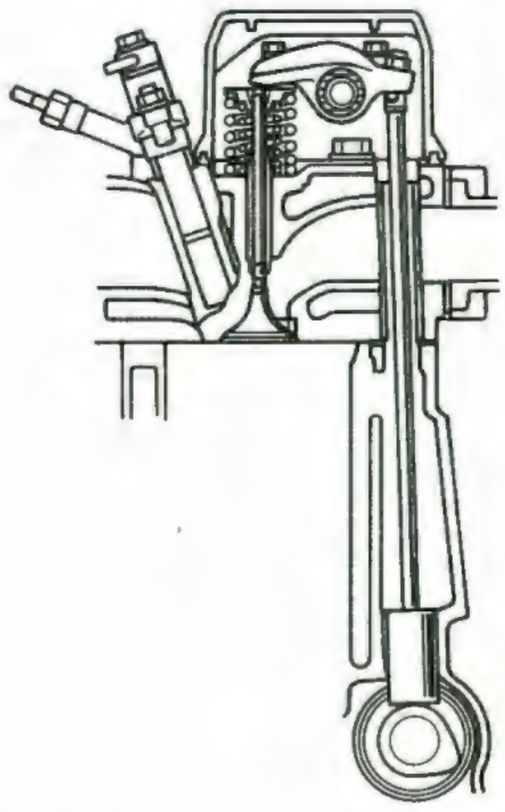


NO. 2

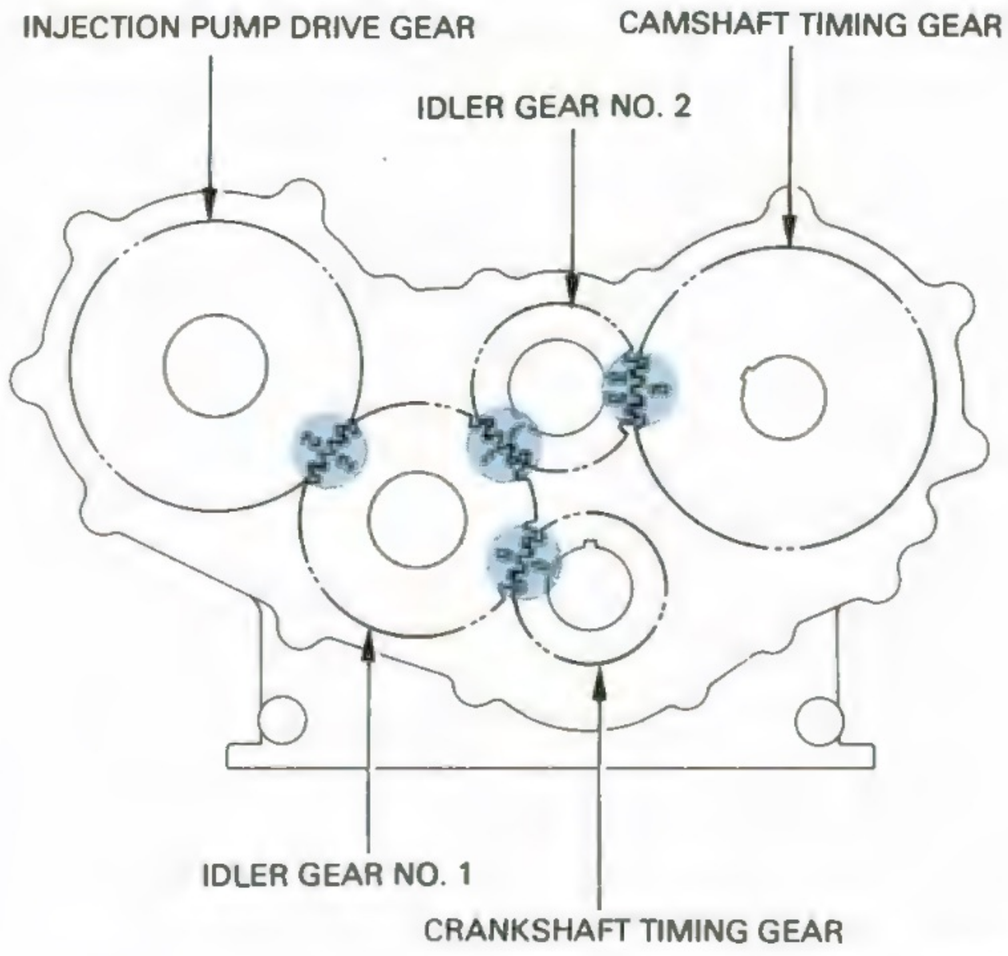
VALVE MECHANISM

DESCRIPTION

The overhead valves are operated by conventional rocker arms via push-rods and valve lifters.



The injection pump drive gear is driven by the crankshaft timing gear via the No. 1 idler gear, and the camshaft is driven by the same via the No. 1 and No. 2 idler gears.



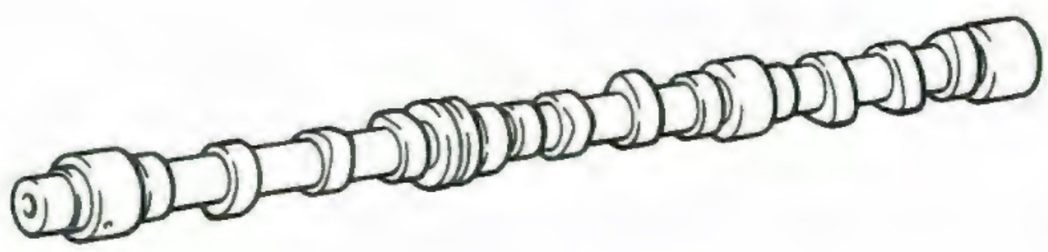
OHP-9

— NOTE —

Each gear should be aligned with its corresponding pre-punched aligning mark when it is installed.

CAMSHAFT

A four-journal camshaft has been adopted. The camshaft bearings are made of aluminum.

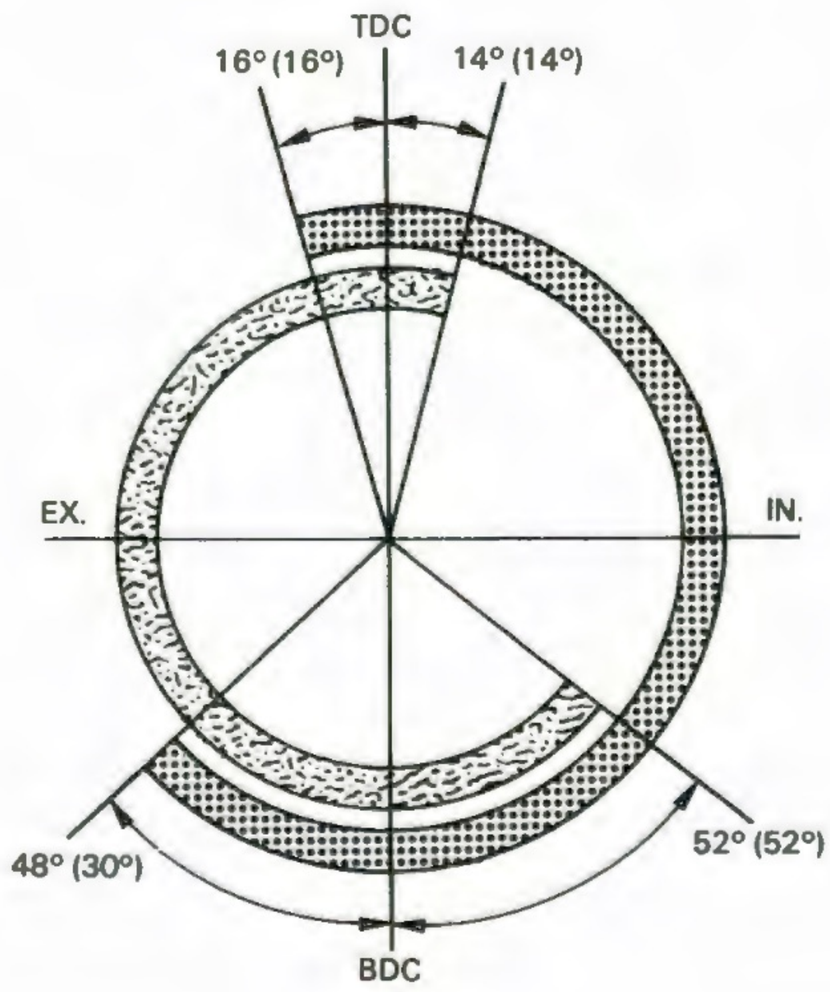


Cam height

Engine	2H	12H-T
Intake cam	41.90	41.72
Exhaust cam	42.29	42.75

VALVE TIMING

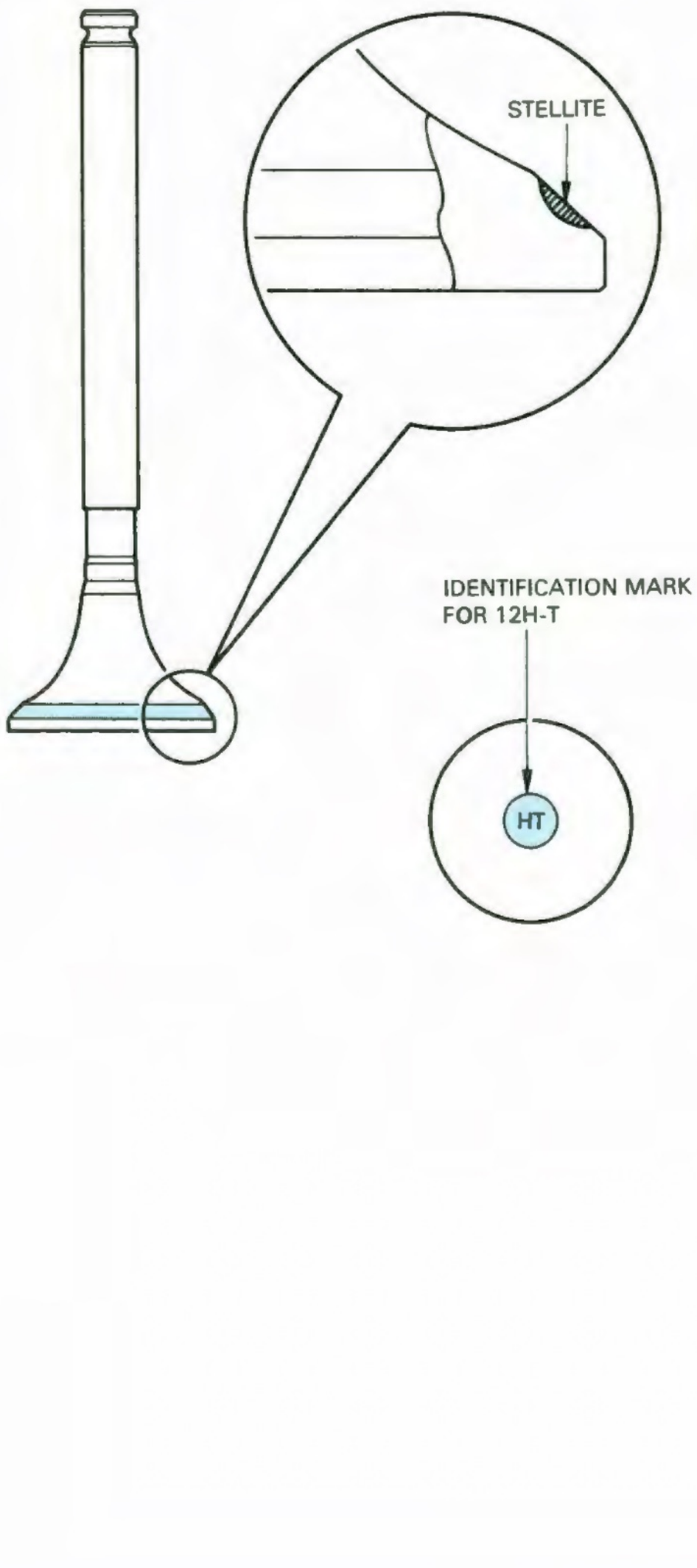
The valve timing is outlined in the diagram below:



( ) : for 12H-T

EXHAUST VALVE FOR 12H-T ENGINE

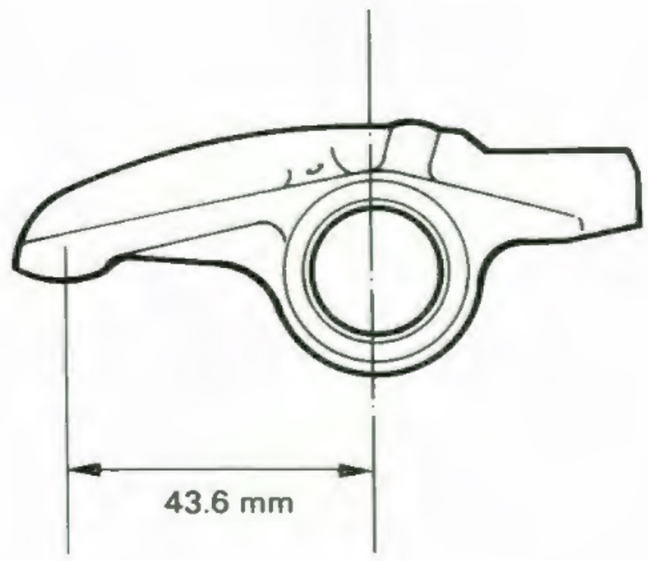
Since a turbocharger is fitted to the 12H-T engine, higher cylinder pressure and hotter exhaust gas are created. A heat- and wear-resisting Stellite alloy ring is embedded into the face of the exhaust valve to cope with those problem. A mark is embossed on the valve head of the 12H-T engine to distinguish it from that for the 2H engine.



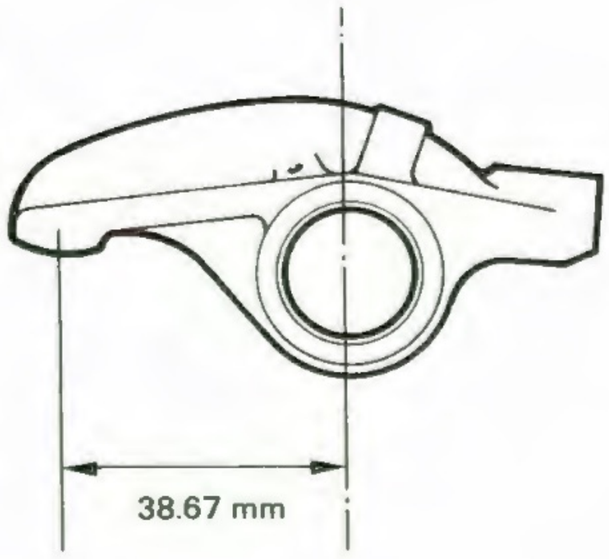
ROCKER ARMS

Identical rocker arms are used for both intake and exhaust valves. However, the shape and length of the 12H-T rocker arms is different from that of the 2H rocker arms: the rocker arms for the 12H-T engine have been made more rigid than those for the 2H engine so that they will be able to withstand the higher combustion pressure resulting from the use of direct injection combustion chambers and turbo-charging.

FOR 2H



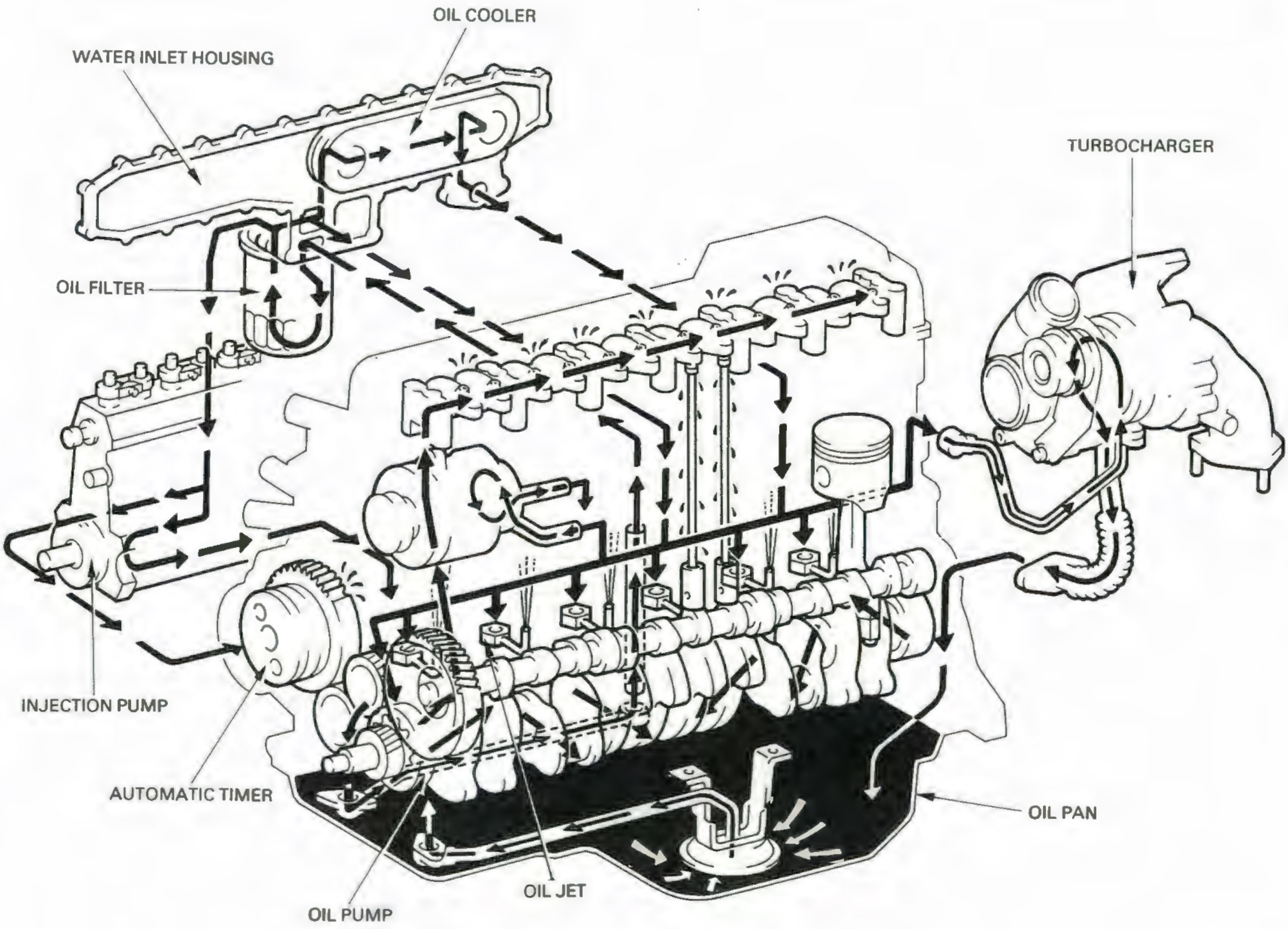
FOR 12H-T



LUBRICATION SYSTEM

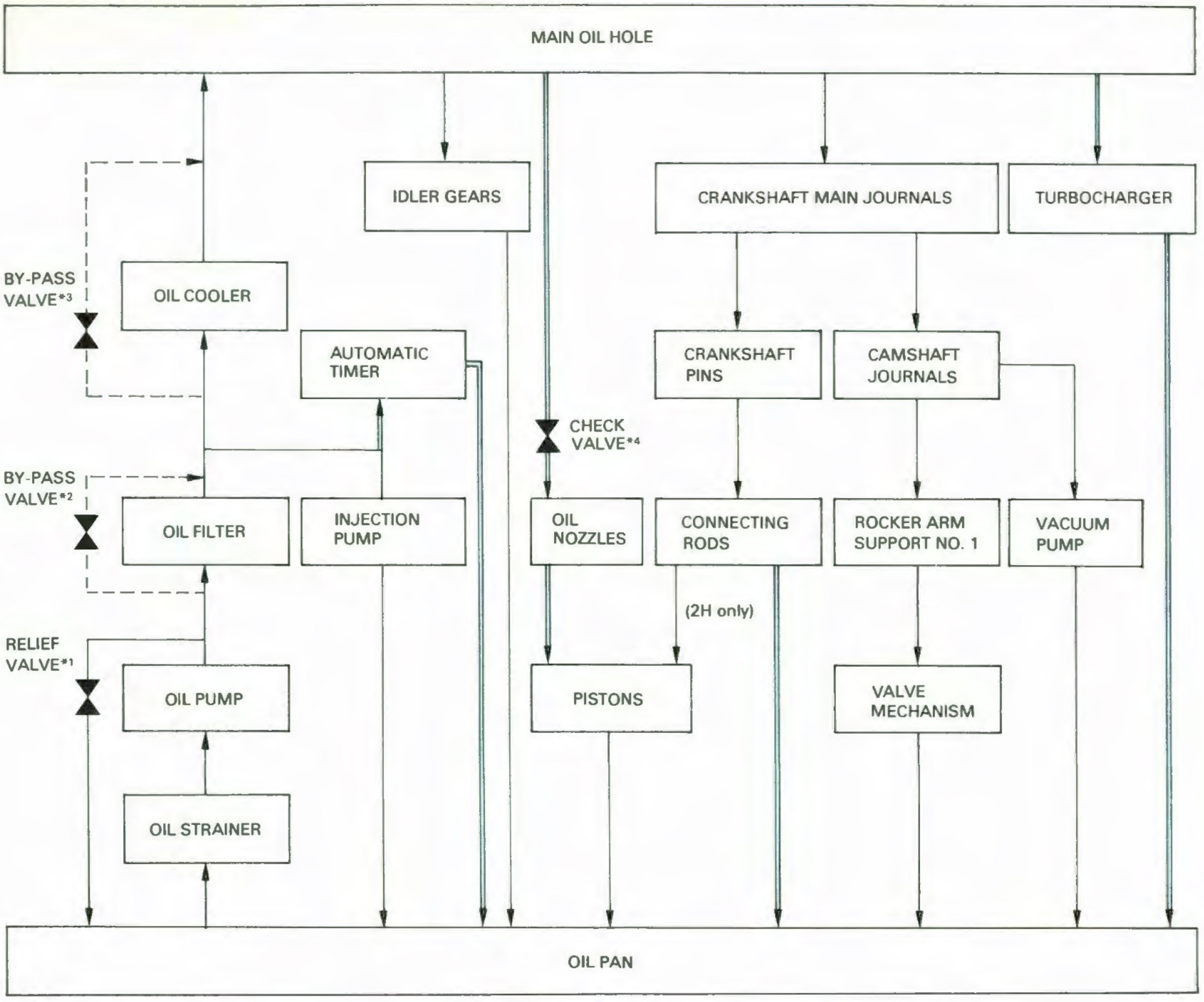
DESCRIPTION

a. The fully-pressurized lubrication system featured in these engines incorporates a water-cooled oil cooler.
b. The 12H-T engine is provided with an oil passage for lubrication of the turbocharger's full-floating bearings. Oil nozzles for cooling the inside of the pistons, the lubricating circuit for the injection timer, etc., are other features not found with the 2H engine.



OHP-10

LUBRICATION SYSTEM



LUBRICATION CIRCUITRY

Valve opening pressure (kg/cm²) :
*1 = 5.5
*2 = 1.0 (differential pressure)
*3 = 1.5 (differential pressure)
*4 = 1.5

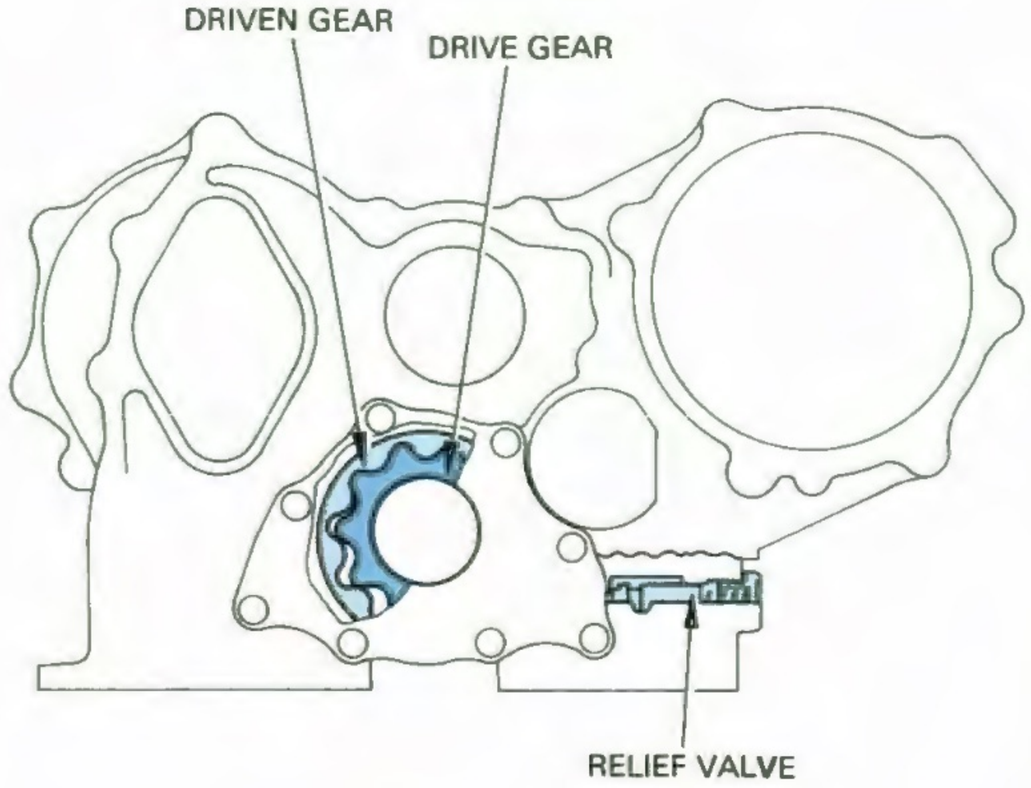
⟶ : 12H-T only

OIL PUMP

The oil pump is a trochoidal type gear pump which is driven by the crankshaft. It is provided with a built-in relief valve.

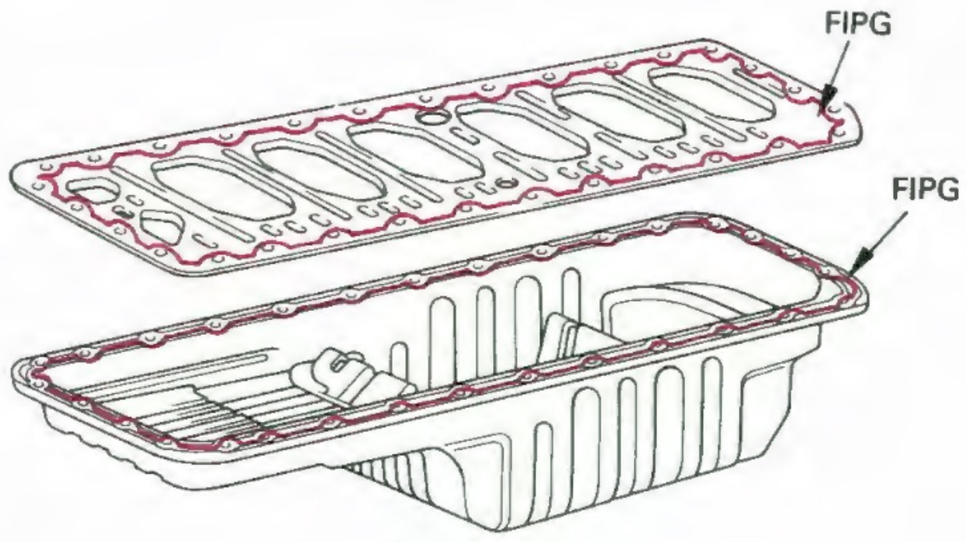
Discharge volume (ℓ/min)	600 rpm	6.7
	3600 rpm	62.0
Discharge pressure (kg/cm²)	600 rpm	2.0
	3600 rpm	3.0

RELIEF VALVE OPENING PRESSURE (kg/cm²)	5.5 at 2000 rpm



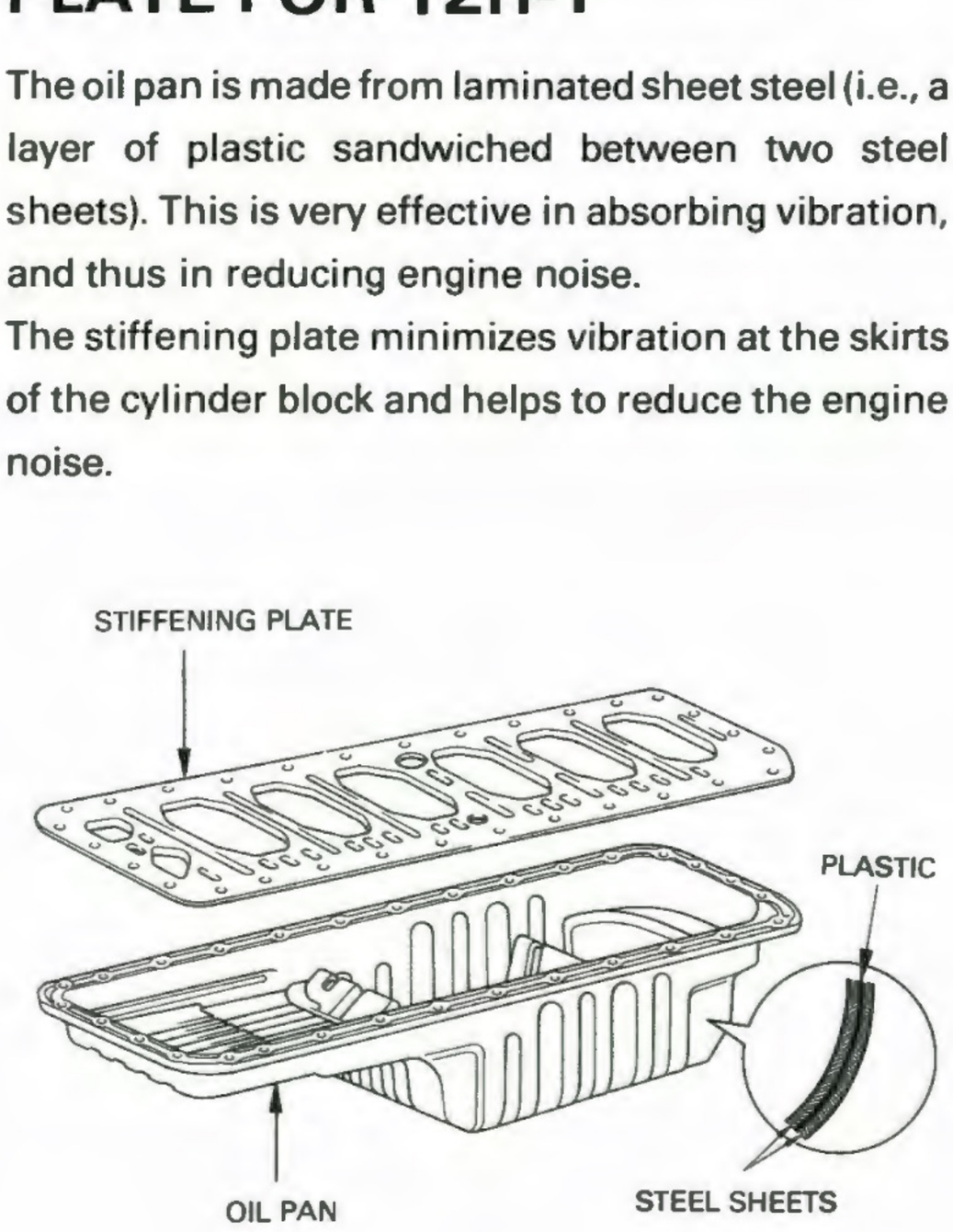
OIL PAN GASKET

The gasket used for the oil pan and stiffening plate is FIPG (formed-in-place gasket P/N 08826-00080) liquid sealant which has superior sealability. To remove the oil pan and the stiffening plate, use the seal cutter SST P/N 09032-00100.



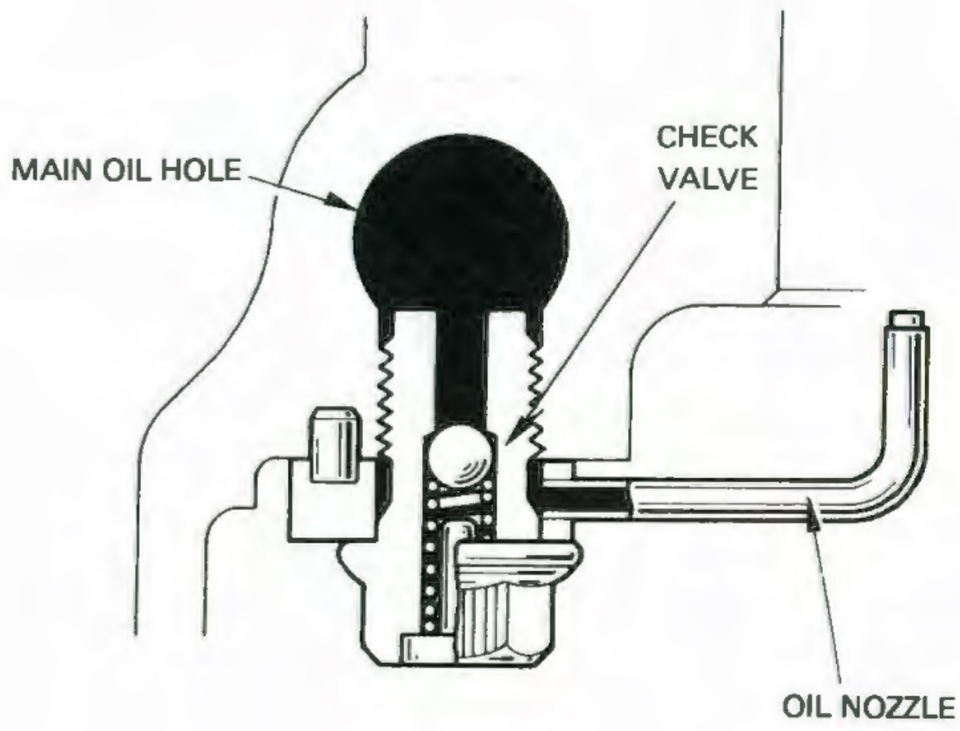
OIL PAN AND STIFFENING PLATE FOR 12H-T

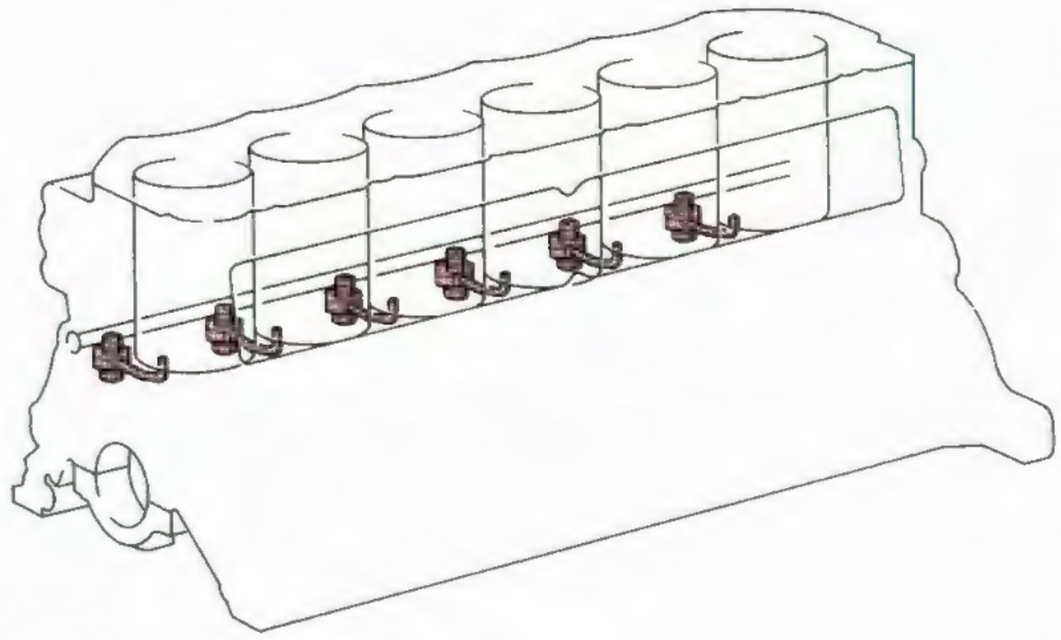
The oil pan is made from laminated sheet steel (i.e., a layer of plastic sandwiched between two steel sheets). This is very effective in absorbing vibration, and thus in reducing engine noise.
The stiffening plate minimizes vibration at the skirts of the cylinder block and helps to reduce the engine noise.



OIL NOZZLES (12H-T only)

a. Part of the oil that flows from the main oil hole in the cylinder block passes through the check valve and is sprayed out of the oil nozzles to cool the insides of the pistons.
b. A spring and ball are built into the check valve to cut off the oil passages to the oil nozzles when the oil pressure drops below a certain level; this is done to prevent the pressure to the whole engine from dropping in such a case.



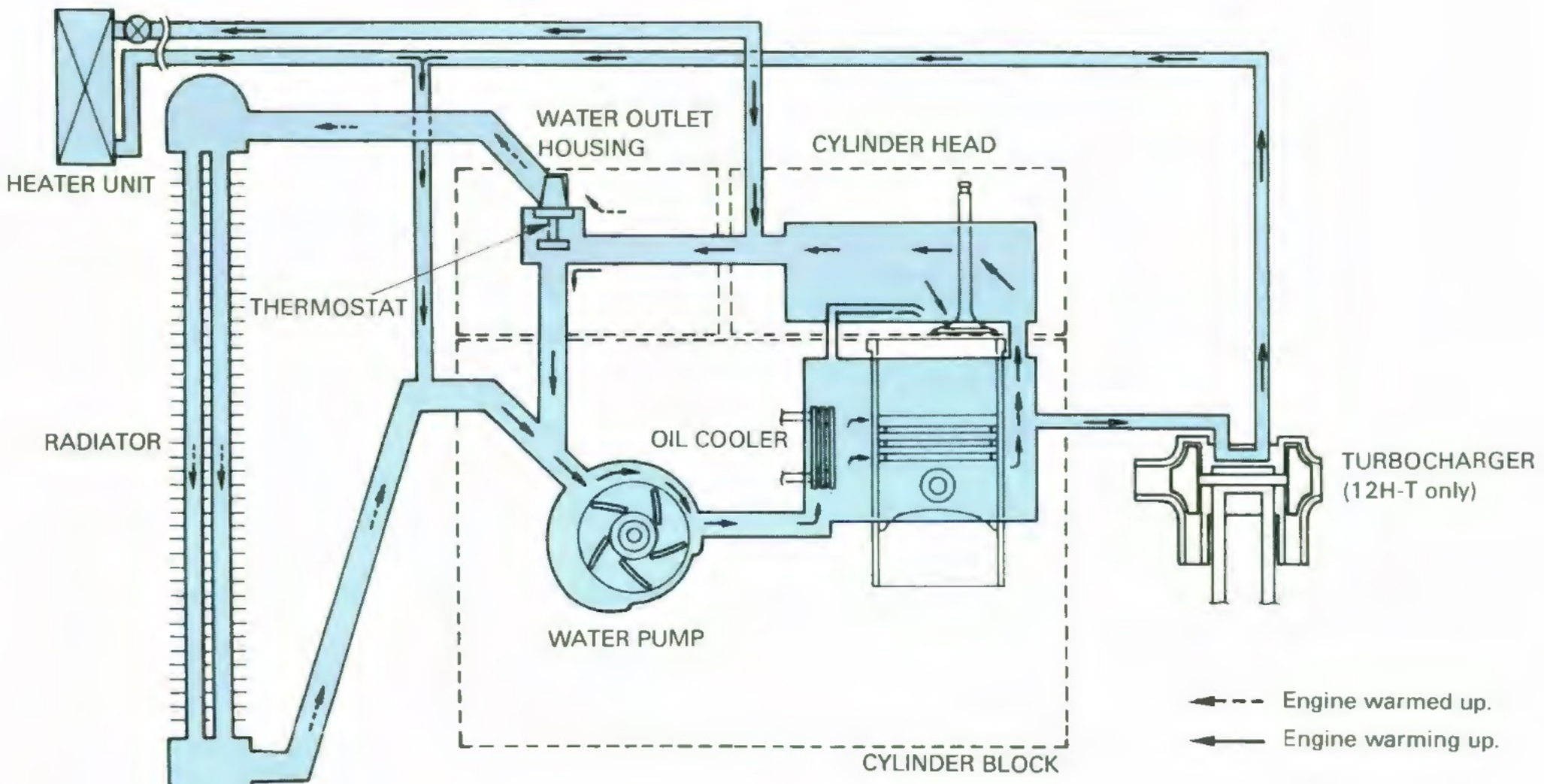


OIL NOZZLES

COOLING SYSTEM

DESCRIPTION

A forced-circulation, pressurized water cooling system is used.
Coolant flow is controlled by a wax type thermostat with by-pass valve.
On the 12H-T engine, coolant is also circulated through the turbocharger bearing housing to remove heat from the turbocharger.



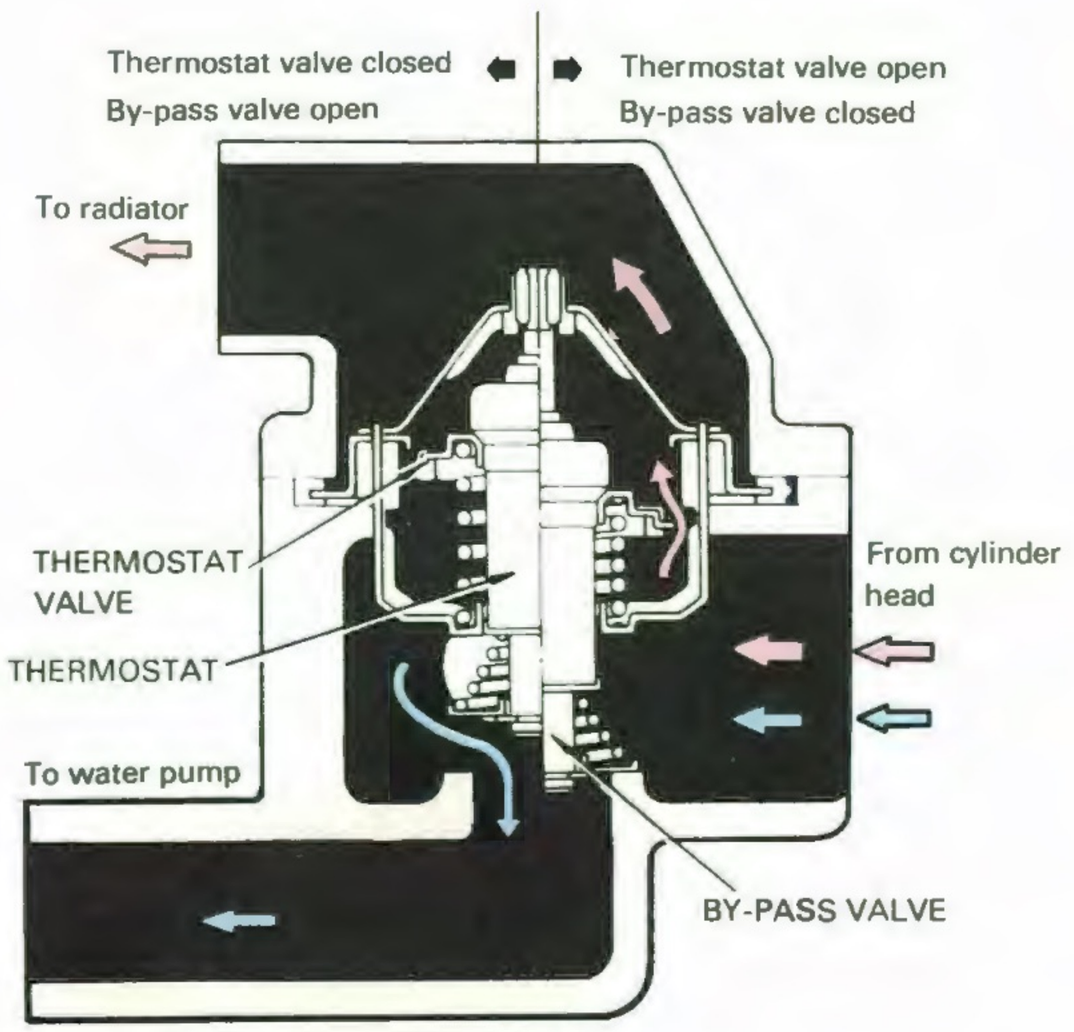
OHP-11

THERMOSTAT

A thermostat with by-pass valve is used to improve cooling efficiency after the engine has warmed up. The by-pass valve closes off the passage from the cylinder head to the water pump when the thermostat valve opens, thus allowing the hot coolant from the engine to go only to the radiator.

— NOTE —

The engine must not be run while the thermostat with by-pass valve is removed. If the engine is run without the thermostat, most of the heated water from the cylinders will return directly to the water pump and flow to the cylinders again without passing through the radiator. This will cause the engine to overheat easily.



INTAKE AND EXHAUST SYSTEM

INTAKE CONSTRICTOR MECHANISM

1. DESCRIPTION

An intake constrictor mechanism has been adopted for 2H engines with automatic transmission and for all 12H-T engines for the following purposes:

a. STOPPING ENGINE

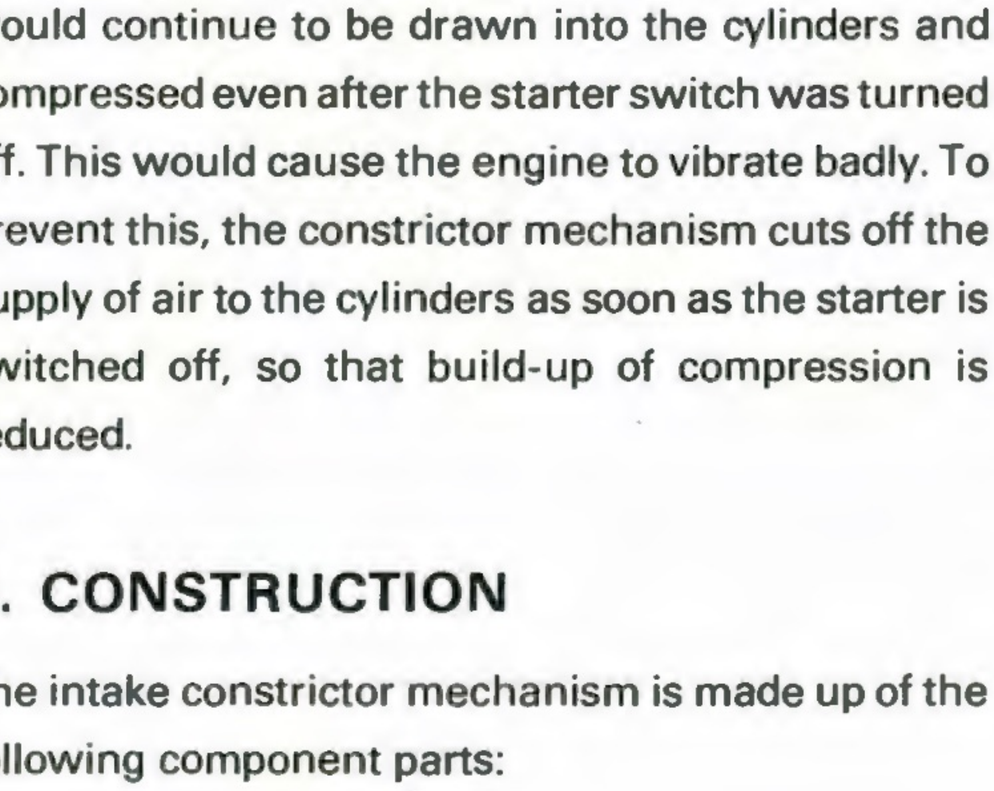
When the starter switch is turned to the OFF position, this mechanism cuts off the supply of air to the cylinders to ensure that the engine stops promptly.

b. REDUCING VIBRATION WHEN ENGINE IS STOPPED

If the constrictor mechanism were not provided, air would continue to be drawn into the cylinders and compressed even after the starter switch was turned off. This would cause the engine to vibrate badly. To prevent this, the constrictor mechanism cuts off the supply of air to the cylinders as soon as the starter is switched off, so that build-up of compression is reduced.

2. CONSTRUCTION

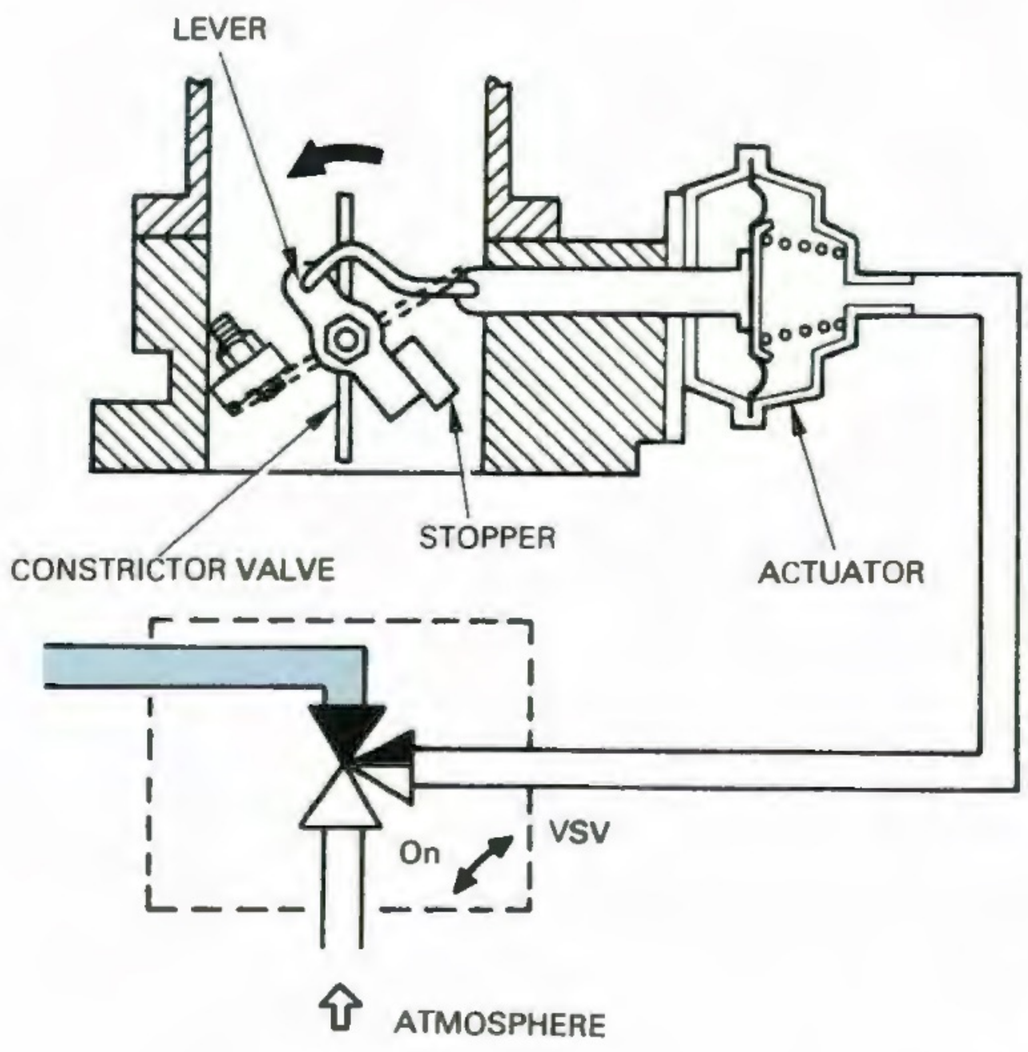
The intake constrictor mechanism is made up of the following component parts:



3. OPERATION

ENGINE STARTING

When the starter switch is turned to the ON position, the VSV (Vacuum Switching Valve) is switched on and atmospheric air is applied to the actuator. This causes the lever to turn counterclockwise. Since the constrictor valve is fixed to the lever, it opens fully.



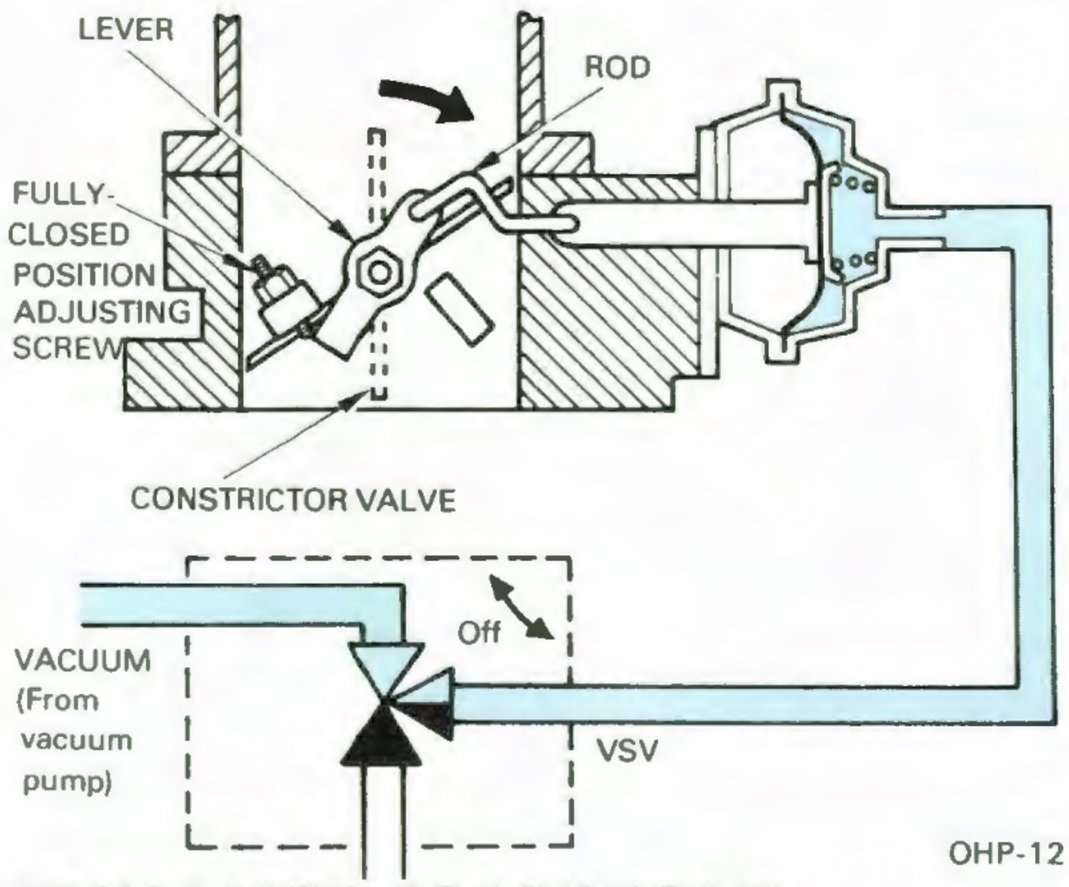
OHP-12

The table below summarizes the operation of the starter switch, the VSV, the actuator, and the intake constrictor mechanism.

STARTER SWITCH	VSV	ACTUATOR	CONSTRICTOR VALVE
ON	On	Atmospheric pressure applied	Fully open
OFF	Off	Vacuum applied	Fully closed

WHEN ENGINE IS STOPPED

When the starter switch is turned to the OFF position, the VSV is switched off and a vacuum is applied to the actuator. The rod is pulled back and the lever turns clockwise. This completely closes the constrictor valve, cutting off the intake of all air into the cylinders to ensure that the engine completely stops.

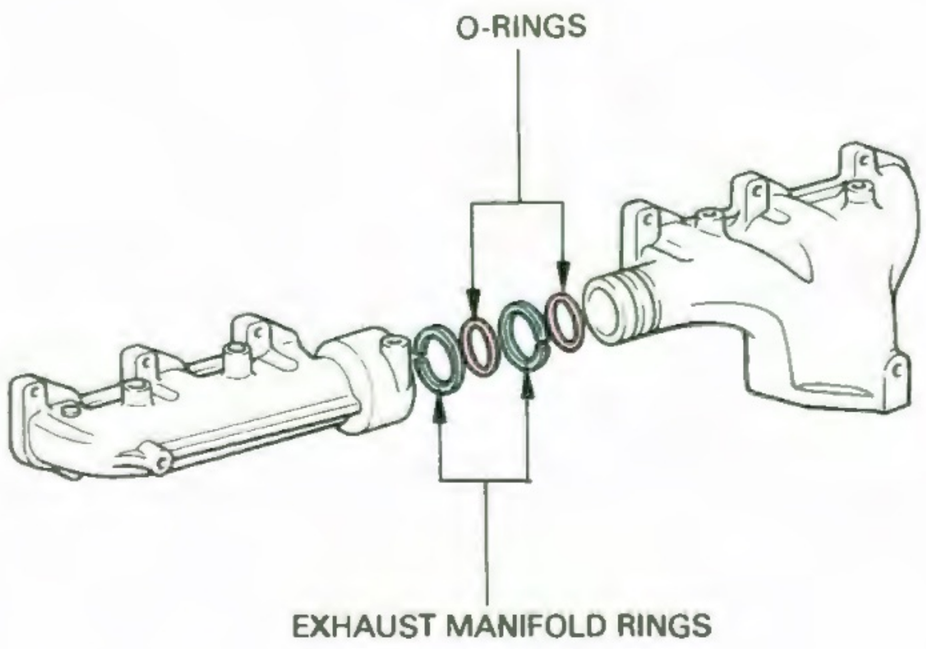


OHP-12

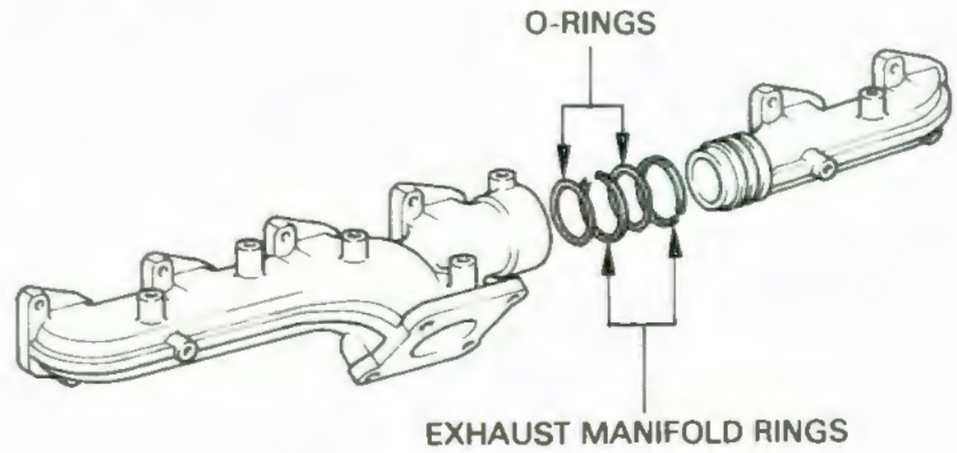
EXHAUST MANIFOLD

The exhaust manifold is of the two-piece type. This design helps to minimize thermal stress and improve sealing at the fitting.
In addition, O-rings and steel rings are located at the joint between the front and rear exhaust manifold sections to prevent exhaust gas leakage.

FOR 2H

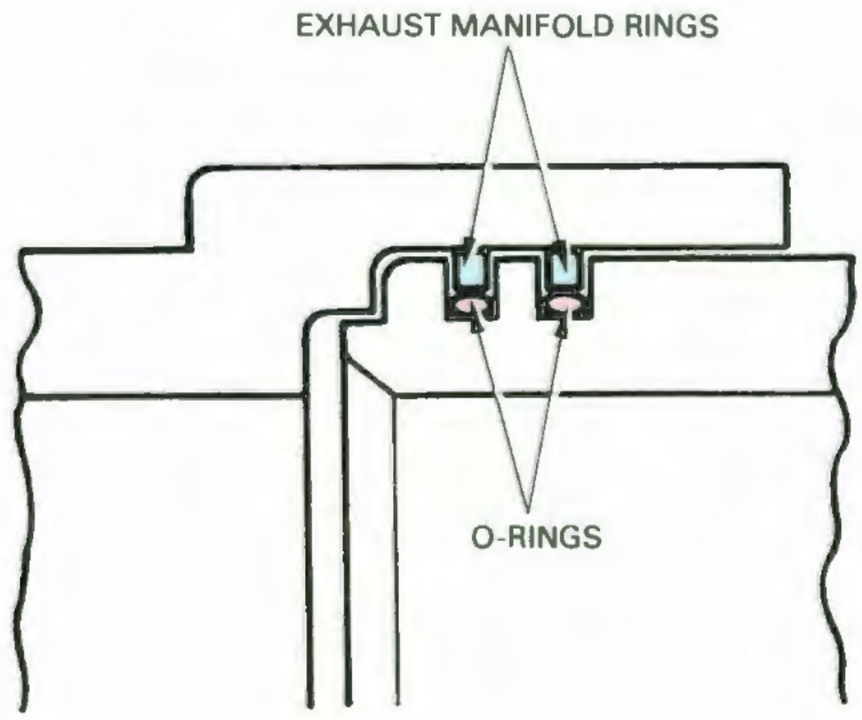


FOR 12H-T



— NOTE —

The synthetic rubber O-rings immediately burn due to the heat of the exhaust gas, producing a powdery ash. The ash is pushed by the pressure of the exhaust gas into the gaps between the steel rings and the exhaust manifolds, serving as a sealant.



When the front and rear exhasut manifold sections are disconnected for servicing, the O-rings and steel exhaust manifold rings must be replaced with new ones. Each new steel ring must be installed with its gap turned 180° away from that of the other steel ring.

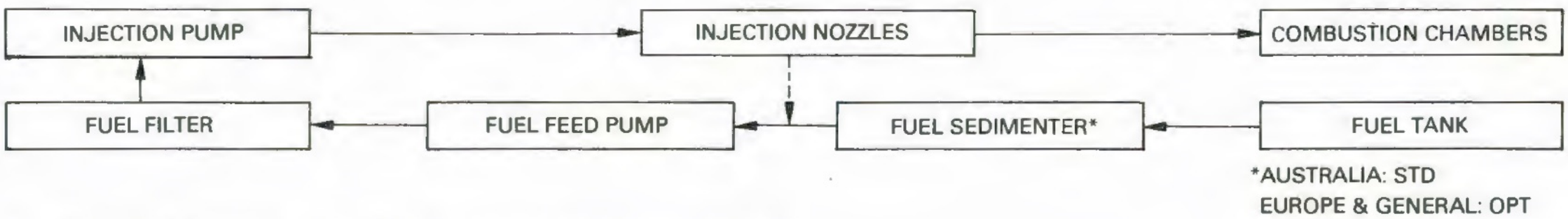
FUEL SYSTEM

DESCRIPTION

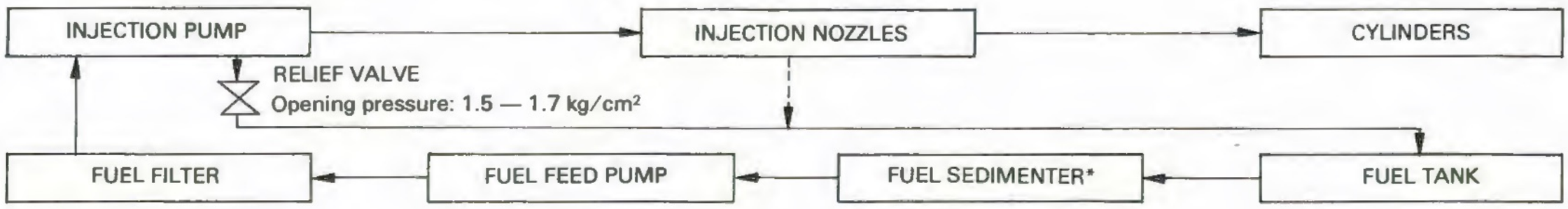
As shown below, the fuel system is nearly identical to that used with other diesel engines:

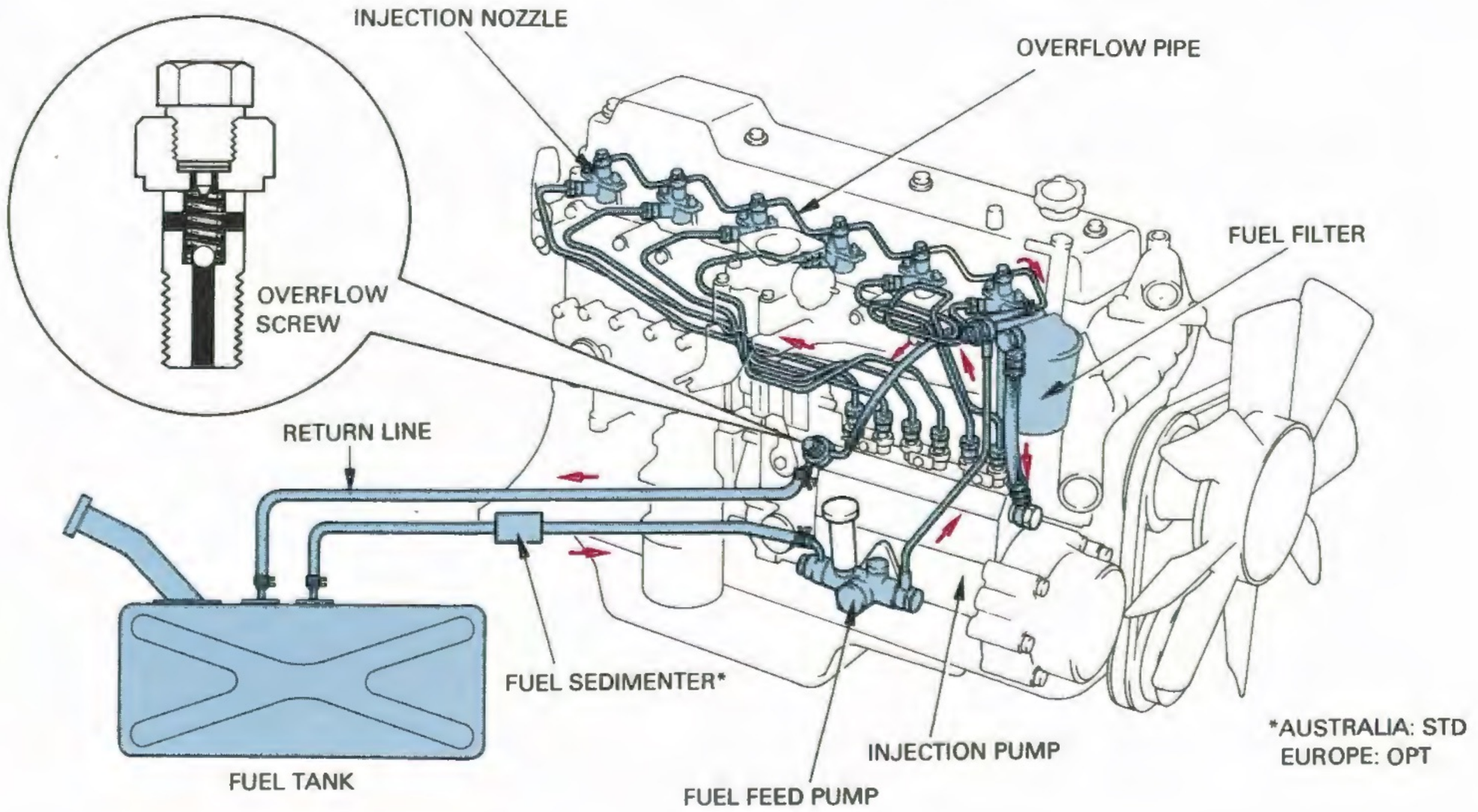
1. The fuel is drawn from the fuel tank by the feed pump and sent the injection pump via the fuel filter.
2. The injection pump then pressurizes the fuel and supplies it to the injection nozzles.
3. Any unused fuel remaining in the injection nozzles is returned to the inlet of the feed pump through an overflow pipe (on the 2H engine), or to the fuel tank through an overflow pipe and a return line (on the 12H-T engine).
4. On the 12H-T engine, part of the fuel that passes through the injection pump is returned to the fuel tank via the return line after cooling the injection pump. The fuel pressure inside the injection pump is kept at 1.5 — 1.7 kg/cm² by the relief valve in the overflow screw.

- The fuel flows in the 2H engine as shown below:



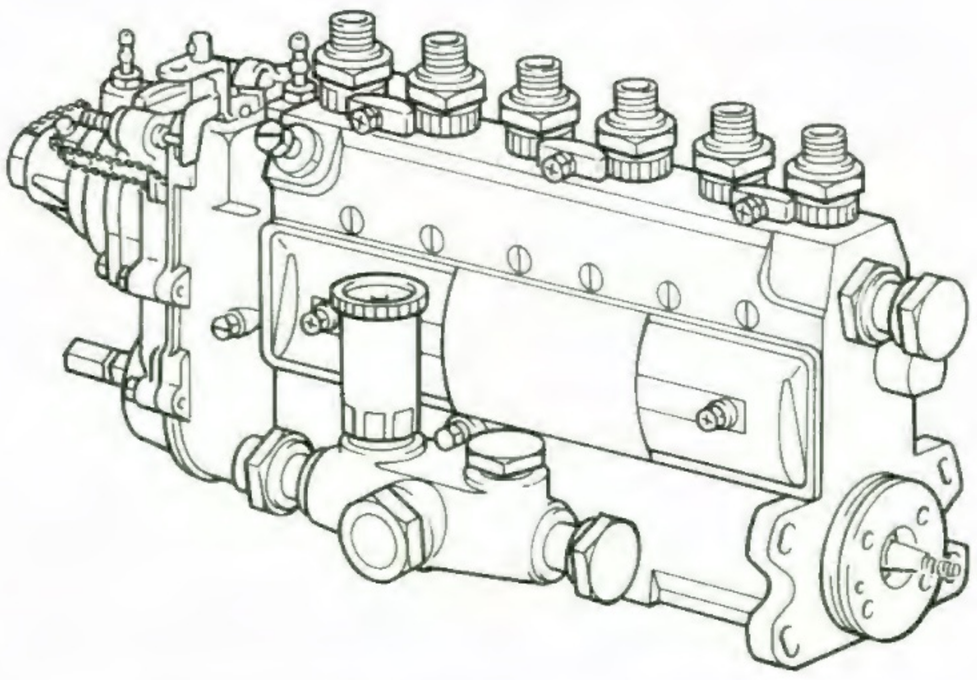
- The fuel flows in the 12H-T engine as shown below:



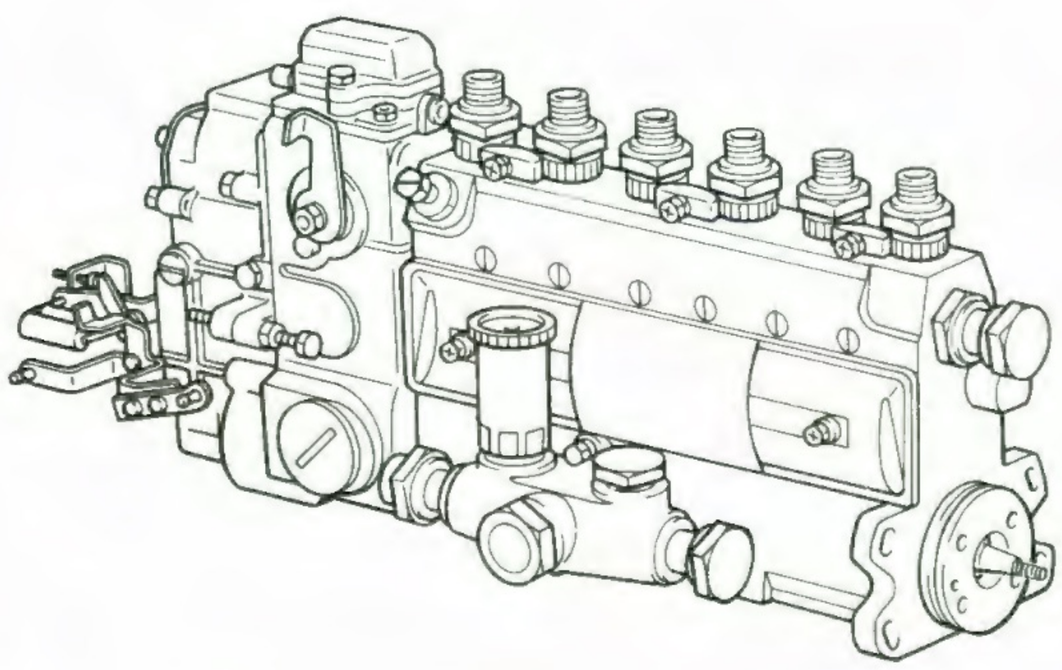


INJECTION PUMP

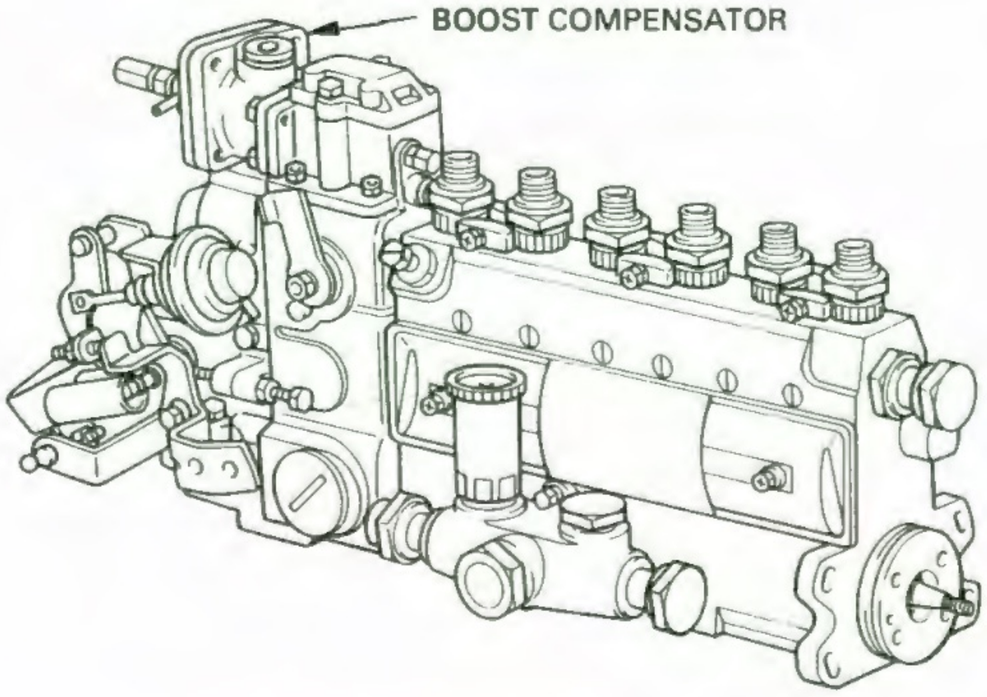
The injection pump is of the in-line type. The injection pump for the 12H-T engine is specially designed to withstand the high pressures resulting from the direct injection of fuel into the cylinders.



INJECTION PUMP WITH COMBINED GOVERNER FOR 2H ENGINE



INJECTION PUMP WITH MECHANICAL GOVERNER FOR 2H ENGINE



INJECTION PUMP WITH MECHANICAL GOVERNER FOR 12H-T ENGINE

— NOTE —

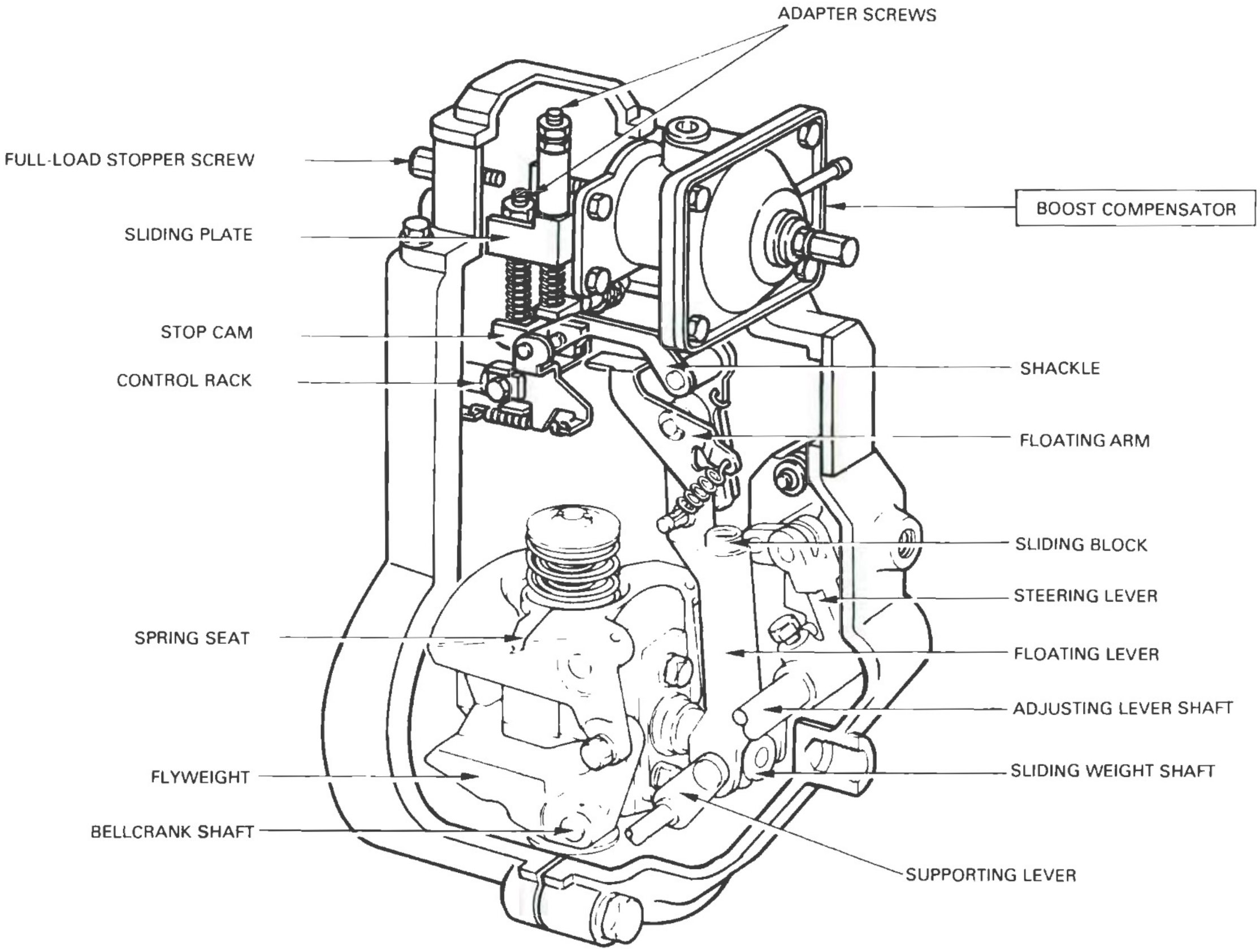
For further details on the construction and operation of the in-line type injection pump, refer to the Diesel Injection Pump STI (Pub. No. STI003E).

INJECTION PUMP SPECIFICATIONS

Item \ Engine	2H	12H-T
Pump layout	In-line	In-line
Injection timing	18° BTDC	11° BTDC
Injection order	1-4-2-6-3-5	1-4-2-6-3-5
Plunger diameter (mm)	7.0	9.0
Direction of rotation	Clockwise (as seen from front of engine)	←
Cam lift (mm)	8.0	←
Feed pump cam lift (mm)	6.0	←
Camshaft diameter (mm)	17.0	20.0
Delivery valve diameter (mm)	5.0	←
Governor	Mechanical or combined	Mechanical w/boost compensator

BOOST COMPENSATOR

The relationship of the boost compensator to the mechanical governor is as shown in the following illustration.



COMPONENTS OF MECHANICAL GOVERNOR FOR 12H-T

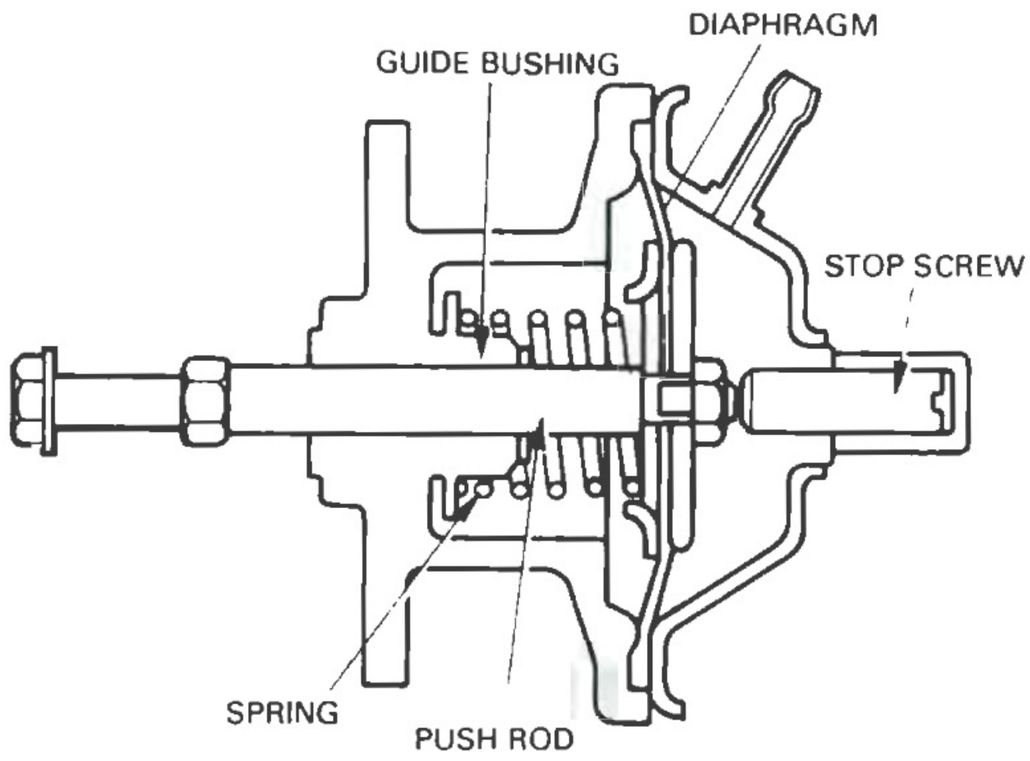
OHP-13

1. CONSTRUCTION

The boost compensator is a device which increases and decreases the injection volume in accordance with changes in the boost pressure of the turbocharger, and is composed of a diaphragm, push rod, spring, guide bushing, etc.

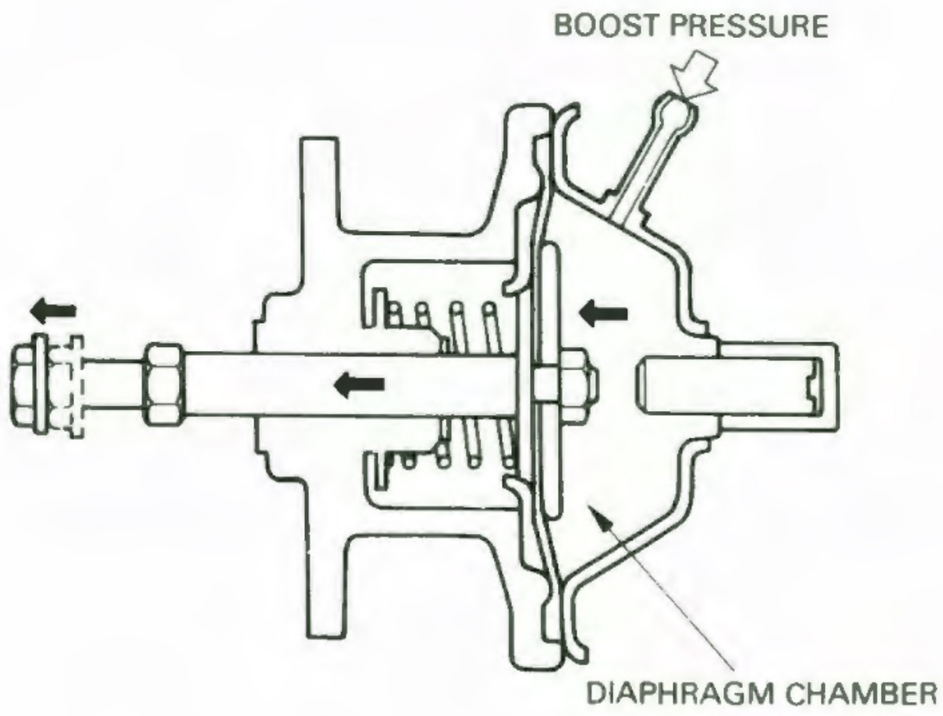
The boost pressure acts on the diaphragm, which moves the push rod in accordance with the difference between this force and the force of the spring.

The stop screw governs the maximum fuel injection volume when the boost compensator is not operating.



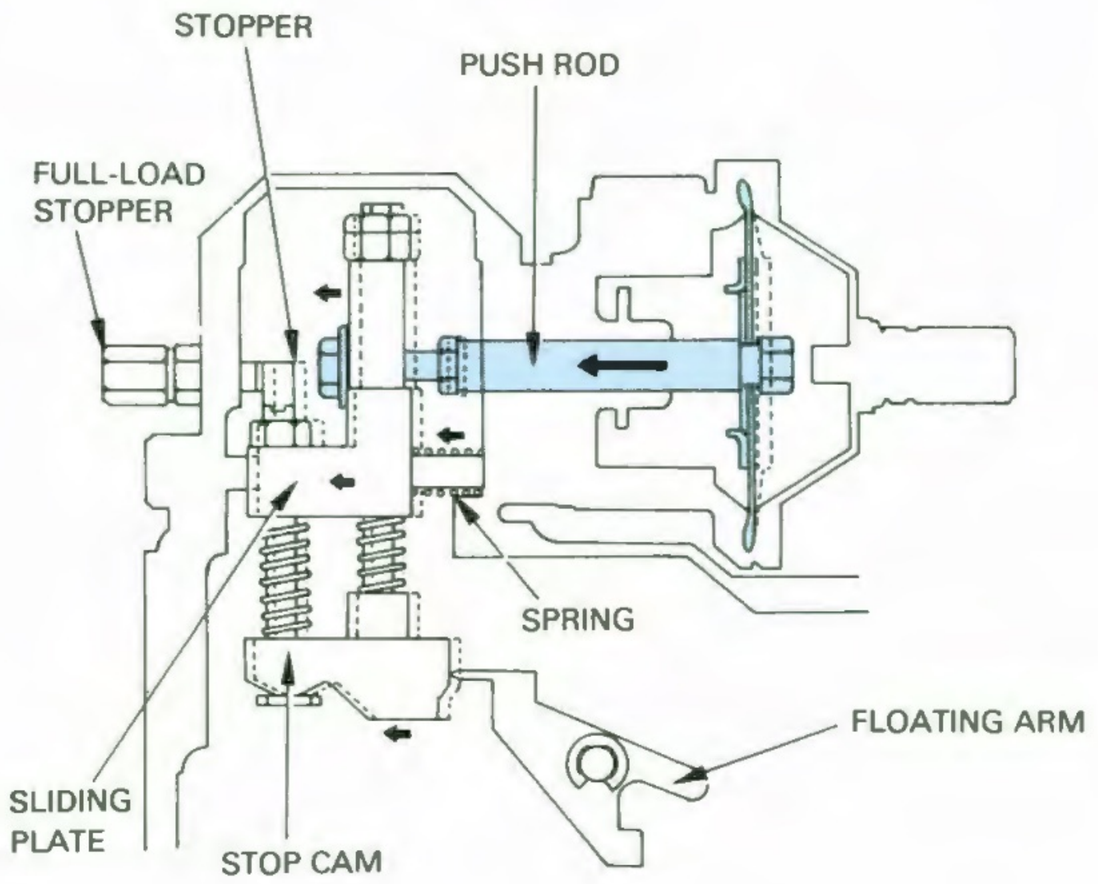
2. OPERATION

a. The pressure in the diaphragm chamber rises with increases in the boost pressure, and the diaphragm and push rod are pushed to the left until the pressure balances the spring force.



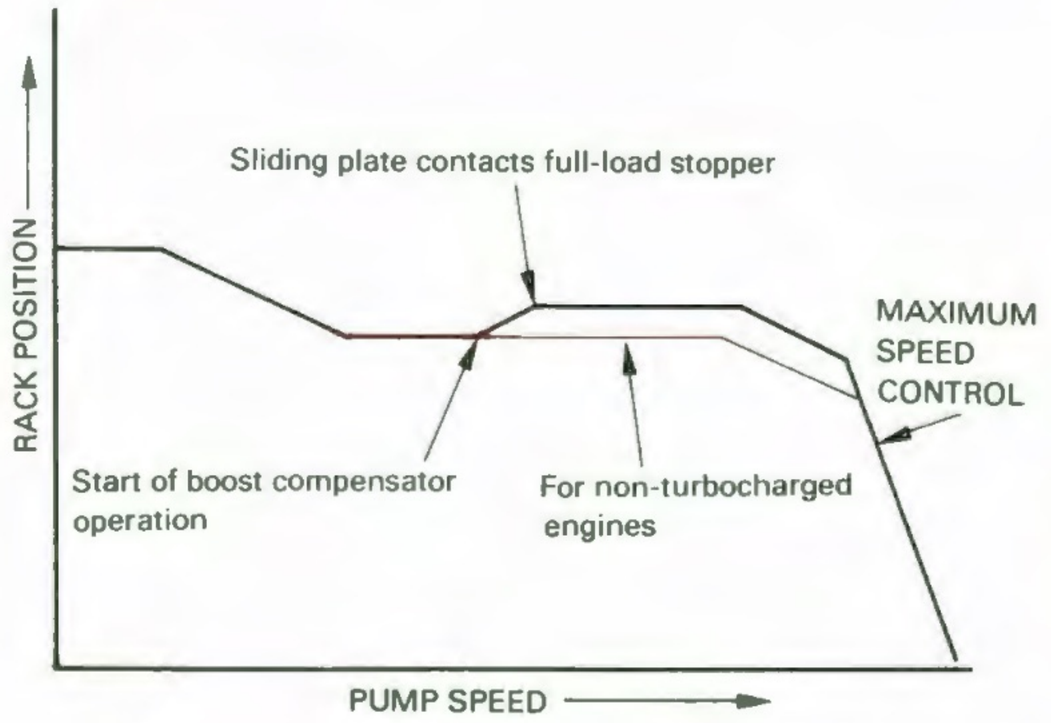
b. The sliding plate is kept pushed to the left by the spring, but the movement of the sliding plate is limited by the push rod.

If the boost pressure rises and the push rod of the boost compensator is moved to the left, the sliding plate moves to the left by the same amount as the push rod is moved due to the spring force.
At the same time, the stop cam connected to the sliding plate also moves to the left.
The floating arm also follows the movement of the stop cam, so the control rack moves in the direction of increased fuel injection by the amount of that change, bringing about an increase in the injection volume.
However, at the point that the sliding plate strikes the full load stopper, it stops.



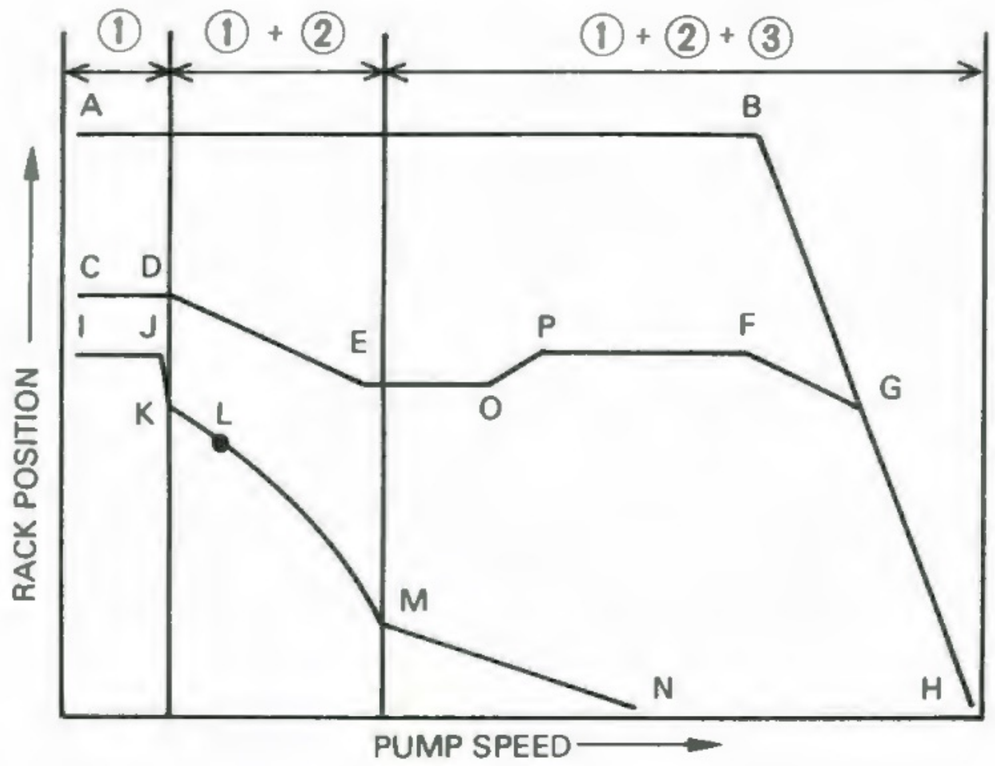
OHP-14

c. Since the boost pressure changes with changes in the engine speed, the position of the rack with respect to the pump speed is as shown in the following graph.



If the boost pressure becomes greater than the diaphragm spring force, the push rod moves and the fuel injection volume increases.
At this time, at the point when the sliding plate strikes the full load stopper, the increase in the fuel injection volume stops and maximum speed control begins.

3. GOVERNOR CONTROL CHARACTERISTIC DIAGRAM

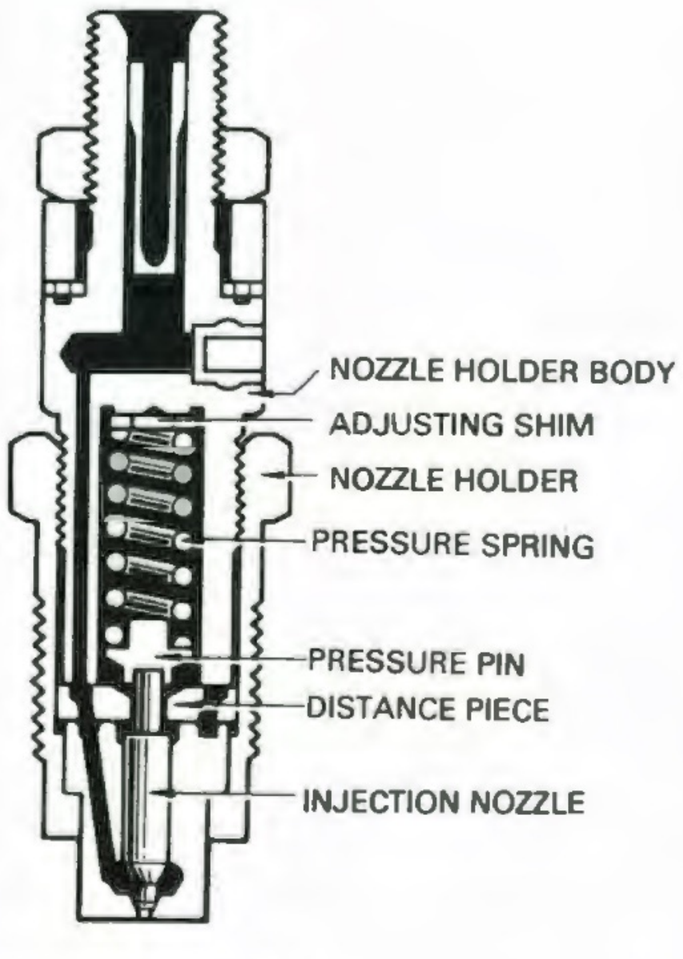


OHP-15

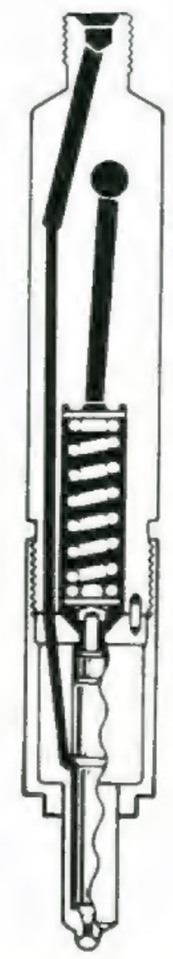
A-B-G: Start of boost pressure increased
C-D-E-O-P-F-G: Full-load control
G-H: Maximum speed control
I-J-K-M-N: Idle speed control
L: Idling point
O: Start of boost compensator operation
P: End of increase boost pressure
(sliding plate contacts full-load stopper)
① : Idling outer spring operates
② : Idling inner spring operates
③ : Control spring operates

INJECTION NOZZLES

a. The indirect injection type 2H engine has pin type throttle nozzles.
b. Since the 12H-T engine is a direct-injection type engine, the injection nozzles must be able to withstand high injection pressures. For this reason, the multi-hole type injection nozzle has been adopted.
The high injection pressure used insures good atomization and complete combustion of fuel, thus significantly reducing fuel consumption.



INJECTION NOZZLE FOR 2H



INJECTION NOZZLE FOR 12H-T

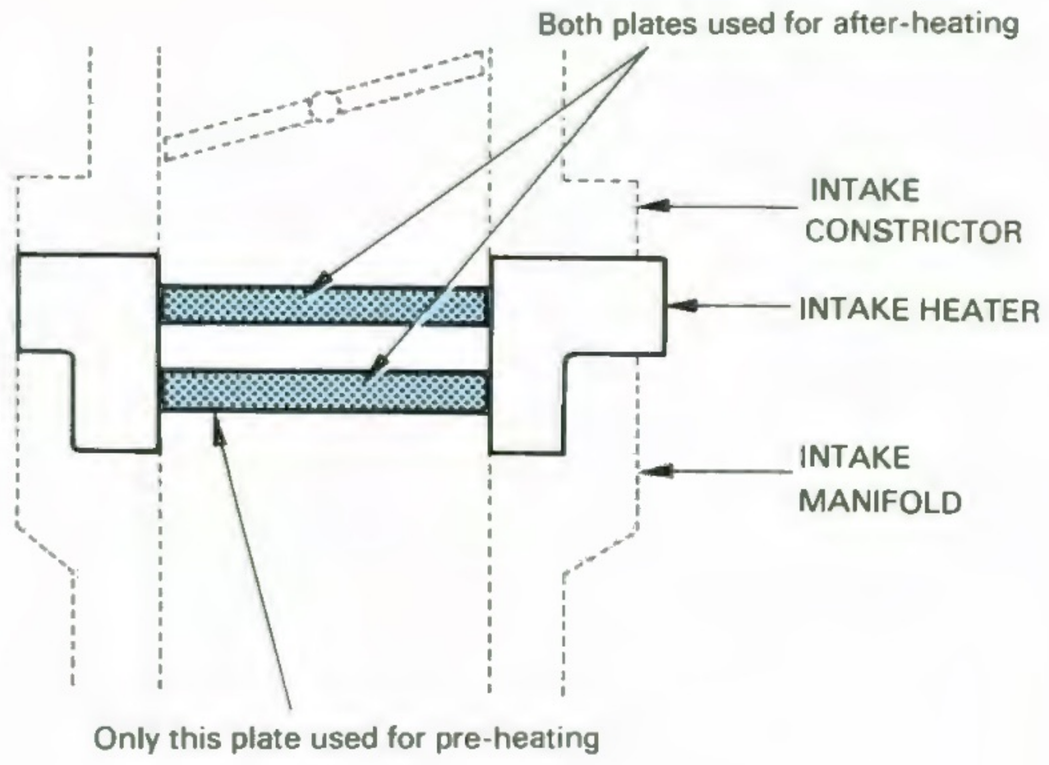
INJECTION NOZZLE SPECIFICATIONS

ITEM \ ENGINE		2H	12H-T
NOZZLE TYPE		Throttle	Multi-hole long-stem
INJECTION HOLES	NUMBER	1	5
	DIAMETER (mm)	1.0	0.25
INJECTION PRESSURE (kg/cm^2)		120	200

INTAKE HEATER SYSTEM (24-V SPEC.)

DESCRIPTION

In place of the glow type of starting assist system used with the 2H engine, an intake heter system is used on the 12H-T engine to improve starting performance under extemely cold conditions. An electrical heater mounted on the intake manifold warms ("pre-heats") the intake air before it is drawn into cylinders, thereby improving the starting performance. Once the engine has started, this heater continues to heat the intake air for a further fixed period of time ("after-heating") in order to stabilize engine idling; this also insures that a minimum of white exhaust smoke is produced.

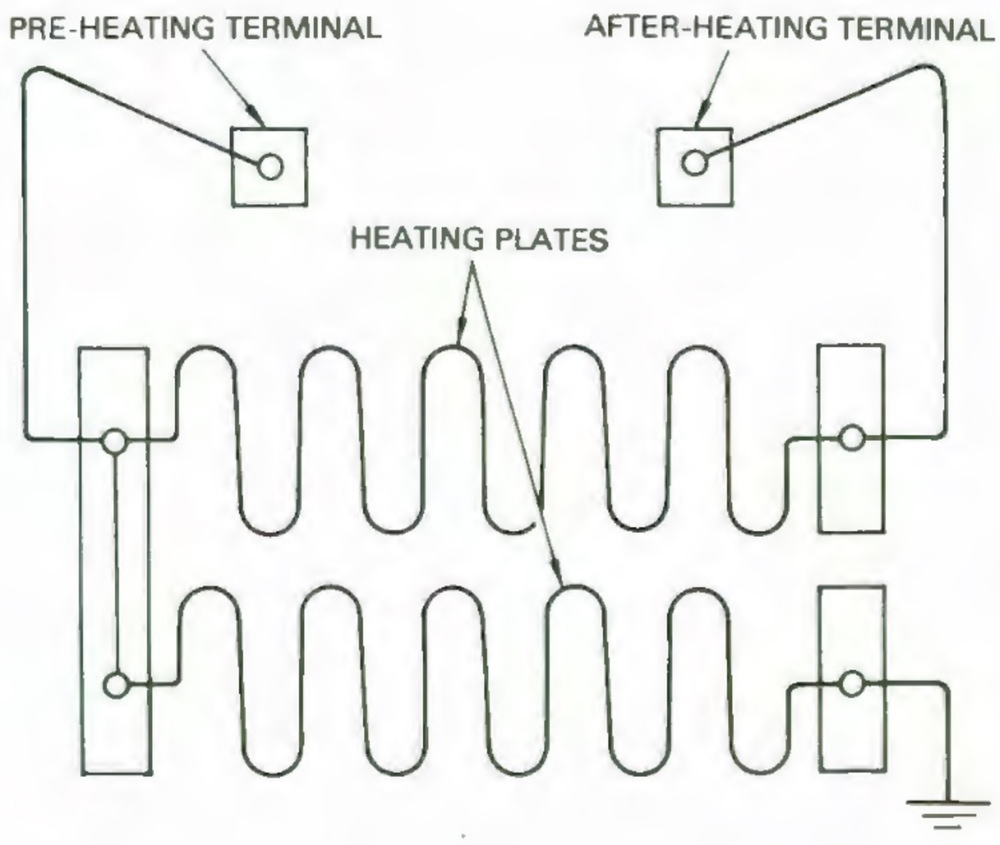


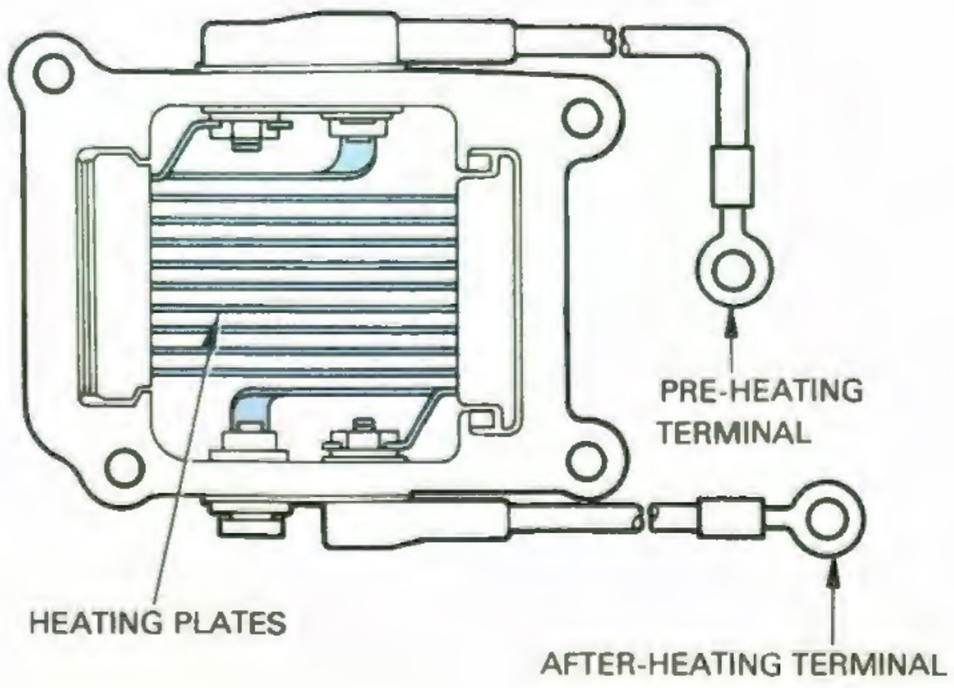
CONSTRUCTION

The intake heater system consists of the following component parts:

1. INTAKE HEATER

Mounted on the intake manifold are heating plates which generate heat when current is passed through them. This heat warms the intake air before it is drawn into the cylinders. The heating plates are arranged in two rows. Although current is only passed through one row during the pre-heating stage, both rows are heated during the after-heating stage.



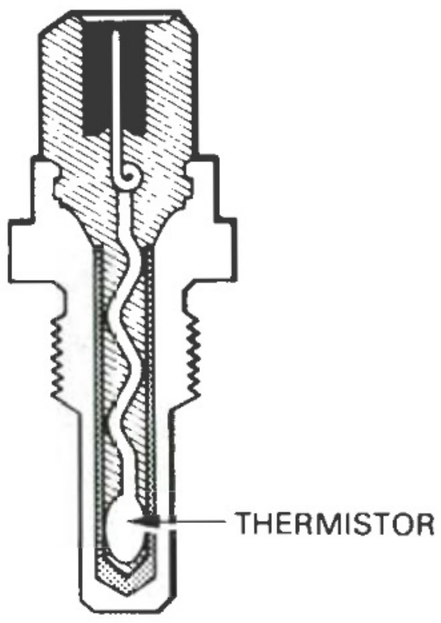


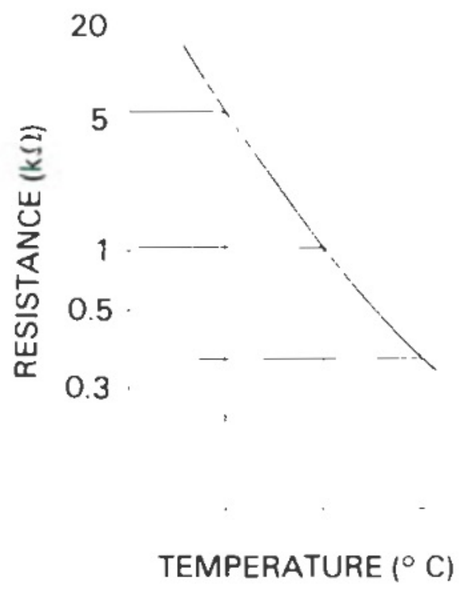
SPECIFICATIONS OF INTAKE HEATER

ITEM	PRE-HEATING	AFTER-HEATING
RATED VOLTAGE (V)	21	22.5
RATED CURRENT (A)	100	56 ± 5.6
HEATER RESISTANCE (Ω at 20° C)	0.19	0.36
HEATER TEMPERATURE (° C)	900 ± 90	900 ± 90

2. WATER TEMPERATURE SENSOR

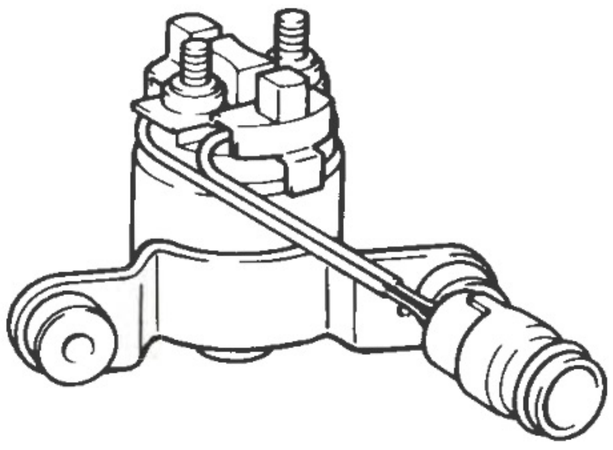
Mounted on the water inlet housing, the water temperture sensor measures the temperature of the coolant. This sensor incorporates a thermistor, whose resistance rises rapidly with temperature. The sensor is therefore aboe to convert temperature into a resistance value.

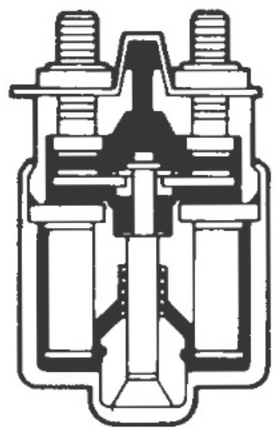




3. RELAYS

These two relays pass current from the battery to the heating plates of the intake heater during both pre-heating and after-heating. These relays are identical and are mounted on the inside of the right-hand front fender.



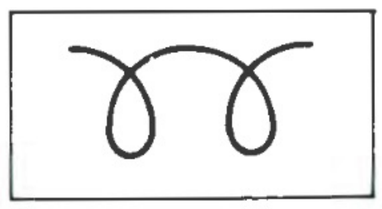


RELAY SPECIFICATIONS

RATED VOLTAGE	(V)	24
MINIMUM OPERATING VOLTAGE	(V)	9
RATED COIL CURRENT	(A)	1.7
CONTACT CURRENT CAPACITY	(A)	150 (5 seconds)

4. INTAKE HEATER INDICATOR

The intake heater indicator light mounted on the instrument panel lights up during pre-heating and also comes on to warn the driver when there is a malfunction in the system. It uses the same symbol as that used for the glow indicator light:

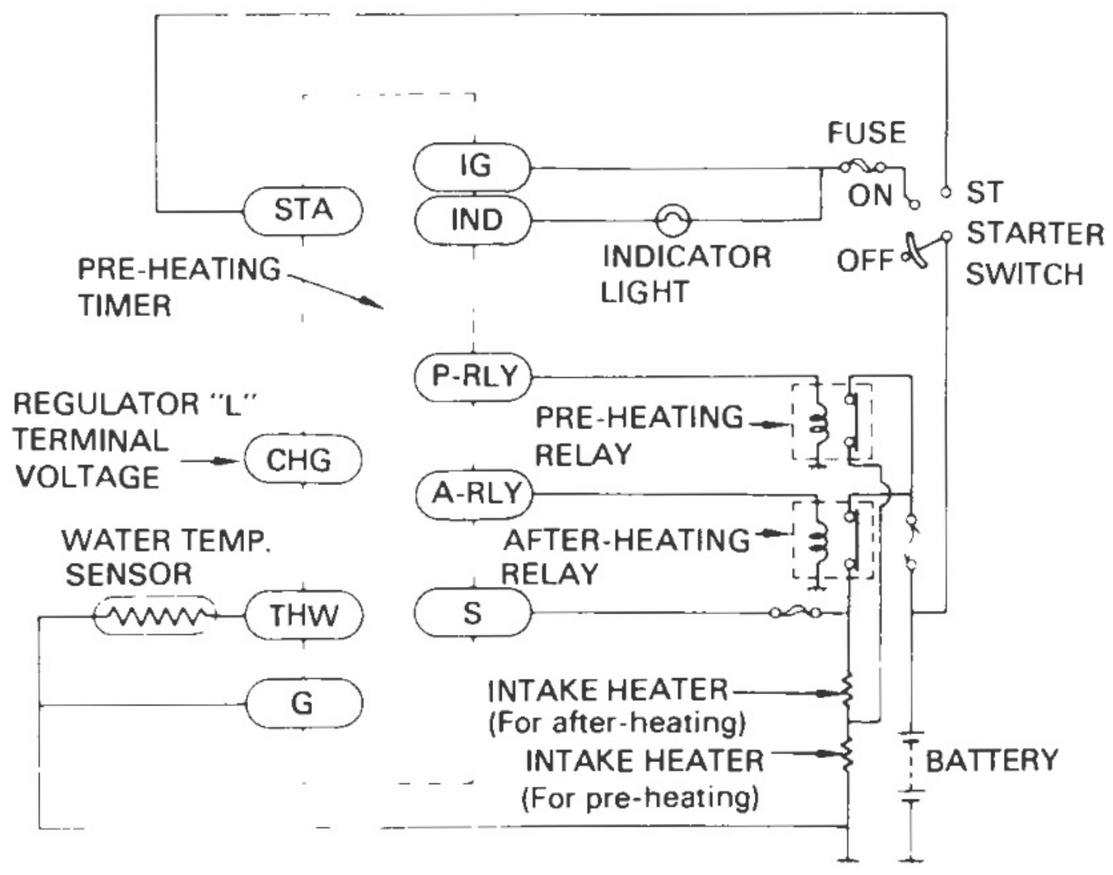


— NOTE —

This light does not go on during after-heating.

5. PRE-HEATING TIMER

The pre-heating timer determines which relay(s) to activate for pre-heating and after-heating depending upon the starter switch position, coolant temperature, and the presence or absence of a starter signal and alternator regulator terminal "L" voltage. The length of time that current is passed through these relays varies with the coolant temperature.



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ON	STARTER SWITCH ON
IND	INDICATOR LIGHT
P-RLY	PRE-HEATING RELAY
A-RLY	AFTER-HEATING RELAY
S	MALFUNCTION CHECK
STA	STARTER
CHG	CHARGE
THW	THERMO
G	GROUND

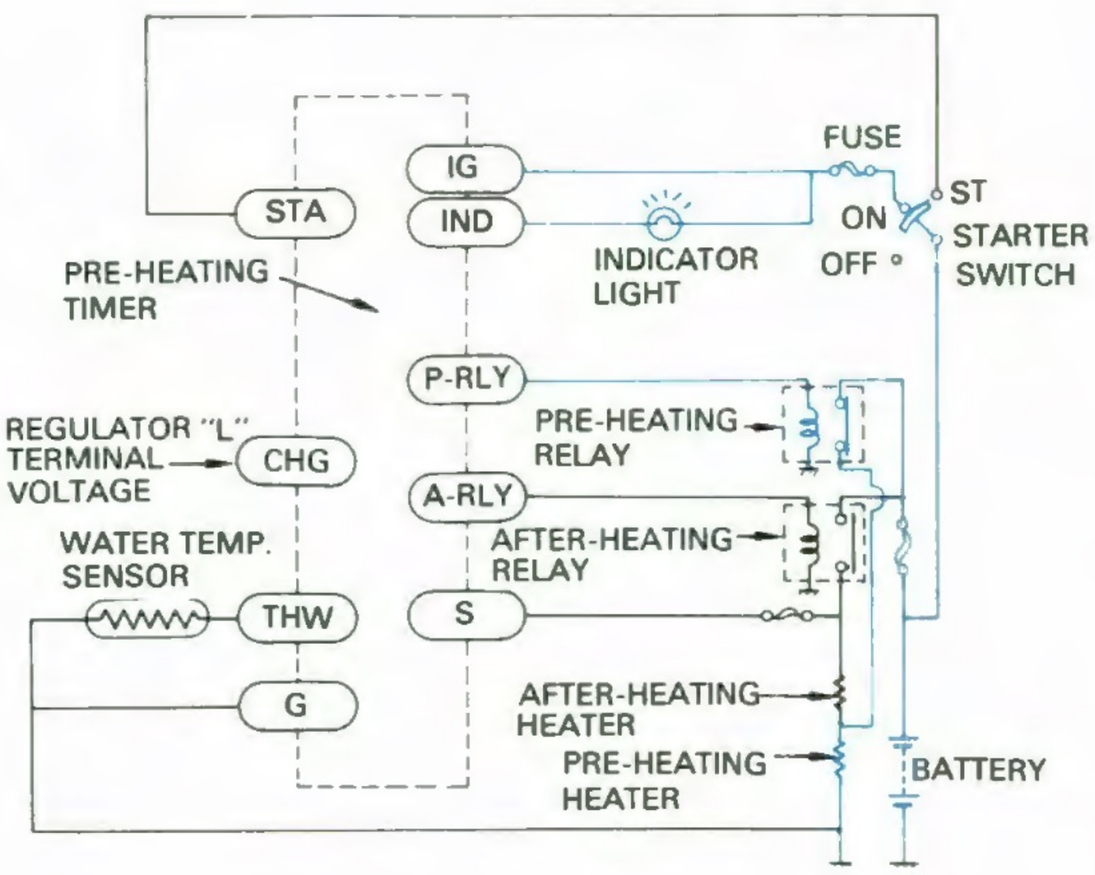
— NOTE —

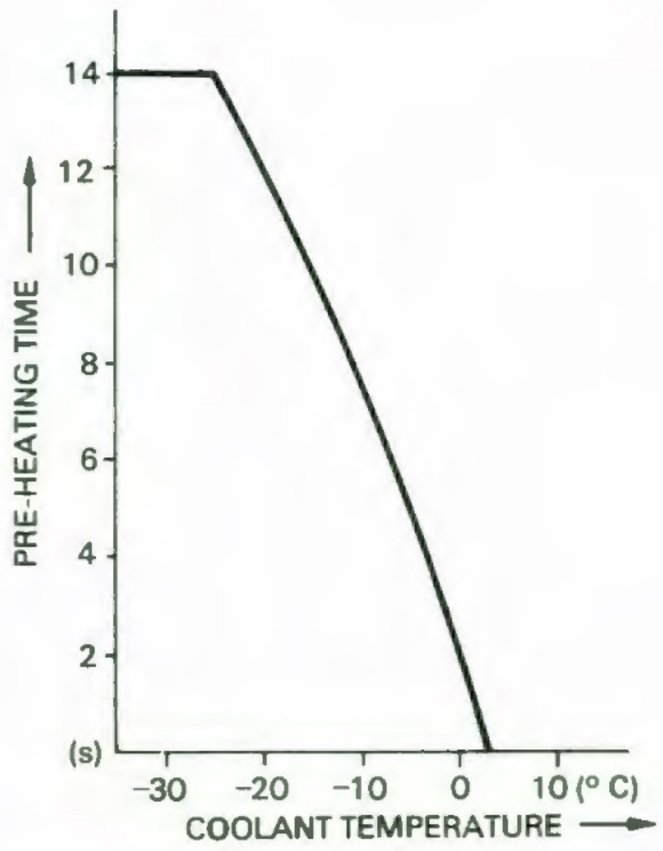
The S (MALFUNCTION CHECK) terminal is used by the pre-heating timer to check for heater or relay malfunctions.

OPERATION

1. COOLANT TEMPERATURE BELOW 2.5°C

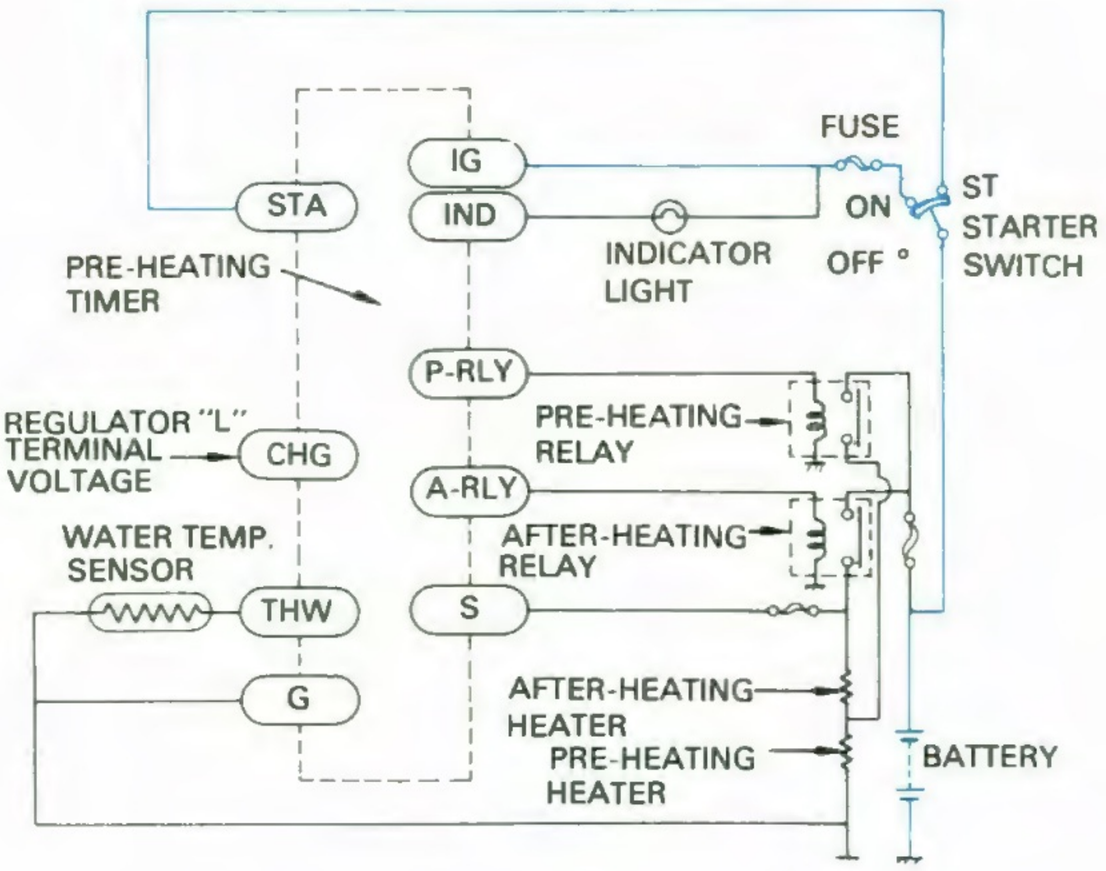
a. When the starter switch is first switched on, the pre-heating timer switches the intake heater indictor light on. At the same time, the pre-heating relay switches on to pass current through the pre-heating plate in the intake heater, and thus warm the intake air. The pre-heating time (T_1) depends on the coolant temperature, but the maximum time is 14 ±2 seconds.





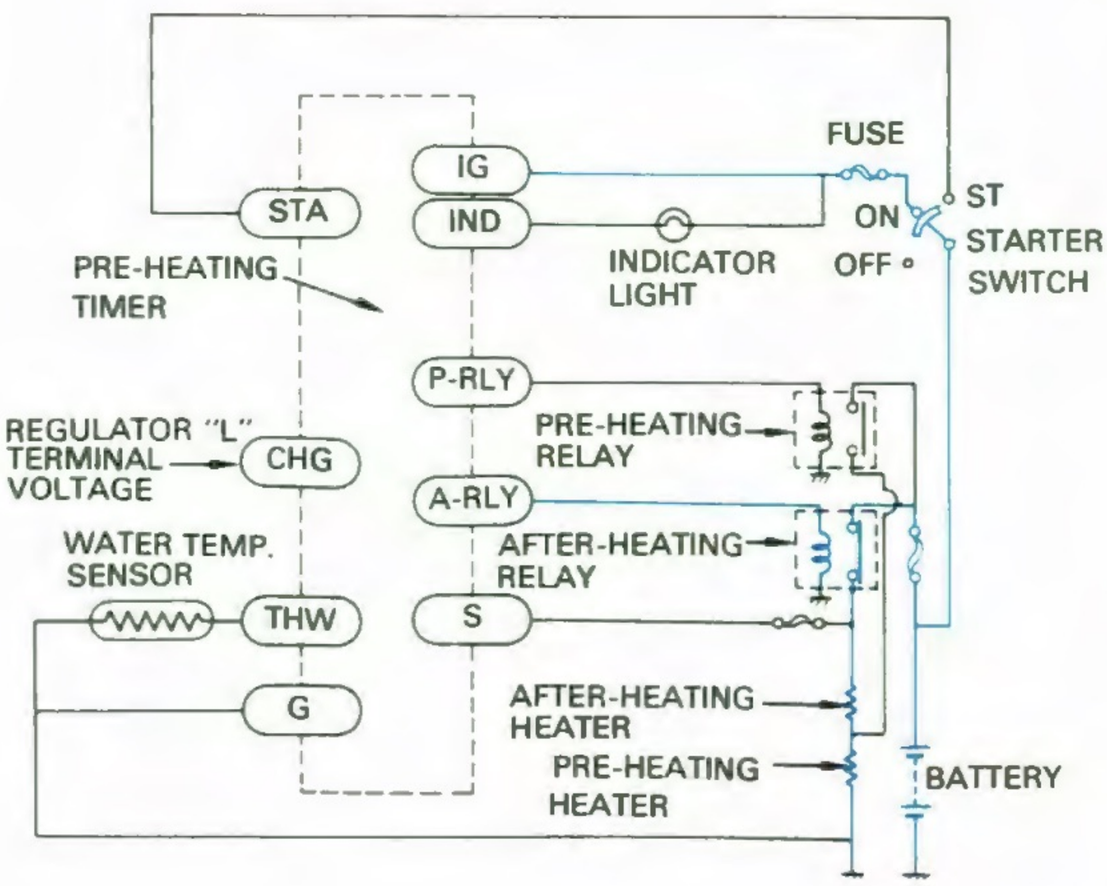
RELATIONSHIP BETWEEN PRE-HEATING TIME (T_1) AND COOLANT TEMPERATURE

b. Turning on the starter during this pre-heating period causes the timer to switch off the pre-heating relay (the indicator light also goes out). The timer does this because all available current is required for starter operation.



c. Once the engine has started, the pre-heating timer switches off the after-heating relay when it detects the voltage from alternator regulator terminal "L". Current then passes through both pre- and after-heating plates to begin after-heating. The maximum after-heating time (T_2) is 70 ±10 seconds.

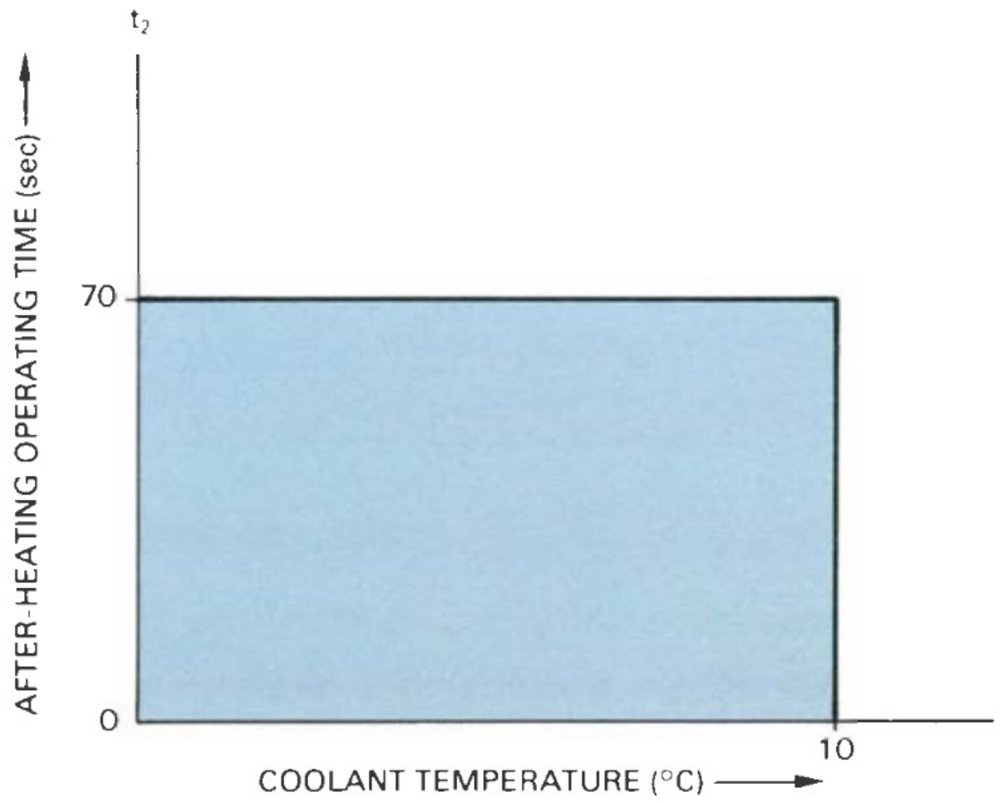
Note that the indicator light does not come on during after-heating.



2. COOLANT TEMPERTURE BETWEEN 2.5°C and 10°C

If the engine is started with the coolant temperature in the above range, the pre-heating timer does not initiate the pre-heating process, but only after-heating.

After 70 ±10 seconds, or as soon as the coolant temperature exceeds 10° C, the pre-heater timer switches the after-heating relay off to terminate after-heating.



3. COOLANT TEMPERATURE ABOVE 10° C

In this case, neither pre-heating nor after-heating takes place.

4. INTAKE HEATER OR RELAY MALFUNCTION

If an intake heater malfunctions, or if relay points fuse, the pre-heating timer switches on the intake heater indicator light to alert the driver of the malfunction.

a. INTAKE HEATER MALFUNCTION

If either the pre-heating heater or after-heating heater malfunctions, the pre-heating timer switches on the indicator light to alert the driver that the intake heater system is not operating normally.

b. FUSED RELAY POINTS

If points in either of the pre-heating or after-heating relay fuse, the intake heater system will remain on, continuously drawing a large amount of current. The pre-heating timer therefore again switches the indicator light on to warn the driver of the malfunction.

— NOTES —

a. If a malfunction occured when the vehicle was last driven, or ocurs during pre-heating, the pre-heating timer causes the indicator light to stay on even after pre-heating has ended.

b. If a malfunction occurs during after-heating, the pre-heating timer causes the indicator light to go on after the completion of after-heating.

INTAKE HEATER SYSTEM (12-V SPEC.)

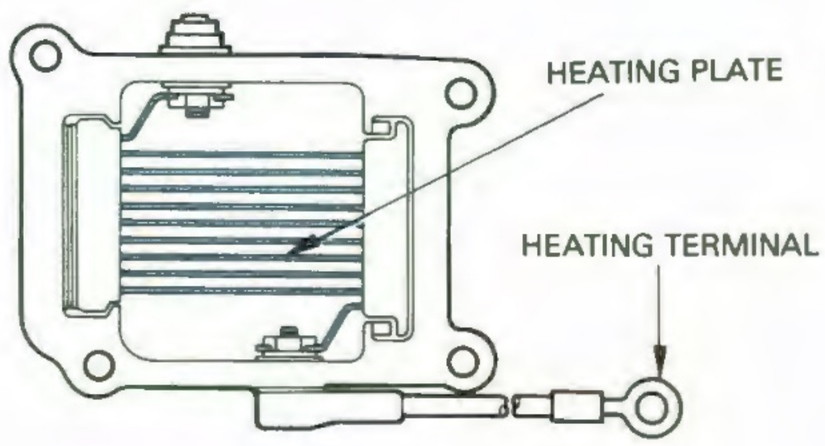
DESCRIPTION

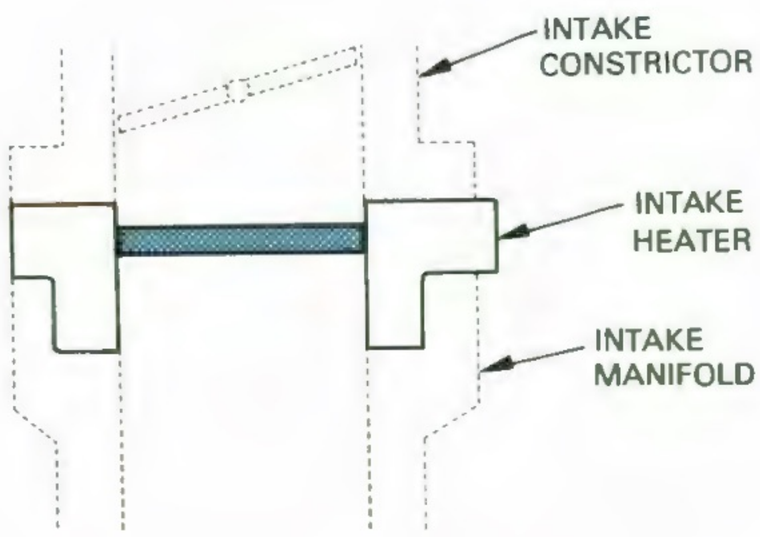
This section describes the 12-volt intake heater system. The construction and opertion are essentially the same as those of the 24-volt intake heater system, so only the points in which the two systems differ will be explained.

CONSTRUCTION

1. INTAKE HEATER

While the 24-volt intake heater has two heating plates, the 12-volts system has only one. This single heating plate is used for both pre- and after-heating.





INTAKE HEATER SPECIFICATIONS

	PRE- & AFTER-HEATING
RATED VOLTAGE (V)	10.5
RATED CURRENT (A)	56 ± 5.6
HEATER RESISTANCE (Ω at 20° C)	0.17
HEATER TEMPERATURE (° C)	900 ± 90

2. WATER TEMPERATURE SENSOR

The water temperature sensor functions in exactly the same as way that in the 24-V system. The only difference is in the voltage rating (12 V).

3. RELAYS

The same 12-volt relays are used for both pre- and after-heating.

4. INTAKE HEATER INDICATOR LIGHT

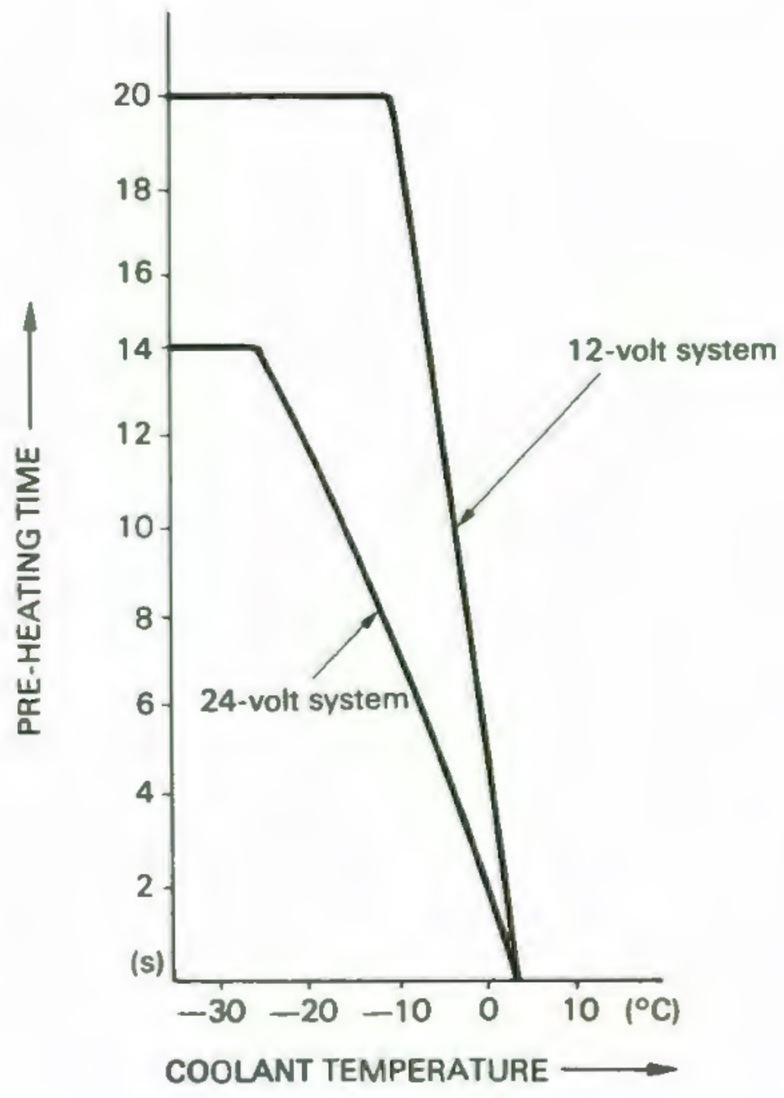
The only difference is in the voltage rating (12 V).

5. PRE-HEATING TIMER

The 12-volt pre-heating timer is essentially the same as the 24-volt one. Only the voltage rating is different.

OPERATION

This is the same in all respects as for the 24-volt system except that the maximum pre-heating time (T_1) is longer: 20 ±3 seconds.



PRE-HEATING TIME (T_1) *VS* COOLANT TEMPERATURE

GLOW SYSTEM

DESCRIPTION

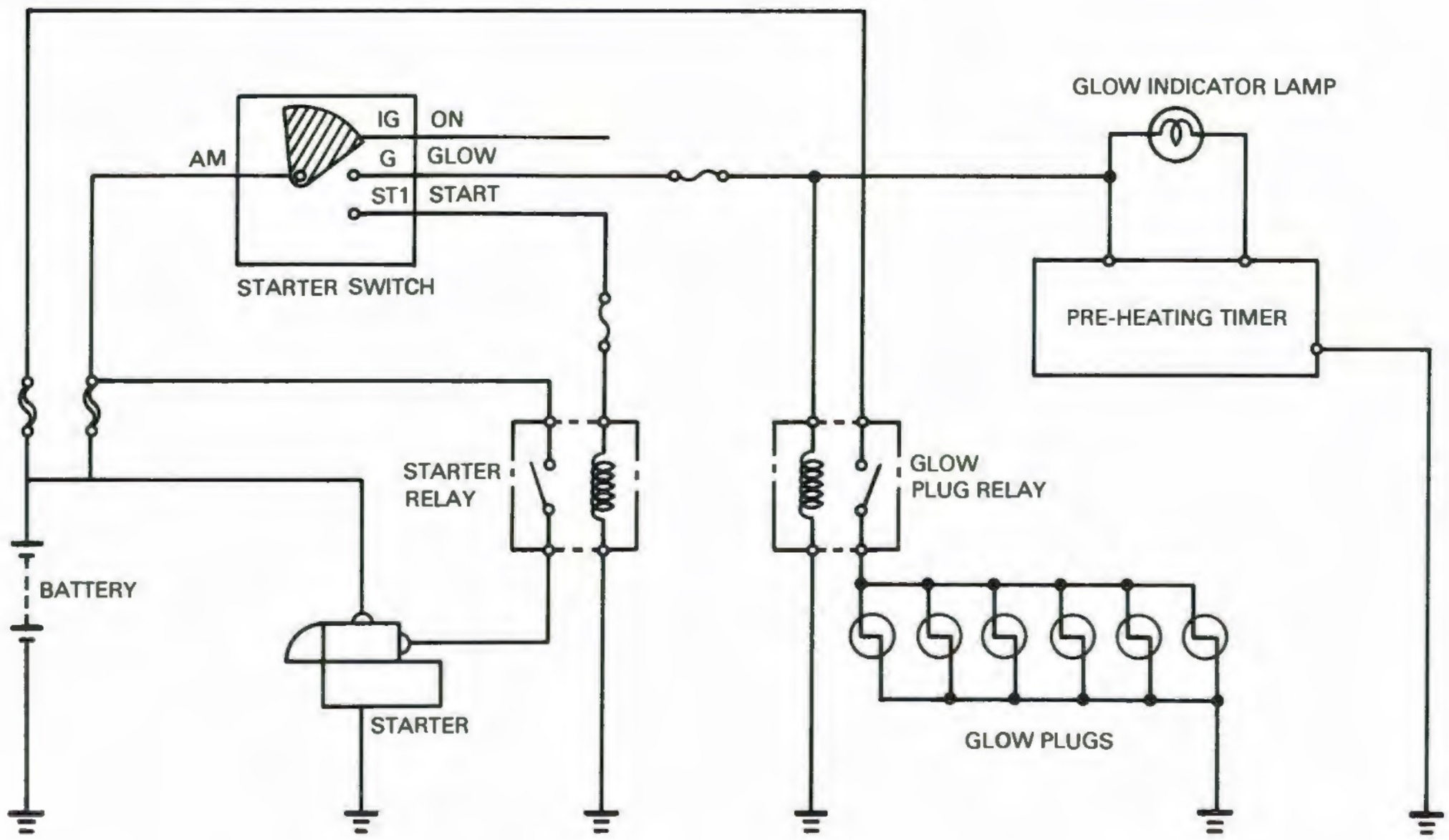
The 2H engine is provided with a pre-heating glow system to improve startability. There are two glow system types, the fixed-delay type and the super-glow type; which is used depends upon the destination of the vehicle.

The operation of each type of glow system will be explained on subsequent pages. However, the following items are applicable to both systems and should be noted when troubleshooting and/or giving instruction.

- The glow indicator light operates independently of the glow plug heating system and does not indicate whether the plugs have actually heated up or not. Therefore, when troubleshooting for hard starting problems (including rough idling when the engine is cold), glow plugs should be checked one by one even if the glow indicator is functioning normally.
- The rated voltage of the glow plugs differs depending on the glow system. Therefore, the correct type of glow plugs should always be used. This can be found by referring to the parts catalogue. Use of incorrect glow plugs will cause premature burning out or insufficient heating.

FIXED-DELAY TYPE

This pre-heating system keeps the glow indicator light lit for a fixed time of approximately 17 seconds in accordance with the operation of the pre-heating timer. When this light goes off, pre-heating is completed and the engine is ready for starting.



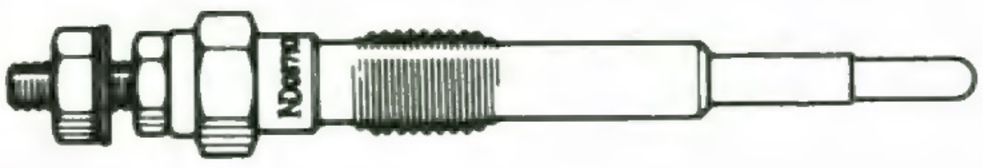
ELECTRICAL CIRCUITRY OF FIXED-DELAY TYPE

OPERATION

a. When the starter switch is placed in the G (glow) position, the glow plug relay operates, allowing the current to flow from the battery to the glow plugs to begin pre-heating. At this time, the glow indicator light will also come on in accordance with timer operation.
b. The timer will turn off the indicator light after approximately 17 seconds, telling the driver that the engine is ready for cranking.
c. Even after the indicator light goes off, the glow plug relay will remain on, allowing current to flow to the glow plugs for continuous pre-heating.
d. When the starter switch is turned to the ST position for cranking, the glow plug relay will remain on because current is still passing through it from the G terminal of the starter switch.
e. If the starter switch should again happen to be placed in the G (glow) position after the completion of pre-heting, the glow indicator light will light up for a shorter time if the capacitor in the timer has not been completely discharged.

GLOW PLUG SPECIFICATIONS

Voltage system	12 V
Rated voltage	10.5 V



SUPER-GLOW TYPE

Super-glow is a system in which pre-heating is quickly completed by applying relatively high battery voltage to the low-voltage-rated glow plugs in order to shorten the driver's waiting time for engine starting. However, the glow plugs have to be kept below a predetermined temperature to prevent them from overheating.

In addition to this quick pre-heating operation, an after-glow function is provided to improve combustion in cold weather in order to reduce white exhaust smoke and diesel knocking.

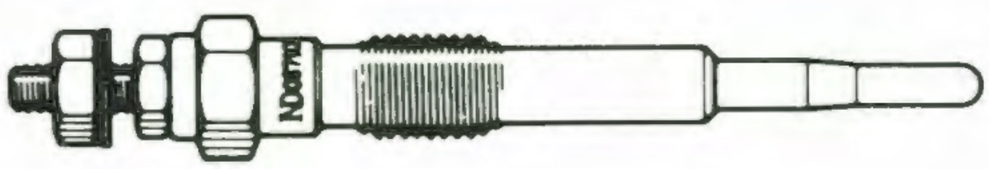
The super-glow system is composed of low-voltage-rated glow plugs, glow plug resistor, coolant temperature sensor, glow plug current sensor, and pre-heating timer. Each of these components functions as follows:

1. GLOW PLUGS

The glow plugs used are a rapid-heating type with a low voltage rating. Depending upon the heating time (required time to reach 800°C with the rated voltage applied at 20° C) of the glow plug, rated voltage differs as shown below:

GLOW PLUG SPECIFICATIONS

Voltage system	12 V	24 V
Rated voltage	6 V	14 V

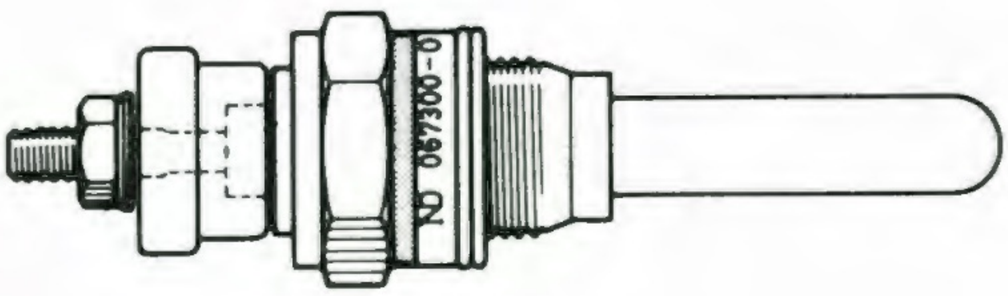


— CAUTION —

When testing super-glow plugs, do not apply battery voltage to them for more than five seconds, as this may cause them to burn out.

2. GLOW PLUG RESISTOR

This resistor reduces the voltage applied to the glow plugs. When the No. 1 glow plug relay is off (i.e., glow plug temperature is raised to approximately 800° C), current flows to the glow plugs through this resistor.



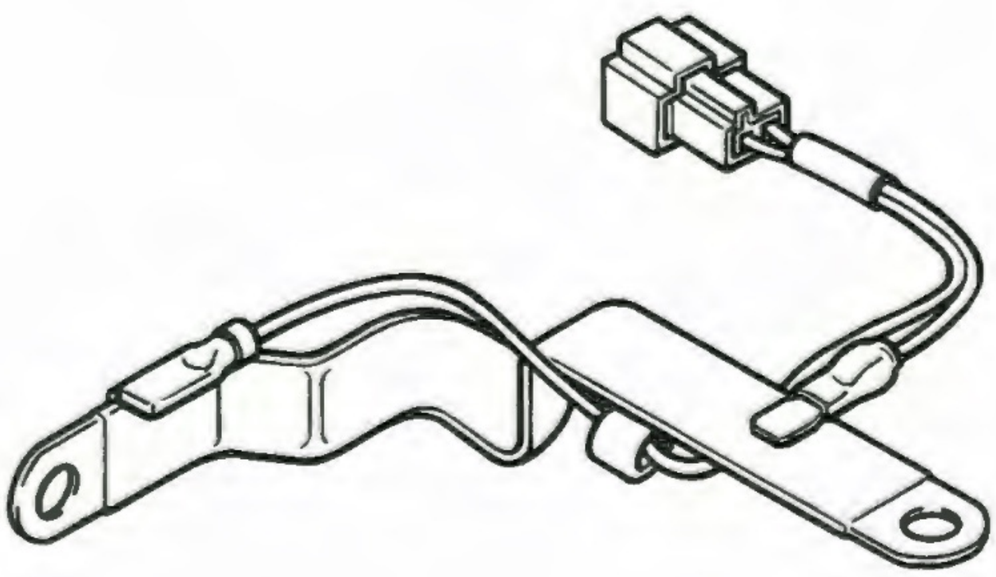
— NOTE —

Both the 12-V and 24-V systems have been equipped with two glow plug resistors. However, the 12-V system uses only one of them. The other resistor is used as a hole plug.

The glow plug resistors for the 24-V system are connected in series.

3. GLOW PLUG CURRENT SENSOR

This sensor maintains an almost constant resistance even if its temperature changes. However, as the resistance value of the glow plugs reatly changes with variations in their temperature, the pre-heating timer detects the voltge difference at each end of this sensor to maintain glow plug temperature between 750 and 900° C.



4. WATER TEMPERATURE SENSOR

A water temperature sensor is equipped on the cylinder head. An internal thermistor detects changes in coolant temperature by means of differences in resistance, and sends a signal to the pre-heating timer.

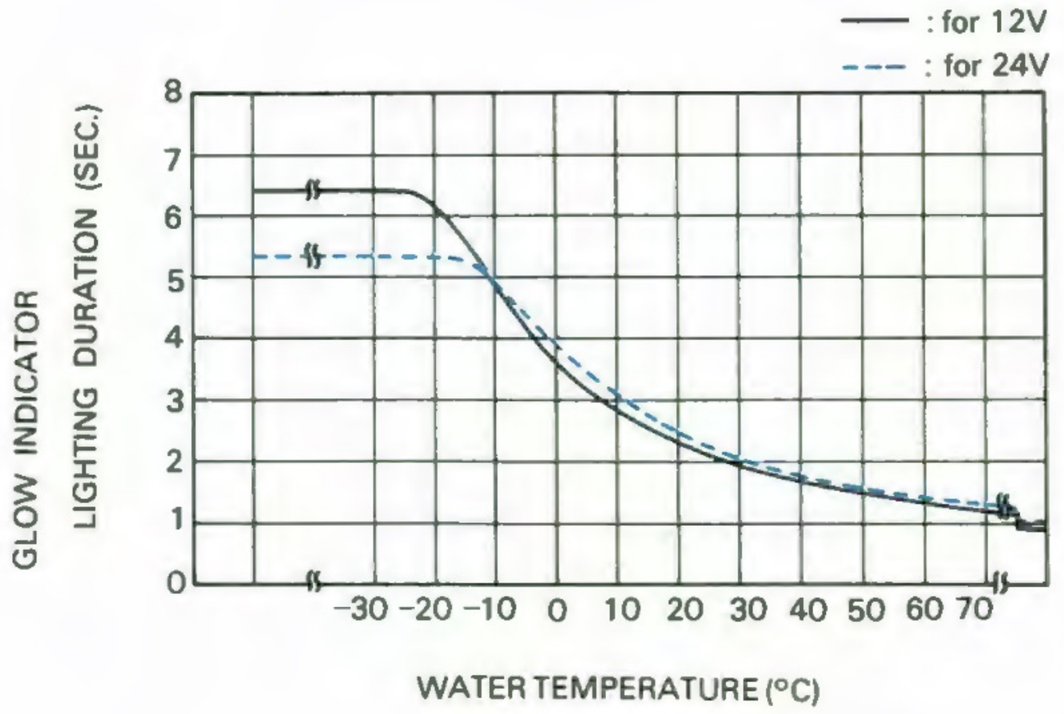
5. PRE-HEATING TIMER

a. The pre-heating timer is kept informed of coolant temperature by means of the coolant temperature sensor and causes the glow indicator light to illuminate in accordance with coolant temperature (see the graph of T_1 glow indicator lighting time on the next page).

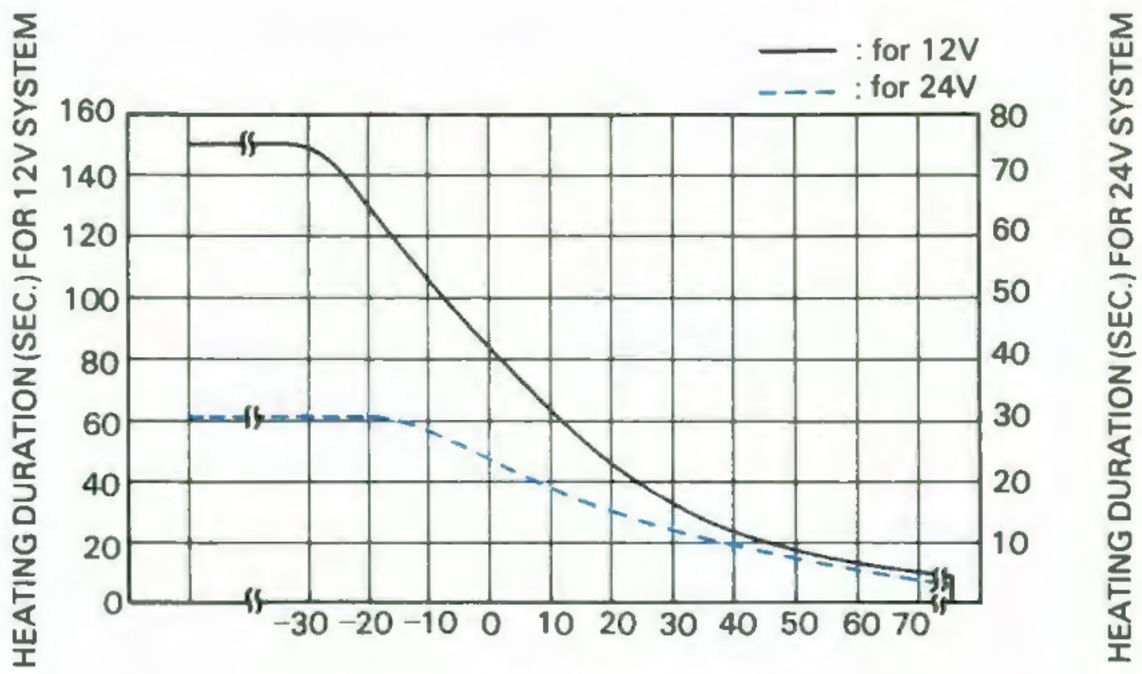
b. The pre-heating timer also controls pre-heating time and after-glow time in accordance with the temperature of the coolant (see the graph of T_2 heating time).

c. By detecting voltage variations at both ends of the glow plug current sensor, the pre-heating timer controls glow plug temperature, keeping it between 750° and 900° C.

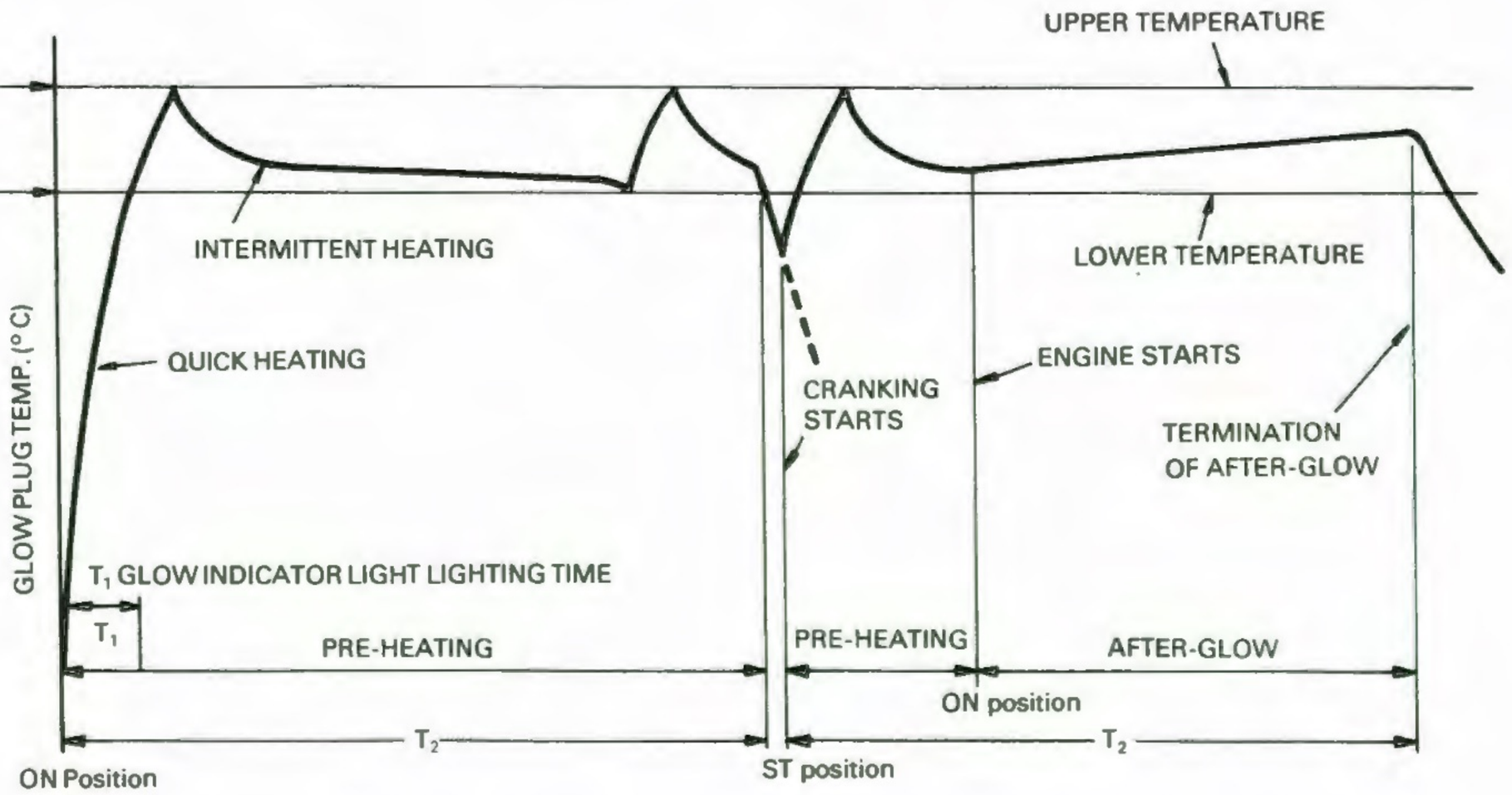
d. After the engine has started, the pre-heating timer lowers the voltage applied to the glow plugs and switches to after-glow.



T_1 GLOW INDICATOR LIGHT LIGHTING TIME



T_2 HEATING TIME



Preheating duration controlled by timer B for T_2 time period depending on coolant temperature.

Also controlled by timer B for $T_2$2 time period.

SUMMARY OF PRE-HEATING & AFTER-GLOW OPERATION

6. OPERATION

STARTER SWITCH "ON"

a. When the starter switch is turned to the ON position, the glow indicator lamp is illuminated due to timer A operation for T_1 time period (1 to 6 seconds, depending on the coolant temperature). (TR_3 comes on.)

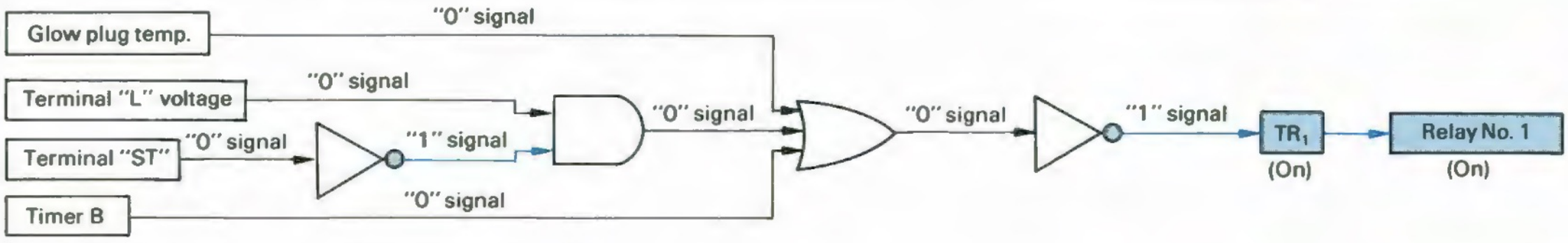
b. At the same time that the glow indicator illuminates, glow plug relay No. 1 is also turned on by TR_1 as shown below to allow current to flow from the battery to the glow plugs via the glow plug current sensor. The glow plugs are therefore quickly heated. (TR_1 on, TR_2 on)

OPERATION OF LOGIC GATES

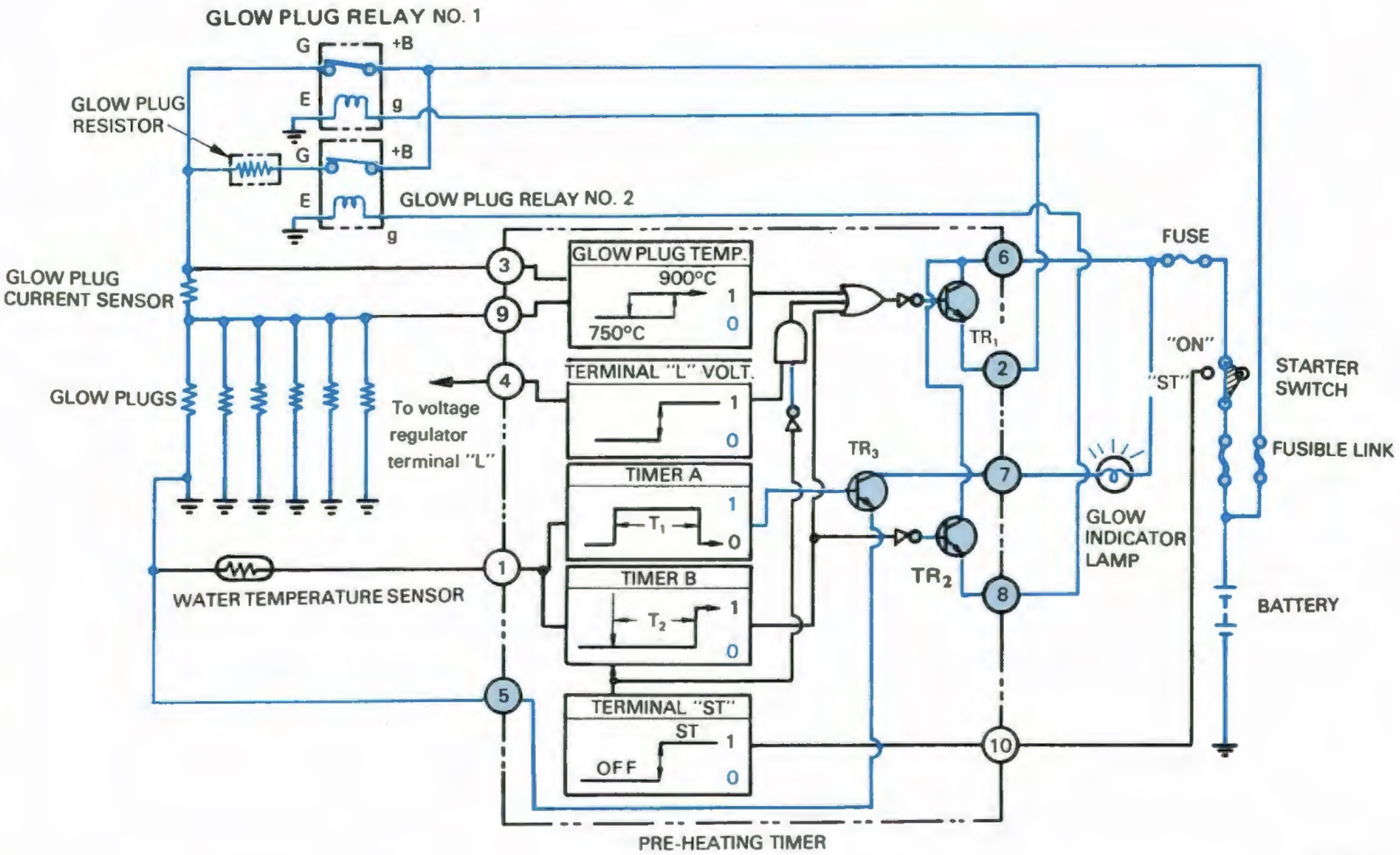
NOT Circuit — Reverses input signal: "1" input → "0" output, "0" input → "1" output

OR Circuit — If *either* input is "1", output will be "1"

AND Circuit — Output will be "1" only if *both* inputs are "1"



Glow plug relay No. 2 is also turned on (by TR_2) at the same time as glow plug relay No. 1, but the current flows only through relay No. 1 due to the glow plug resistor.



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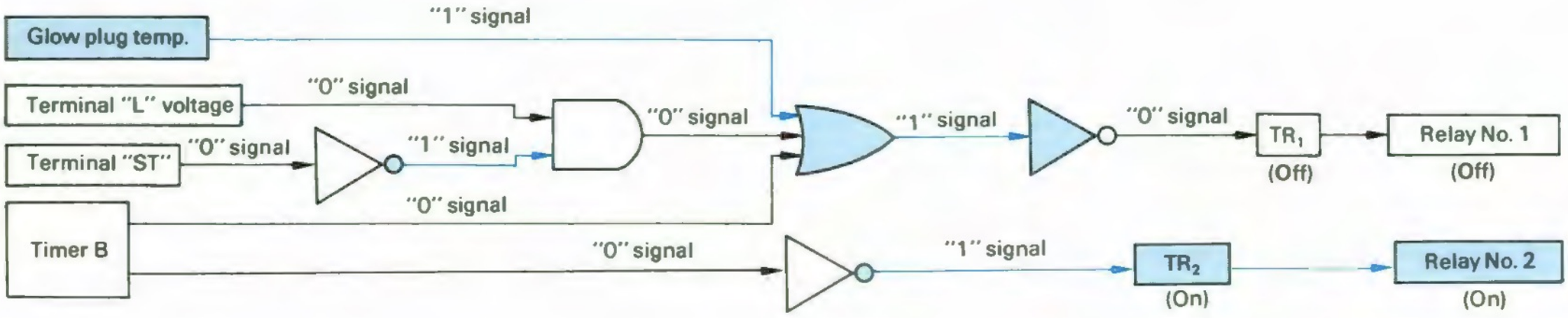
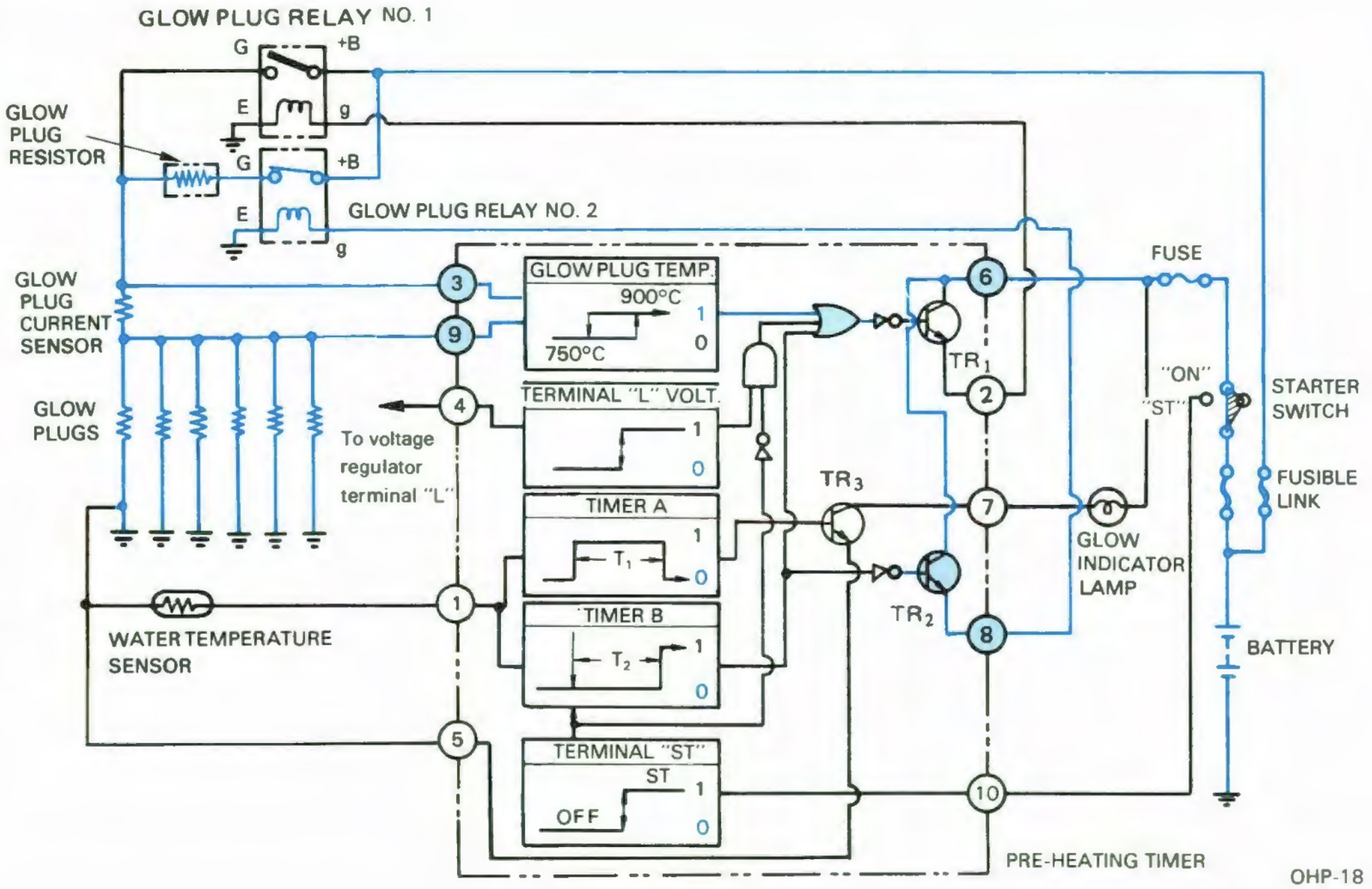
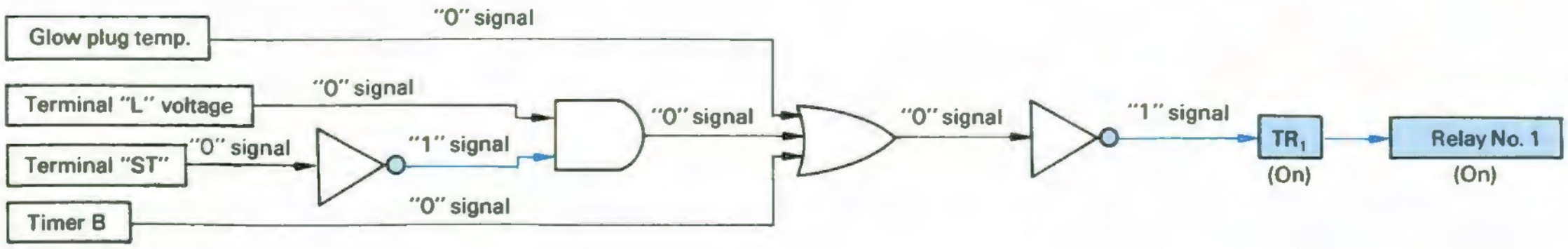
c. When the glow plug temperature reaches 900° C, the pre-heating timer detects the voltage change of the glow plug current sensor as a temperature change and turns off glow plug relay No. 1 to prevent the glow plugs from overheating



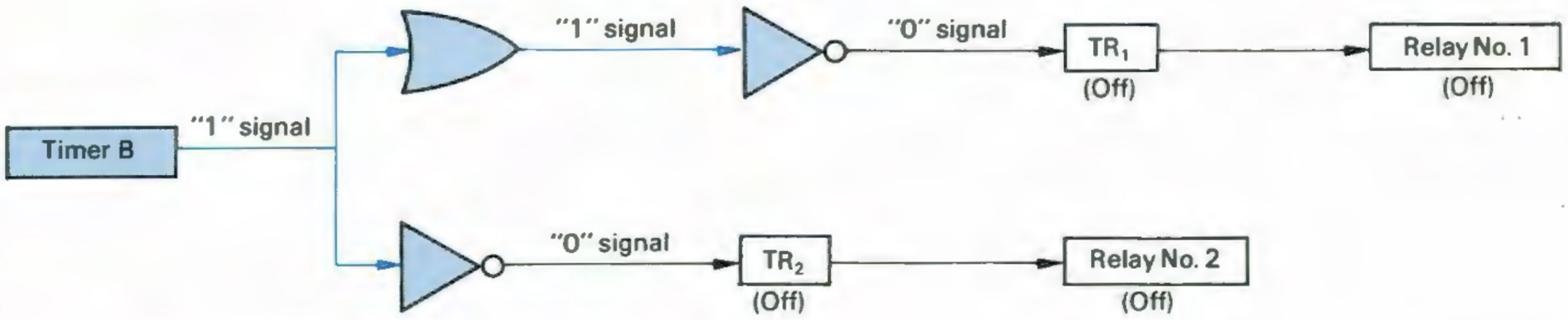
When glow plug relay No. 1 is turned off, the current to the glow plugs passes through the glow plug resistor, so the glow plug temperature drops.



d. When the glow plug temperature reaches 750° C, glow plug relay No. 1 is again turned on, and the glow plug temperature quickly rises.

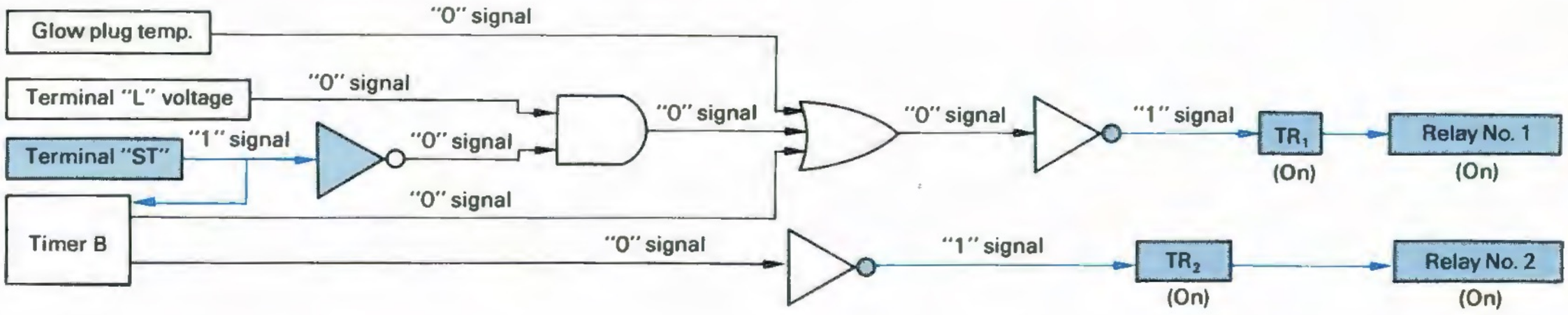


e. The pre-heating timer keeps the glow plug temperature in a set range (750° C—900° C) by repetition of the above steps while Timer B is on, in accordance with the coolant temperature. When T_2 time elapses, pre-heating ends.



ENGINE STARTING

When the starter switch is turned to ST (start), timer B is again activated by a signal from terminal "ST". Therefore, TR_2 comes on and, if the glow plug temperature is less than 900° C, TR_1 also comes on, and rapid pre-heating is effected until the engine is started. To keep glow plug temperature between 750° C and 900° C, TR_1 repeats its on-off operation in accordance with the glow plug temperature.



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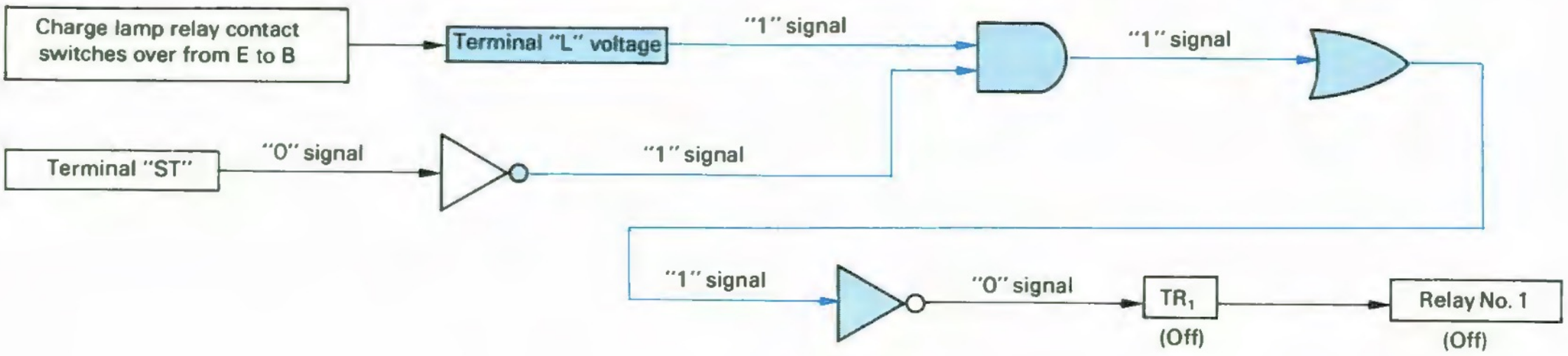
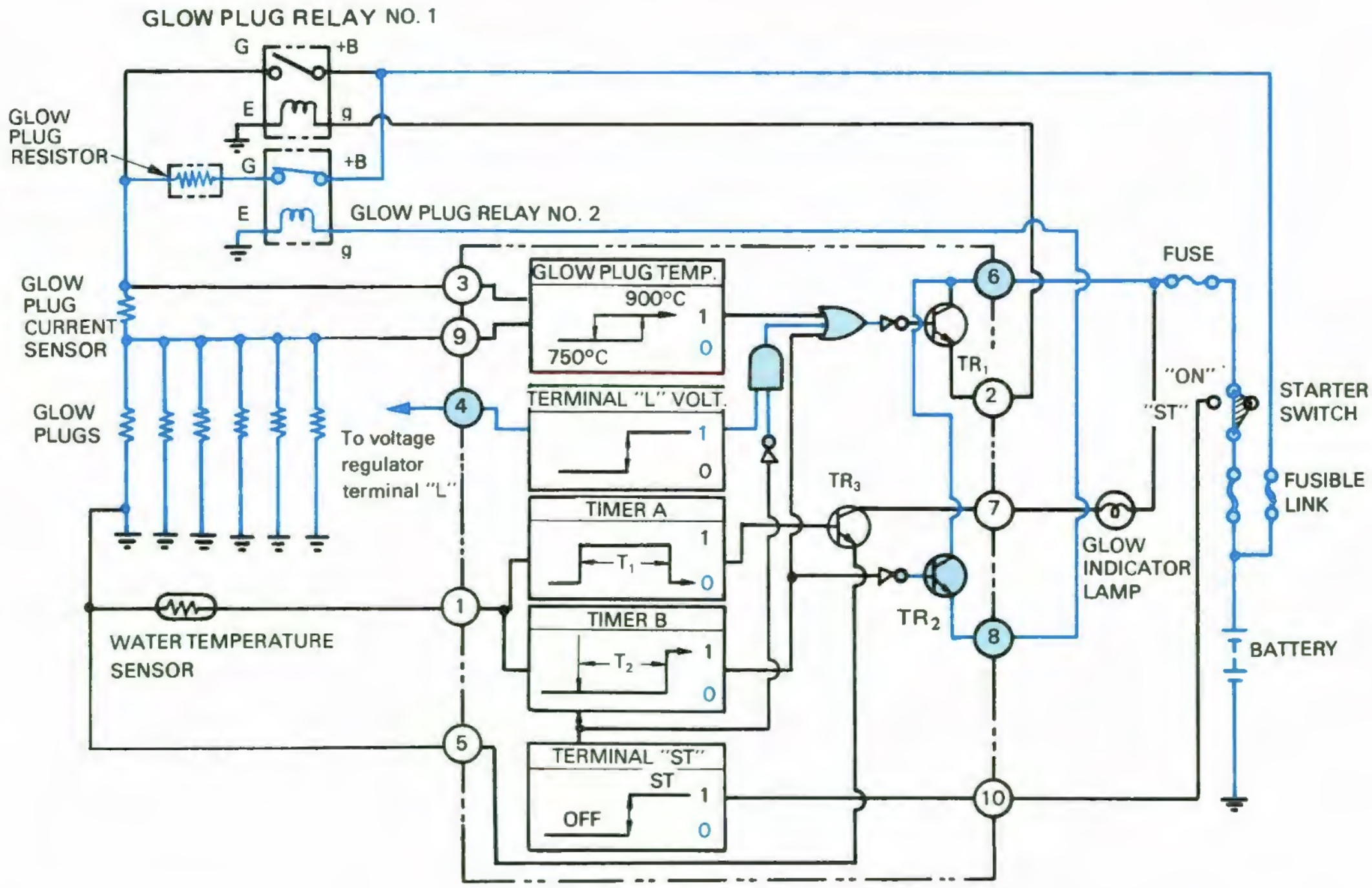
AFTER ENGINE STARTS

a. After the engine starts, the voltge of terminal "L" rises from zero to battery voltge (because the charge lamp relay contact in the point type voltage regulator switches over from E to B) due to the generation of voltage by the alternator. TR_1 therefore goes off, terminating pre-heating.



b. Because timer B is still on (TR_2 on), current flows from the battery to the glow plugs through glow plug relay No. 2 and the glow plug resistor to effect after-glow.



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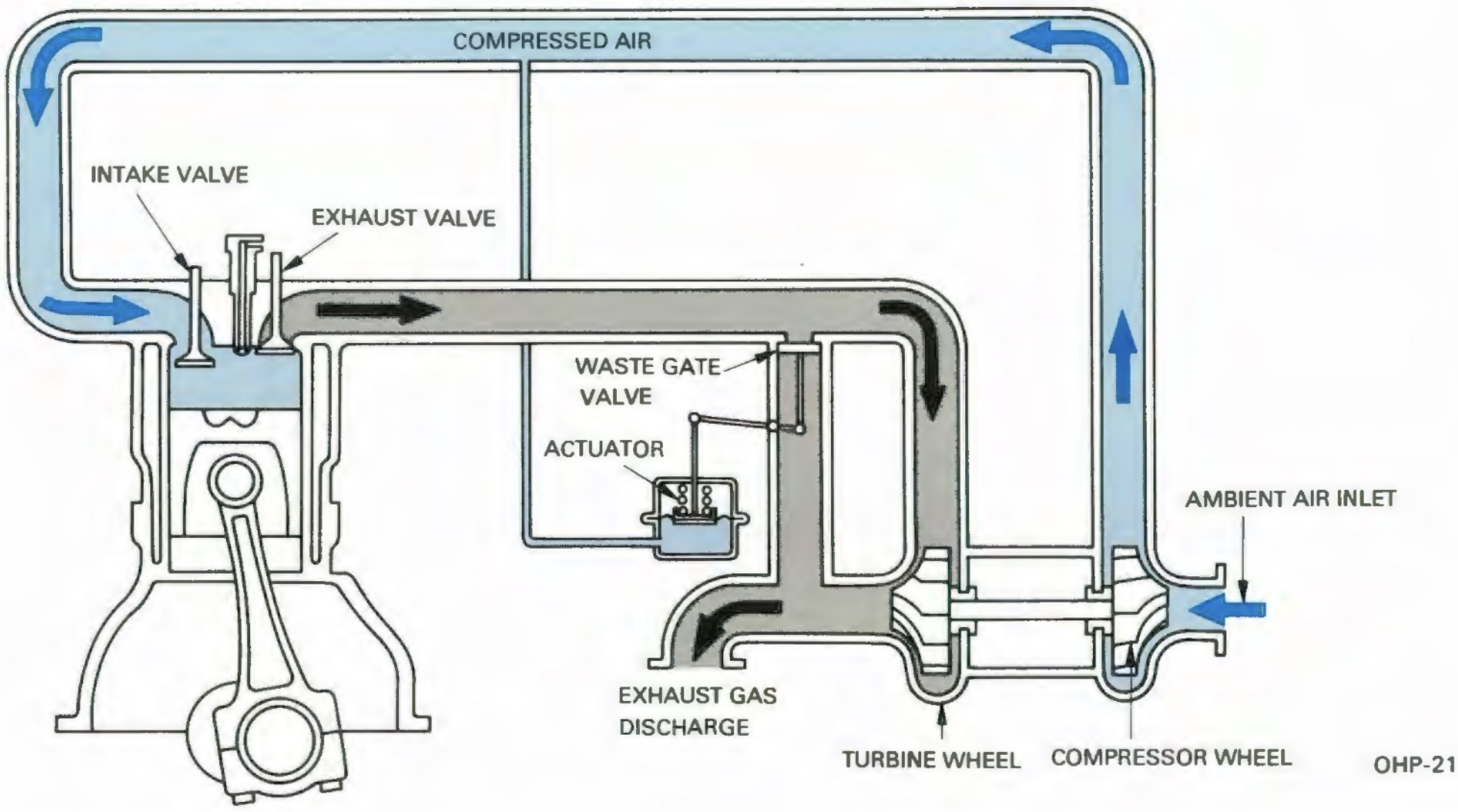
c. The duration of T_2 after-glow is controlled by timer B in accordance with engine coolant temperature.

TURBOCHARGER SYSTEM

DESCRIPTION

A turbocharger is a device which utilizes the wasted heat energy of the exhaust gas to increase the volume of air supplied to the engine over the normal volume, thus improving the engine's output and fuel consumption. There are various methods that can be used to increase the engine's output, but since the engine's output is determined by the volume of air-fuel mixture burnt per unit time, the most effective method is to feed more mixture or air into the cylinder.

Therefore, providing the engine with a turbocharger, which not only supplies the cylinders with more air than normal, but also raises the pressure during combustion, makes it possible to maximize engine output without increasing the volume of exhaust gas produced.



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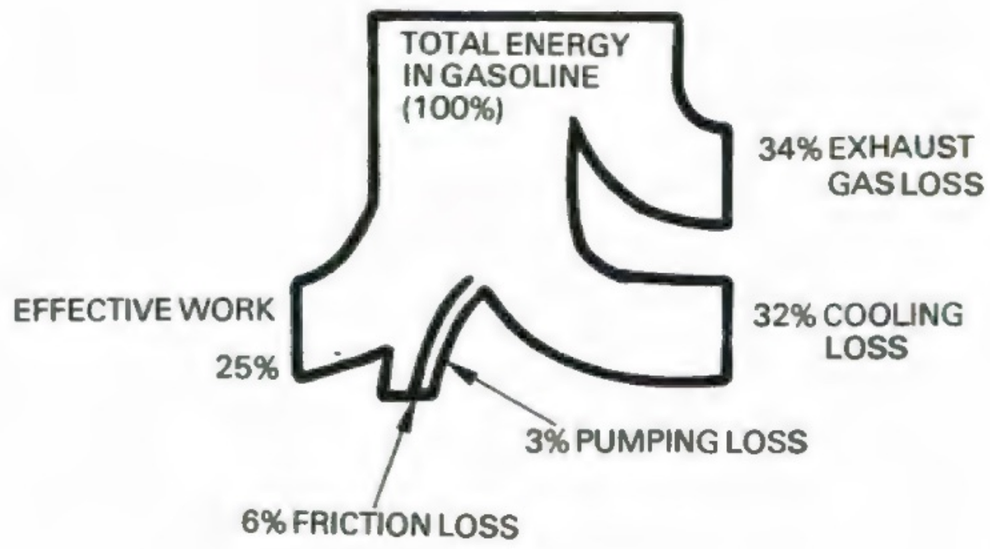
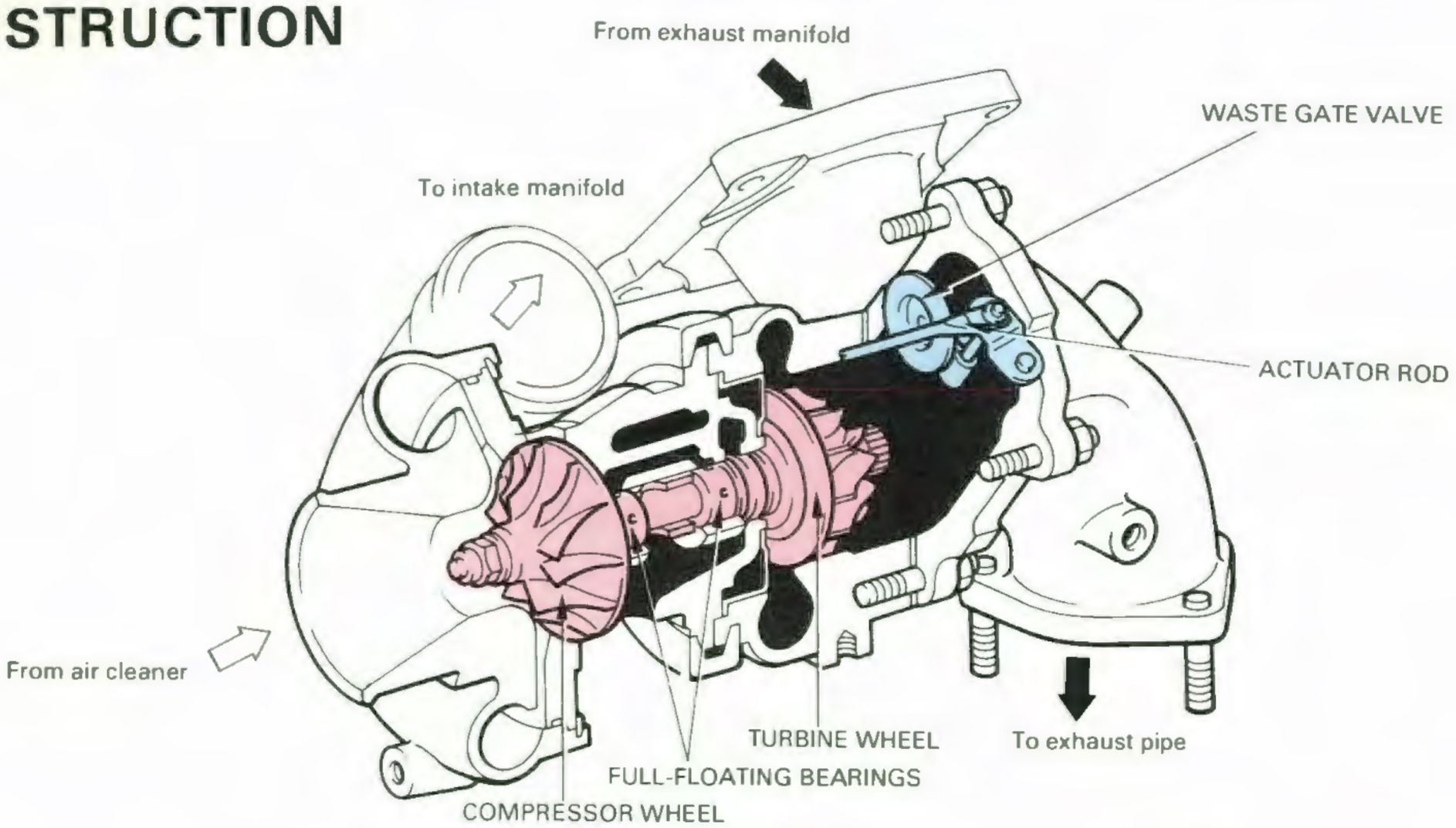
FOR REFERENCE

Thermal Balance

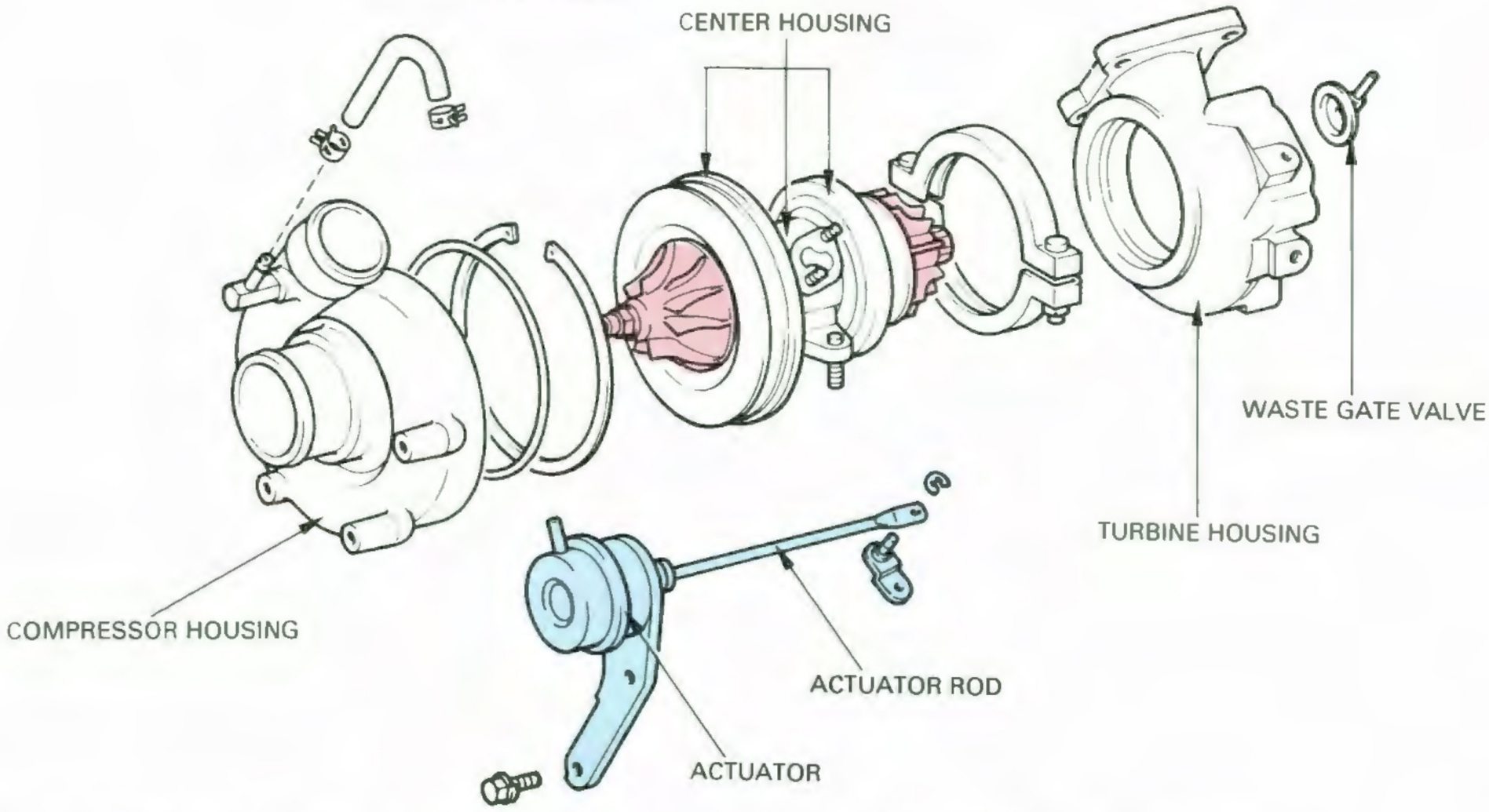
In most gasoline engines, the amount of the heat produced by the combustion of the fuel in the cylinders that can be effectively utilized is between 23 and 28%; this figure is 30 to 40% for diesel engines. The remaining energy is lost. Of this loss, the greatest is the heat energy lost in exhaust gases (33 to 38%); the turbocharger recovers part of this energy and uses it to increase the output of the engine.



CONSTRUCTION



OHP-22



OHP-23

1. TURBINE AND COMPRESSOR WHEELS

The turbine wheel and the compressor wheel are mounted on the same shaft. Exhaust gas flows from the exhaust manifold to the turbine wheel, and the pressure of the exhaust gas turns the turbine wheel. When the turbine wheel turns, the compressor wheel, which is mounted on the same shaft, also turns, boosting the intake air.

Since the turbine wheel is exposed directly to the exhaust gases, it becomes extremely hot; and since it rotates at high speeds, and must be heat resistant and durable, it is made of an ultra-heat-resistant alloy.

2. CENTER HOUSING

The center housing supports the turbine and compressor wheels via the shaft.

The center housing is lubricated and cooled by the oil and coolant that flow through channels provided for these purposes.

3. FULL-FLOATING BEARINGS

Since the turbine and compressor wheels turn at speeds of up to 110,000 rpm, full-floating bearings are used in order to assure the absorption of vibrations from the shaft and lubrication of the shaft and bearings.

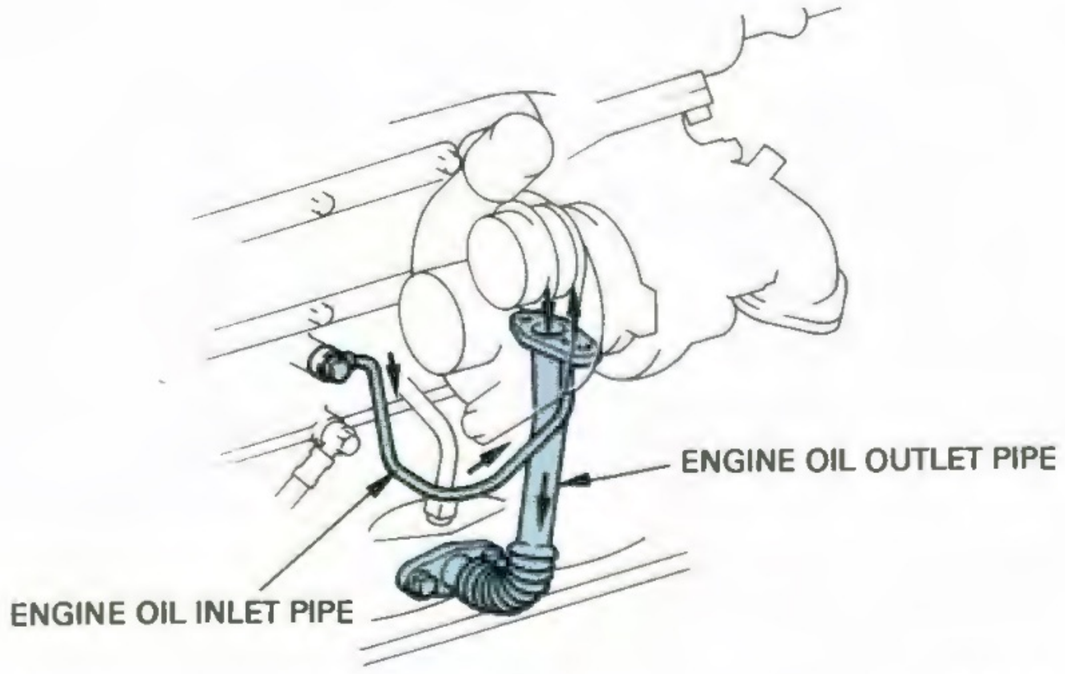
These bearings are placed so as to rotate freely between the shaft and the housing, preventing freeze-up during high-speed rotation.

4. ACTUATOR AND WASTE GATE VALVE

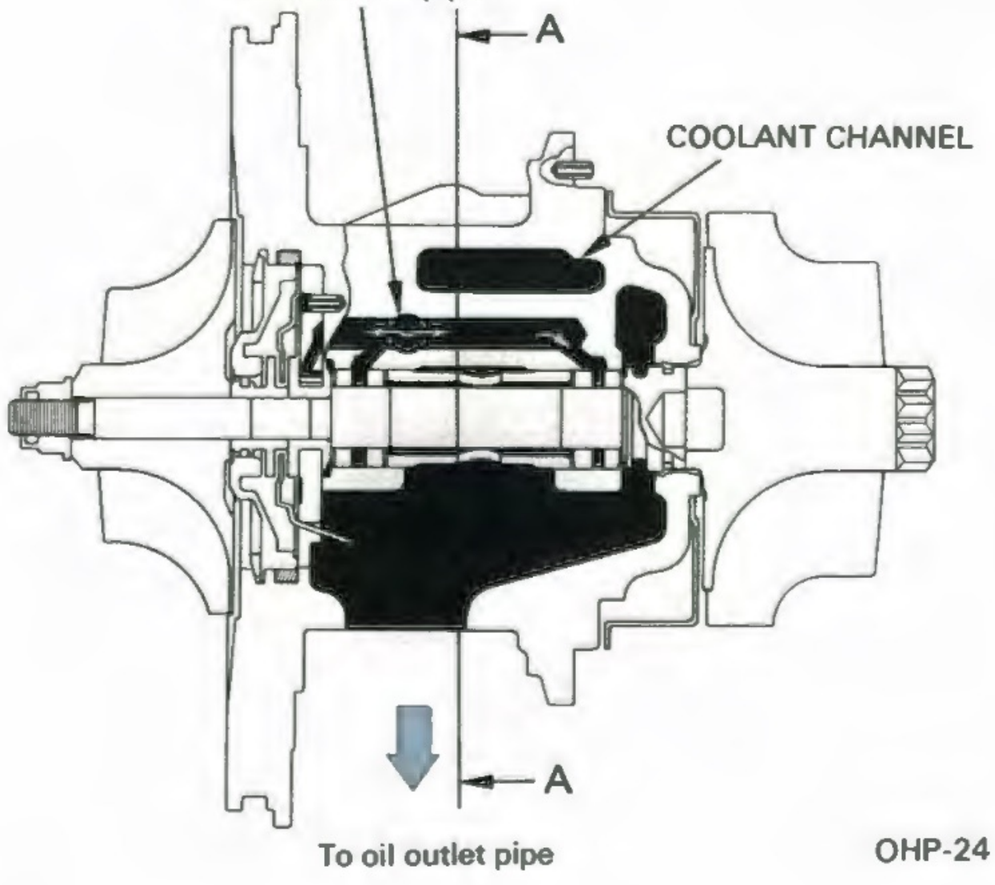
A turbocharger attains a high output by boosting the pressure of the air fed into the cylinders, but if the boost pressure rises too high, the explosive force created by combustion of the air-fuel mixture will become too great and the engine will be unable to withstand the presure. Therefore, boost pressure is controlled by the actuator and waste gate valve.

TURBOCHARGER LUBRICATION SYSTEM

In order to lubricate the full-floating bearings inside the center housing, engine oil is supplied from the oil inlet pipe and circulated among the bearings.



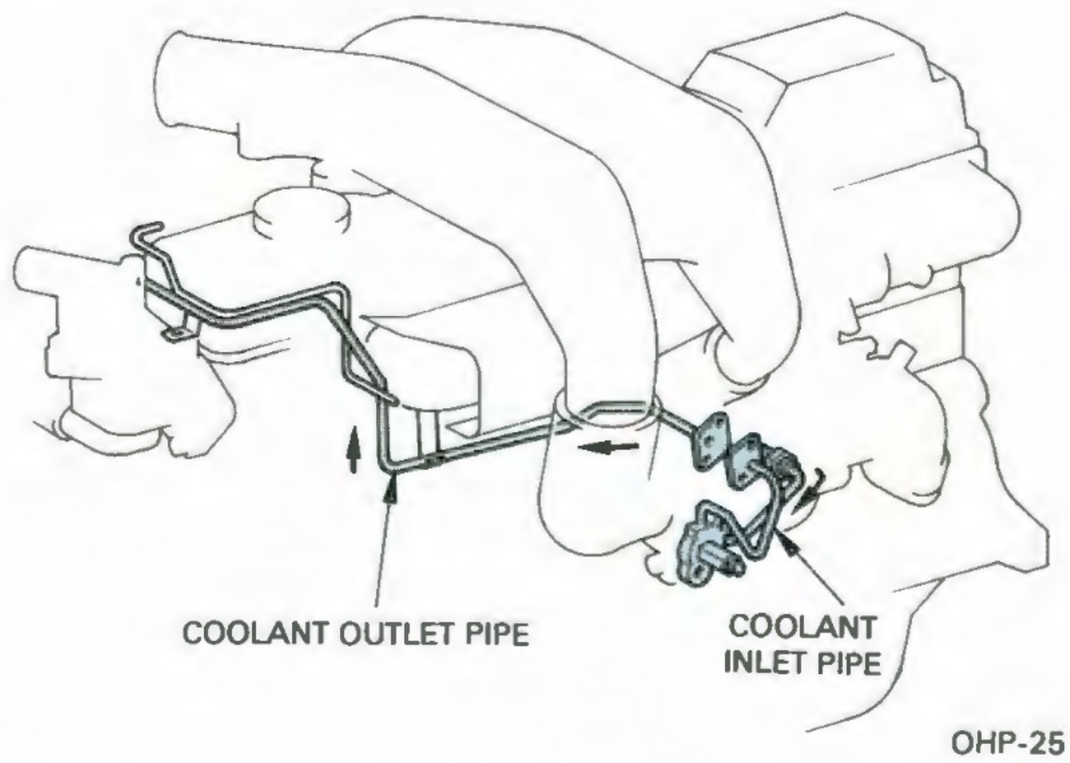
OHP-24



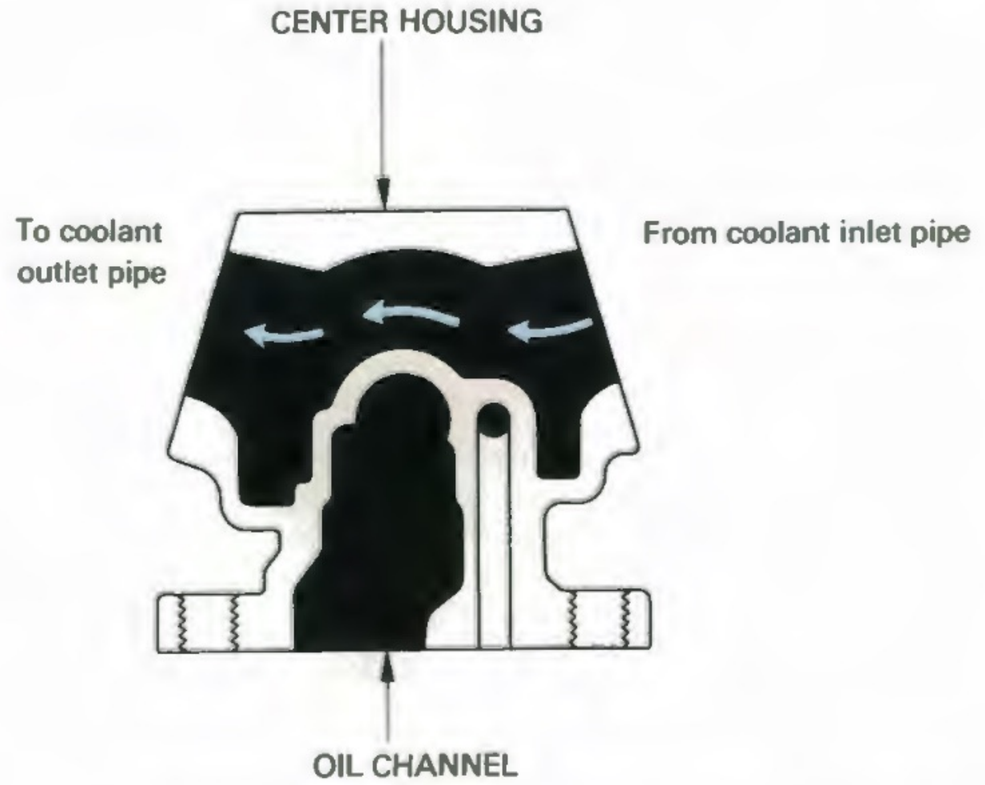
OHP-24

TURBOCHARGER COOLING SYSTEM

Due to the circulation of some of the engine's coolant through the turbocharger housing, the temperature of the oil channels in the turbocharger housing is lowered and the oil's lubricating characteristics are improved.



OHP-25



CUT-AWAY VIEW A-A (in illustration at left) OHP-25

OPERATION

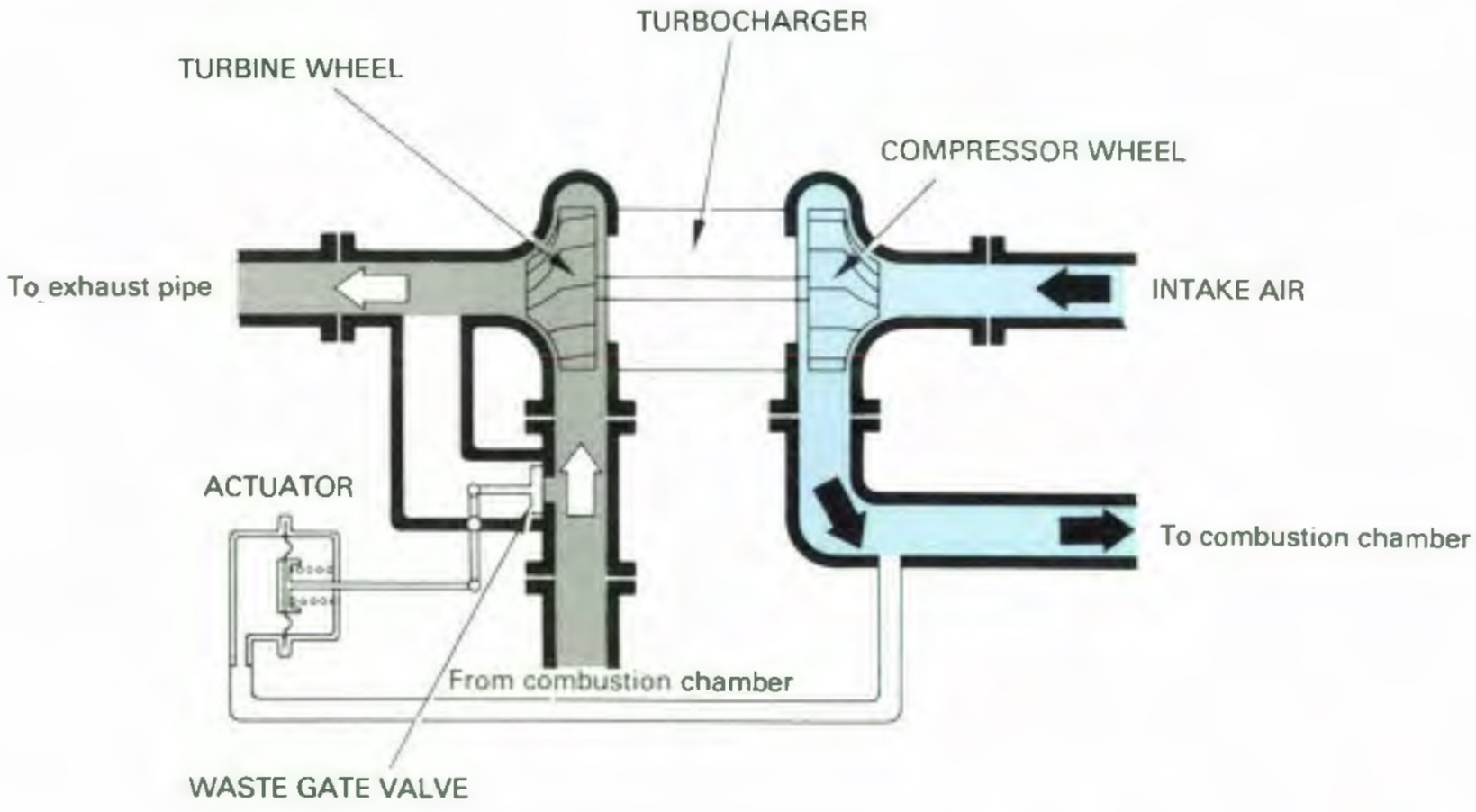
Exhaust gas from the exhaust ports strikes the turbine wheel, causting it to rotate.
When the turbine wheel turns, the compressor wheel, which is mounted on the same shaft, also turns. Intake air passing through the air cleaner is therefore compressed and forced out of the compressor housing and supplied to the cylinders

If the engine's speed is increased, the amount of exhaust gas will increase, so the turbine wheel's rotational speed will also increase.
When the turbine wheel's rotational speed increases, the boost pressure (that is, the pressure of the air compressed by the compressor wheel and forced into the combustion chamber), will increase, increasing the explosive force of combustion, and boosting engine output.

However, boost pressure rises along with engine speed, and if the explosive force of combustion becomes too great, the engine will be unable to withstand it. Therefore, the waste gate valvė keeps the boost force below 0.61 kg/cm^2.

BOOST PRESSURE BELOW 0.61 kg/cm^2.

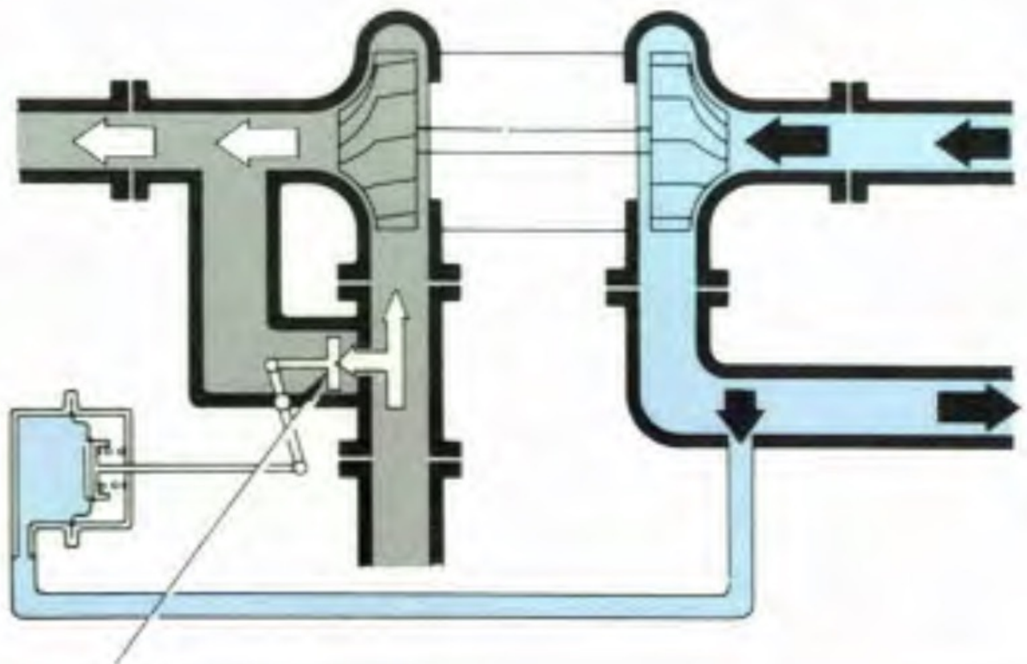
When the boost pressure is below 0.61 kg/cm^2, the actuator does not operte and the waste gate is closed, so the full volume of the exhaust gas passes to the turbine wheel.



OHP-26

BOOST PRESSURE 0.61 kg/cm^2 OR HIGHER.

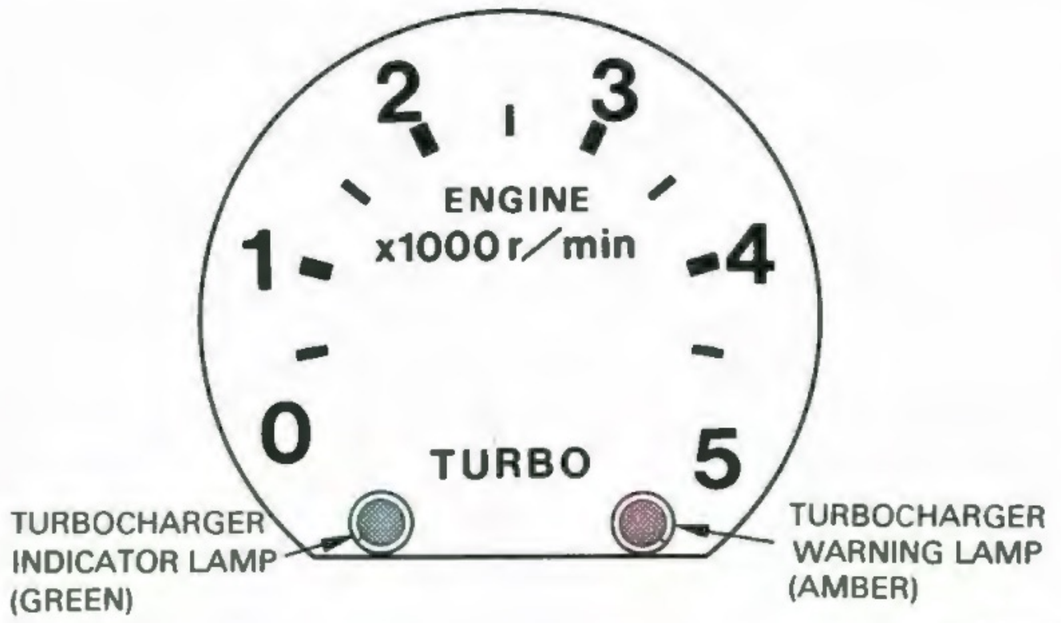
When the engine speed increases and the boost pressure reaches 0.61 kg/cm^2, the actuator opens the waste gate valve. This causes part of the exhaust gas to flow to the exhaust pipe without passing the turbine wheel, thus maintaining the boost pressure at about 0.61 kg/cm^2.



OHP-26

TURBOCHARGER INDICATOR & WARNING SYSTEMS

An indicator lamp and warning lamp are provided on the tachometer to keep the driver informed of the turbocharger's operation.



OHP-27

1. TURBOCHARGER INDICATOR SYSTEM

The boost pressure inside the intake manifold is detected by a low pressure switch. If this pressure rises above a certain level, a transistor inside the meter turns on, and the indicator lamp (green) lights up, informing the driver that the turbocharger is operating.

2. TURBOCHARGER WARNING SYSTEM

In the unlikely event that the turbocharger waste gate valve and actuator should malfunction and the boost pressure rise too high, a high pressure switch is provided which detects the high boost pressure and turns on the amber warning lamp to inform the driver that the turbocharger is operating abnormally.

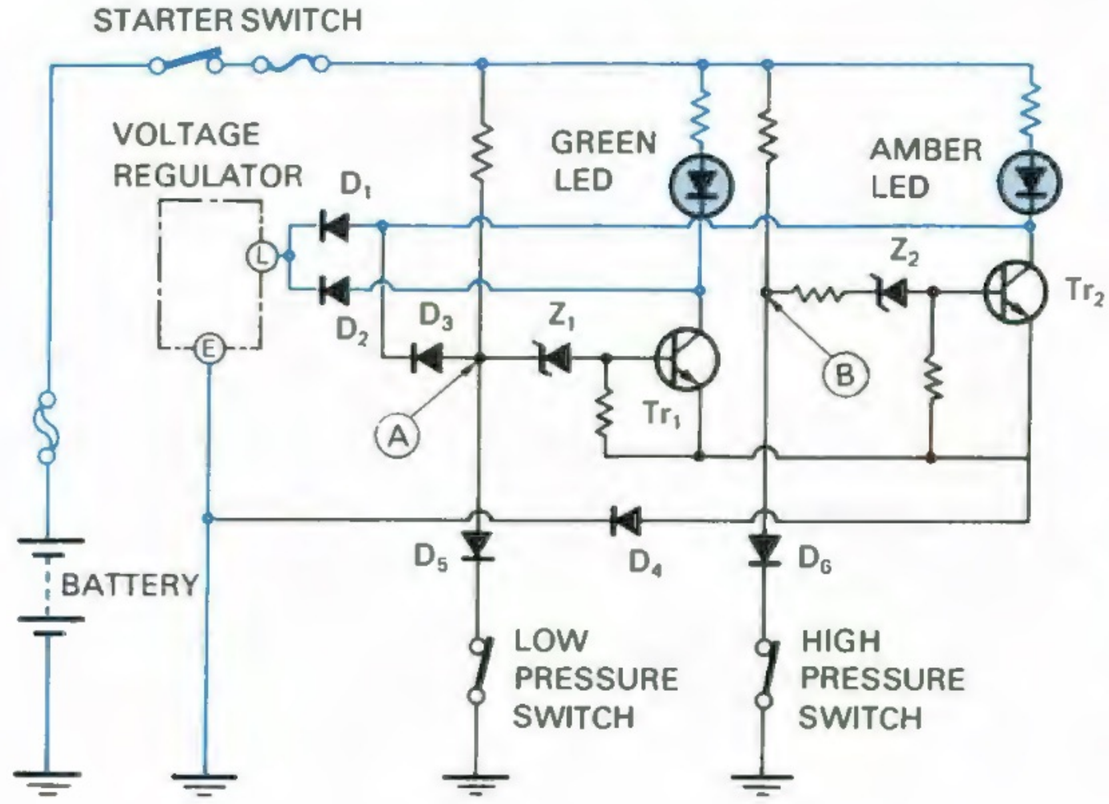
INDICATOR/WARNING LAMP OPERATION

LAMPS / CONDITION	INDICATOR LAMP	WARNING LAMP
KEY SWITCH ON (ENGINE NOT RUNNING)	ON	ON
ENGINE IDLING	OFF	OFF
BOOST PRESSURE GREATER THAN 0.14 kg/cm² AND LESS THAN 1.09 kg/cm²	ON	OFF
BOOST PRESSURE ABOVE 1.09 kg/cm²	OFF	ON

3. OPERATION

STARTER SWITCH ON (ENGINE NOT RUNNING)

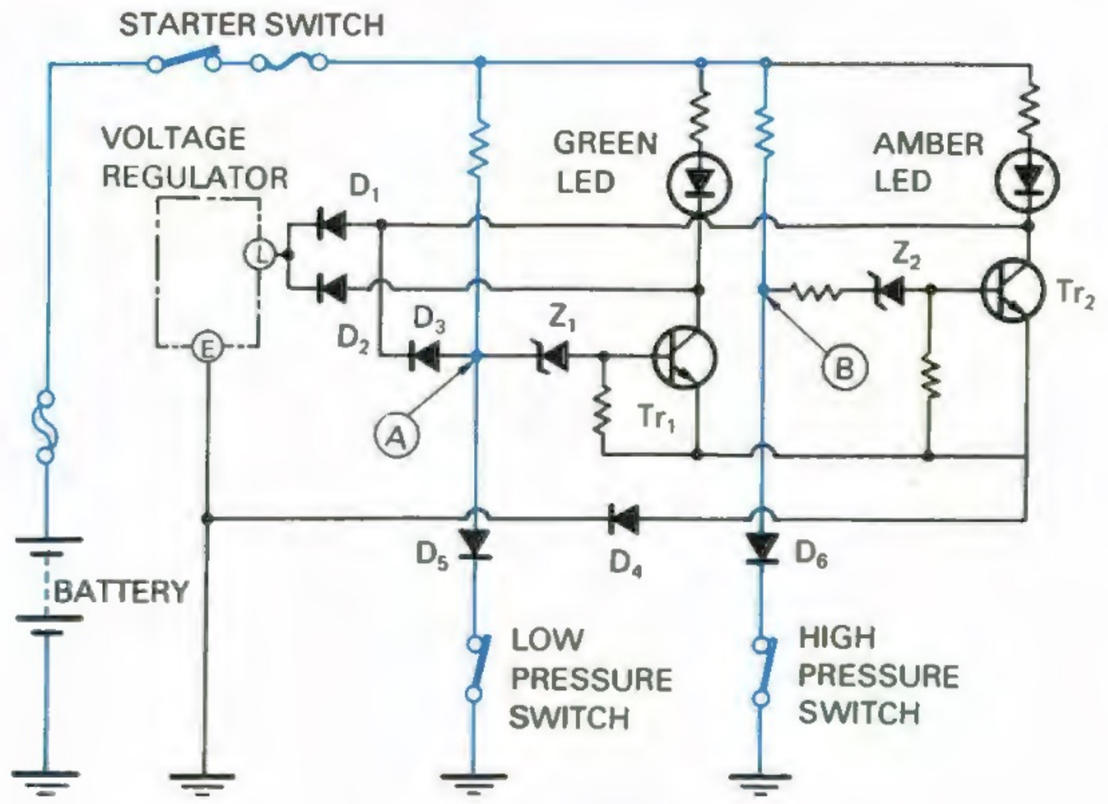
Electric current flows through the circuits shown below and turns on the green and amber LEDs to allow LED failure checking to be carried out:



OHP-28

ENGINE IDLING

Since the alternator is charging, the green and amber LEDs, which are grounded via terminal L of the voltage regulator, are turned off.

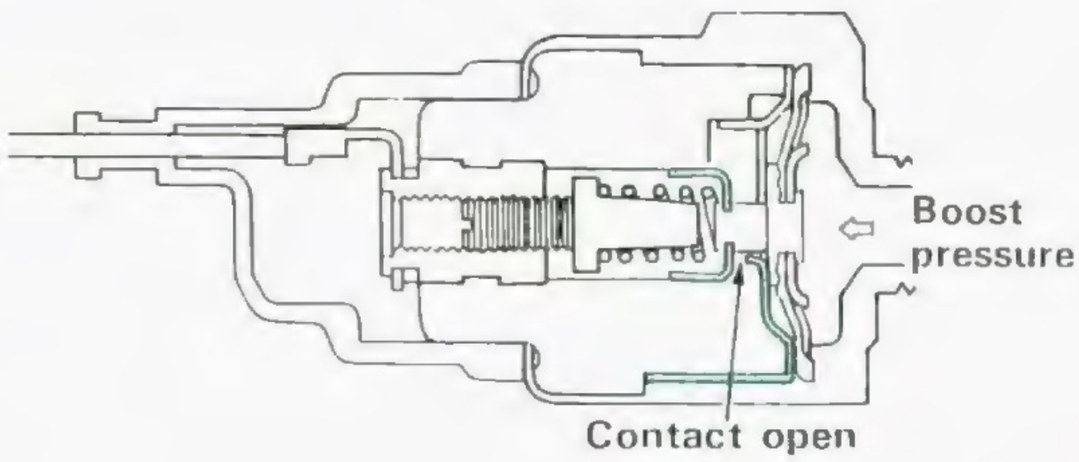


OHP-28

BOOST PRESSURE GREATER THAN 0.14 kg/cm² AND LESS THAN 1.09 kg/cm²

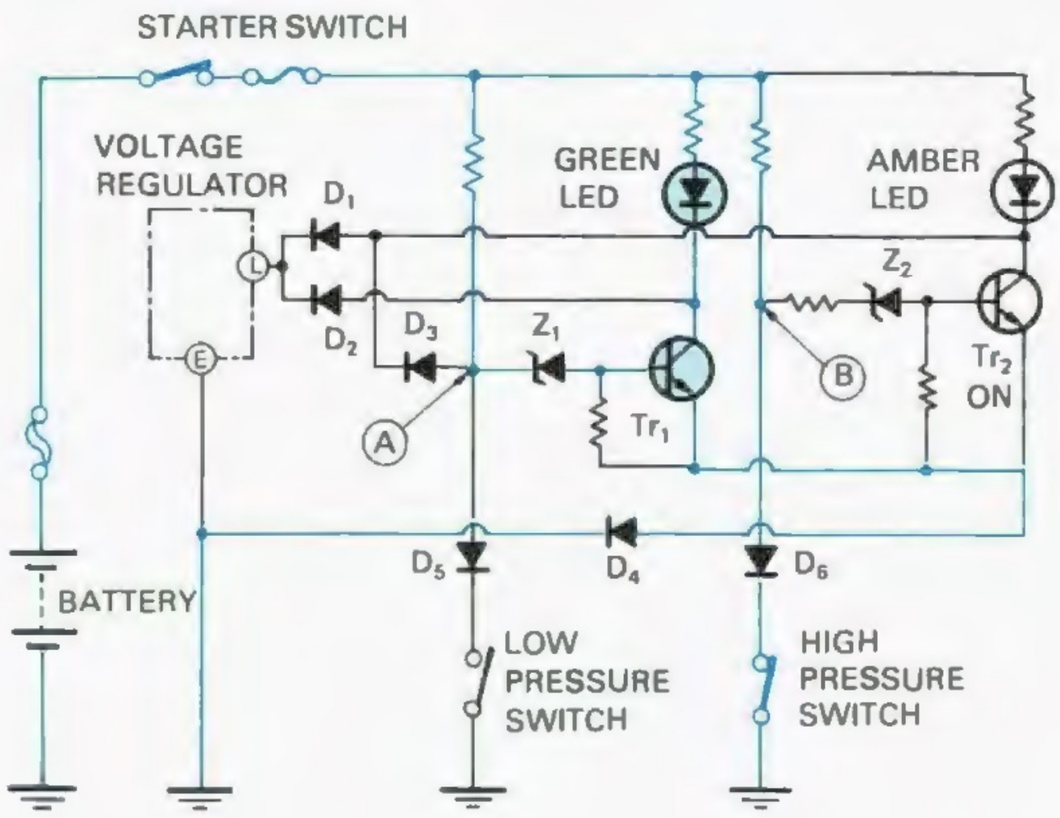
When the boost pressure rises above 0.14 kg/cm², the contacts of the low pressure switch open and the potential at point Ⓐ rises. The current therefore passes through zener diode Z_1 and turns on transistor Tr_1. This causes the green LED to light up, indicating that the turbocharger is operating.

The causes the green LED to light up, indicating that the turbocharger is operating.



TURBOCHARGER LOW PRESSURE SWITCH

OHP-29



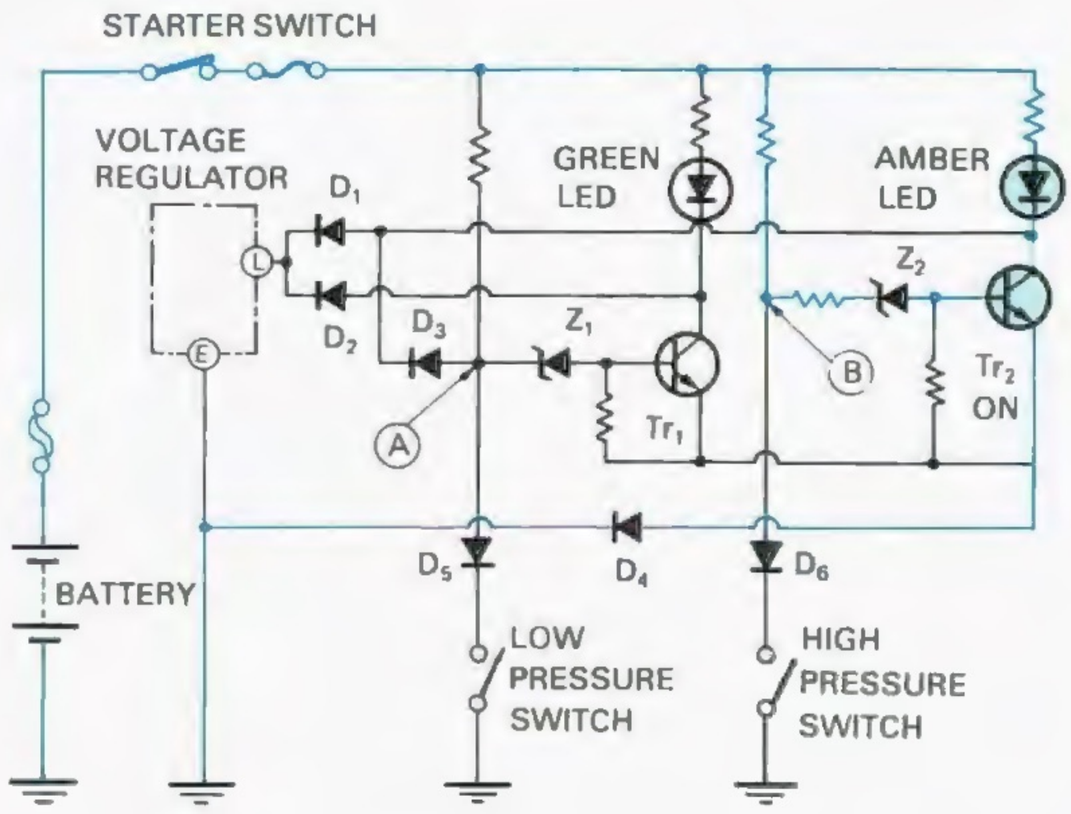
OHP-29

BOOST PRESSURE ABOVE 1.09 kg/cm²

If the boost pressure rises even higher and reaches 1.09 kg/cm², the contacts of the high pressure switch open and the potential at point Ⓑ rises. This causes current to flow through zener diode Z_2, which turns transistor Tr_2 on. As a result the amber LED lights up, warning the driver that the turbocharger is operating abnormally.

At this time, the contacts of the low pressure switch remain open, but the since the internal resistance of Tr_2 is low compared to that of Tr_1, the current flows in Tr_2 and Tr_1 goes off.

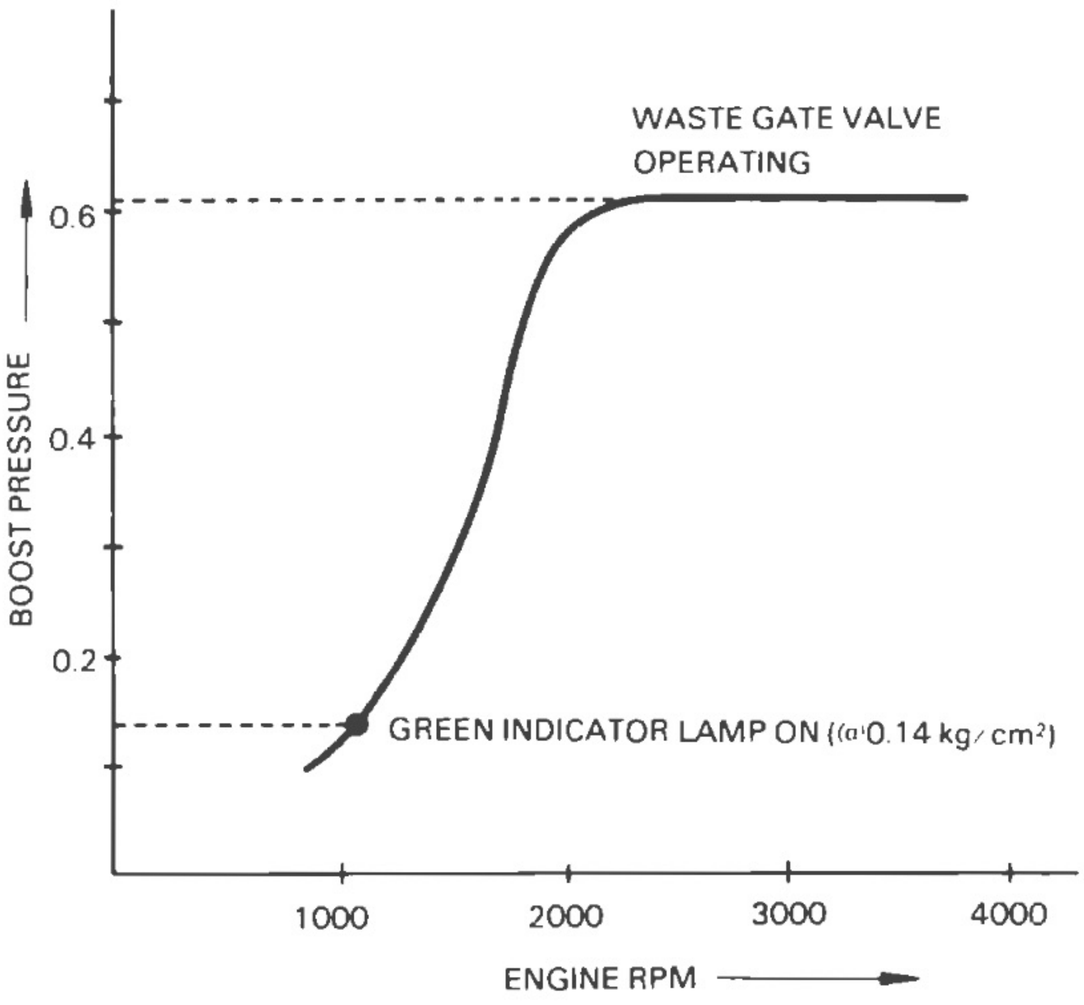
Note that the only difference in the construction of the high- and low-pressure switches is in the strength of the springs.



OHP-30

4. RELATIONSHIP BETWEEEN ENGINE SPEED AND BOOST PRESSURE

The relationship between the engine speed and boost pressure when the accelerator pedal is fully depressed is shown in the graph below:



OHP-30

— NOTE —

These characteristics will vary depending upon the load that is placed upon the engine.

MAINTENANCE PRECAUTIONS

1. GENERAL CAUTIONS

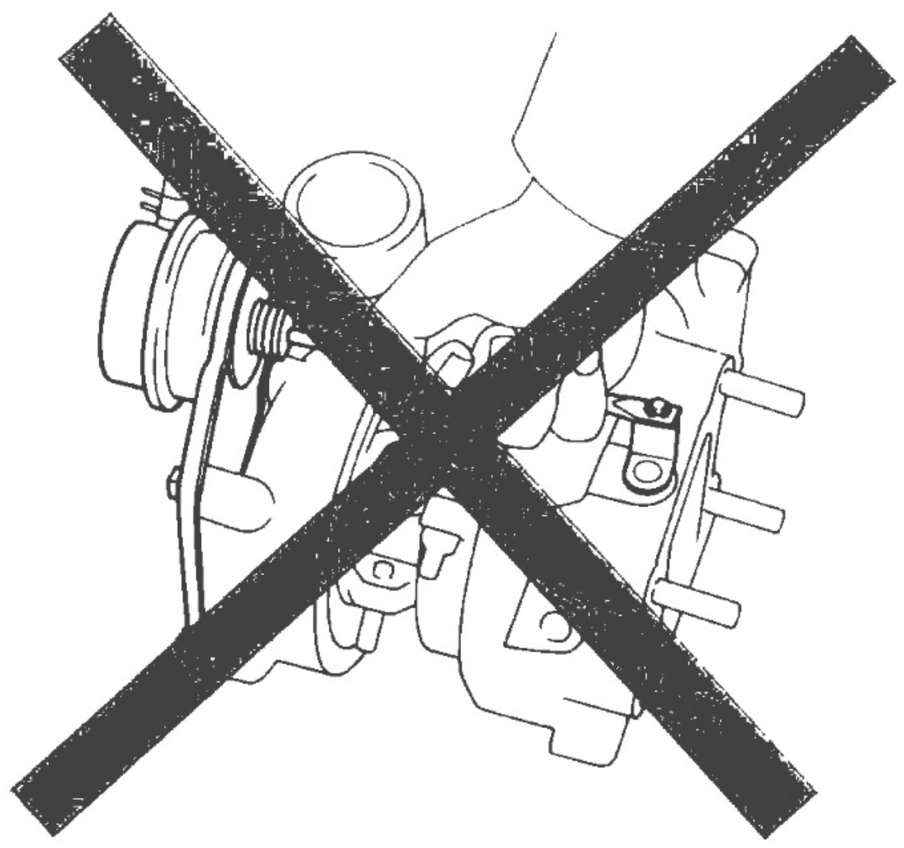
As the turbocharger is a precision-built part, the following precautions should be observed:

a) The turbocharger should never be disassembled.

b) The turbocharger should never be dropped under any circumstances. Also, when carried, it should not be allowed to bump into anything.

c) If the actuator rod and waste gate link are bent, the waste gate valve will not oprate correctly, so caution should be exercised in the following points:

- The turbocharger should not be set down with the actuator rod and waste gate link at the bottom.
- The turbocharger should not be held by the actuator rod when carried.



d) If the compressor outlet and air intake connector hose do not line up, never tap the side of the compressor with a hammer or other metal object and never apply excess force.

e) High exhaust gas pressures are brought to bear on the exhaust system before the turbine wheel, so each part should be tightened securely.

f) Since high air pressure is brought to bear on the air intake after the compressor wheel, hose installation and hose clamp tightening should be done correctly.

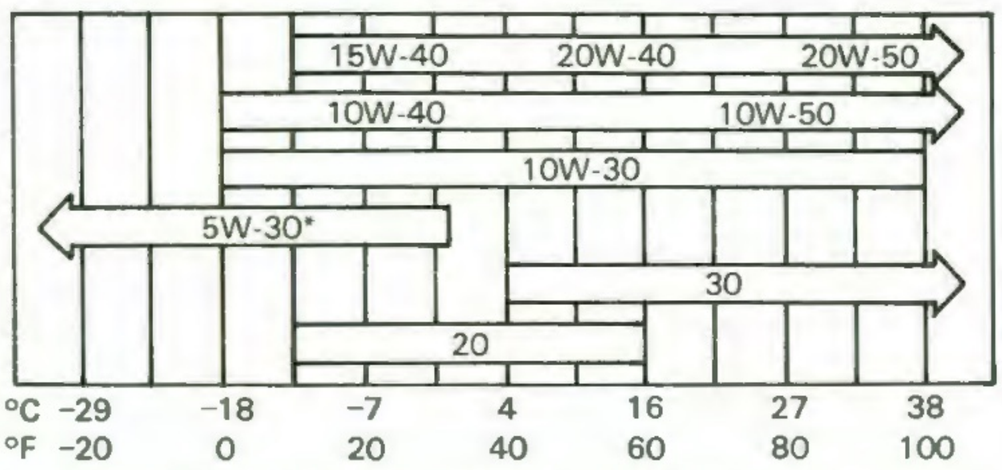
2. OPERATING CARE

As the turbocharger operates at extremely high speeds and temperatures, the following operating precautions should be observed:

a) The engine oil becomes hot very quickly due to its use in cooling and lubricating the turbocharger, so it deteriorates rapidly. For this reason, engine oil and oil filter maintenance should be carried out faithfully.

b) Be sure to use the following types of engine oil:

RECOMMENDED OIL VISCOSITY (SAE)



TEMPERATURE RANGE ANTICIPATED BEFORE NEXT OIL CHANGE
*: On turbocharged engines, never use above 0°C (32°F)

OHP-31

— NOTE —

Always use oil of API service grade CD or SF-CD.

c) Immediately after starting when the engine is cold (or after the vehicle has not been used for a long time), do not race the engine suddenly or accelerate quickly. If this is done, the turbocharger will rotate at high speeds while the oil pressure is still low, and this could have an adverse effect on the bearings.

d) Before stopping the engine immediately after high speed running or driving up a hill, let it idle from 20 seconds to 2 minutes, depending on conditions.

— REFERENCE —

Reasons for letting the engine idle before turning off the engine:

During high-speed driving, the turbine wheel is exposed to very hot exhaust gases, and its temperature rises extremely high, but since the temperature of the shaft linking the turbine wheel to the compressor wheel cooled by oil and coolant, its temperature does not rise as high.

However, if the engine is stopped immediately after high-speed driving, circulation of oil and coolant will stop, and the temperature of the shaft will suddenly rises due to the temperature of the turbine wheel.

Therefore, letting the engine idle before shutting it off will allow the shaft to cool off gradually. (This is because the temperature of the exhaust gas is lower during idling.)

SUGGESTED IDLING TIME BEFORE ENGINE SHUT-OFF

DRIVING		IDLING TIME
Town or suburban driving below 80 km/h		Not required
High-speed driving	Cruising at 80 km/h	Approx. 20 sec.
	Cruising at 100 km/h	Approx. 1 min.
Driving over mountainous roads racing, or driving over 100 km/h continuously		Approx. 2 min.

OHP-31

CHECKING TURBO-CHARGING SYSTEM

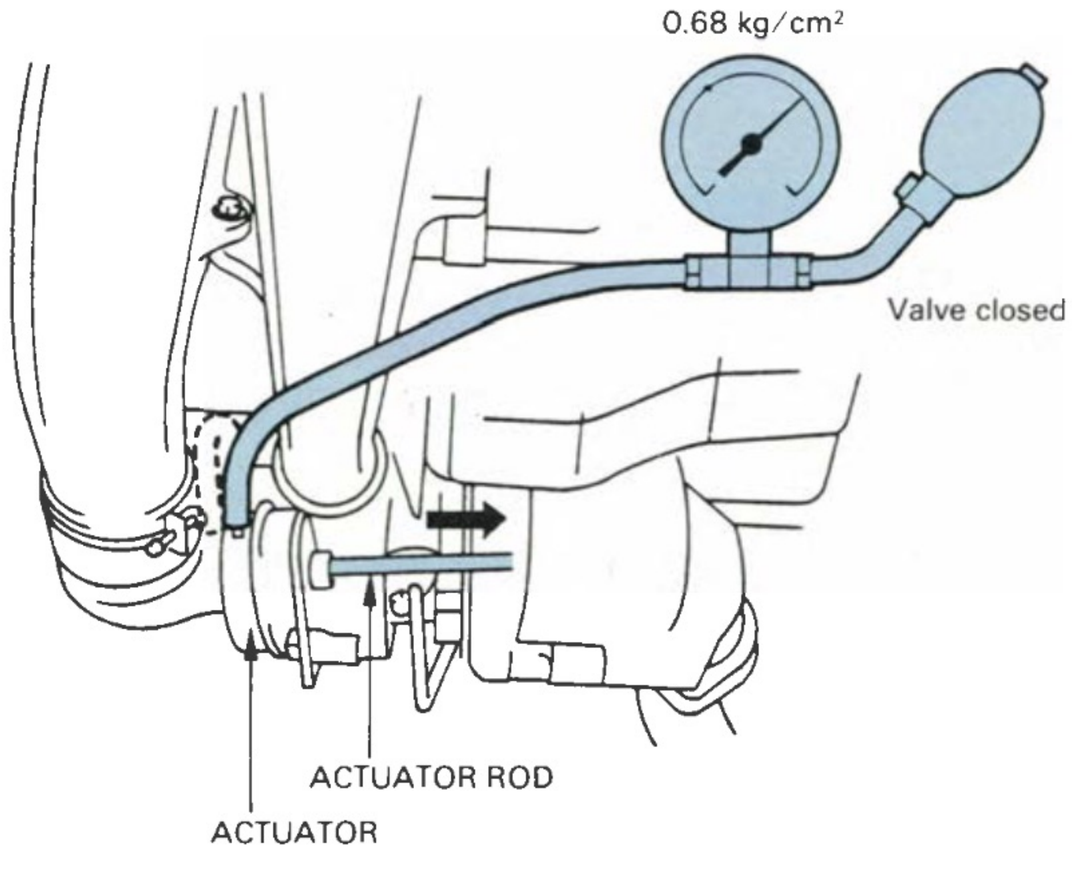
If it is suspected that the turbocharging system is malfunctioning, the boost pressure and the operation of the waste gate valve actuator and/or pressure switches must be checked.

For accurate troubleshooting, the SST (Turbocharger Pressure Gauge P/N 09992-00240) must be used.

1. WASTE GATE VALVE ACTUATOR CHECKING

Take off the actuator hose, then check using a turbocharger pressure gauge to make sure that the rod moves when a pressure of approximately 0.68 kg/cm² is applied to the actuator.

If the rod does not move, replace the turbocharger assembly.



— NOTE —

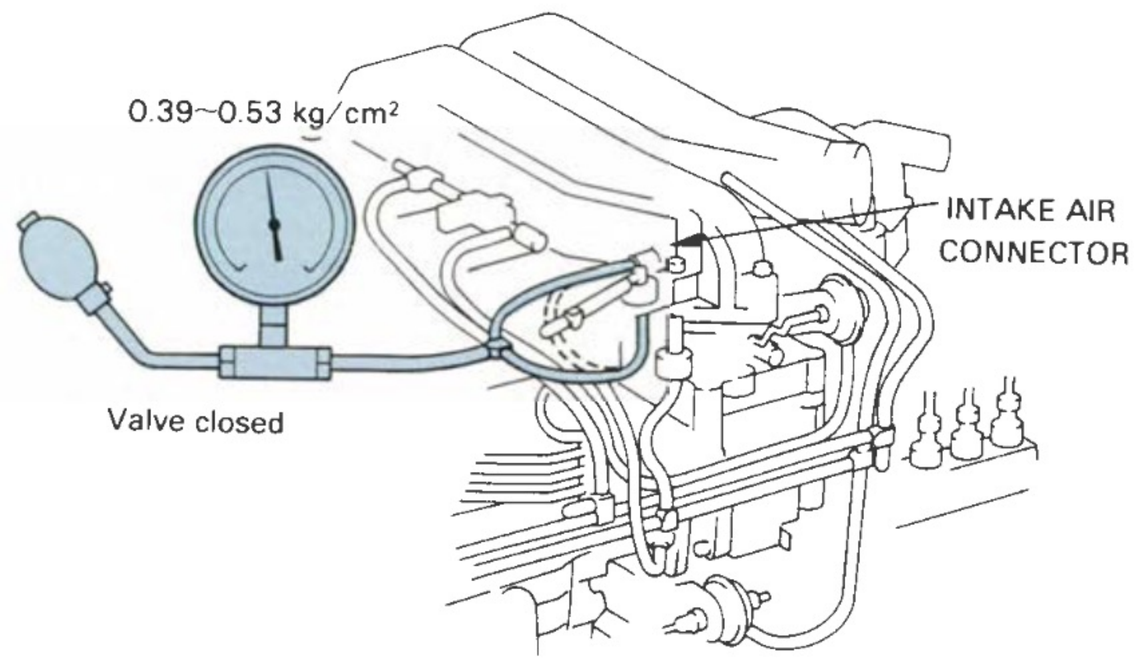
To prevent damaging the actuator's diaphragm and spring, do not apply pressure greater than 0.75 kg/cm².

2. BOOST PRESSURE CHECKING

After the engine is warmed up (the coolant temperature is 80 - 90°C), install a turbocharger pressure gauge on the intake air connector.

Next, disengage the clutch and depress the accelerator pedal fully and measure the boost pressure at the maximum no-load engine speed (4050-4200 rpm).

If the pressure is less than specification, check the intake air and exhaust systems for leakage. If there is no leakage, replace the turbocharger assembly.
If the pressure is above specification, check if the actuator hose is disconnected or cracked. If not, replace the turbocharger assembly.



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