8. AIR INJECTION (AI) SYSTEM

CONTENTS

8. AIR INJECTION (AI) SYSTEM

DESCRIPTION

The AI system serves to blow compressed air into the hot gases discharged from the cylinder head exhaust ports for the purpose of reburning the unburnt HC (hydrocarbons) and CO (carbon monoxide).
In the vehicles equipped with catalytic converter (CCo), the air blown into the exhaust system also serves to promote the oxidizing reaction.

OPERATION

1. AI system operation (2T-C engine except for California)

- The clean air from the air cleaner is compressed by the air pump and then passes through the air by-pass valve (ABV), air switching valve (ASV), AI manifold, and check valve, to discharge into the exhaust ports.
- When the air pump discharge pressure rises above the specified value, the ASV relief valve opens to relieve the air back to the air cleaner.
- At sudden deceleration, the intake manifold vacuum acts on the ABV and lowers the valve. The air from the air pump is temporarily relieved from the ABV into the air cleaner. (To prevent after burn)
- At heavy load, the decrease in the intake manifold vacuum causes the ASV to close the passage at the AI manifold side. Therefore, the air is relieved into the air cleaner. This action is delayed by the vacuum transmitting valve.

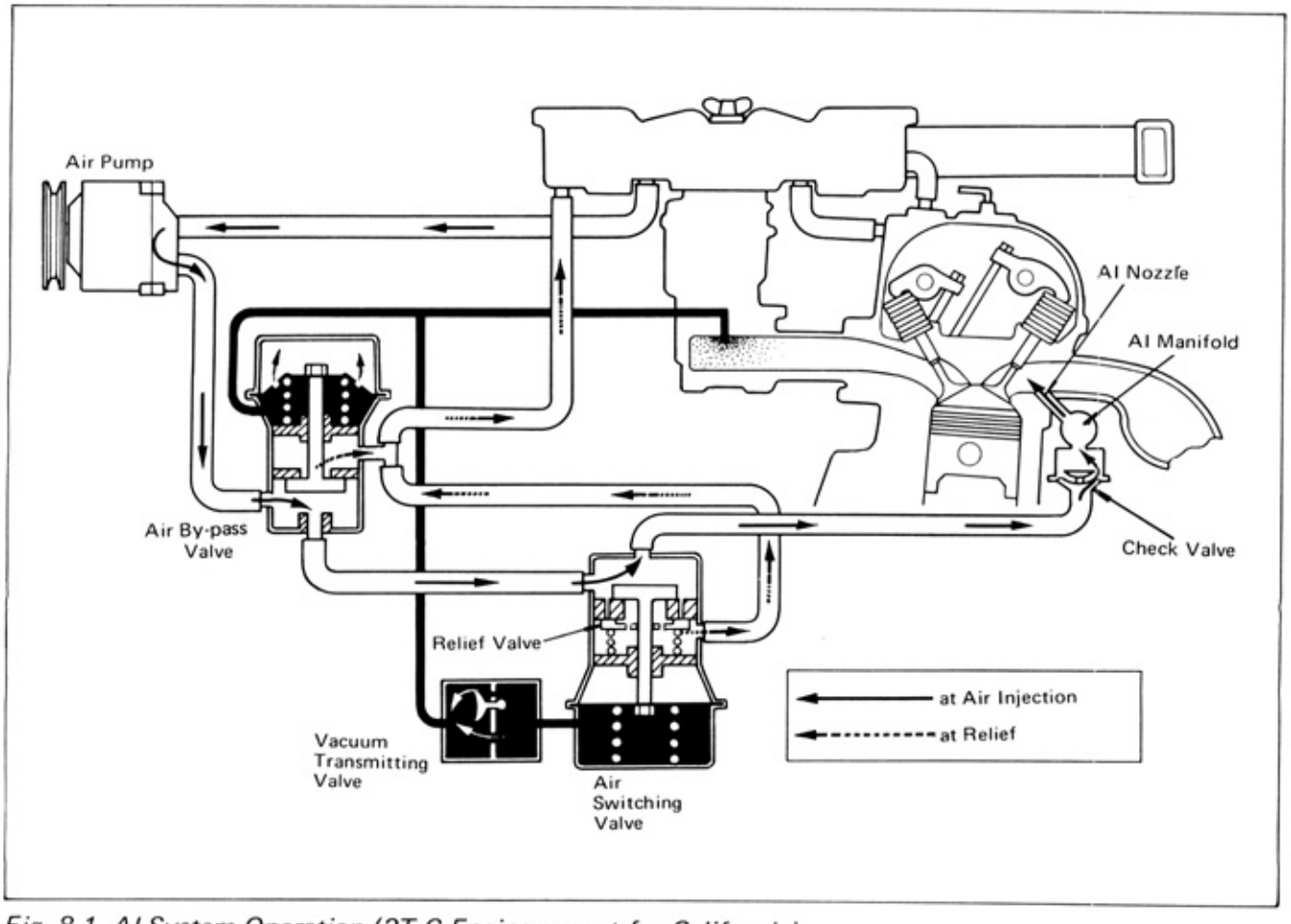


Fig. 8-1 AI System Operation (2T-C Engine except for California)

2. AI system operation (2T-C engine for California and 20R engine)

The operation is basically the same as that for the AI system in the 2T-C engine except for California.

["ON" condition]

When the vehicle speed, coolant temperature, and catalytic converter (CCo) temperature all reach the "ON" range, the computer turns the VSV "ON". Turning on the VSV causes the intake manifold vacuum to act on the ASV and inject the air.

["OFF" condition]

- If any one of the "ON" conditions changes into the "OFF" range, the computer turns the VSV "OFF".
- Turning off the VSV allows the atmosphere to act on the ASV and causes the ASV to close by spring action.
- Ther air is relieved into the air cleaner.

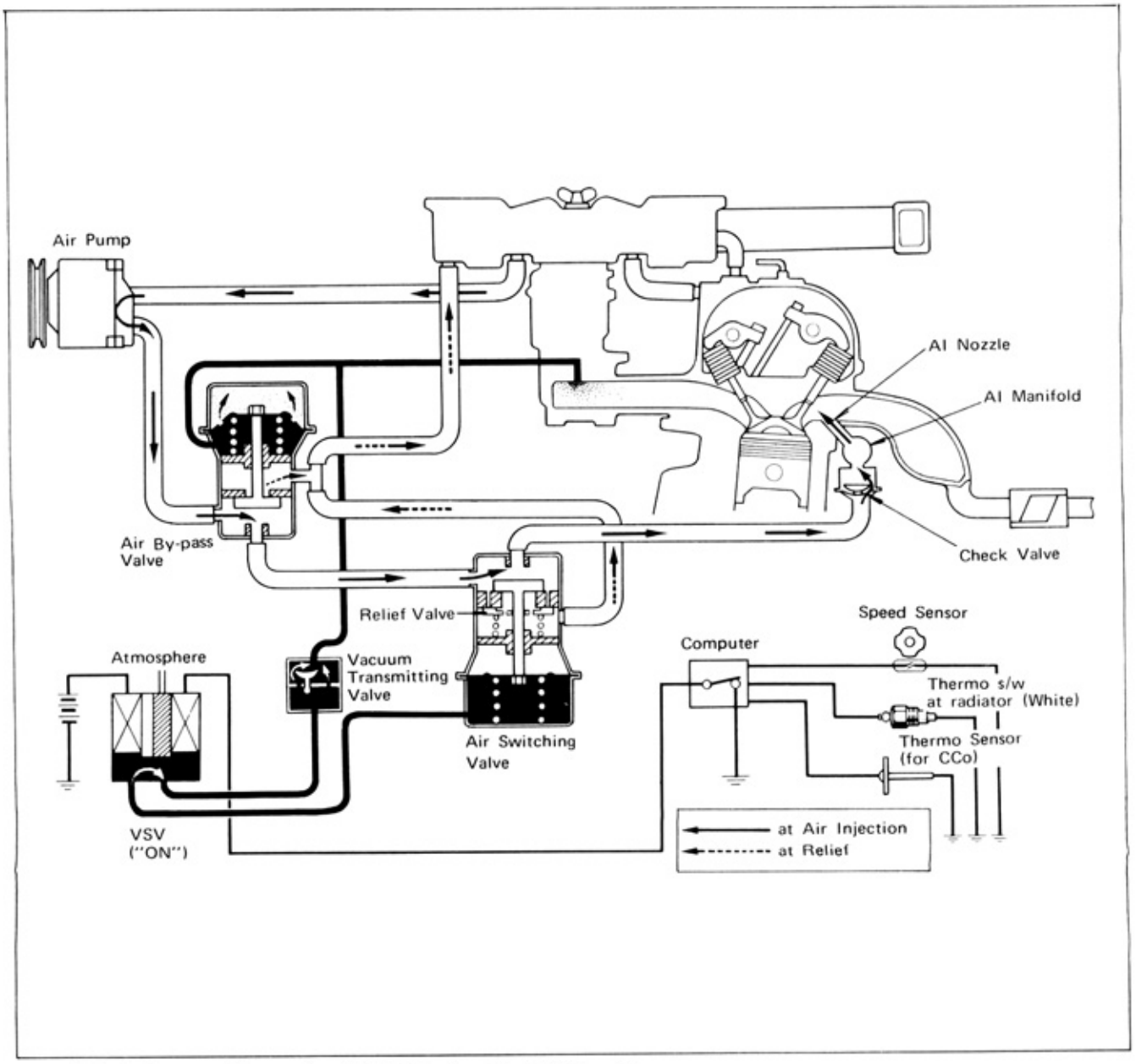


Fig. 8-2 AI System Operation (2T-C Engine for California)

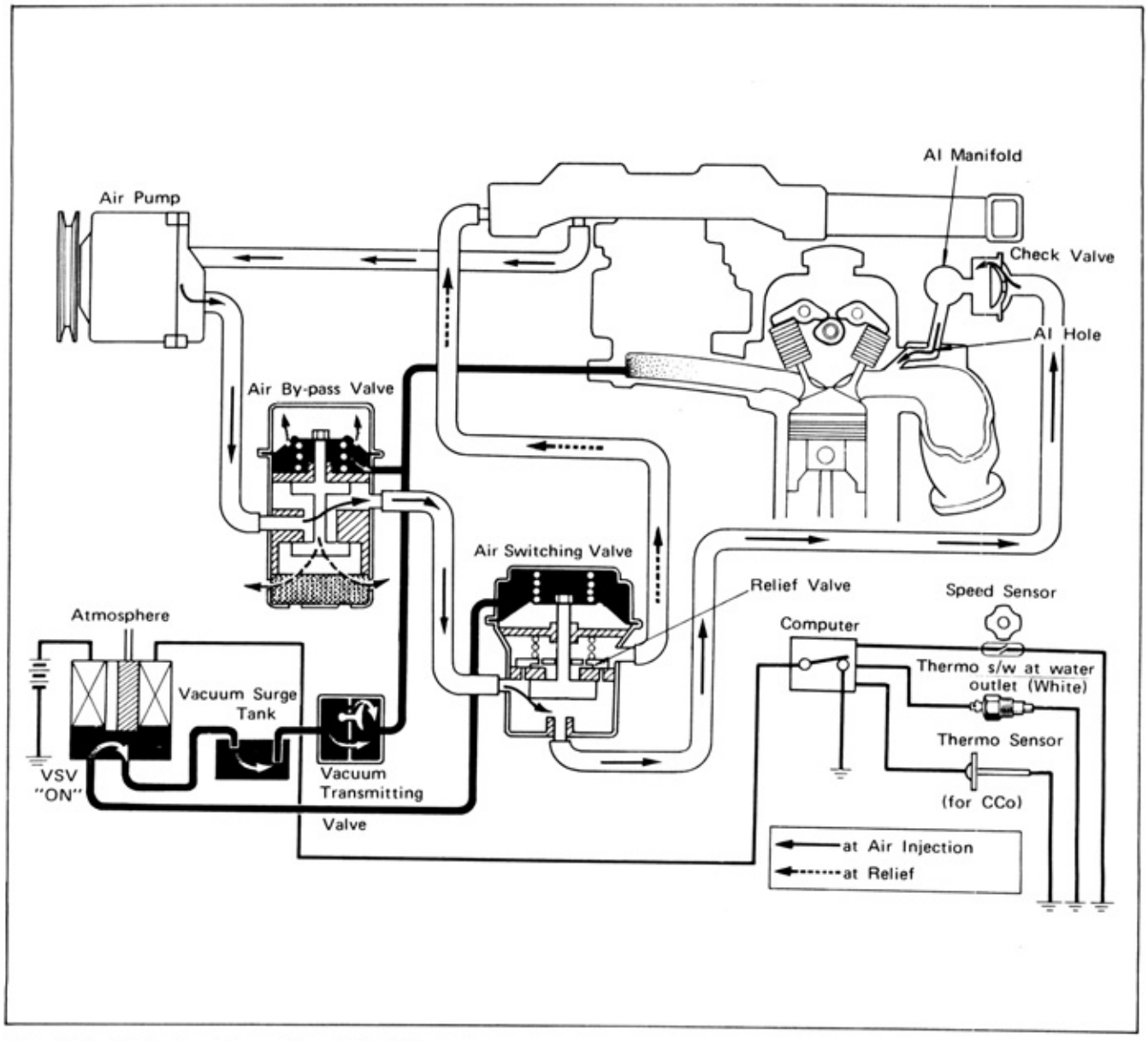


Fig. 8-3 AI System Operation (20R Engine)

3. AI system operation (4M engine)

["ON" condition]

- When the vehicle speed, coolant temperature, and catalytic converter (CCo) temperature all reach the "ON" range, the VSV (installed on the ASV) closes the vacuum passage between the chambers "A" and "B" in the ASV.
- The ASV rises up by spring tension.
- Therefore, the clean air from the air cleaner, after being compressed by the air pump, passes through the ASV, check valve, and AI manifold and sent into the exhaust ports.
- When the air pump discharge pressure rises above specified value, the relief valve in ASV opens and causes the air from the air pump to be relieved from the ASV into the air cleaner.
- At sudden deceleration, the intake manifold vacuum acts on the ASV and lowers the valve. The air from the air pump is temporarily relieved into the air cleaner.

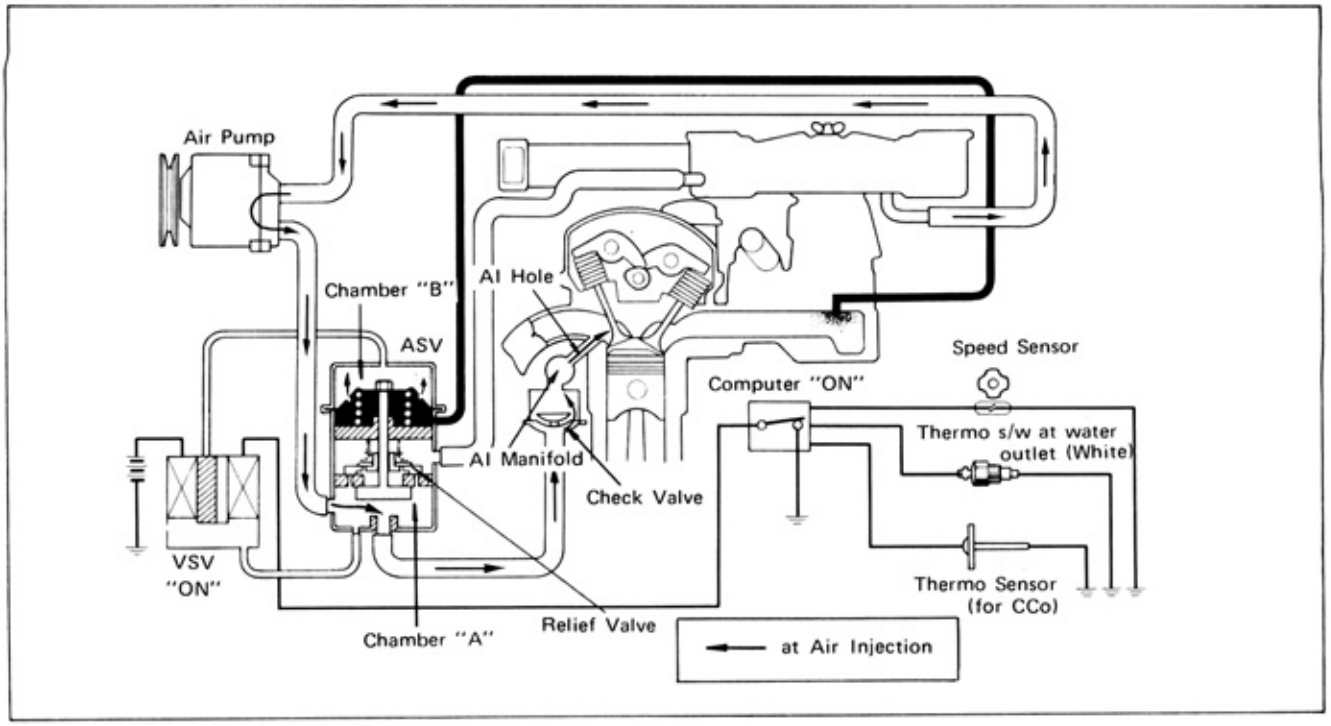


Fig. 8-4 AI System Operation (4M Engine) – "ON" Condition

["OFF" condition]

- If any one of the "ON" conditions changes into the "OFF" range, the VSV opens the passage between the chambers "A" and "B" in ASV. Therefore, the air pump pressure acts on chamber "B" to lower the valve.
- Consequently, the air from the air pump is by-passed by the ASV into the air cleaner and does not go to the exhaust ports.

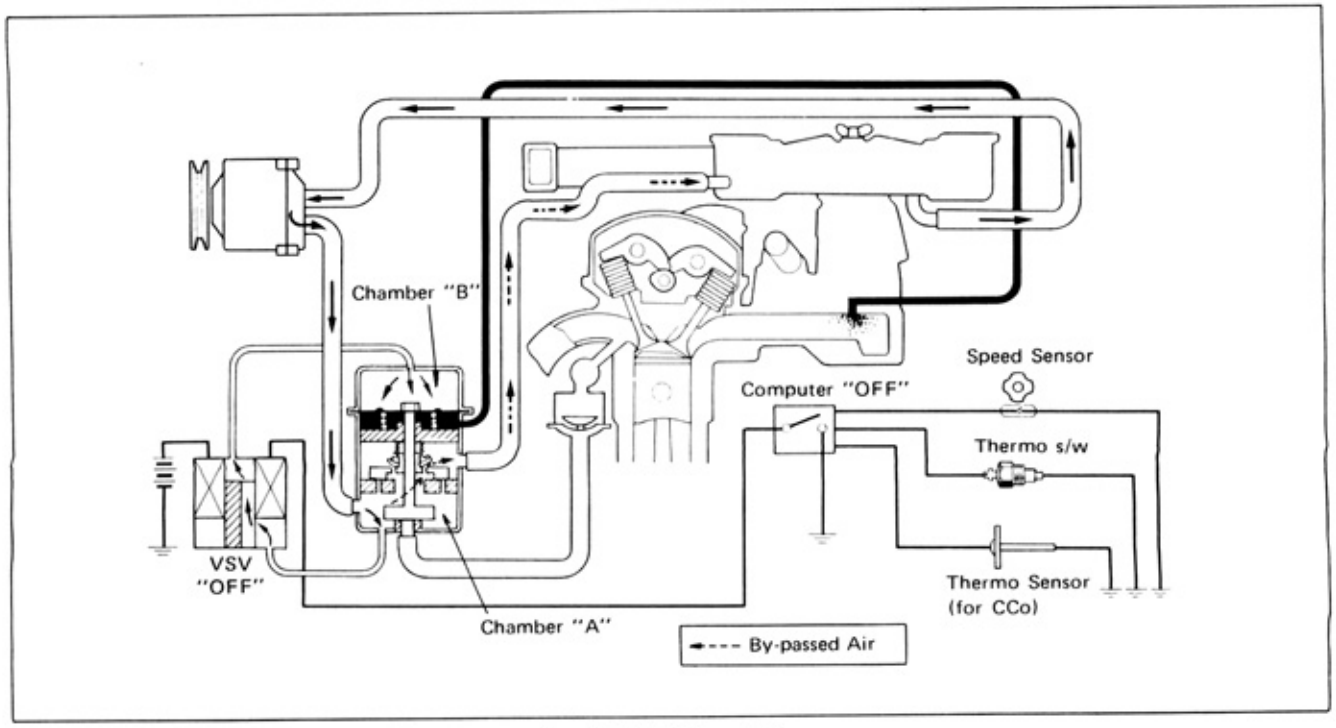


Fig. 8-5 AI System Operation (4M Engine) – "OFF" Condition

4. AI system operation (2F engine)

- The clean air from the air cleaner is compressed by the air pump and discharged into the ABV, from where it passes through the check valve, air injection manifold, and air injection nozzle.
- When the air pump discharge pressure rises above the specified value, the air pump relief valve opens and allows the air to discharge into the atmosphere.
- The "A" and "B" chambers in the ABV are normally under the same intake manifold vacuum due to continuity provided by the balancing hole and the diaphragm will be pushed up by spring tension. At sudden deceleration, the balance between chambers "A" and "B" will be disrupted due to intake manifold vacuum acting suddenly on chamber "B". The diaphragm will drop temporarily until the balance in vacuum between chambers "A" and "B" is restored. Therefore, the air from the air pump will be by-passed into the atmosphere during the time the diaphragm is in lowered position.

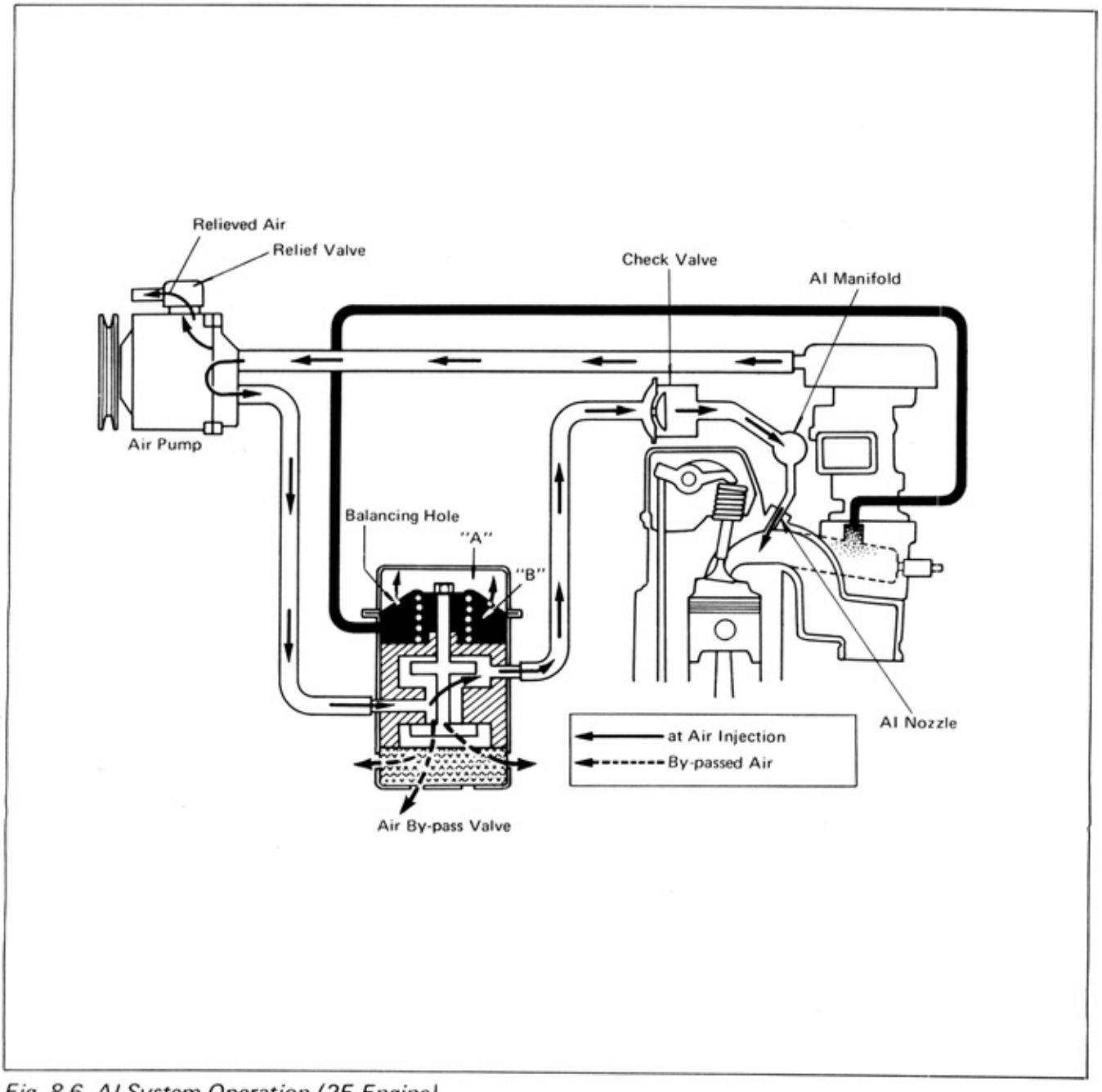


Fig. 8-6 AI System Operation (2F Engine)

5. Air pump operation

- As shown in the drawing, the rotor revolves out-of-center with the housing inner wall.
- The two vanes revolve in-center with the housing inner wall.
- Therefore, the chambers formed by the rotor, vanes, and housing inner wall change in accordance with the rotor revolution.
- The revolution of the rotor causes the two chambers to respectively increase in volume and draw in the air when revolving away from the inlet port, and decrease in volume, compress and discharge the air when approaching the outlet port.
- In case of 2F engine, a relief valve is provided at the outlet port, which serves to control the air pressure by opening and discharging the air into the atmosphere when the discharged pressure rises too high. In the other engines, this function is performed by the air switching valve (ASV).

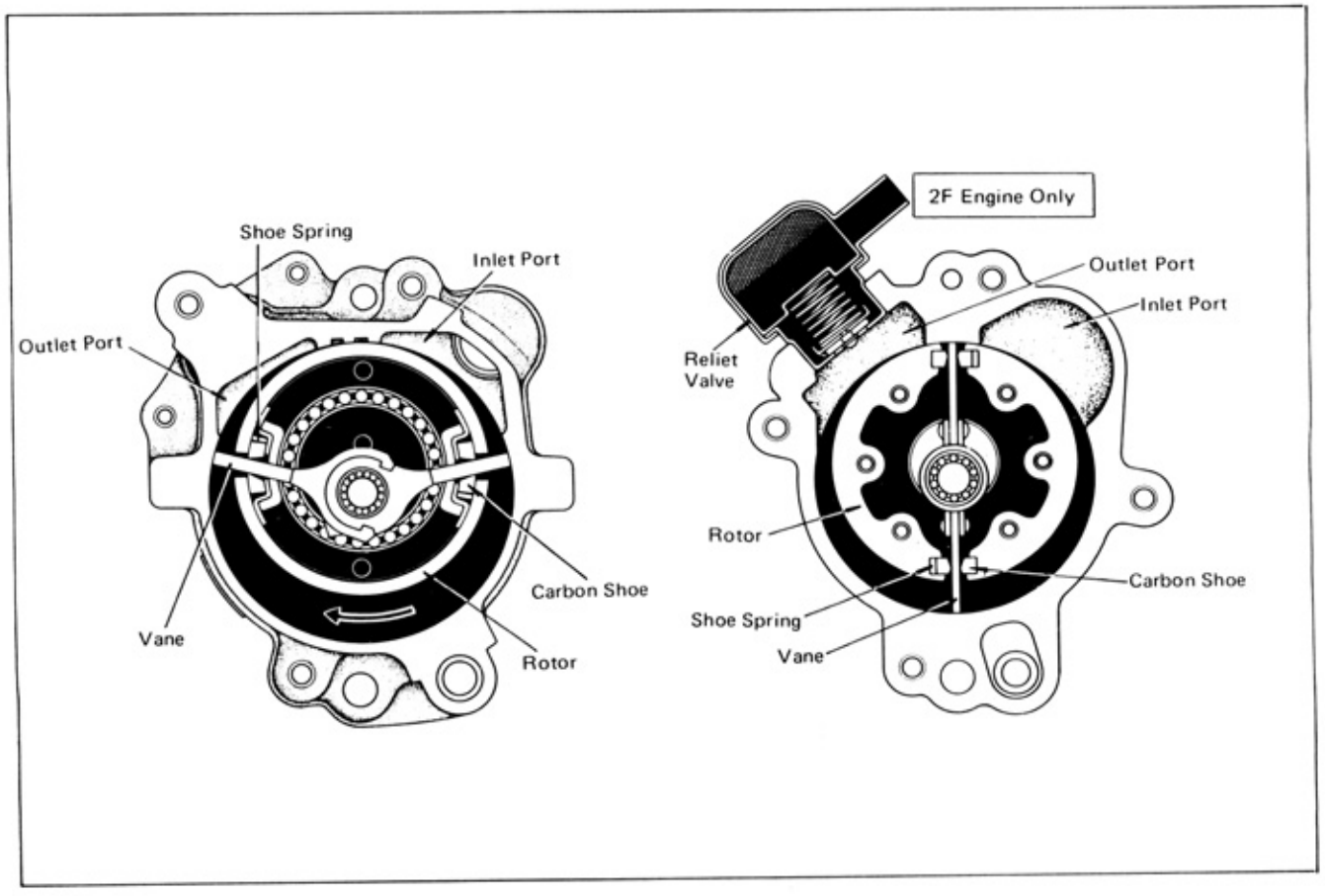


Fig. 8-7 Air Pump Operation

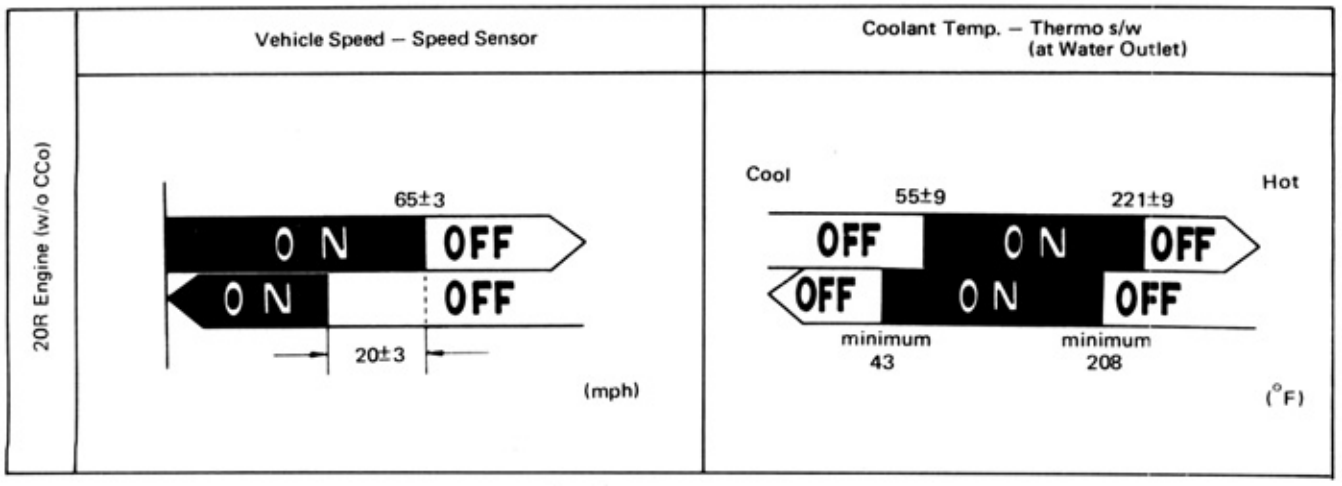
6. Operation of various valves.

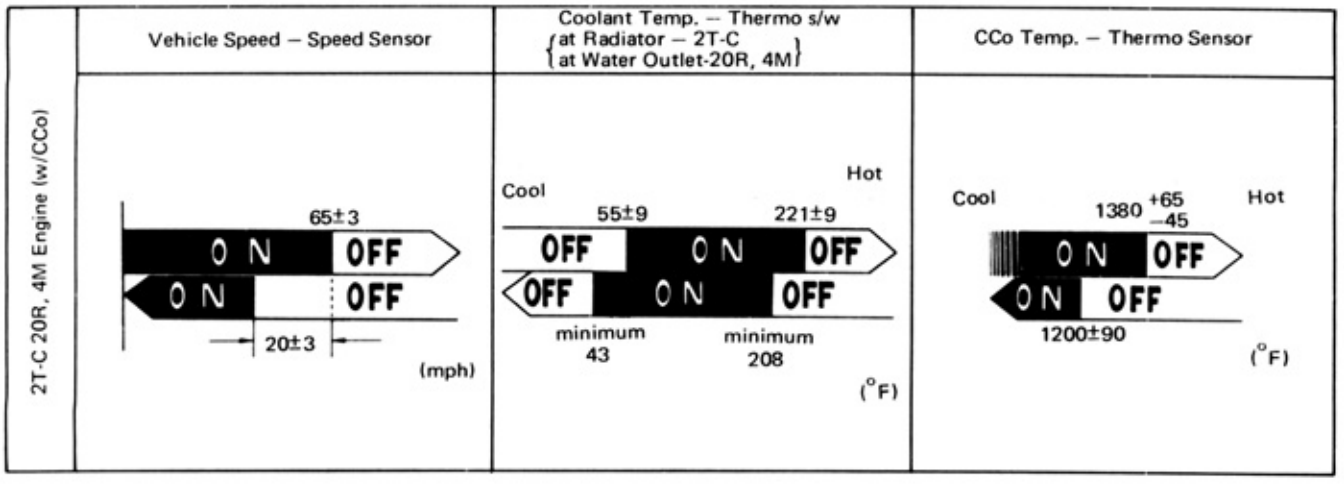
Refer to each section under AI system operations.

AI system Operating Ranges (2T-C engine for California, and 20R and 4M engines)

In the 2T-C (except for California) and 2F engines, there are no computer control so that there is constant air injection.

AI system "ON" – Air injected when all following conditions are "ON".
AI system "OFF" – Air injection is cut out when any of the following conditions is "OFF".





Note:
In the above figure, thermo switch "ON" denotes cut-out state and "OFF" the continuity state.

INSPECTION

1. Air pump drive belt inspection

- Inspect the drive belt for crack, deformation, and wear.
- Inspect for adherence of oil or grease on the belt.
- Check the belt inner perimeter to see that it is not touching the bottom of pulley groove.

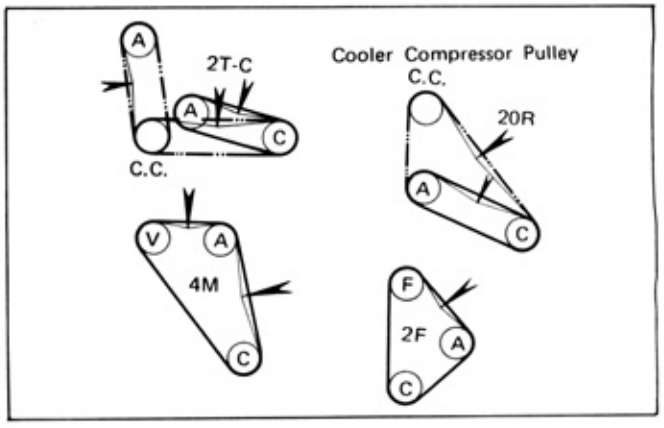


Fig. 8-8 Tension Check Points

2. Drive belt tension inspection and adjustment

- Press the drive belt at specified pressure and check the amount of deflection.
- To adjust, loosen the adjusting lever bolt, shift the air pump toward the direction of belt tension, and retighten the bolt.

Caution:
Do not attempt to shift the air pump by prying its die cast part with a lever.
Pry the rear cover or bolt pin (20R, 4M) in making the adjustment.

Table 8-1 Standard Belt Tension (at 22 lbs.)

Engine Family	Inspection Location	Tension (at 22 lbs)
2T-C	Air Pump Pulley x Crank Pulley	0.51 to 0.71"
2T-C	Air Pump Pulley x Cooler Compressor Pulley (w/cooler)	0.39 to 0.55"
2T-C	Cooler Compressor Pulley x Crank Pulley (w/cooler)	0.43 to 0.55"
20R	Air Pump Pulley x Crank Pulley	0.31 to 0.51"
20R	Cooler Compressor Pulley x Crank Pulley (w/cooler)	0.43 to 0.51"
4M	Air Pump Pulley x Crank Pulley (w/o Vane Pump)	0.71 to 0.85"
4M	Air Pump Pulley Vane Pump Pulley (w/ Vane Pump)	0.31 to 0.41"
2F	Air Pump Pulley x Fan Pulley	0.28 to 0.39"

3. Air pump inspection

- Check the air pump operation for abnormal noise.
- Check the air pump discharge pressure.

1. Connect the air pump tester [09258-14010] to the hose at air pump outlet.
2. Set the engine at specified speed.
3. The tester should deflect in the green zone.
4. If the tester deflects in the red zone, replace the pump assembly.
   (In case of 2T-C, 20R, and 4M engines)
5. In case of 2F engine, if the tester deflects in the red zone, close the relief valve outlet with hand and recheck. Then if the tester deflects in the green zone, replace the relief valve. If it continues to deflect in the red zone, inspect the air pump and repair or replace it.

Note
Select and use specified orifice on tester end as shown in Fig. 8-9.

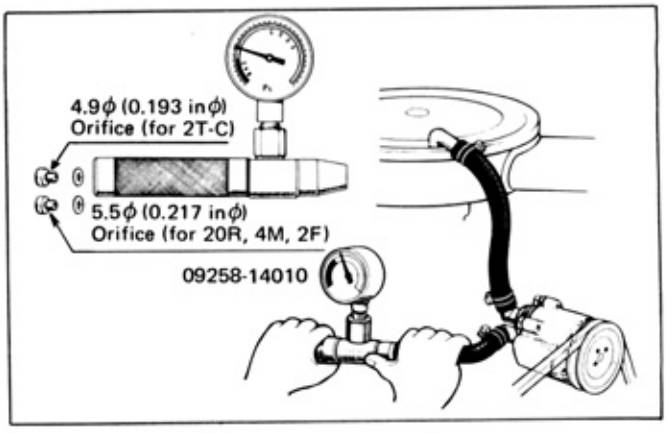


Fig. 8-9 Discharge Pressure Test

Table 8-2 Discharge Pressure & Engine rpm

Discharge Pressure		Green Zone of Tester (2.1 Psi, minimum)
Engine rpm	2T–C 20R	1800 rpm
	4M	1750 rpm
	2F	1450 rpm

4. Air by-pass valve (ABV) inspection

[2T-C, 20R, and 2F engines]

○ At idling, the air from the air pump should pass out toward the check valve (2F) or ASV (2T-C and 20R).

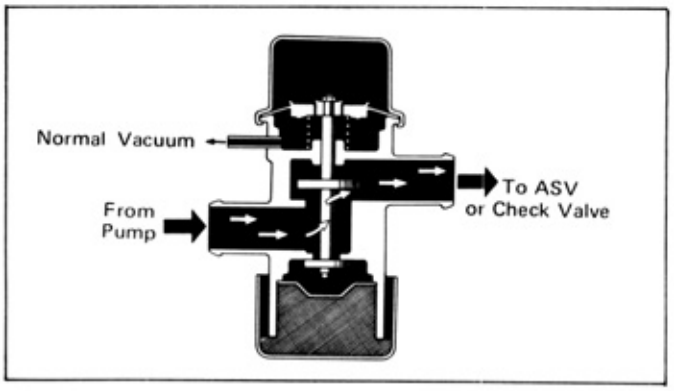


Fig. 8-10 ABV Inspection

○ Race the engine and suddenly close the throttle valve. The air from the air pump should be temporarily discharged into the atmosphere (20R and 2F) or to air cleaner (2T-C).

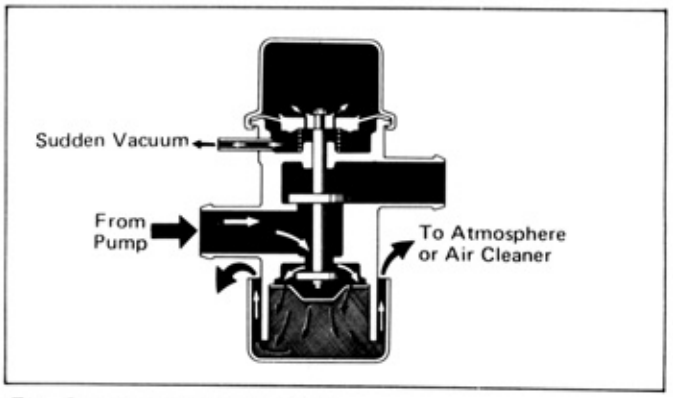


Fig. 8-11 ABV Inspection

5. Air switching valve (ASV) inspection

[2T-C and 20R engines]

○ At idling, the air from the ABV should discharge out toward the check valve.

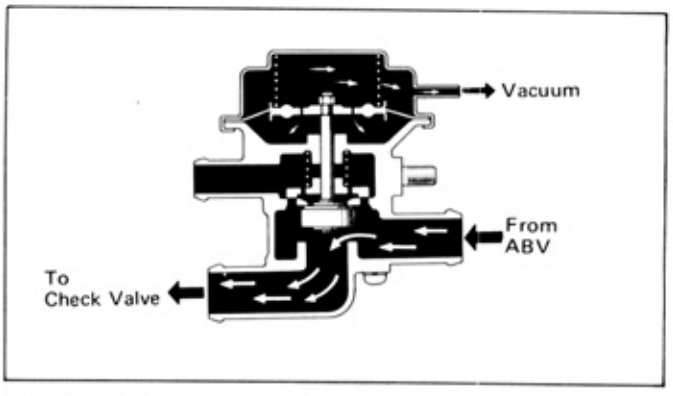


Fig. 8-12 ASV Inspection

○ When the ASV vacuum sensing hose is disconnected, the air from the ABV should discharge out toward the air cleaner.

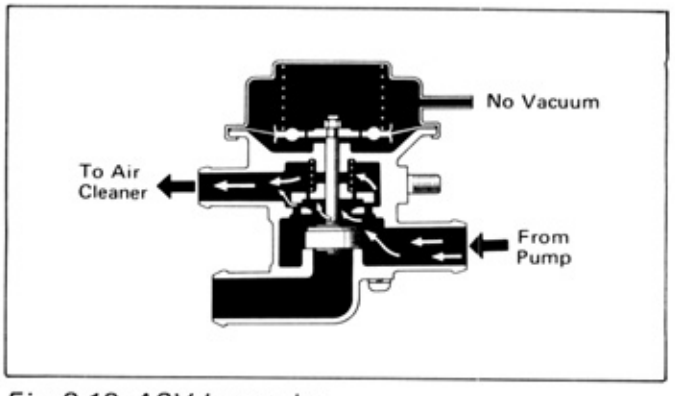


Fig. 8-13 ASV Inspection

6. Air switching valve (ASV) inspection

[4M engine]

- At idling, the air from the air pump should discharge out toward the check valve.

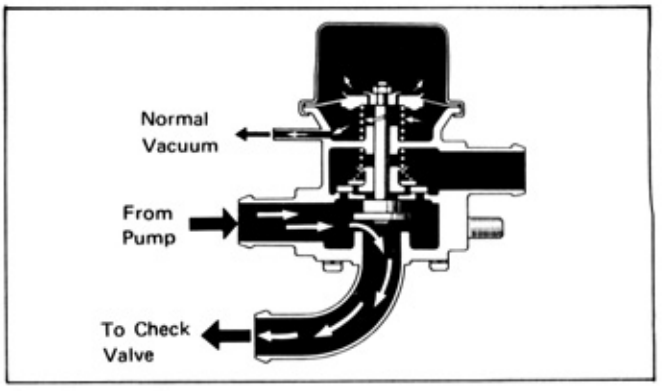


Fig. 8-14 ASV Inspection

- Race the engine and suddenly close the throttle valve. The air from the air pump should be discharged out toward the air cleaner.

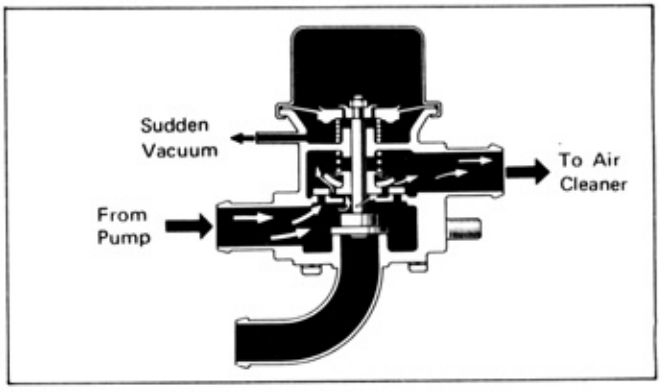


Fig. 8-15 ASV Inspection

7. ASV relief valve opening pressure measurement

- As shown in Fig. 8-16, disconnect the hose between the ASV and check valve at the check valve end and connect the SST [09258-14010]
- Raise the engine speed gradually and measure the relief valve opening pressure.
- Relief valve opening pressure:

Engine Family	Relief Valve Opening Pressure Psi. (kg/cm²)
2T-C, 20R	2.7 to 6.5 (0.19 to 0.46)
4M	3.7 to 7.7 (0.26 to 0.54)

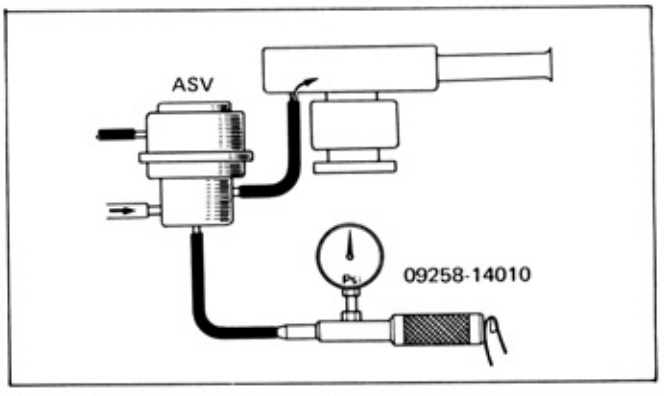


Fig. 8-16 Relief valve opening pressure measurement

8. Check valve inspection

- Make air passage test from the ASV or ABV (2F) side. There should be continuity toward the AI manifold side.
- There should be no passage of air from the AI manifold side toward the ASV or ABV side.

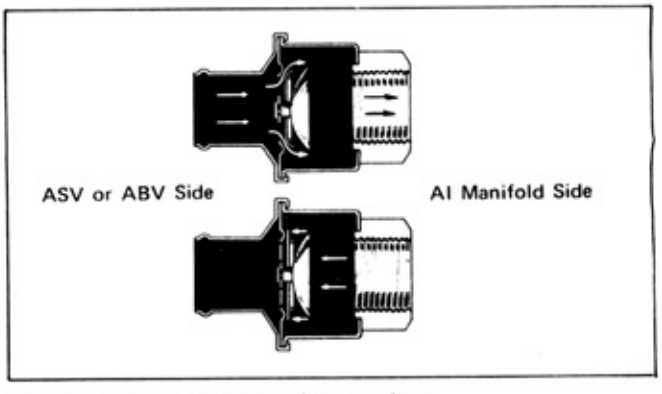


Fig. 8-17 Check Valve Inspection

9. Vacuum transmitting valve inspection

[2T-C and 20R engines]

- Check to see that the air passes through easier when blow in from the ASV side than from the intake manifold side.

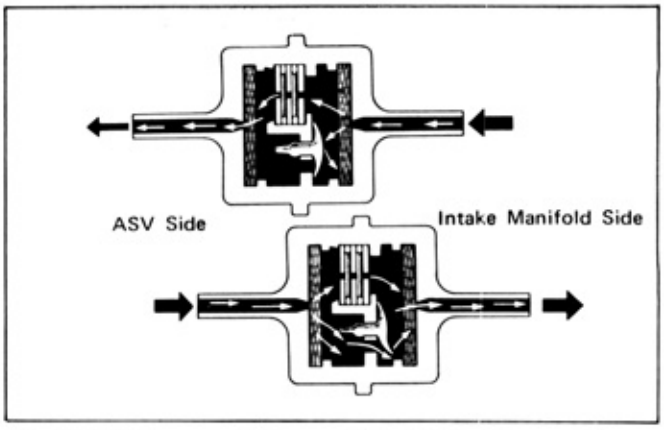


Fig. 8-18 Vacuum Transmitting Valve Inspection

10. Vacuum surge tank inspection (20R engine)

Visually inspect the vacuum surge tank to see that it is free from cracks or deformation.

11. VSV inspection (4M engine)

- Unplug the wiring connector from the VSV installed on the ASV and check for passage of air through the VSV upper and lower pipes.
- Hook on a battery to the VSV connector as shown in the drawing, or have the engine warmed up and the ignition switch turned on. Then check to see that at such time there will be no passage of air through the VSV upper and lower pipes.

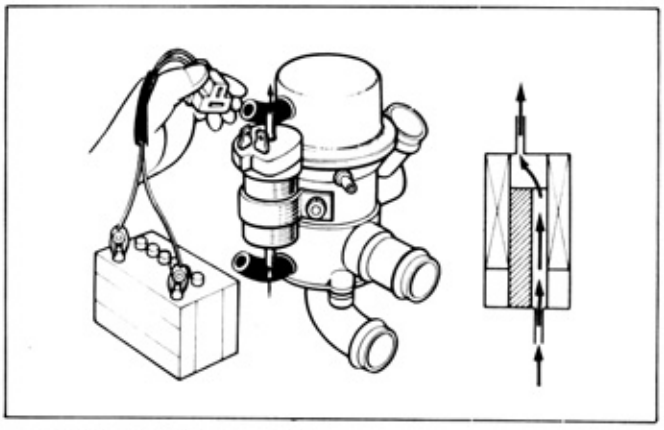


Fig. 8-19 VSV Inspection

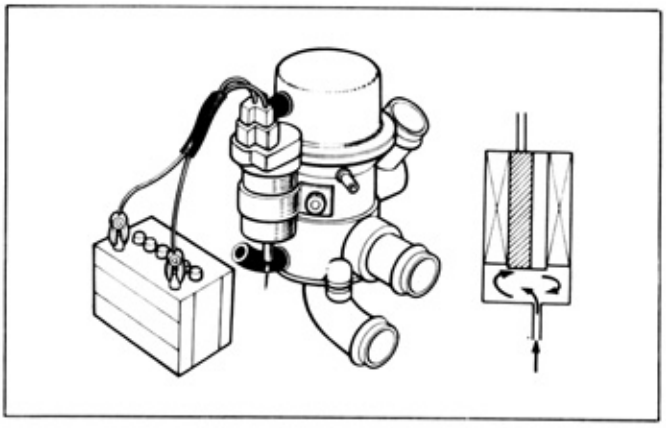
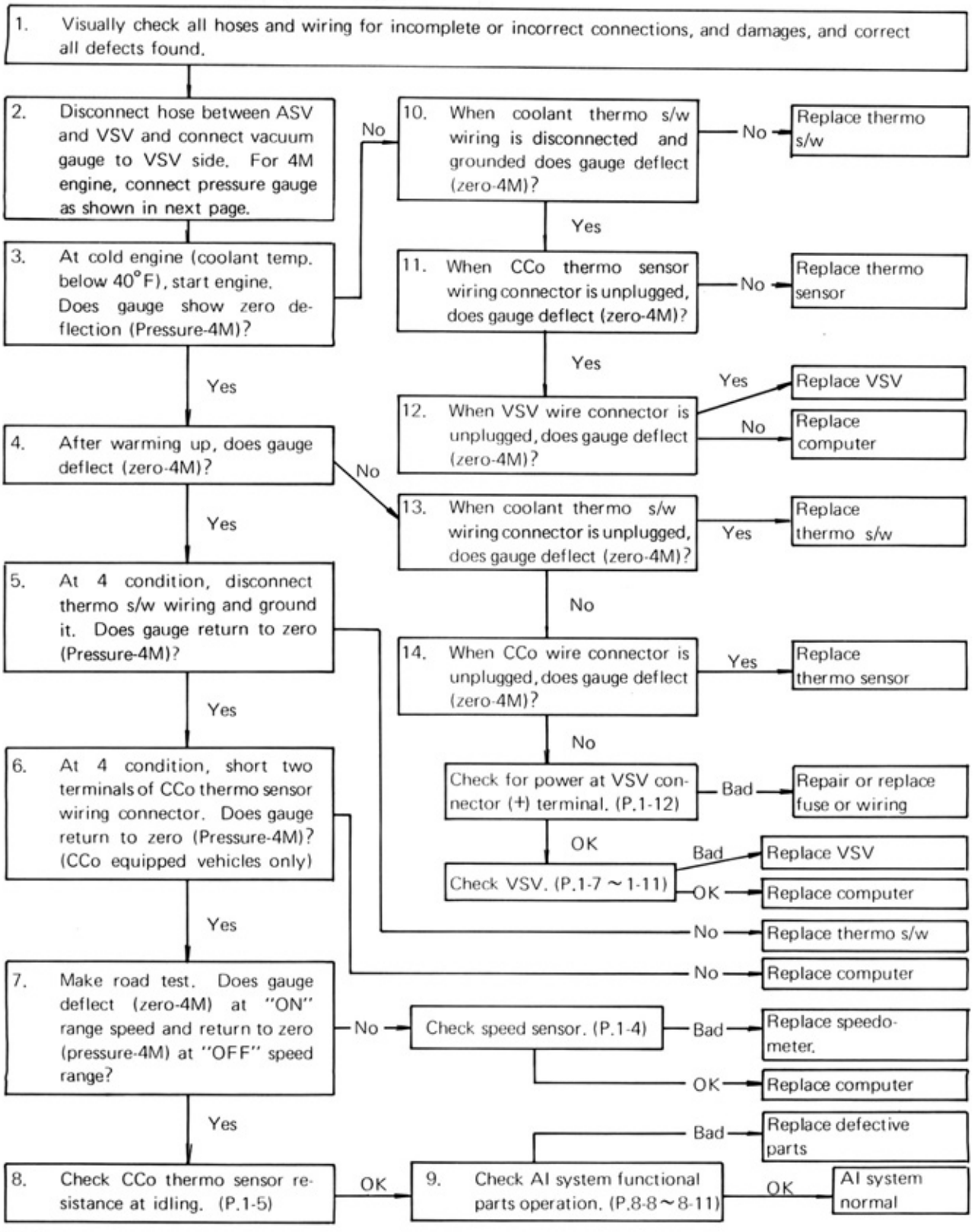


Fig. 8-20 VSV Inspection

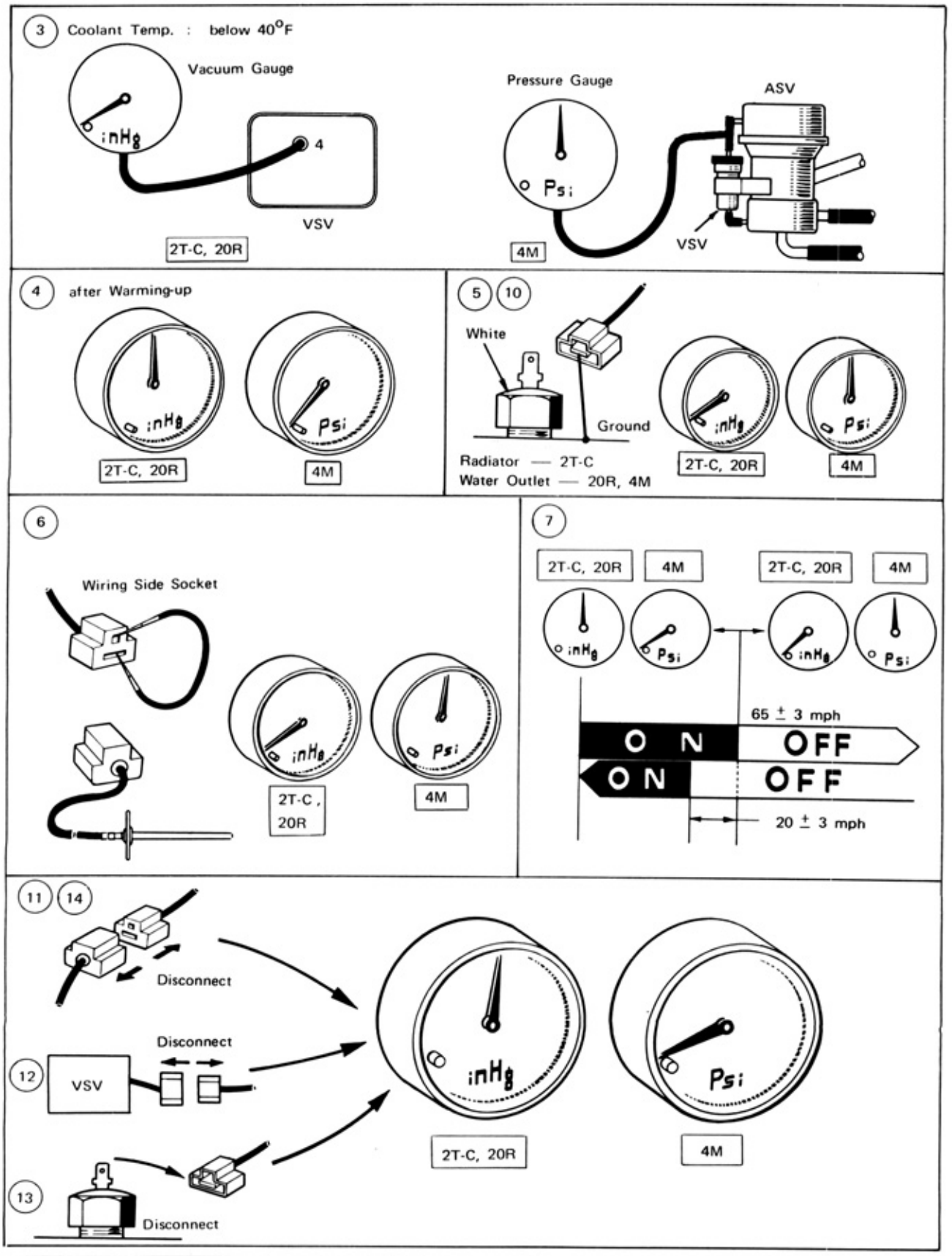
12. Inspection of tubes and hoses

- Inspect the hoses and tubes to see that they are free from cracks or are not deteriorated.
- Check the tubes and hoses to see that they are in properly connected state and that they are not interfering with the other parts.

AI SYSTEM ELECTRICAL CONTROL INSPECTION PROCEDURE
(20R and 4M engines and 2T-C engine for California)



Note
In case of Inspection 3, the inspection cannot be performed if the coolant temperature does not drop below 40°F by unplugging the thermo switch wiring connector and grounding the wire terminal, and then perform Inspection 3.



when the vehicle is parked in the shade for more than one hour. In such case, forcibly obtain the cold condition Inspection of thermo switch itself must be made later (P1-6).

AI SYSTEM ELECTRICAL CONTROL INSPECTION PROCEDURE (Using Checker)

1. Visually check all hoses and wiring for incorrect connections and damages, and correct any defects found.

2. Connect the checker to inspection connector and VSV connectors.
3. Set all checker switches to "VEHICLE" side, and turn on the ignition switch.

4. At cold engine (coolant temp. below 40°F), does light "C" turn off? In CCo vehicle, does light "D" turn on?
   - No → If light "C" not working properly, replace radiator (2T-C) or water outlet thermo s/w.
5. After warming up, does light "C" turn on? In CCo vehicle, does light "D" turn off?
   - No → If light "D" not working properly, replace CCo thermo sensor.

Yes

6. Light "I" ("J"-20R) is on.
7. Set switch "K" to "SIMULATION" side. When dial "K" is turned, does light "I" ("J"-20R) turn off at "OFF" range speed?
   - No → After making sure that computer wiring connector is plugged in properly, replace computer.
8. Does light "I" ("J"-20R) turn off when switch "N" is set to "SIMULATION" side? Have switch "N" returned to "VEHICLE" side (w/CCo vehicle only)

Yes

9. Connect vacuum gauge to VSV No. 4 pipe (2T-C) and No. 4 pipe (20R). Have engine idling. On 4M engine, connect pressure gauge on upper pipe of VSV for ASV as shown in next page. With dial "K", turn on light "I" ("J"-20R) from off state. Does gauge deflect from zero to vacuum (Pressure to zero-4M)?
   - No → Does ASV work properly? (P.8-9 ~ 8-10)
     - No → Replace ASV.
     - Yes → Replace VSV.

Yes

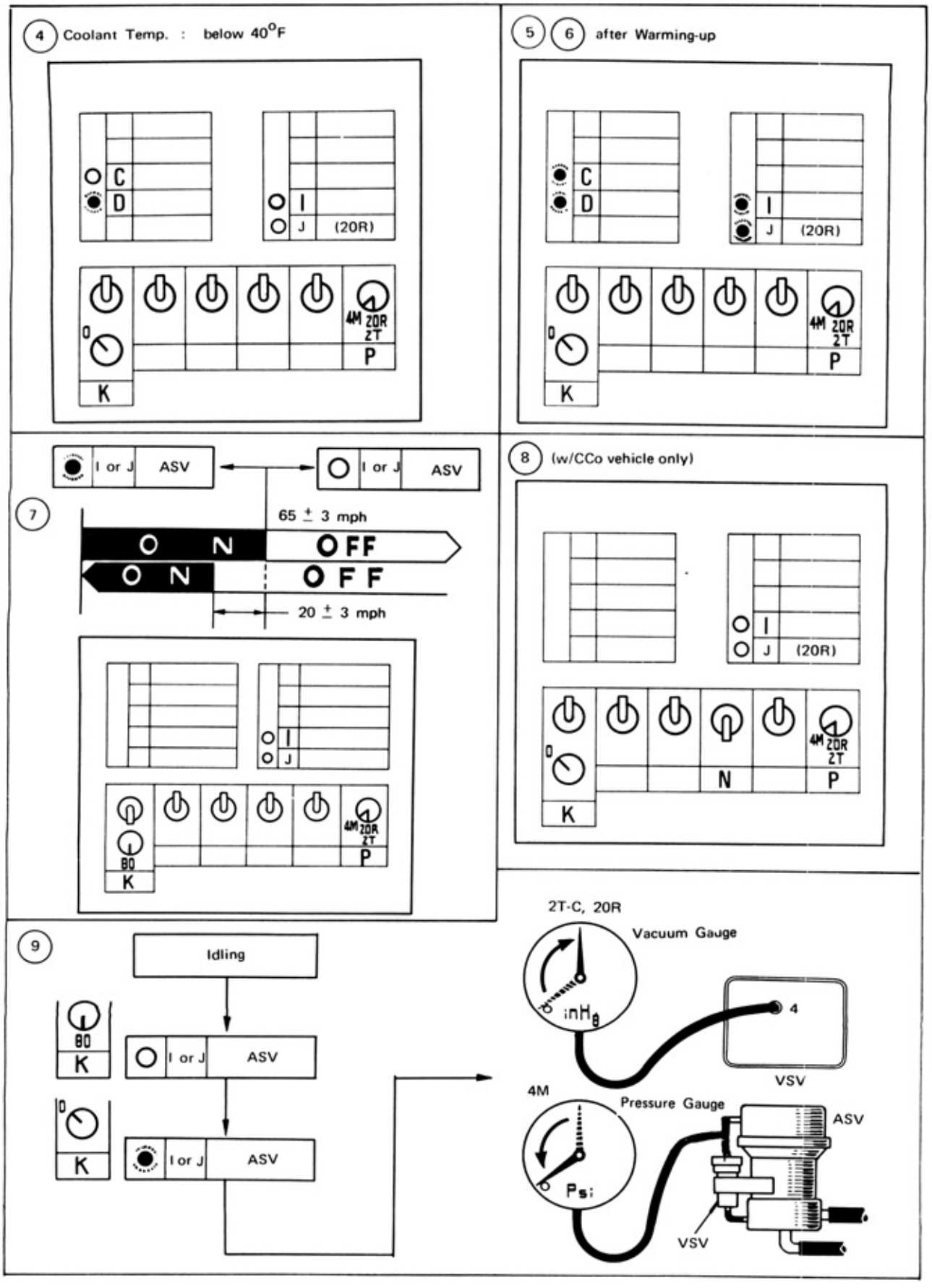
10. Set switch "K" to "VEHICLE" side and run at low speed (about 5 mph). Does light "A" flash properly?
    - No → Replace speedometer.

Yes

11. Set all checker switches to "VEHICLE" side and start the engine. When accelerator pedal is pumped for about a minute, does light "D" go off?
    - No → Replace thermo sensor or wiring.

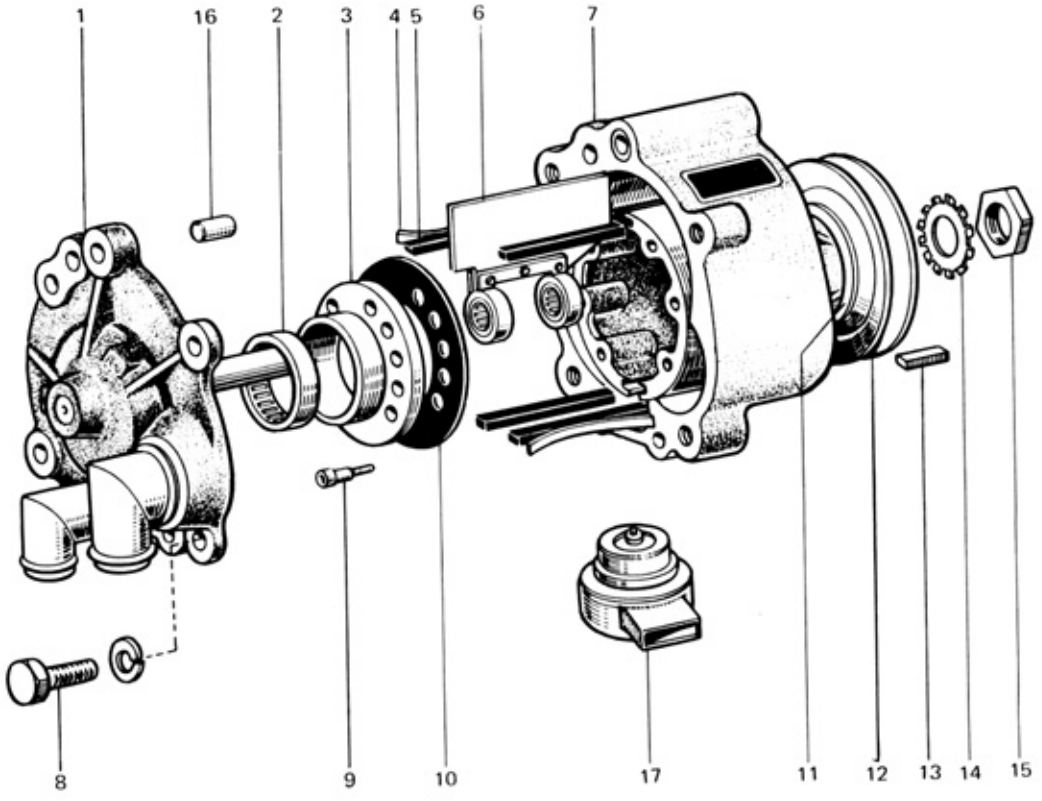
Yes

12. Check operation of AI system functional parts. Repair or replace any found defective. (P.8-8)
    → AI system normal


4 Coolant Temp. : below 40°F
C
D
I
J
(20R)
4M 20R 2T
P
D
K
5 6 after Warming-up
7
I or J ASV
I or J ASV
65 ± 3 mph
ON
OFF
ON
OFF
20 ± 3 mph
80
8 (w/CCo vehicle only)
N
9
Idling
2T-C, 20R
Vacuum Gauge
inHg
4
VSV
4M
Pressure Gauge
Psi
ASV
VSV

AIR PUMP REPAIR (2F Engine only)

The air pump for other than 2F engine is of the type that cannot be disassembled so that in case of trouble, the pump assembly must be replaced.



1. Housing Cover
2. Rear Bearing
3. Rotor Ring
4. Shoe Spring
5. Carbon Shoe
6. Vane
7. Rotor Housing
8. Bolt
9. Rotor Ring Screw
10. Rear Seal
11. Pulley Plate
12. Pulley
13. Key
14. Lock Washer
15. Lock Nut
16. Dowel Pin
17. Relief Valve

Fig. 8-21 Air Pump Components

RELIEF VALVE REPLACEMENT

Note :
The relief valve must not be removed unless it is to be replaced. If it should be removed, it must never to reused.

1. Use SST [09297-60010] and pull out the relief valve from the rotor housing.

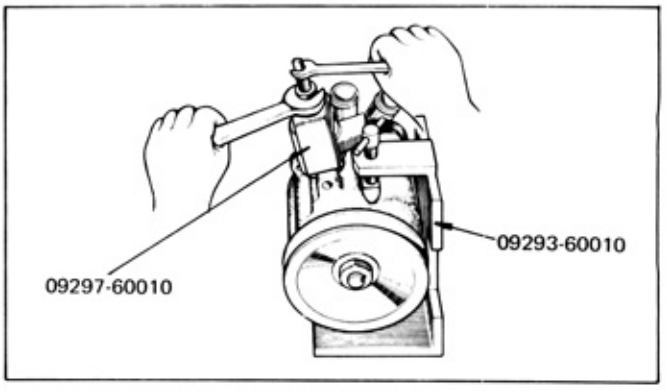


Fig. 8-22 Removing Relief Valve

2. Mount SST [09293-60010] on the air pump.
3. Set a wood block under the SST [09293-60010] so that the relief valve will be positioned vertically upward.
4. Using a press and SST [09296-60010], force the new relief valve into the rotor housing.

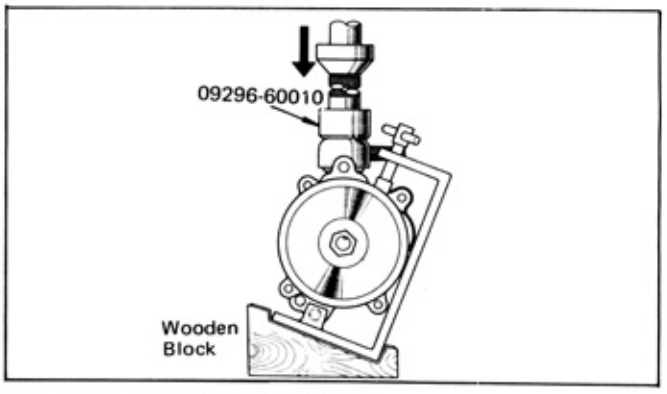


Fig. 8-23 Installing Relief Valve

Disassembly

1. Mount SST [09293-60010] on the air pump.
2. Remove the four housing cover bolts.
3. Drive out the two dowel pins toward the front side.

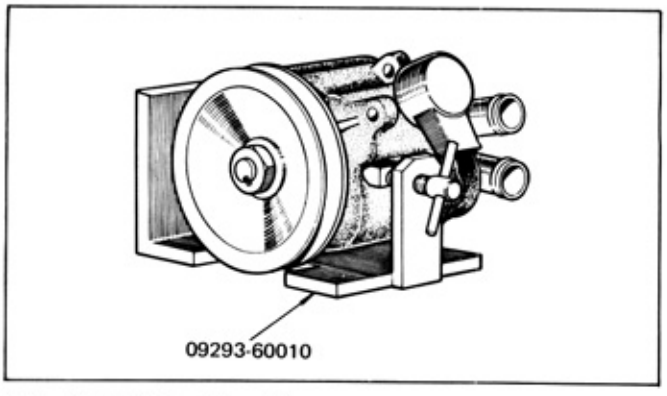


Fig. 8-24 Mounting Air pump

4. Clamp the pulley in a vise over wood blocks or copper plates.
5. Remove the six rotor ring screws, and take off the rotor ring and rear seal.
6. Take out the two vanes, carbon shoes, and shoe springs from the inside of rotor.

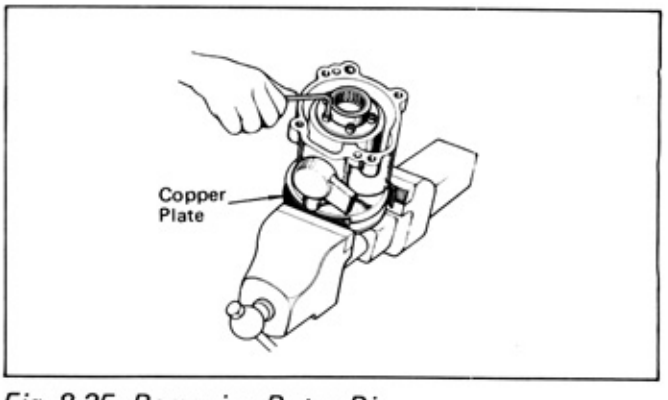


Fig. 8-25 Removing Rotor Ring

7. If found necessary to remove the rotor or pulley, clamp the pulley in a vise over wood blocks or copper plates, and remove the nut.

   Note:
   The nut has left-hand threads.
   Using SST [09294-60010], pull out the pulley.
   Take out the woodruff key.

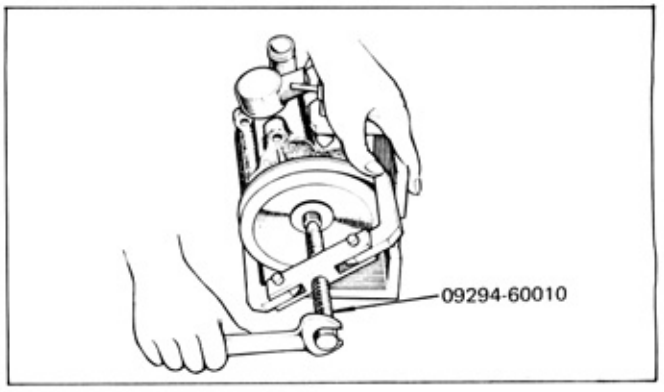


Fig. 8-26 Removing Pulley

Inspection

The disassembled parts must not be washed. Therefore, use shop towel and wipe off the carbon and grease, and then blow clean with compressed air.

1. Inspect the inner surface of the rotor housing for damage and wear.

2. Inspect the vanes and vane bearings. If defective, replace the vane assembly.
   If the vane longitudinal dimension ("A" in Fig. 8-27) is found less than 2.35", replace the vane assembly.

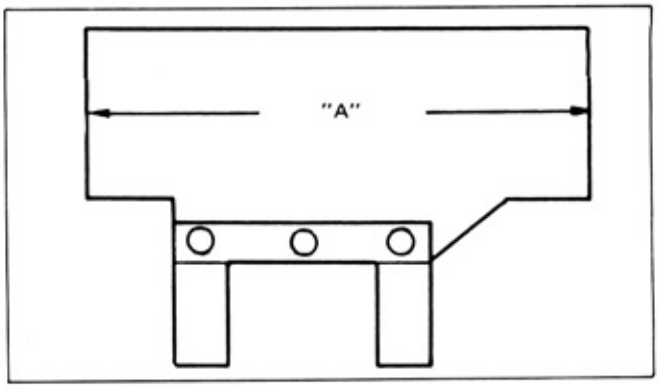


Fig. 8-27 Vane Inspection

3. Inspect the carbon shoes for damage and wear. Check the carbon shoe heights (Fig. 8-28). If "B" is less than 0.180" and "C" less than 0.159", replace with shoe kit.

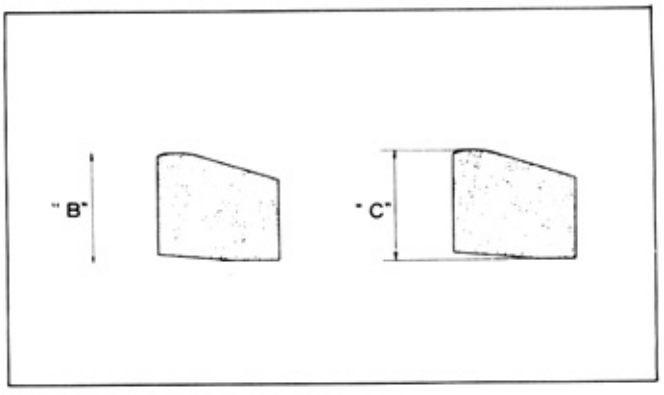


Fig. 8-28 Carbon Shoe Inspection

4. Check the rear seal for damage.

5. Check the shoe spring height ("D" in Fig. 8-29). If less than 0.12", replace the spring.

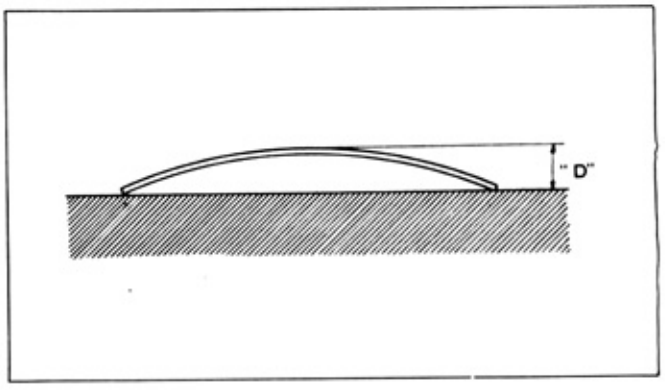


Fig. 8-29 Shoe Spring Tension

6. Inspect the rear bearing for damage.
   If defective, force out the bearing from the rotor ring with SST [09295-60010] and press, and install the new bearing by same method.

   Note:
   Install the bearing such that the letters on its outer race will be positioned toward the rear.

7. Inspect the front bearing. If defective, replace the rotor housing subassembly.

Assembly

1. Apply multipurpose grease on the vane bearings and rear bearing.

2. Fit the woodruff key on the rotor shaft, and install the pulley, lock washer, and lock nut.

   Tightening torque: 21.7 to 28.9 ft-lb

3. Mount the SST [09298-60010] on the rotor housing.

4. Assemble the two vanes into the rotor.

5. Assemble the shoe spring and carbon shoes in the positions shown in Fig. 8-32.

   Note:
   Insert the shoe spring and smaller-width carbon shoe at the side in direction of rotation, and insert only the larger-width carbon shoe at the other side.

6. Assemble the shoe spring and carbon shoes in the same manner at the vane at other side.

   Note:
   Install the shoe spring so that its curved side will be contacting on the carbon shoe. (Fig. 8-33)

7. Install the rear seal and rotor ring to the rotor, and tighten the screws uniformally.

8. Install the housing cover.

   Tightening torque 7.2 to 10.3 ft-lb.

   Note:
   In case new carbon shoes had been installed, a sliding noise may be produced, but after the shoes are worn-in in about two or three hours, this noise should disappear.

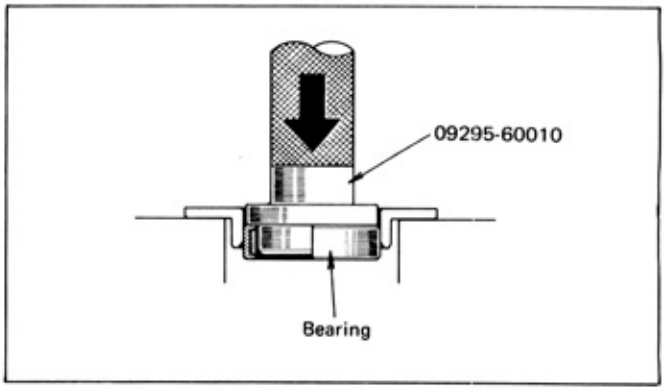


Fig. 8-30 Replacing Rear Bearing

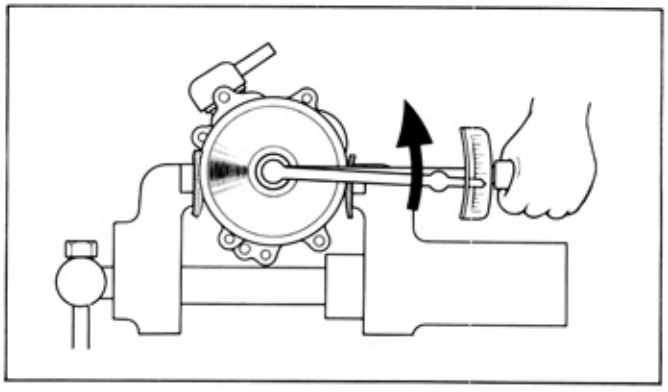


Fig. 8-31 Tightening Lock Nut

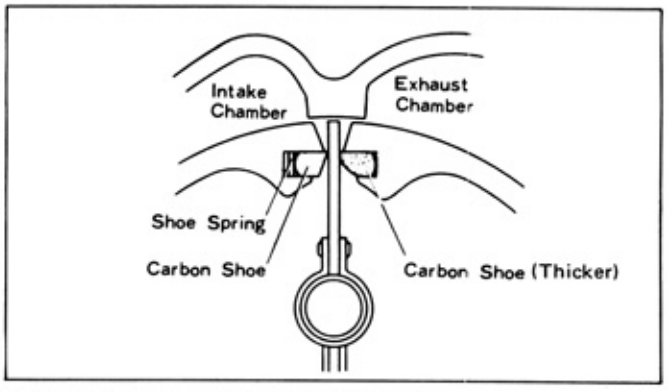


Fig. 8-32 Shoe and Spring Position

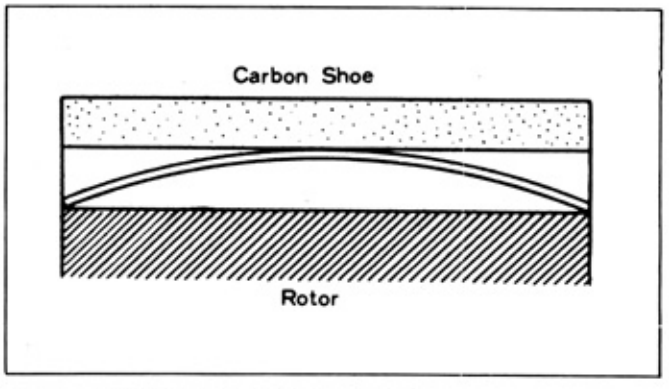


Fig. 8-33 Shoe Spring Direction