VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (PIERCE)

IN-LINE INDUSTRIAL ENGINES

After adjusting the exhaust valves and timing the fuel injectors, position the injector rack control levers and adjust the governor.

Position Injector Rack Control Levers

The injector rack settings govern the quantity of fuel injected into each cylinder. All of the injectors must be set to inject the same quantity of fuel into each cylinder to ensure equal distribution of the load. Position the injector rack control levers as follows:

1. Disconnect the linkage between the governor rocker shaft lever and the bell crank mounted on the flywheel housing.

2. Loosen all of the inner and outer rack control lever adjusting screws (Fig. 1). Be sure all of the levers are free on the injector control tube.

3. Lift upward on the bell crank, as shown in Fig. 1, to move the injector racks into the full-fuel position and turn the inner adjusting screw down until a 1/16" clearance exists between the fuel rod and the cylinder head or the cylinder head bolt, whichever it contacts.

Turn the outer adjusting screw down until it bottoms on the control tube, then alternately tighten the inner and outer screws to retain the adjustment.

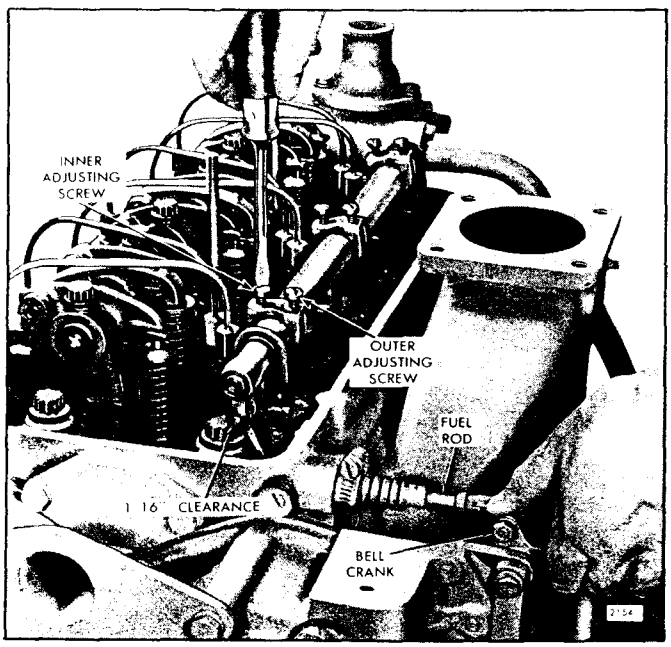


Fig. 1 - Positioning Injector Rack Control Lever

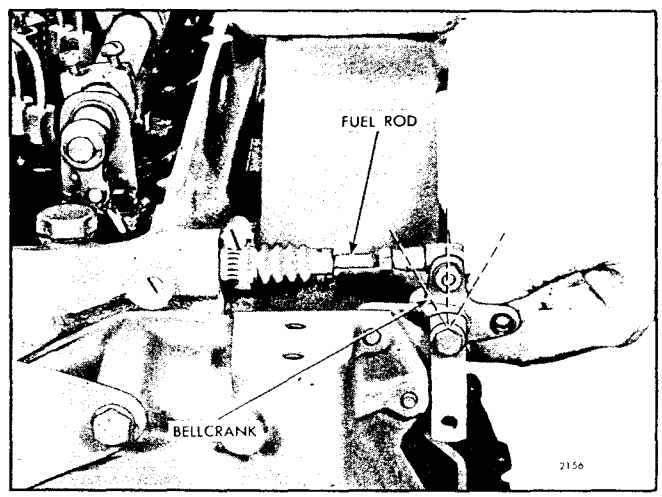


Fig. 2 - Adjusting the Fuel Rod

4. Manually hold the rear injector control rack in the full-fuel position and turn the inner adjusting screw of the adacent injector rack control lever down until it has moved into the full-fuel position and the screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both screws.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lb**.

5. Recheck the rear injector rack to be sure it has remained snug on the pin of the rack control lever while positioning the adjacent injector rack. If the rack of the rear injector has become loose, back off the inner adjusting screw slightly on the adjacent injector rack control lever and tighten the outer adjusting screw to retain the adjustment. When the settings are correct, the racks of both injectors will be snug on the ball end of each rack control lever.

6. Position the remaining rack control levers as outlined in Steps 4 and 5.

Adjust Governor Linkage

1. Check the travel of the bell crank as shown in Fig. 2. The vertical arm of the bell crank should move

VARIABLE SPEED MECHANICAL GOVERNOR (ENCLOSED LINKAGE) AND INJECTOR RACK CONTROL ADJUSTMENT

IN-LINE ENGINES

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

NOTE: If the engine is equipped with a supplementary governing device, it must be disconnected before proceeding with the governor and injector rack adjustments (refer to Section 14.14).

Adjust Governor Gap

With the engine stopped and at operating temperature, adjust the governor gap as follows:

1. Disconnect any linkage attached to the governor levers.

2. Remove the governor cover.

3. Place the speed control lever in the maximum speed position.

4. Insert a .006 " feeler gage between the spring plunger and the plunger guide as shown in Fig. 1. If required, loosen the lock nut and turn the gap adjusting screw in or out until a slight drag is noted on the feeler gage.

5. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust if necessary.

6. Install the governor cover as follows:

a. Place the cover on the governor housing, with the pin in the throttle shaft assembly entering the slot in the differential lever.

b. Install the four cover screws and lock washers finger tight.

c. Pull the cover assembly in a direction away from the engine, to take up the slack, and tighten the cover screws.

NOTE: This step is required since no dowels are used to locate the cover on the housing.

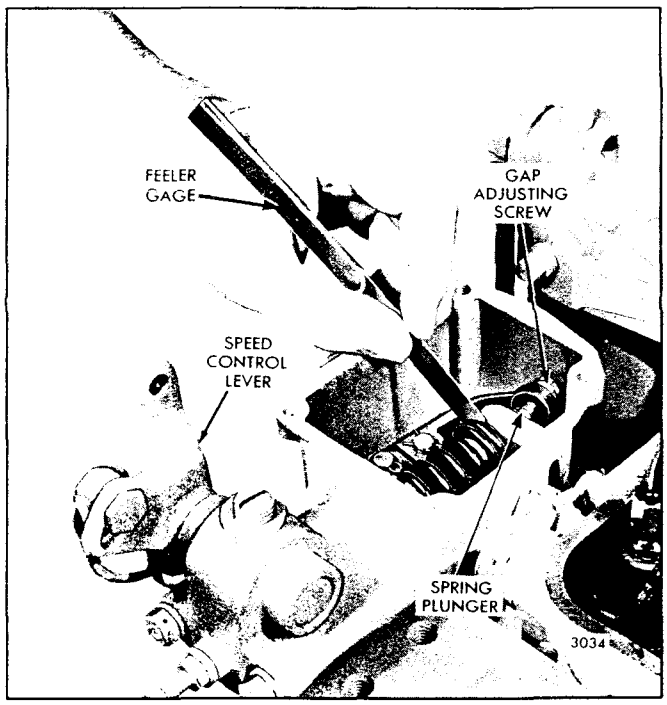


Fig. 1 - Checking Governor Gap

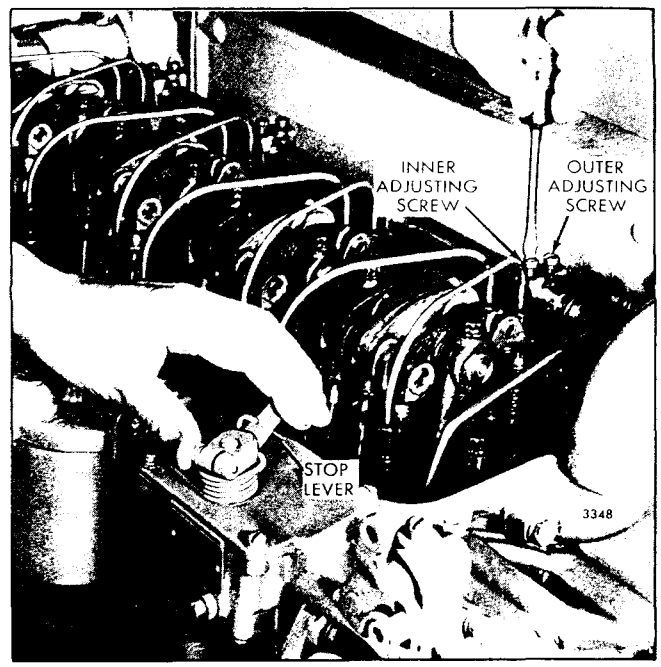


Fig. 2 - Positioning the Rear Injector Rack Control Lever

Position Injector Rack Control Levers

The position of the injector control racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load. Adjust the rear injector rack control lever first to establish a guide for adjusting the remaining levers.

1. Loosen the lock nut and back the buffer screw (Fig. 5) out approximately 5/8 ".

2. Clean and remove the valve rocker cover.

3. Loosen all of the inner and outer injector rack control lever adjusting screws (Fig. 2). Be sure all of the levers are free on the injector control tube.

4. Move the speed control lever to the maximum speed position.

5. Move the stop lever to the RUN position and hold it in that position with light finger pressure. Turn the inner adjusting screw of the rear injector rack control lever down until a slight movement of the control tube is observed or a step-up in effort to turn the screw driver is noted. This will place the rear injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws. This should result in placing the governor linkage and control tube in the respective positions that they will attain while the engine is running at full load.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screw is 24-36 **in-lbs**.

6. To be sure the control lever is properly adjusted, hold the stop lever in the RUN position and press down on the injector rack with a screw driver or finger tip, causing the rack to rotate. The setting is sufficiently tight if the rack returns to its original position when the pressure is released. If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw. The setting is too tight if, when moving the stop lever from the STOP to the RUN position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the RUN position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

7. Manually hold the rear injector rack in the full-fuel position with the lever on the injector control tube and turn the inner adjusting screw of the adjacent injector rack control lever down until the rack of the adjacent injector moves into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

8. Recheck the rear injector rack to be sure that it has remained snug on the ball end of the rack control lever while adjusting the adjacent injector rack. If the rack of the rear injector has become loose, back off the inner adjusting screw slightly on the adjacent injector rack control lever and tighten the outer adjusting screw. When the settings are correct, the racks of both

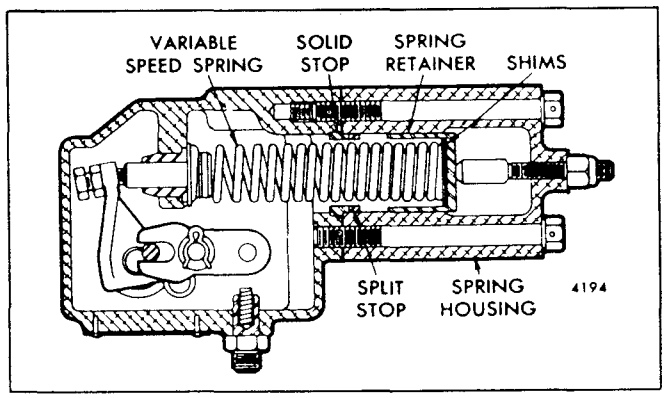


Fig. 3 - Location of Shims and Stops

Fig. 4 - Adjusting Idle Speed

injectors must be snug on the ball end of their respective control levers.

9. Position the remaining injector rack control levers as outlined in Steps 6, 7 and 8.

Adjust Maximum No-Load Speed

The maximum no-load speed varies with the full load operating speed desired as shown in Table 1.

Add droop to full-load speed to obtain the required no-load speed.

Use an accurate tachometer to determine the maximum no-load speed of the engine, then make the following adjustments, if required.

1. Refer to Fig. 6 and disconnect the booster spring and the stop lever retracting spring.

DROOP REQUIREMENTS	
ENGINE FULL LOAD SPEED	DROOP RPM
0-1400	220
1401-1600	205
1601-1800	185
1801-2000	175
2001-2200	160
2201-2400	145
2401-2800	140

TABLE 1

Fig. 5 - Adjusting Buffer Screw

Full Load Speed RPM	STOPS		SHIMS
	Solid Ring	Split Ring	
2575-2800	0	0	As Required
2101-2575	1	0	As Required
1701-2100	1	1	As Required
1200-1700	1	2	As Required

TABLE 2

2. Remove the two attaching bolts and withdraw the variable speed spring housing and the variable speed spring retainer located inside of the housing.

3. Refer to Table 2 and determine the stops or shims required for the desired full-load speed. Do not use more than four thick and one thin shim. A split stop can only be used with a solid stop (Fig. 3).

4. Install the variable speed spring housing.

5. Connect the booster spring and stop lever spring and recheck the maximum no-load speed.

6. If required, add shims to obtain the necessary operating speed. For each .001 " in shims added, the operating speed will increase approximately 2 rpm.

IMPORTANT: If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

NOTE: Governor stops are used to limit the compression of the governor spring which determines the maximum speed of the engine.

Adjust Idle Speed

After the maximum no-load speed has been set, adjust the idle speed as follows:

1. Place the stop lever in the RUN position and the speed control lever in the IDLE position.

2. With the engine operating, loosen the lock nut and turn the idle speed adjusting screw (Fig. 4) in or out until the engine idles at the recommended speed. The recommended minimum idle speed is 550 rpm. However, the idle speed may vary with special engine applications.

Fig. 6 - Adjusting Booster Spring

3. Hold the idle speed adjusting screw and tighten the lock nut.

Adjust Buffer Screw

With the engine idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at idle speed, loosen the lock nut and turn the buffer screw in (Fig. 5) so that it contacts the differential lever as lightly as possible and still eliminates engine roll.

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the lock nut.

Adjust Booster Spring

With the engine idle speed set, adjust the booster spring as follows:

1. Move the speed control lever to the idle speed position.

2. Refer to Fig. 6 and loosen the booster spring retaining nut on the speed control lever. Loosen the lock nuts on the eye bolt at the opposite end of the spring.

3. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginary line through the bolt, lever shaft and eye bolt. Hold the bolt and tighten the lock nut.

4. Start the engine and move the speed control lever to the maximum speed position and release it. The lever should return to the idle speed position. If it does not, reduce the booster spring tension. If it does, continue to increase the spring tension until the point is reached where it will not return to idle. Then reduce the spring tension until the lever does return to idle and tighten the lock nuts on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.

If the engine is equipped with a supplementary governing device, refer to Section 14.14 and adjust it at this time.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (PIERCE)

IN-LINE TRACTOR ENGINE

After timing the fuel injectors and adjusting the exhaust valves, position the injector rack control levers and adjust the governor.

Position Injector Rack Control Levers

The injector rack settings govern the quantity of fuel injected into each cylinder. All of the injectors must be set to inject the same quantity of fuel into each cylinder to ensure equal distribution of the load. Position the injector rack control levers as follows:

1. Disconnect the linkage between the governor rocker shaft lever and the bell crank mounted on the end plate.

2. Loosen all of the inner and outer rack control lever adjusting screws (Fig. 1). Be sure all of the levers are free on the injector control tube.

3. Lift upward on the bell crank to move the injector racks into the full-fuel position and turn the inner adjusting screw down until a 1/16" clearance exists between the fuel rod and the cylinder head or the cylinder head bolt, whichever it contacts.

Turn the outer adjusting screw down until it bottoms on the control tube, then alternately tighten the inner and outer screws to retain the adjustment.

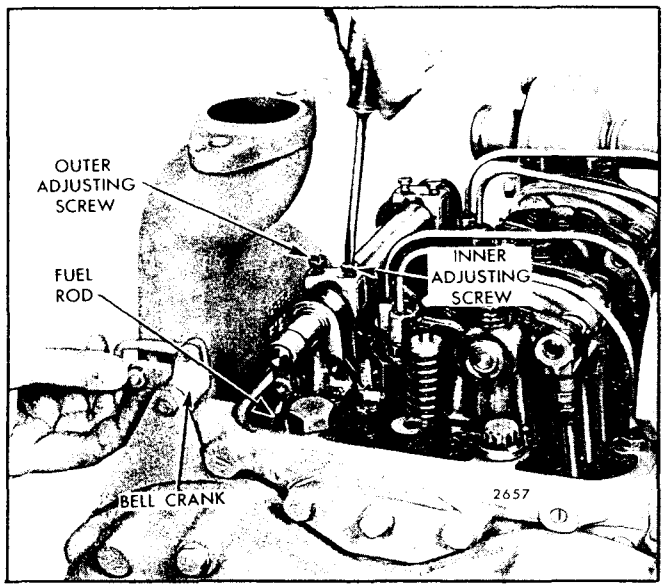


Fig. 1 - Positioning Injector Rack Control Levers

Fig. 2 - Adjusting the throttle rod

4. Manually hold the rear injector control rack in the full-fuel position and turn the inner adjusting screw of the adjacent injector rack control lever down until it has moved into the full-fuel position and the screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both screws.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lb.**

5. Recheck the rear injector rack to be sure it has remained snug on the pin of the rack control lever while positioning the adjacent injector rack. If the rack of the rear injector has become loose, back off the inner adjusting screw slightly on the adjacent injector rack control lever and tighten the outer adjusting

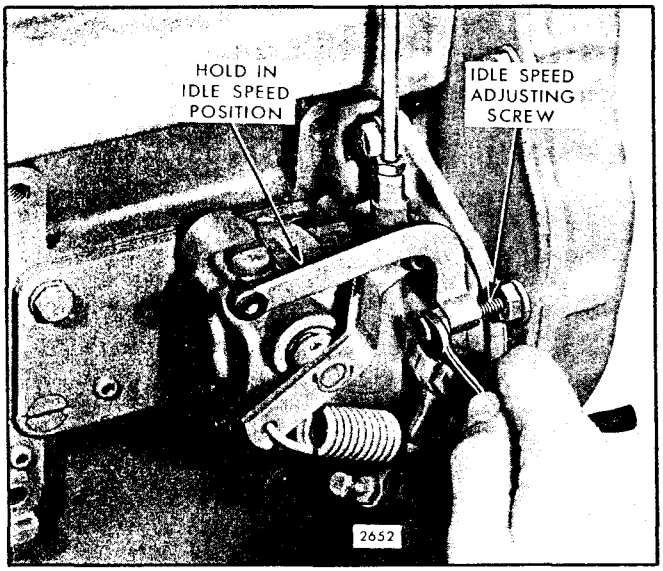


Fig. 3 - Adjusting Idle Speed

screw to retain the adjustment. When the settings are correct, the racks at both injectors will be snug on the ball end of each rack control lever.

Adjust Governor Linkage

1. Advance the governor rocker shaft lever to the maximum fuel position. Hold the lever in this position, after backing out the buffer screw, by advancing the governor speed control lever to its maximum speed position.

2. Hold the injector control racks in the full-fuel position; then adjust the length of the throttle rod, by turning the ball and socket on the rod, until it can be connected to the rocker shaft lever (Fig. 2).

3. Check the injector racks to be sure the governor holds the racks in the full-fuel position.

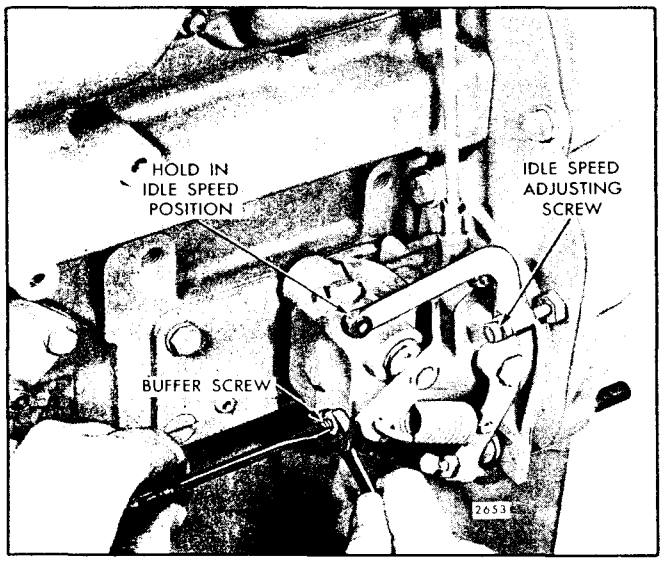


Fig. 4 - Adjusting Buffer Screw

Adjust Engine Idle Speed

1. Back out the buffer screw.

2. Start the engine and adjust the idle speed adjusting screw (Fig. 3) to obtain the desired idle speed.

NOTE: The idle speed must be set in excess of 575 rpm or engine operation at idle will be erratic.

Adjust Buffer Screw

1. Loosen the buffer screw lock nut and, with the engine operating at idle speed, turn the buffer screw (Fig. 4) in until engine roll is eliminated.

NOTE: Do not raise the engine speed more than 20 rpm with the buffer screw.

2. Tighten the lock nut to retain the adjustment.

Adjust Maximum No-Load Speed

1. Move the speed control lever, with the engine running, to the full-speed position.

NOTE: Do not overspeed engine.

2. Adjust the maximum speed adjusting screw (Fig. 5) until the desired no-load speed is obtained.

3. Tighten the maximum speed adjusting screw lock nut to retain the adjustment.

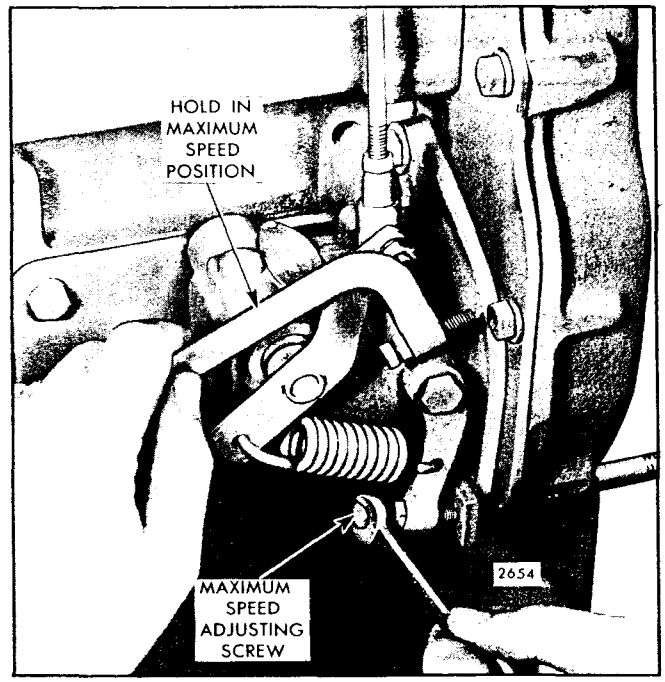


Fig. 5 - Adjusting Maximum No-Load Speed

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6V ENGINE

The variable speed mechanical governor assembly is mounted at the rear of the 6V engine, between the flywheel housing and the blower (Fig. 1). The governor is driven by the right-hand blower rotor drive gear.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and the injector rack control levers.

Adjust Governor Gap

With the engine stopped, adjust the governor gap as follows:

1. Disconnect any linkage attached to the governor levers.

2. Remove the governor cover.

3. Place the speed control lever in the maximum speed position.

4. Insert a .006" feeler gage between the spring plunger and the plunger guide as shown in Fig. 2. If required, loosen the lock nut and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.

5. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust if necessary.

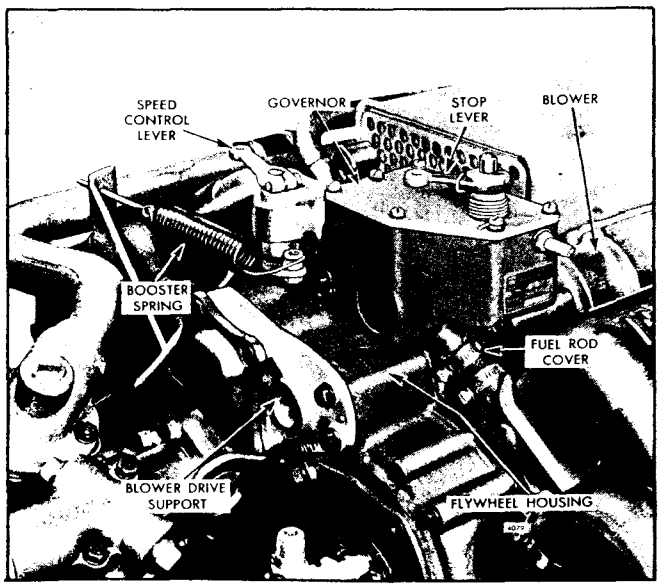


Fig. 1 - Variable Speed Governor Mounting

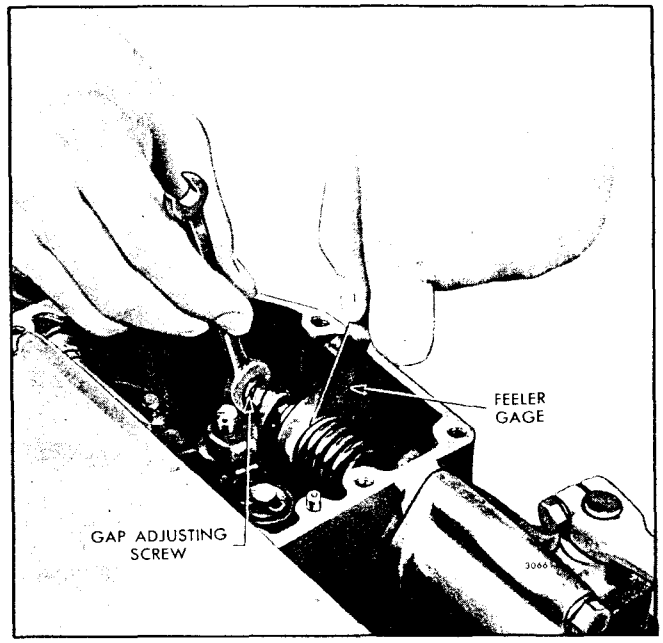


Fig. 2 - Adjusting Governor Gap

6. Install the governor cover.

Position Injector Rack Control Levers

The position of the injector control racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The letters R or L indicate the injector location in the right or left cylinder bank as viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 3L injector rack control lever first to establish a guide for adjusting the remaining levers.

1. Loosen the lock nut and back out the buffer screw approximately 3/4" .

2. Remove the valve rocker covers.

3. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

4. Loosen all of the inner and outer injector rack control lever adjusting screws on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

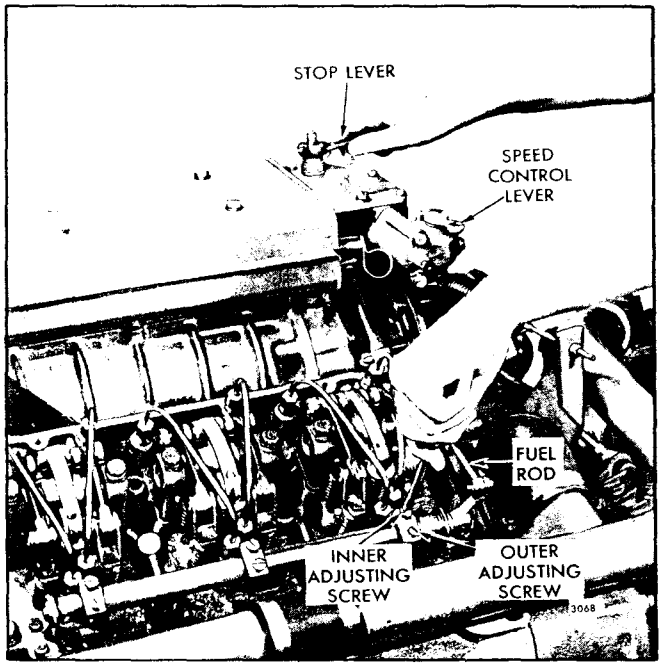


Fig. 3 - Positioning No. 3L Injector Rack Control Lever

5. Move the speed control lever to the maximum speed position.

6. Move the stop lever to the RUN position and hold it in that position with light finger pressure. Turn the inner adjusting screw of the No. 3L injector rack control lever down (Fig. 3) until a slight movement of the control tube is observed, or a step-up in effort to turn the screw driver is noted. This will place the No. 3L injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is **24-36 in-lb**.

The above steps should result in placing the governor linkage and control tube in the respective positions that they will attain while the engine is running at full load.

7. To be sure the control lever is properly adjusted, hold the stop lever in the RUN position and press down on the injector rack with a screw driver or finger tip causing the rack to rotate. The setting is sufficiently tight if the rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw. The setting is too tight if, when moving the stop lever from the STOP to the RUN posiiton, the injector rack becomes tight before the governor stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the RUN position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 3R injector rack control lever as previously outlined in Step 6 for the No. 3L control lever.

10. Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the 3L and 3R injector rack control levers as outlined in Step 7. Check for and eliminate any deflection which may occur at the bend in the fuel rod where it enters the cylinder head.

11. Manually hold the No. 3L injector rack in the full-fuel position, with the lever on the injector control tube, and turn the inner adjusting screw of the No. 2L injector rack control lever down until the injector rack of No. 2L injector has moved into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

12. Recheck the No. 3L injector rack to be sure that it has remained snug on the ball end of the rack control lever while positioning the No. 2L injector rack. If the rack of the No. 3L injector has become loose, back off the inner adjusting screw slightly on No. 2L injector rack control lever and tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective control levers.

13. Positon the 1L injector rack control lever as outlined in Steps 11 and 12.

14. Position the No. 2R and 1R injector rack control levers as outlined above for the left cylinder bank in Steps 11 through 13.

15. Install the valve rocker covers.

Adjust Maximum No-Load Speed

The maximum no-load speed varies with the full-load operating speed desired.

Use an accurate hand tachometer to determine the maximum no-load speed of the engine, then make the following adjustments, if required.

1. Refer to Fig. 7 and disconnect the booster spring and the stop lever retracting spring.

2. Remove the two attaching bolts and withdraw the variable speed spring housing and the variable speed spring retainer located inside of the housing.

3. Refer to the following table and determine the stops or shims required for the desired full-load speed. A split stop can only be used with a solid stop (Fig. 4).

Full-Load Speed	Stops		Shims*
	Solid	Split	
1200-2100	1	1	As Required
2100-2500	1	0	As Required
2500-2800	0	0	As Required

*Maximum amount of shims .325"

4. Install the variable speed spring housing and recheck the maximum no-load speed.

5. If required, add shims to obtain the necessary operating speed. For each .001" in shims added, the operating speed will increase approximately 2 rpm.

IMPORTANT: If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

NOTE: Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

Adjust Idle Speed

After the maximum no-load speed has been set, adjust the idle speed as follows:

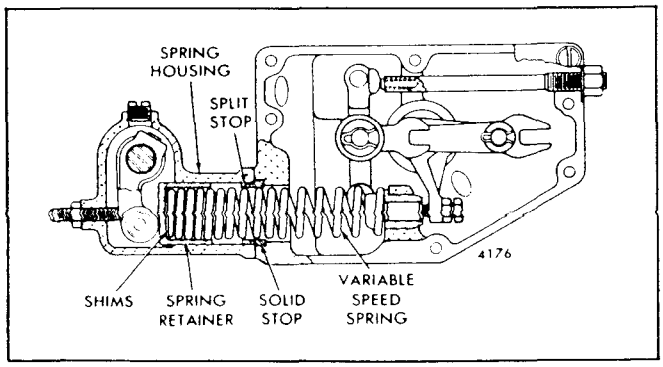


Fig. 4 - Location of Shims and Stops

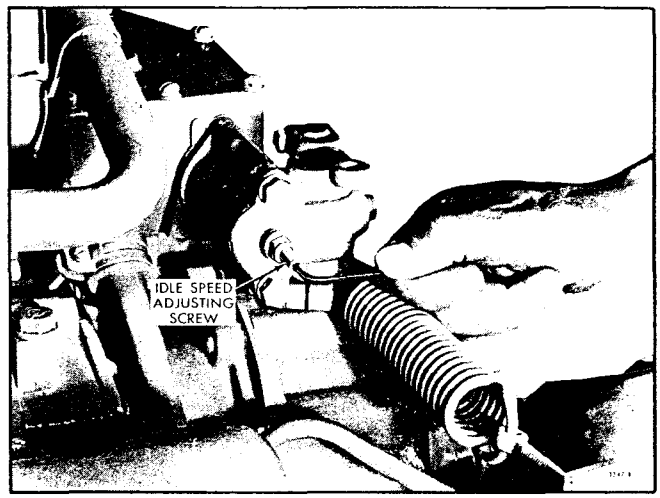


Fig. 5 - Adjusting Idle Speed

1. Place the stop lever in the RUN position and the speed control lever in the IDLE position.

2. With the engine operating, loosen the lock nut and turn the idle speed adjusting screw (Fig. 5) in or out until the engine idles at the recommended idle speed. The recommended idle speed is 550 rpm, but may vary with special engine applications.

3. Hold the idle speed adjusting screw and tighten the lock nut.

Adjust Buffer Screw

With the engine idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at idle speed, turn the buffer screw in (Fig. 6) so that it contacts the

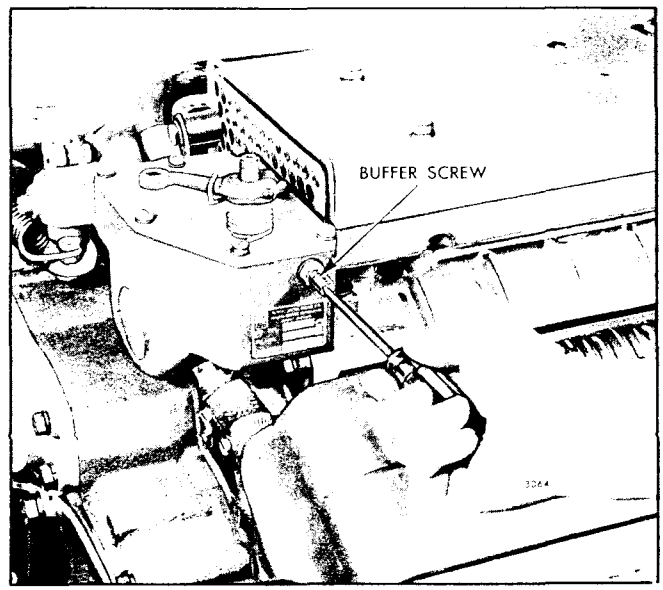


Fig. 6 - Adjusting Buffer Screw

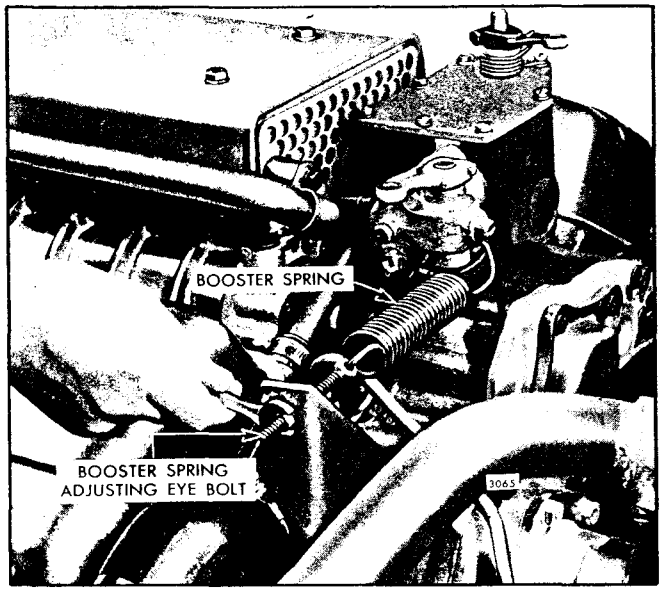


Fig. 7 - Adjusting Booster Spring

differential lever as lightly as possible and still eliminates engine roll.

NOTE: Do not raise the engine idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the lock nut.

Adjust Booster Spring

With the idle speed set, adjust the booster spring as follows:

1. Refer to Fig. 7 and loosen the booster spring retaining nut on the speed control lever. Loosen the lock nuts on the eye bolt at the other end of the spring.

2. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on an imaginary line through the center of the bolt, lever shaft and eye bolt. Hold the bolt and tighten the lock nut.

3. Start the engine and move the speed control lever to the maximum speed position and release it. The speed control lever should return to the idle position. If it does not, reduce the tension on the booster spring. If the lever does return to the idle position, continue to increase the spring tension until the point is reached that it will not return to idle. Then reduce the tension until it does return to idle and tighten the lock nut on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.

4. Connect the linkage to the governor levers.

8V ENGINE

The variable speed mechanical governor assembly (Fig. 8) is mounted at the front end of the 8V engine. After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and the injector rack control levers.

Adjust Governor Gap

With the engine stopped, adjust the governor gap as follows:

1. Disconnect any linkage attached to the governor levers.

2. Remove the governor cover.

3. Place the speed control lever in the maximum speed position.

4. Insert a .006" feeler gage between the spring plunger and the plunger guide as shown in Fig. 9. If required, loosen the lock nut and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.

5. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust, if necessary.

6. Install the governor cover.

Position Injector Rack Control Levers

The position of the injector control racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

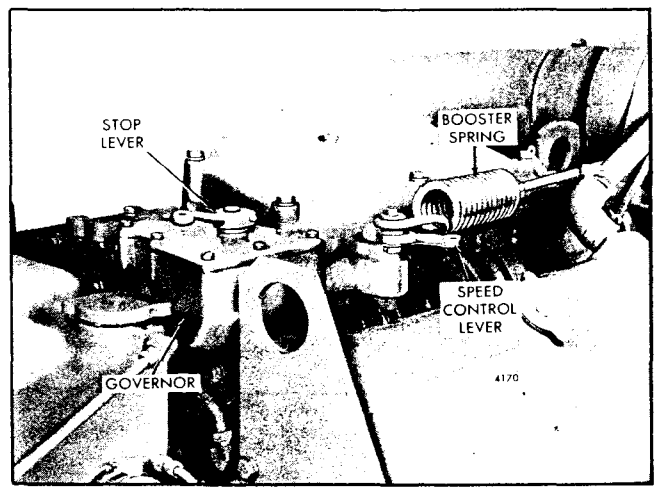


Fig. 8 - Variable Speed Governor Mounting

The letters R or L indicate the injector location in the right or left cylinder bank as viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining levers.

1. Loosen the lock nut and back out the buffer screw approximately 3/4" .

2. Remove the valve rocker covers.

3. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

4. Loosen all of the inner and outer injector rack control lever adjusting screws on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

5. Move the speed control lever to the maximum speed position.

6. Move the stop lever to the RUN position and hold it in that position with light finger pressure. Turn the inner adjusting screw of the No. 1L injector rack control lever down (Fig. 10) until a slight movement of the control tube is observed, or a step-up in effort to turn the screw driver is noted. This will place the No. 1L injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lb.**

The above steps should result in placing the governor linkage and control tube in the respective positions that they will attain while the engine is running at full load.

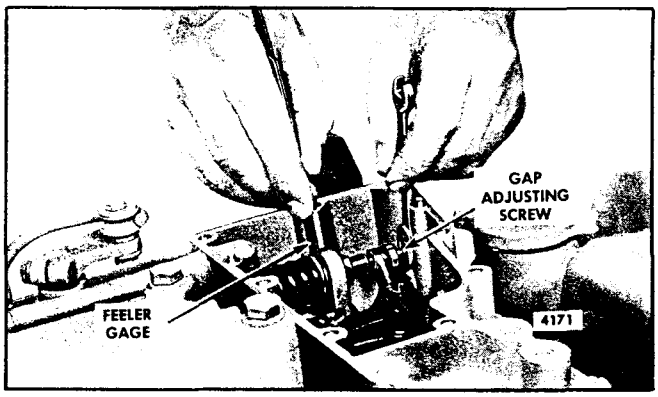


Fig. 9 - Adjusting Governor Gap

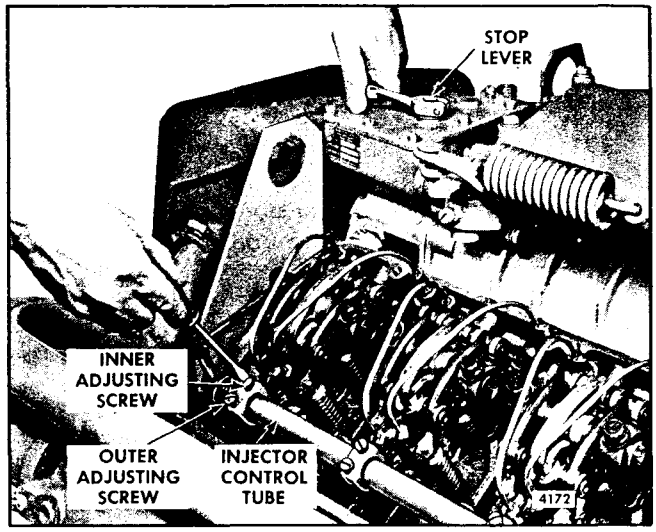


Fig. 10 - Positioning No. 1L Injector Rack Control Lever

7. To be sure the control lever is properly adjusted, hold the stop lever in the RUN position and press down on the injector rack with a screw driver or finger tip causing the rack to rotate. The setting is sufficiently tight if the rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw. The setting is too tight if, when moving the stop lever from the STOP to the RUN position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the RUN position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 1R injector rack control lever as previously outlined in Step 6 for the No. 1L control lever.

10. Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the 1L and 1R injector rack control levers as outlined in Step 7. Check for and eliminate any deflection which may occur at the bend in the fuel rod where it enters the cylinder head.

11. Manually hold the No. 1L injector rack in the full-fuel position, with the lever on the injector control tube, and turn the inner adjusting screw of the No. 2L injector rack control lever down until the No. 2L injector rack moves into the full-fuel position. Turn

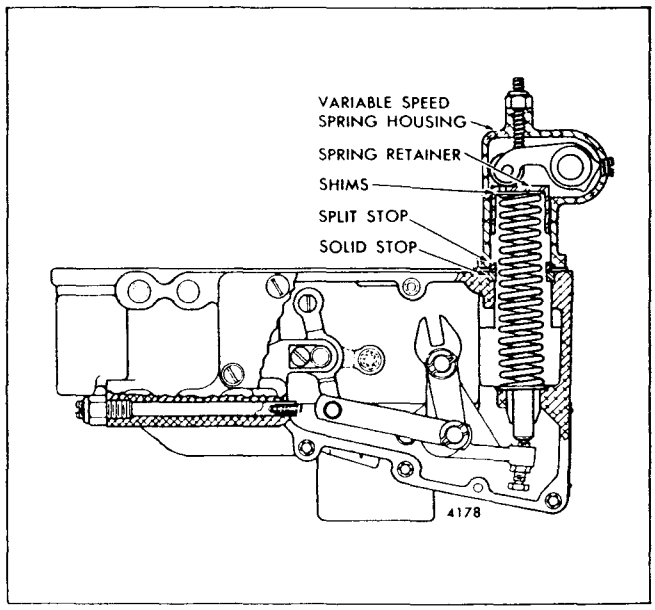


Fig. 11 - Location of Shims and Stops

the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

12. Recheck the No. 1L injector rack to be sure that it has remained snug on the ball end of the rack control lever while positioning the No. 2L injector rack. If the rack of the No. 1L injector has become loose, back off the inner adjusting screw slightly on the No. 2L injector rack control lever and tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective control levers.

13. Position the No. 3L and No. 4L injector rack control levers as outlined in Steps 11 and 12.

14. Position the No. 2R, 3R and 4R injector rack control levers as outlined for the left cylinder bank in Steps 11 through 13.

15. Install the valve rocker covers.

Adjust Maximum No-Load Speed

The maximum no-load speed must not exceed 150 rpm above the full-load speed.

Use an accurate hand tachometer to determine the maximum no-load speed of the engine, then make the following adjustments, if required.

1. Refer to Fig. 14 and disconnect the booster spring and the stop lever retracting spring.

2. Remove the two attaching bolts and withdraw the variable speed spring housing and the spring retainer located inside of the housing.

3. Refer to the following table and determine the stops or shims required for the desired full-load speed. A split stop can only be used with a solid stop (Fig. 11).

Full-Load Speed	Stops		Shims*
	Solid	Split	
1200-2100	1	1	As Required
2100-2500	1	0	As Required
2500-2800	0	0	As Required

*Maximum amount of shims .325"

4. Install the variable speed spring housing and recheck the maximum no-load speed.

5. If required, add shims to obtain the necessary operating speed. For each .001" in shims added, the speed will increase approximately 2 rpm.

IMPORTANT: If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

NOTE: Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

Adjust Idle Speed

After the maximum no-load speed has been set, adjust the idle speed as follows:

1. Place the stop lever in the RUN position and the speed control lever in the IDLE position.

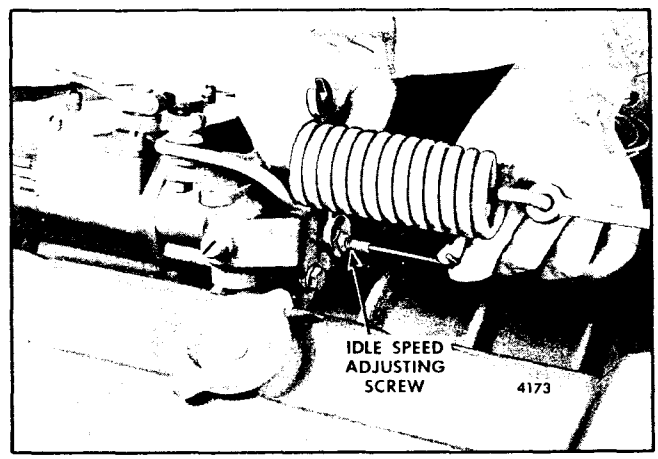


Fig. 12 - Adjusting Idle Speed

2. With the engine operating, loosen the lock nut and turn the idle speed adjusting screw (Fig. 12) in or out until the engine idles at 600 rpm.

3. Hold the idle speed adjusting screw and tighten the lock nut.

Adjust Buffer Screw

With the engine idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at idle speed, turn the buffer screw in (Fig. 13) so that it contacts the differential lever as lightly as possible and still eliminates engine roll.

NOTE: Do not raise the engine idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the lock nut.

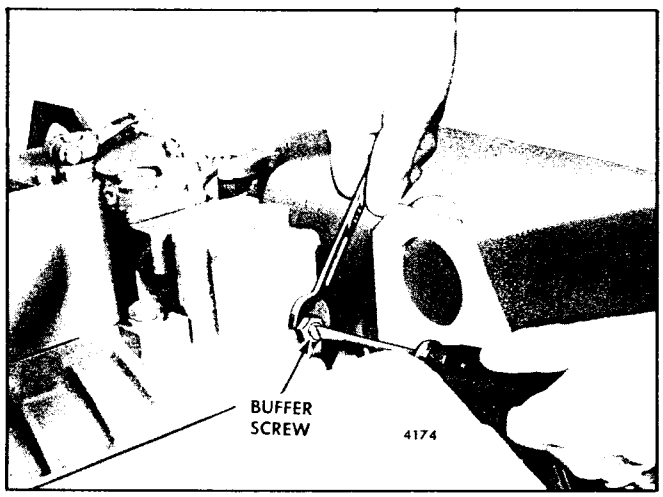


Fig. 13 - Adjusting Buffer Screw

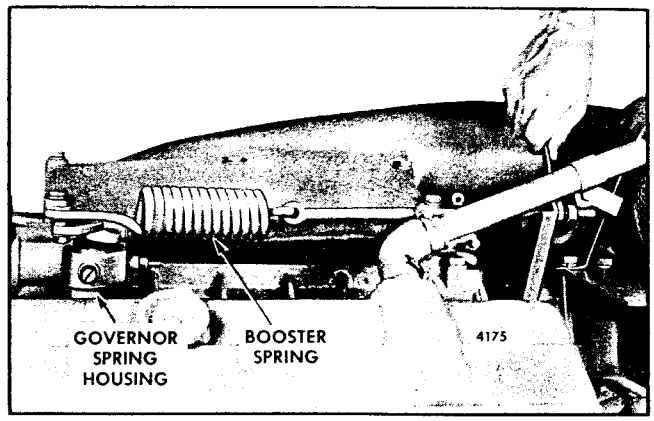


Fig. 14 - Adjusting Booster Spring

Adjust Booster Spring

With the engine idle speed set, adjust the booster spring as follows:

1. Refer to Fig. 14 and loosen the booster spring retaining nut on the speed control lever. Loosen the lock nuts on the eye bolt at the other end of the spring.

2. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on an imaginary line through the center of the bolt, lever shaft and eye bolt. Hold the bolt and tighten the lock nut.

3. Start the engine and move the speed control lever to the maximum speed position and release it. The speed control lever should return to the idle position. If it does not, reduce the tension on the booster spring. If the lever does return to the idle position, continue to increase the spring tension until the lever does not return to idle. Then reduce the tension until it does return to idle and tighten the lock nut on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.

4. Connect the linkage to the governor levers.

CONSTANT SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and injector rack control levers.

Adjust Governor Gap

1. Stop the engine and disconnect any linkage attached to the speed control lever.

2. Remove the governor cover and lever assembly.

3. Remove the fuel rod from the differential lever and the injector control tube lever.

4. Insert a .006" feeler gage between the spring plunger and the plunger guide as shown in Fig. 1. If required, loosen the lock nut and turn the gap adjusting screw in or out until a slight drag is noted on the feeler gage.

5. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust if necessary.

6. Install the governor cover as follows:

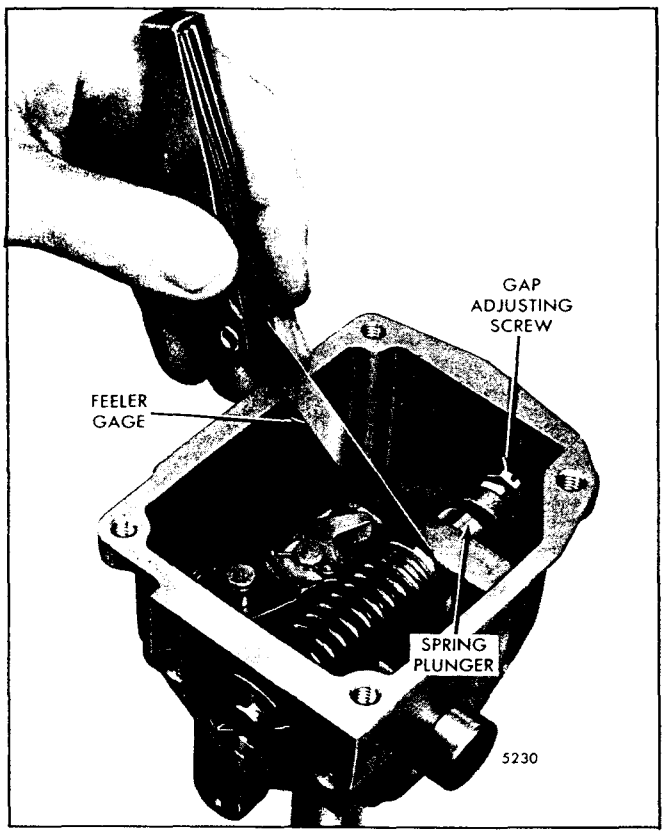


Fig. 1 - Adjusting Governor Gap

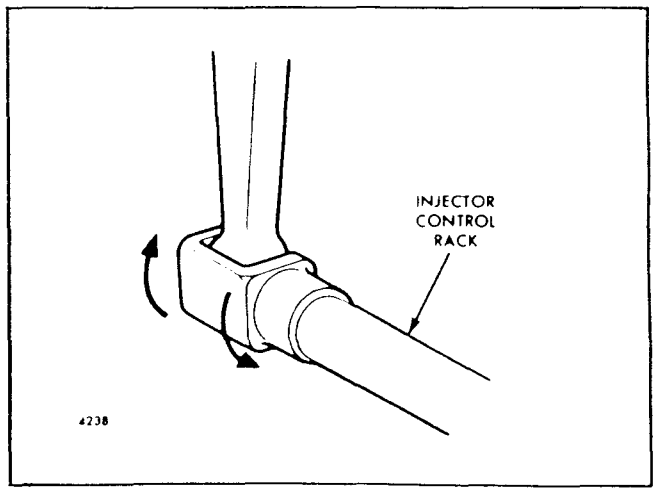


Fig. 2 - Checking Rotating Movement of Injector Control Rack

a. Place the cover on the governor housing, with the pin in the throttle shaft assembly entering the slot in the differential lever.

b. Install the four cover screws and lock washers finger tight.

c. Pull the cover assembly in a direction away from the engine, to take up the slack, and tighten the cover screws.

NOTE: This step is required since no dowels are used to locate the cover on the housing.

Position Injector Rack Control Levers

The position of the injector control racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Adjust the No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the control lever.

2. Remove the valve rocker cover.

3. Loosen all of the inner and outer injector rack control lever adjusting screws. Be sure all of the control levers are free on the injector control tube.

4. Move the control lever to the maximum speed position. Turn the inner adjusting screw down until a step-up in effort is noted. This will place the No. 1

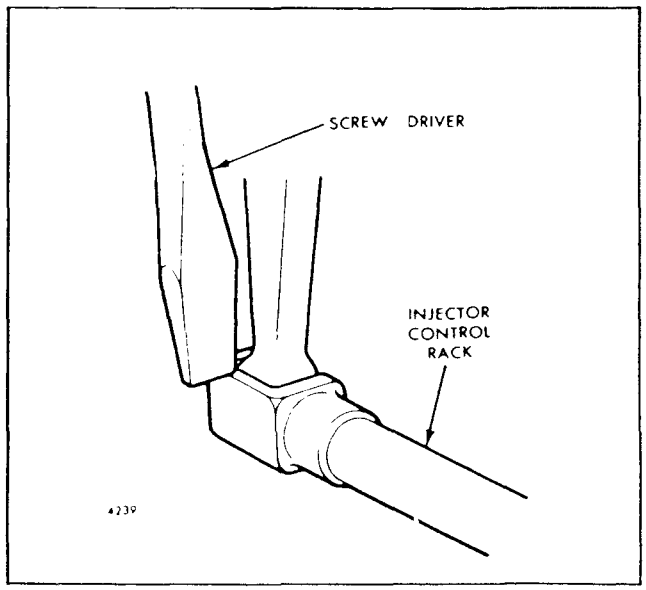


Fig. 3 - Checking Injector Control Rack "Spring"

injector rack in the full-fuel position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lb.**

5. To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screw driver or finger tip and note the "rotating" movement of the injector control rack (Fig. 2). Hold the speed control lever in the maximum speed position and, using a screw driver, press downward on the injector control rack. The rack should tilt downward (Fig. 3) and when the pressure of the screw driver is released, the control rack should "spring" back upward.

6. If no movement is observed, back off the inner adjusting screw approximately 1/8 of a turn and tighten the outer adjusting screw. If the movement exceeds that specified, back off the outer adjusting screw approximately 1/8 of a turn and tighten the inner adjusting screw. When the setting is correct, the injector rack will be snug on the pin of the rack control lever and still maintain the movement specified in Step 5.

NOTE: Performing Steps 4, 5 and 6 will result in placing the governor linkage and control tube assembly in the same positions that they will attain while the engine is running at full load. These positions are:

a. The governor speed control lever is at the maximum speed position.

b. The governor gap is closed.

c. The governor spring plunger is on its seat in the governor control housing.

d. The injector fuel control racks are in the maximum speed position.

7. Remove the clevis pin between the fuel rod and the injector control tube lever.

8. Manually hold the No. 1 injector in the maximum fuel position and turn down the inner adjusting screw of the No. 2 injector until the injector rack has moved into the maximum speed position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

9. Recheck the No. 1 injector fuel rack to be sure that it has remained snug on the pin of the rack control lever while adjusting the No. 2 injector. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever and tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the pins of their respective rack control levers.

10. Position the remaining control rack levers as outlined in Steps 8 and 9.

11. Insert the clevis pin between the fuel rod and the injector control tube lever.

12. Install the valve rocker cover.

Adjust Maximum No-Load Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine name plate, the maximum no-load speed may be set as follows:

1. Start and warm up the engine.

2. Run the engine at no-load and observe the engine speed. Be sure the speed control lever is in the run position.

CAUTION: There must be no load on the engine during the maximum no-load speed adjustment.

3. Observe the engine speed and set it, if necessary, to the recommended speed with shims placed between the operating speed spring and the spring plunger.

Since the engine performance and efficiency will be governed, to a large extent, by the accuracy with which the tune-up adjustments are made, the serviceman should always perform these operations carefully.

HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

IN-LINE ENGINE

The hydraulic governor is mounted on the 2, 3 and 4-53 engines as shown in Fig. 1. The terminal lever return spring and the fuel rod are attached to an external terminal shaft lever. The maximum fuel position of the governor load limit is determined by the internal governor terminal lever striking against a boss that projects from the governor cover.

Adjust the hydraulic governor after adjusting the exhaust valve clearance and timing the fuel injectors.

Adjust Fuel Rod and Injector Rack Control Levers

1. Adjust the inner and outer adjusting screws (Fig. 2) on the rear injector rack control lever on the control tube. Check the clearance between the fuel rod and the cylinder head bolt or the cylinder head casting (below the bolt) for at least 1/16" clearance when the injector rack is in the full-fuel position and the rack adjusting screws are tight. If the fuel rod contacts the bolt or the cylinder head casting, re-adjust the screws to obtain the 1/16" clearance.

2. Remove the governor terminal lever return spring.

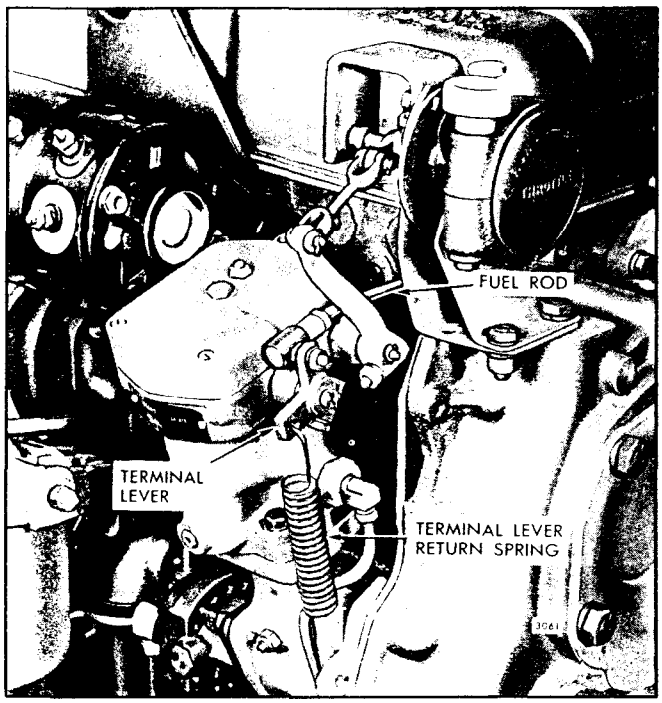


Fig. 1 - Hydraulic Governor Mounting

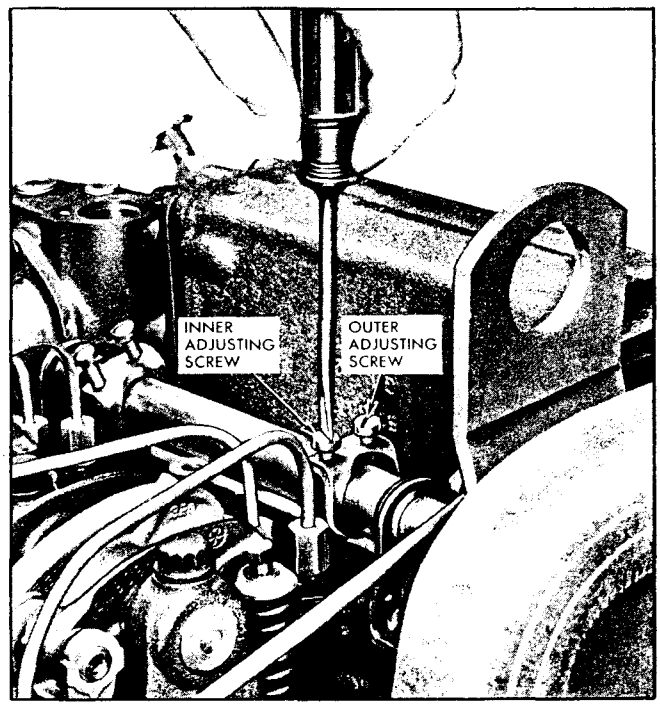


Fig. 2 - Adjusting Height of Rack Control Lever Adjusting Screws

3. Remove the fuel rod end bearing or ball joint from the terminal shaft lever and the terminal lever from the terminal shaft.

4. Place the terminal lever on the terminal shaft so that the hole for attaching the fuel rod end bearing or ball joint is in line vertically above the terminal lever shaft at one half the arc of travel. Do not tighten the clamping bolt.

5. Hold the injector rack control tube and the terminal lever in the full-fuel position and adjust the length of the fuel rod until the end bearing or ball joint will slide freely into the hole of the terminal lever as shown in Fig. 3. Tighten the lock nut, to retain the ball joint or end bearing, and the terminal lever clamping bolt securely.

> **NOTE:** It will be necessary to slide the terminal lever partially off of the shaft to attach the fuel rod end bearing or ball joint to the terminal lever.

6. Hold the terminal lever in the full-fuel position and loosen the inner adjusting screw 1/8 of a turn and

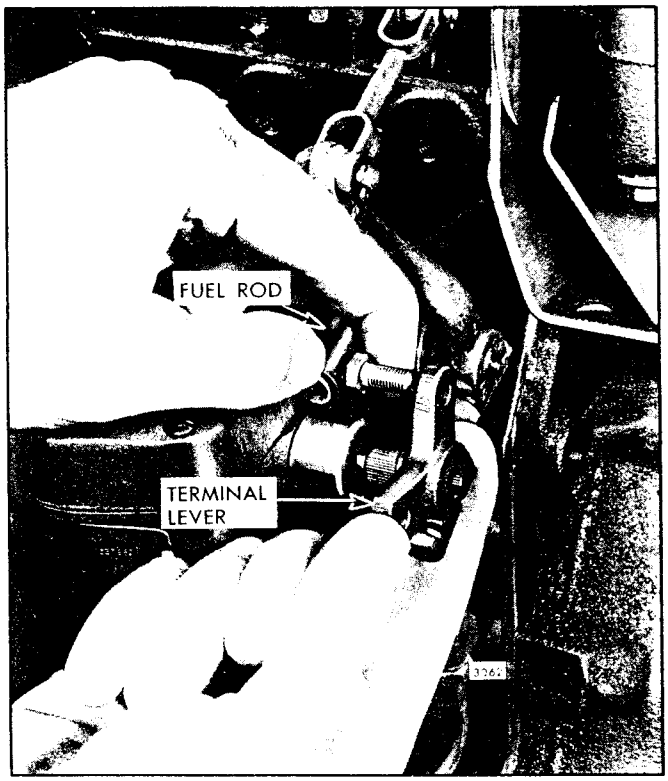


Fig. 3 - Adjusting Length of Fuel Rod

tighten the outer adjusting screw 1/8 of a turn to retain the adjustment. This is done to prevent the governor from bottoming the injector racks, since there is no load limit screw on this governor.

7. Remove the clevis pin between the fuel rod and the injector control tube lever.

NOTE: Cover the cylinder head oil drain-back hole, located under the control lever, when removing the fuel rod clevis pin to prevent loss of the pin and possible damage to the engine.

8. Manually hold the rear injector in the full-fuel position and turn down the inner rack control lever adjusting screw of the adjacent injector until the injector rack of the adjacent injector has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer rack control lever adjusting screws.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lb.**

9. Recheck the rear injector fuel rack to be sure that it has remained snug on the ball end of the rack control lever while adjusting the adjacent injector. If the rack of the rear injector has become loose, back off slightly on the inner adjusting screw on the adjacent injector rack control lever. Tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

10. Position the remaining rack control levers as outlined in Steps 8 and 9.

11. Insert the clevis pin between the fuel rod and the injector control tube lever.

12. Install the terminal lever return spring.

Adjust Speed Droop

The purpose of adjusting the speed droop is to establish a definite engine speed at no-load with a given speed at rated full load.

The governor droop is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs, the speed droop should be re-adjusted.

The best method of determining the engine speed is by the use of an accurate hand tachometer.

If a full-rated load on the unit can be established and the fuel rod, injector rack control levers and load limit have been adjusted, the speed droop may be adjusted as follows:

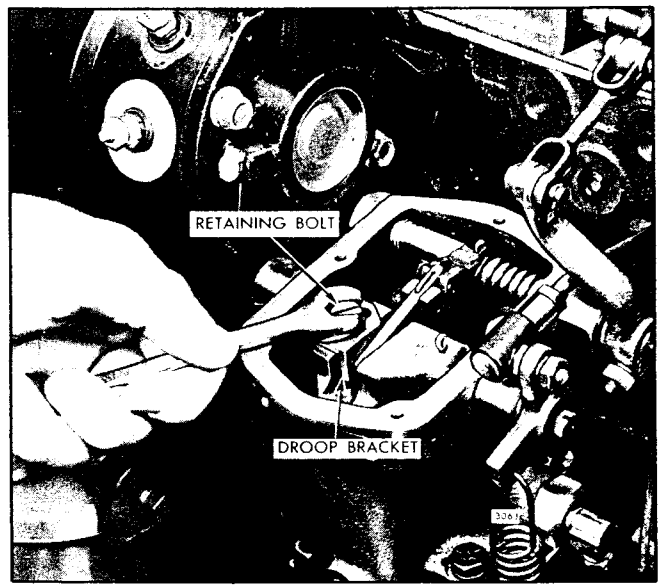


Fig. 4 - Adjusting Droop Bracket

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

NOTE: When the engine lubricating oil is cold, the governor regulation may be erratic. The regulation should become increasingly stable as the temperature of the lubricating oil increases.

2. With engine stopped, remove the governor cover.

3. Loosen the lock nut and back off the maximum speed adjusting screw (Fig. 5) approximately 5/8" .

4. Refer to Fig. 4 and loosen the droop adjusting bolt. Move the droop bracket so that the bolt is midway between the ends of the slot in the bracket. Tighten the bolt.

5. With the throttle in the RUN position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed.

6. Apply the full-rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed stabilizes under no-load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full-load speed.

If the speed droop is too high, stop the engine and again loosen the droop bracket retaining bolt and move the droop adjusting bracket IN toward the engine. Tighten the bolt. To increase the speed droop, move the droop adjusting bracket OUT, away from the engine.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each engine governor to obtain the desired variation between the engine no-load and full-load speeds shown in the following table.

Full Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

Fig. 5 - Adjusting Maximum Engine Speed

The recommended speed droop of generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1000 and 1200 rpm and 75 rpm (2-1/2 cycles) for units operating at 1500 rpm and 1800 rpm full load. This speed droop recommendation may be varied to suit the individual application.

8. Install the governor cover.

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. Loosen the maximum speed adjusting screw lock nut and back out the maximum speed adjusting screw 3 turns.

2. With the engine operating at no-load, adjust the engine speed until the engine is operating at approximately 8% higher than the rated full-load speed.

3. Turn the maximum speed adjusting screw (Fig. 5) in lightly until contact is felt with the linkage in the governor.

4. Hold the maximum speed adjusting screw and tighten the lock nut.

HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6V ENGINE

The hydraulic governor is mounted between the blower and the rear end plate as shown in Fig. 1. The vertical control link assembly is attached to the governor operating lever and the bell crank lever on the governor drive housing (Fig. 2).

Perform the following adjustment on a 6V engine that incorporates a hydraulic governor.

1. Remove the rocker covers.

2. Adjust the exhaust valve clearance and time the fuel injectors as stated in Sections 14.1 and 14.2.

3. Disconnect the vertical control link assembly from the governor operating lever.

4. Loosen all of the injector rack control lever adjusting screws.

5. While holding the bell crank lever (on the governor drive housing) in a horizontal position (full-fuel), set the No. 3 injector rack control levers on each bank to full-fuel.

6. Position the remaining rack control levers to the No. 3 control levers.

7. Remove the governor cover.

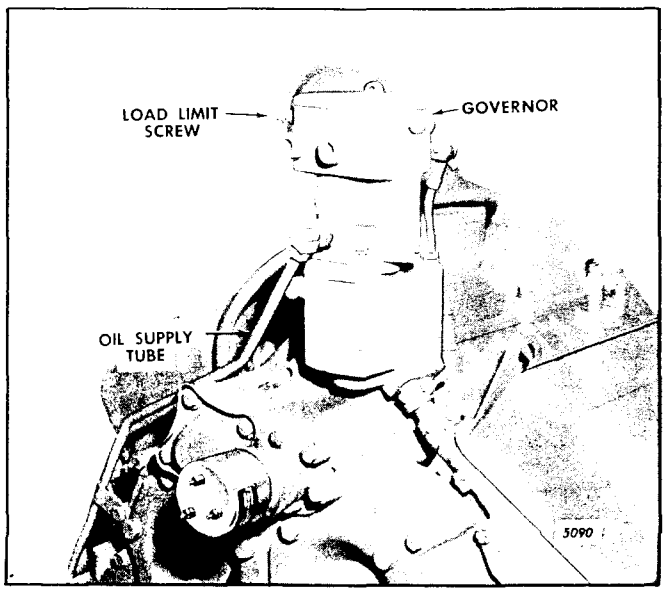


Fig. 1 - Hydraulic Governor Mounting

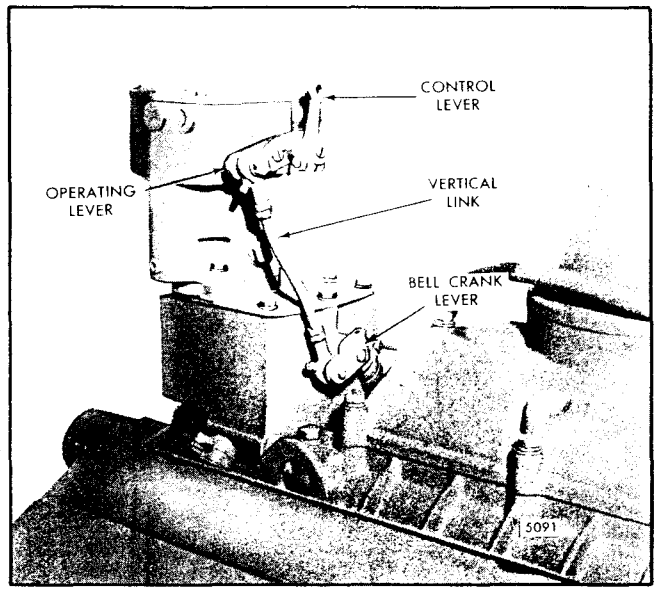


Fig. 2 - Hydraulic Governor Controls

8. To determine the full-fuel position of the terminal lever, adjust the load limit screw to obtain a distance of 2" from the outside face of the boss on the governor sub-cap to the end of the screw.

9. Adjust the operating lever (on the governor) so that it is horizontal, or slightly below (as close as the serrations on the shaft will permit), when the shaft is rotated to the full-fuel position or clockwise when viewed from the front of the engine.

10. Loosen the lock nut and adjust the length of the vertical link assembly, attached to the bell crank lever, to match the full-fuel position of the governor operating lever and the injector rack control levers. This length should be approximately 6-5/16" . Tighten the lock nut.

11. With the governor operating lever held in the full-fuel position, turn the load limit screw (Fig. 1) inward until the injector racks just loosen on the ball end of the control levers to prevent the injector racks from bottoming.

12. Release the governor operating lever and hold the adjusting screw while tightening the lock nut.

13. Install the governor cover.

14. Install the rocker covers.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

ENGINE LOAD LIMIT DEVICE

Engines with mechanical governors may be equipped with a load limit device (Fig. 1) to reduce the maximum horsepower.

This device consists of a load limit screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a load limit lever clamped to the injector control tube.

The load limit device is located between the No. 2 and No. 3 cylinders of a three or four cylinder engine or between the No. 1 and No. 2 cylinders of *each* cylinder head on a V-type engine. However, when valve rocker covers with a breather are used, the load limit device is installed between the No. 1 and No. 2 cylinders on in-line engines and between the No. 2 and No. 3 cylinders on V-type engines to avoid interference with the rocker cover baffles.

When properly adjusted for the maximum horsepower desired, this device limits the travel of the injector control racks and thereby the fuel output of the injectors.

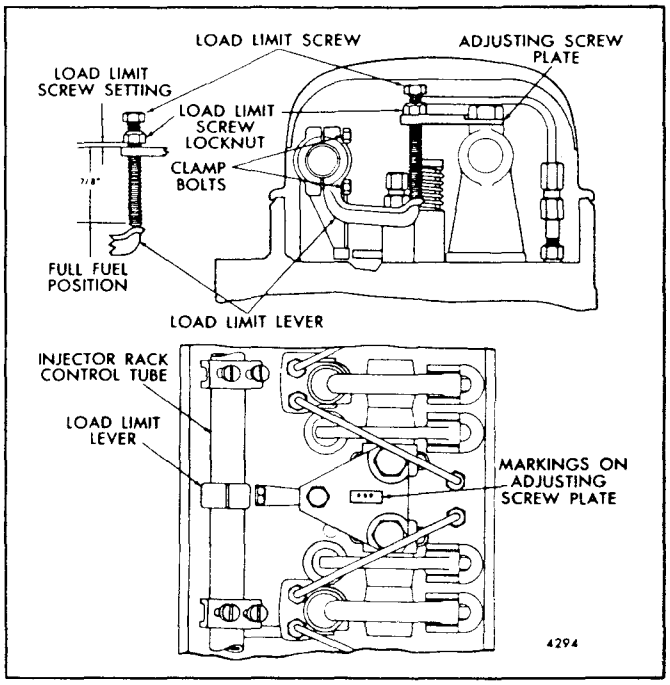


Fig. 1 - Engine Load Limit Device

Adjustment

After the engine tune-up is completed, make sure the load limit device is properly installed as shown in Fig. 1. Make sure the counterbores in the adjusting screw plate are up. The rocker arm shaft bracket bolts which fasten the adjusting screw plate to the brackets are tightened to 50-55 lb-ft torque. Then adjust the load limit device, on each cylinder head, as follows:

1. Loosen the load limit screw lock nut.

2. Back the load limit screw out of the adjusting screw plate until approximately 1 " of the screw is below the plate.

3. Adjust the load limit screw lock nut so the bottom of the lock nut is 7/8 " from the bottom of the load limit screw (Fig. 1) for the initial setting.

4. Loosen the load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

5. Thread the load limit screw into the adjusting screw plate until the lock nut *bottoms* against the top of the plate.

6. Hold the injector rack control tube in the full-fuel position and place the load limit lever against the bottom of the load limit screw. Then tighten the load limit lever clamp bolts.

7. Check to ensure that the injector racks will just go into the full-fuel position -- readjust the load limit lever if necessary.

8. Hold the load limit screw to keep it from turning, then *set* the lock nut until the distance between the bottom of the lock nut and the top of the adjusting screw plate corresponds to the dimension (or number of turns) stamped on the plate. Each full turn of the screw equals .042 ", or .007 " for each flat on the hexagon head.

> **NOTE:** If the plate is not stamped, adjust the load limit screw while operating the engine on a dynamometer test stand and note the number of turns required to obtain the desired horsepower. Then stamp the plate accordingly.

9. Thread the load limit screw into the plate until the lock nut *bottoms* against the top of the plate.

10. Hold the load limit screw to keep it from turning, then tighten the lock nut to secure the setting.

THROTTLE DELAY MECHANISM

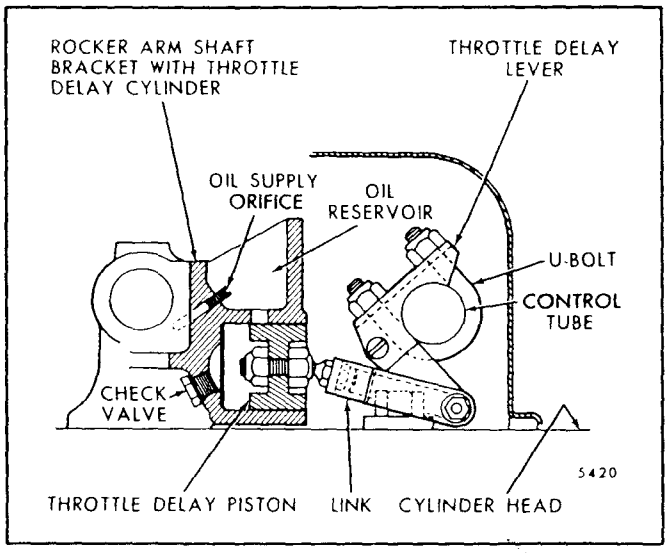


Fig. 2 - Throttle Delay Cylinder

The throttle delay mechanism is used to retard full-fuel injection when the engine is accelerated. This reduces exhaust smoke and also helps to improve fuel economy.

The throttle delay mechanism (Fig. 2) is installed between the No. 1 and No. 2 cylinders on three cylinder engines, between the No. 2 and No. 3 cylinders on four cylinder engines, or between the No. 1 and No. 2 cylinders on the right-bank cylinder head of V-type engines. It consists of a special rocker arm shaft bracket (which incorporates the throttle delay cylinder), a piston, throttle delay lever, connecting link, orifice plug, ball check valve and U-bolt.

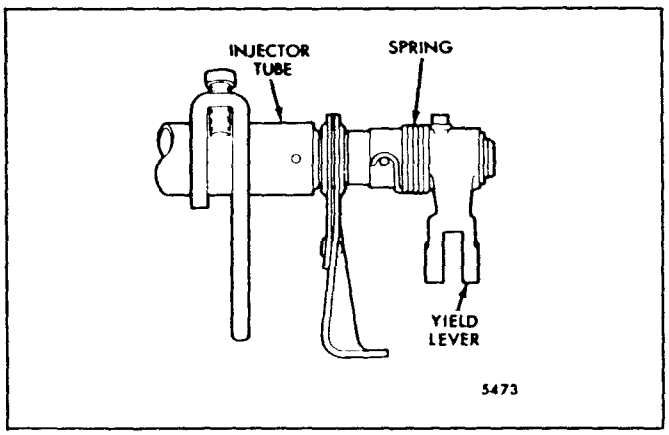


Fig. 3 - Throttle Delay Yield Lever (In-Line Engine)

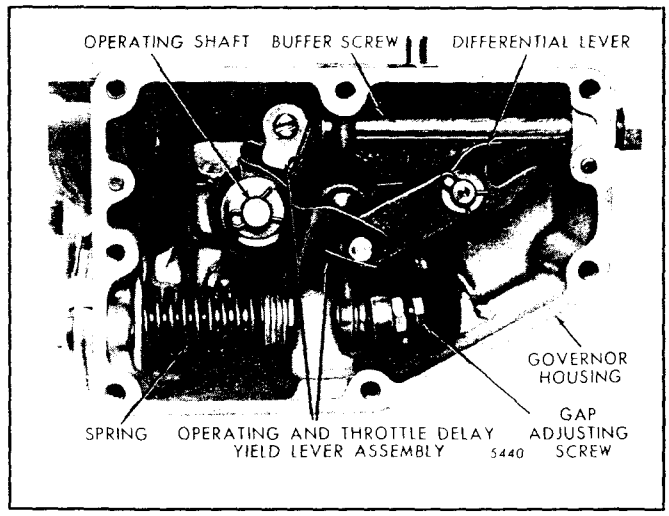


Fig. 4 - Throttle Delay Yield Lever (6V Engine)

A yield lever and spring assembly replaces the standard lever and pin assembly on the rear end of the injector control tube on in-line engines (Fig. 3). A yield lever replaces the standard operating lever in the governor of the 6V-53 engine (Fig. 4) and a yield link replaces the standard operating lever link in the 8V-53 governor (Fig. 5).

Operation

Oil is supplied to a reservoir above the throttle delay

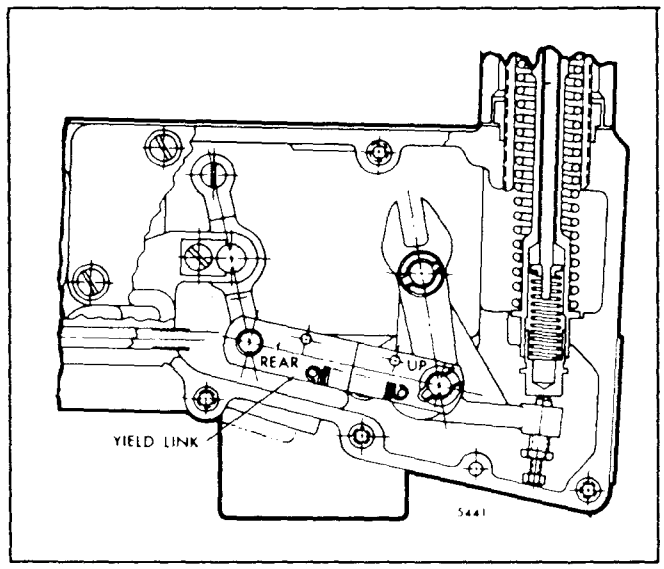


Fig. 5 - Throttle Delay Yield Link (8V Engine)

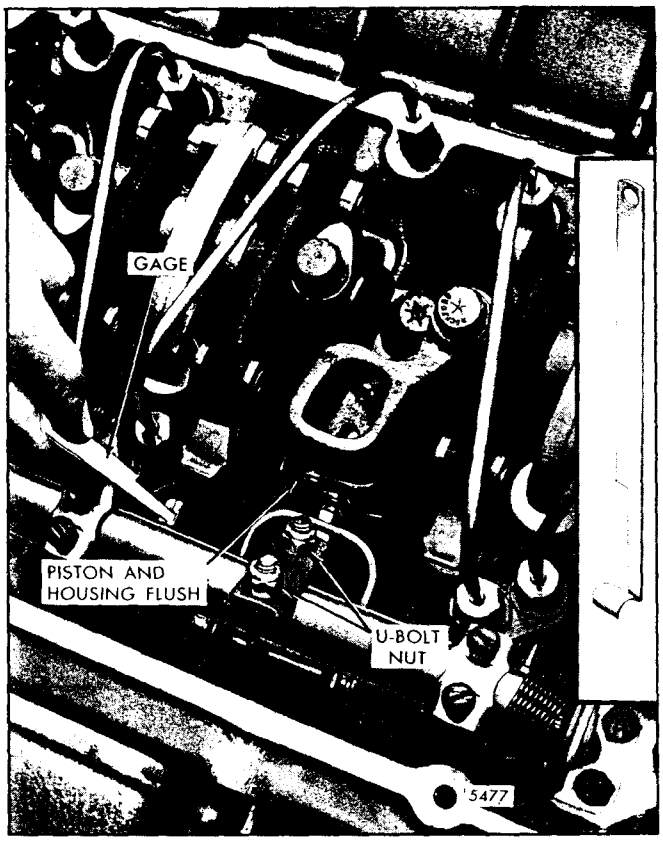


Fig. 6 - Adjusting Throttle Delay Cylinder

cylinder through an orifice plug in the drilled oil passage in the rocker arm shaft bracket (Fig. 2). As the injector racks are moved toward the no-fuel position, free movement of the throttle delay piston is assured by air drawn into the cylinder through the ball check valve. Further movement of the piston uncovers an opening which permits oil from the reservoir to enter the cylinder and displace the air. When the engine is accelerated, movement of the injector racks toward the full-fuel position is momentarily retarded while the piston expels the oil from the cylinder through an orifice. To permit full accelerator travel, regardless of the retarded injector rack position, a spring loaded yield lever or link assembly replaces the standard operating lever connecting link to the governor.

Adjustment

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be re-adjusted. With the engine stopped, proceed as follows:

1. Refer to Fig. 6 and insert gage J 23190 (.454 " setting) between the injector body and the shoulder on the injector rack. Then exert a light pressure on the injector control tube in the direction of full fuel.

2. Align the throttle delay piston so it is flush with the edge of the throttle delay cylinder.

3. Tighten the U-bolt on the injector control tube and remove the gage.

4. Move the injector rack from the no-fuel to the full-fuel position to make sure it does not bind.

ADJUSTMENT OF MECHANICAL GOVERNOR SHUTDOWN SOLENOID

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor, the governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel.

The solenoid plunger can be properly aligned to the governor stop lever as follows:

1. Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs. 7 and 8). Align and clamp the lever to the shutdown shaft in such a way that, at its mid-travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible. The solenoid plunger has available 1/2 " travel which is more than adequate to move the injector control racks from the full-fuel to the complete no-fuel position and shutdown will occur prior to attaining complete travel.

2. With the stop lever in the *run* position, adjust the rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap, with a resultant build-up of pull-in force prior to initiating stop lever movement.

3. The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32 " minimum.

NOTE: The lock nut can be either on top of or below the stop lever.

4. Move the lever to the *stop* position and observe the plunger for any possible bind. If necessary, loosen the

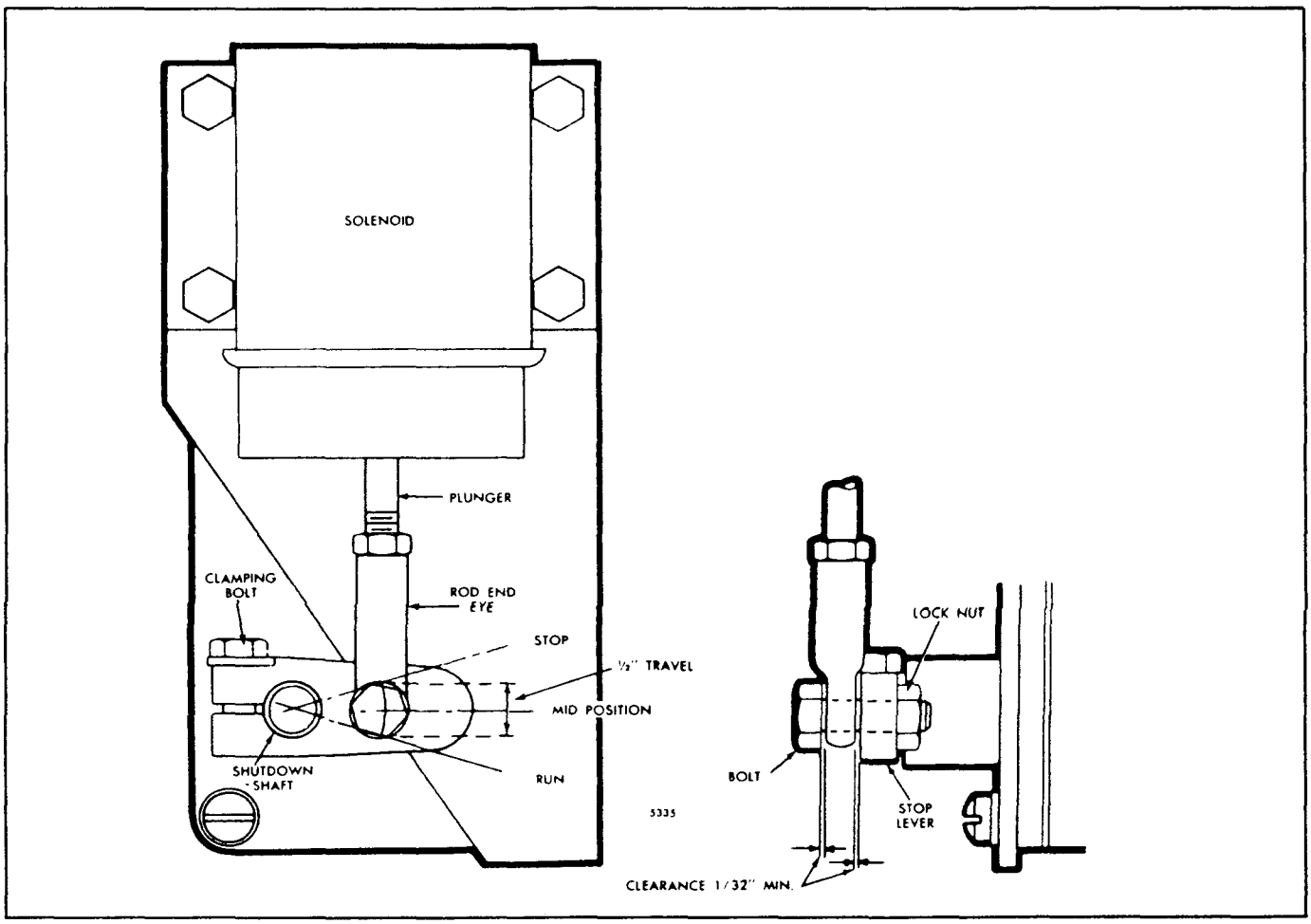


Fig. 7 - Typical Variable Speed Governor Lever Position

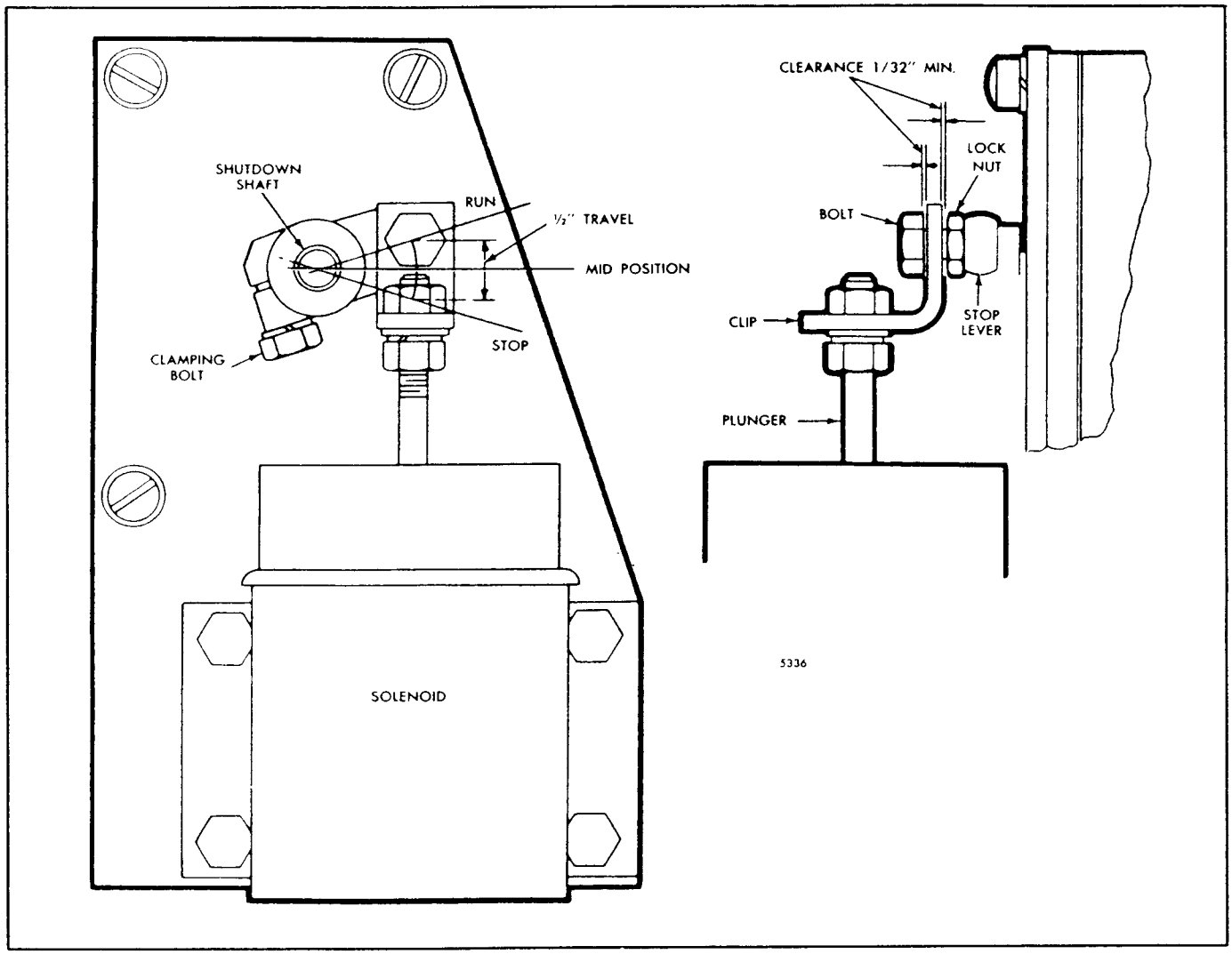


Fig. 8 - Typical Limiting Speed Governor Lever Position

mounting bolts and realign the solenoid to provide free plunger motion.

SECTION 15

PREVENTIVE MAINTENANCE - TROUBLE SHOOTING - STORAGE

CONTENTS

Lubrication and Preventive Maintenance 15.1
Trouble Shooting 15.2
Storage 15.3

LUBRICATION AND PREVENTIVE MAINTENANCE

To obtain the best performance and long life from a Detroit Diesel engine, the Operator must adhere to the following schedule and instructions on lubrication and preventive maintenance.

The daily instructions pertain to routine or daily starting of an engine and not to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, carry out the instructions given under *Preparation for Starting Engine First Time* under *Operating Instructions* in Section 13.

The time intervals given in the chart on the following page are actual operating hours or miles of an engine. If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and, therefore, will drain readily.

LUBRICATION AND PREVENTIVE MAINTENANCE CHART	Time Interval								
	Hours	8	50	100	200	300	500	1,000	2,000
Item Operation	Miles Daily	240	1,500	3,000	6,000	9,000	15,000	30,000	60,000
1. Engine Oil	X								
2. Oil Filter*									
3. Coolant and Filter	X						X	X	
4. Hoses							X		
5. Radiator								X	
6. Heat Exchanger Electrodes and Core							X	X	
7. Raw Water Pump	X								
8. Fuel Tank	X						X		
9. Fuel Strainer and Filter	X					X			
10. Air Cleaners		X					X		
• 11. Air Box Drains							X	X	
12. Ventilating System								X	
13. Blower Screen								X	
14. Starting Motor*									
15. Battery-Charging Generator				X	X		X		X
16. Battery				X					
17. Tachometer Drive				X					
18. Throttle and Clutch Controls					X				
19. Engine Tune-Up*									
20. Drive Belts					X				
21. Overspeed Governor							X		
22. Fan Hub Bearings*									
23. Shut-Down System						X			
24. Hydrostarter System*									
25. Air Compressor Air Strainer					X				
26. Turbocharger*									
27. Power Generator				X		X			
28. Power Take-Off		X	X				X		
29. Torqmatic Converter	X		X				X		
• 30. Marine Gear	X				X				

* See items on following pages

Item 1

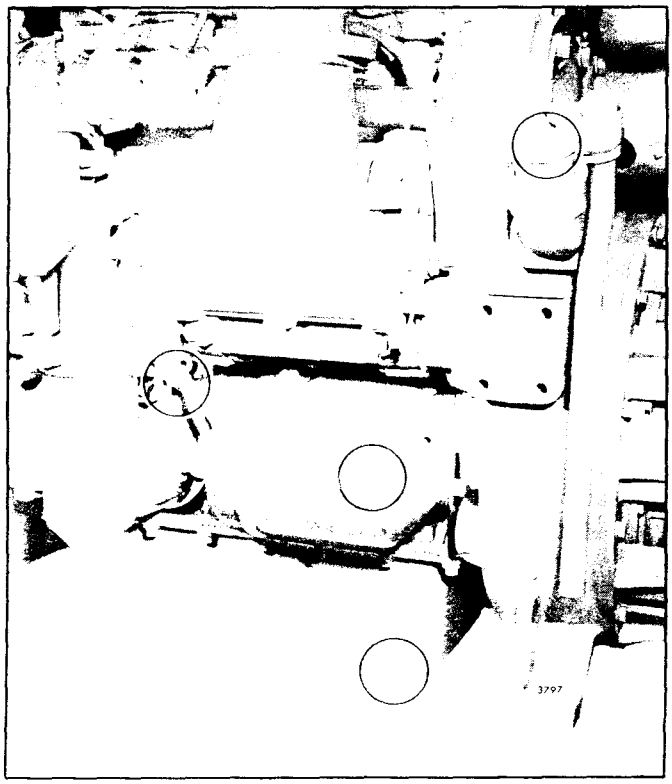
Check the oil level daily before starting the engine. Add oil, if necessary, to bring it to the proper level on the dipstick.

Select the proper grade of oil in accordance with the instructions in the *Lubricating Oil Specifications* in Section 13.3.

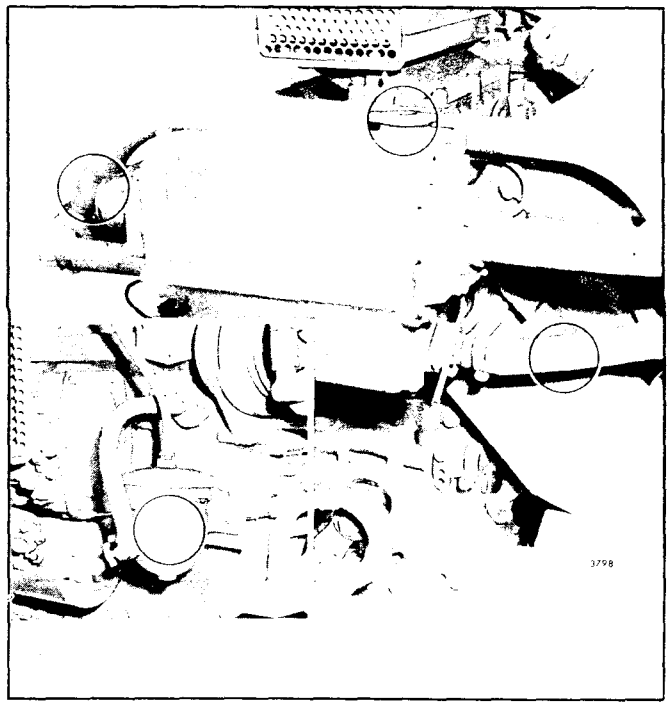
It is recommended that new engines be started with 100 hour oil change periods. For highway vehicles, this corresponds to approximately 3,000 miles, and for city-service vehicles approximately 1,000-2,000 miles. The drain interval may then be gradually increased, or decreased, following the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the oil sample analysis) until the most practical oil change period has been established.

Item 2

Install new engine oil filter elements and gaskets each time the engine oil is changed. Check for oil leaks after starting the engine. If the engine is equipped with a governor oil filter, change the element every 1,000 hours.



Items 1 and 2



Items 3 and 4

Item 3

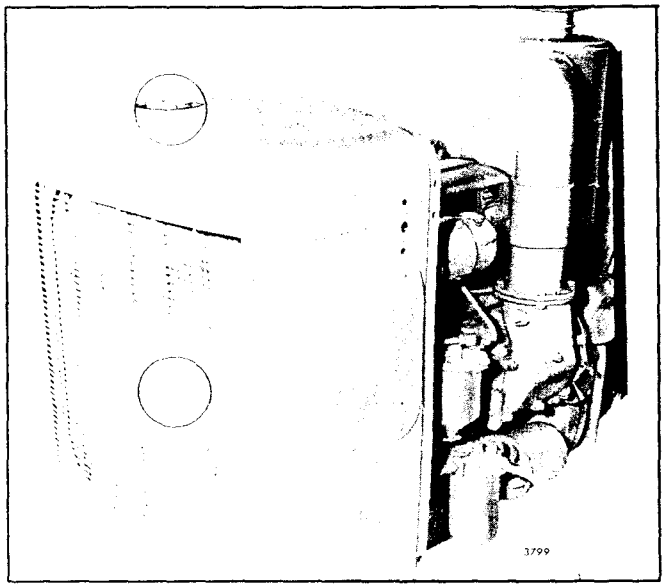
Check the coolant level daily and maintain it near the top of the heat exchanger tank or the radiator upper tank.

Clean the cooling system every 1,000 hours or 30,000 miles using a good radiator cleaning compound in accordance with the instructions on the container. After the cleaning operation, rinse the cooling system thoroughly with fresh water. Then fill the system with soft water, adding a good grade of rust inhibitor or a high boiling point type antifreeze (refer to *Engine Coolant* in Section 13.3). With the use of a proper antifreeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring or fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system. When a thorough cleaning of the cooling system is required, it should be reverse-flushed.

If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 500 hours or 15,000 miles.

Item 4

Inspect all of the cooling system hoses at least once every 500 hours or 15,000 miles for signs of deterioration. Replace the hoses if necessary.



Item 5

Item 5

Inspect the exterior of the radiator core every 1,000 hours or 30,000 miles and, if necessary, clean it with a quality grease solvent such as Oleum and dry it with compressed air. *Do not use fuel oil, kerosene or gasoline.* It may be necessary to clean the radiator more frequently if the engine is being operated in extremely dusty or dirty areas.

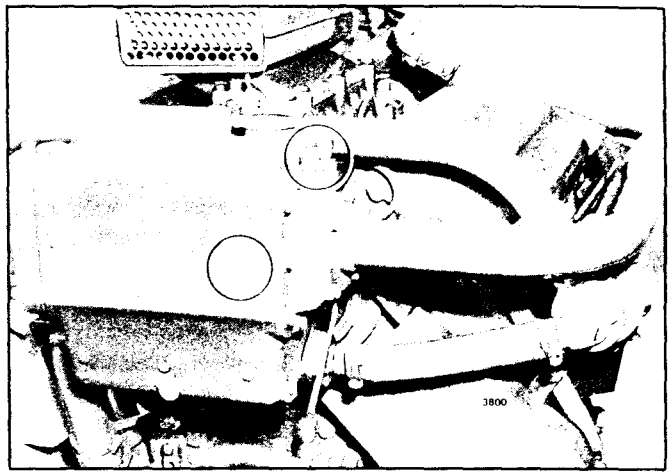
Item 6

Every 500 hours, drain the water from the heat exchanger raw water inlet and outlet tubes. Then remove the zinc electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

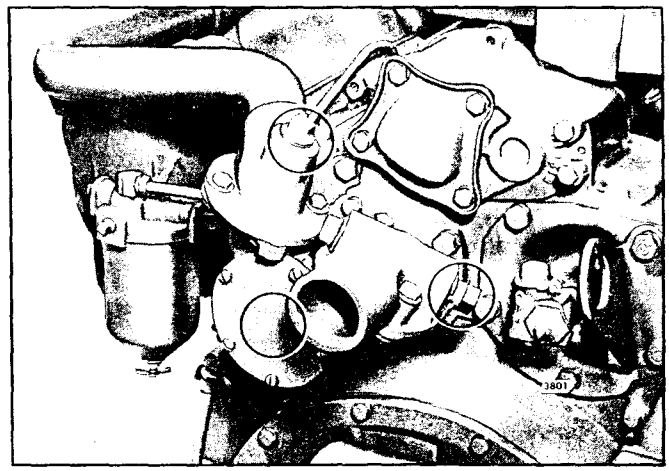
Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1,000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, clean the core as outlined in Section 5.5.

Item 7

Check the prime on the raw water pump; the engine should not be operated with a dry pump. Prime the pump, if necessary, by removing the pipe plug



Item 6



Item 7

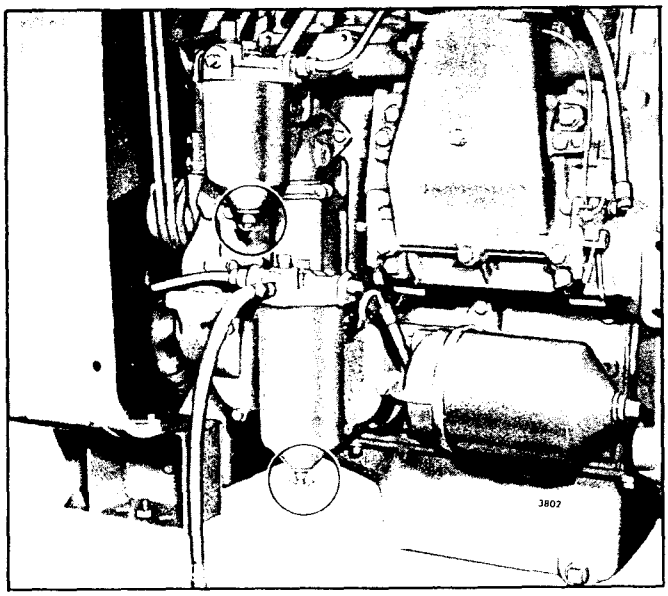
provided in the pump inlet elbow and adding water. Reinstall the plug.

Item 8

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Diesel Fuel Oil Specifications* in Section 13.3. Open the drain at the bottom of the fuel tank every 500 hours or 15,000 miles to drain off any water or sediment.

Item 9

Drain approximately one-fourth pint of fuel to remove sediment and water from the strainer and the filter daily by opening the drain cock in the bottom of each



Item 9

shell. Install new elements every 300 hours or 9,000 miles or when plugging is indicated.

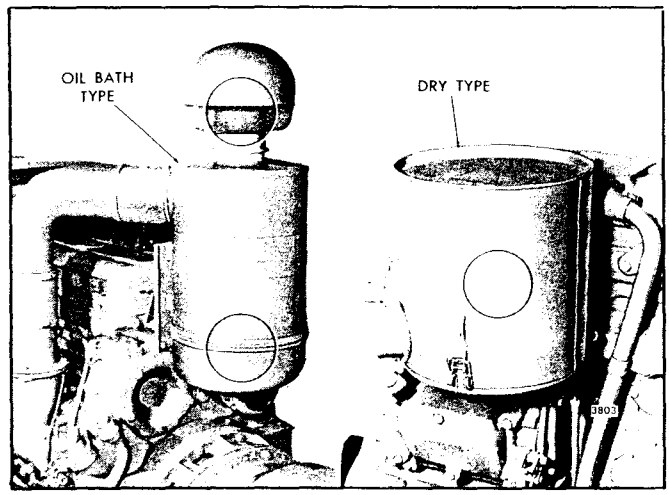
A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury. At normal operating speeds (1800-2800 rpm), the fuel pressure is 45 to 70 psi. Change the fuel filter elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches of mercury at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to 45 psi.

Item 10

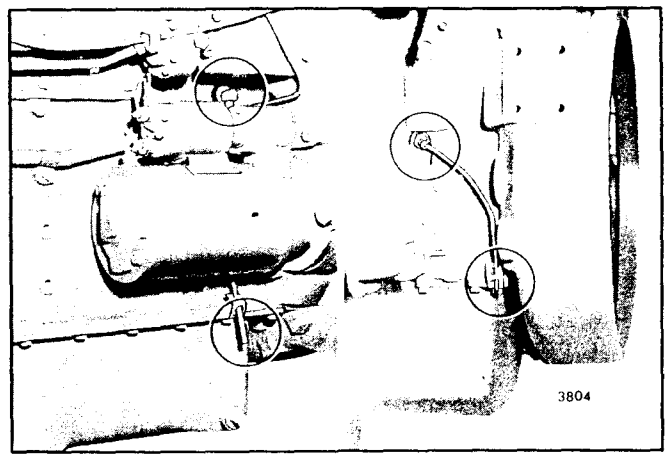
Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours (every 6,000 miles for highway vehicle engines), or less if operating conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark with the same grade and viscosity *heavy-duty* oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions.

It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 500 hours, 15,000 miles or as conditions warrant.

Clean or replace the element in the dry-type air cleaner when the restriction indicator instrument indicates high restriction or when a water manometer



Item 10



Item 11

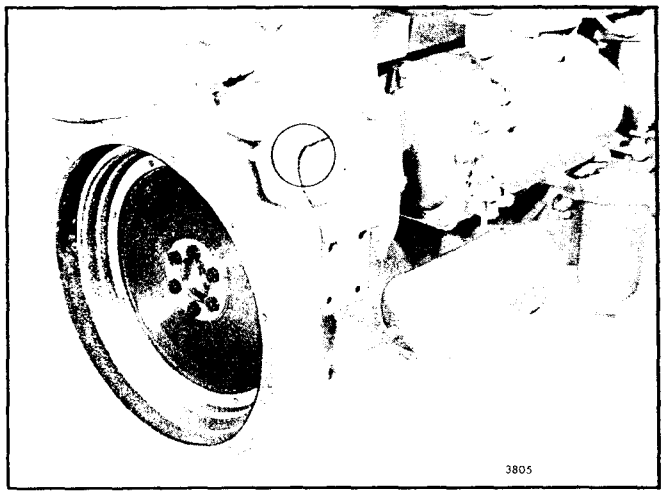
reading at the air inlet housing indicates the maximum allowable air inlet restriction (Section 13.2).

Item 11

With the engine running, check for flow of air from the air box drain tubes every 1,000 hours or 30,000 miles. If the tubes are clogged, remove, clean and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent. If the engine is equipped with an air box drain tank, drain the sediment periodically. If the engine is equipped with an air box drain check valve, replace the valve every 500 hours or 15,000 miles.

Item 12

Remove the externally mounted crankcase breather



Item 12

assembly every 1,000 hours or 30,000 miles and wash the steel mesh pad in clean fuel oil. This cleaning period may be reduced or lengthened according to severity of service (refer to Section 4.8).

Clean the internally mounted breather pads at time of engine overhaul, or sooner if excessive crankcase pressure is observed.

Clean the breather cap, mounted on the valve rocker cover, in clean fuel oil every time the engine oil is changed (refer to Section 4.8).

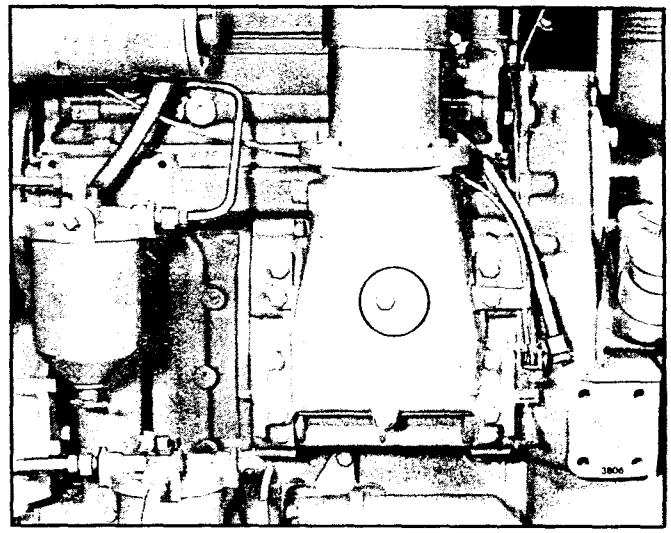
Item 13

Inspect the blower screen and gasket assembly every 1,000 hours or 30,000 miles and, if necessary, clean the screen in fuel oil and dry it with compressed air. Reinstall the screen and gasket assembly with the screen side of the assembly toward the blower.

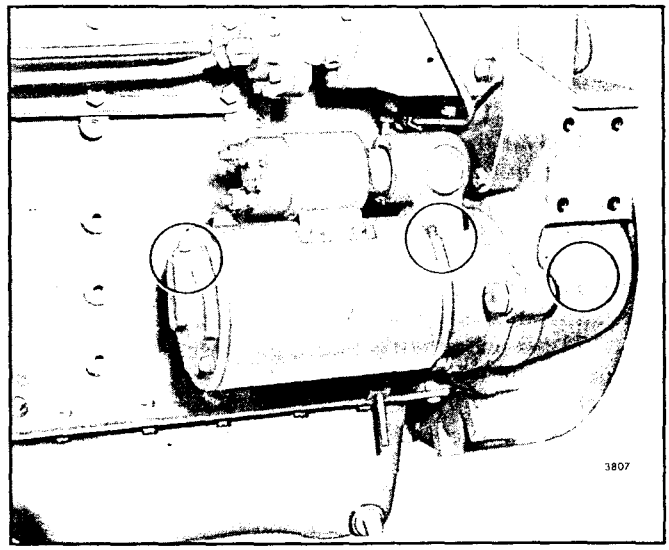
Item 14

The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken off the engine or disassembled.

The Sprag overrunning clutch drive mechanism should be lubricated with a few drops of light engine oil whenever the starting motor is overhauled.



Item 13



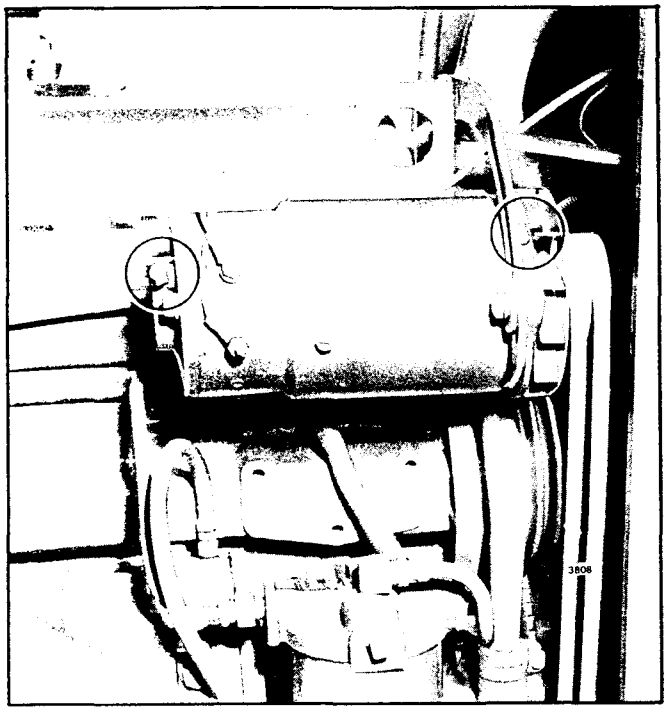
Item 14

Item 15

Lubricate the battery-charging generator (alternator) bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours or 6,000 miles.

On early generators equipped with grease cups, turn the cups down one full turn every 100 hours or 3,000 miles of operation. Keep the grease cups filled with *Delco-Remy Cam and Ball Bearing Lubricating*, or equivalent. Avoid excessive lubrication since this may cause lubricant to be forced onto the commutator.

Some generators have a built-in supply of grease, while others use sealed bearings. In these latter two cases, additional lubrication is not necessary.



Item 15

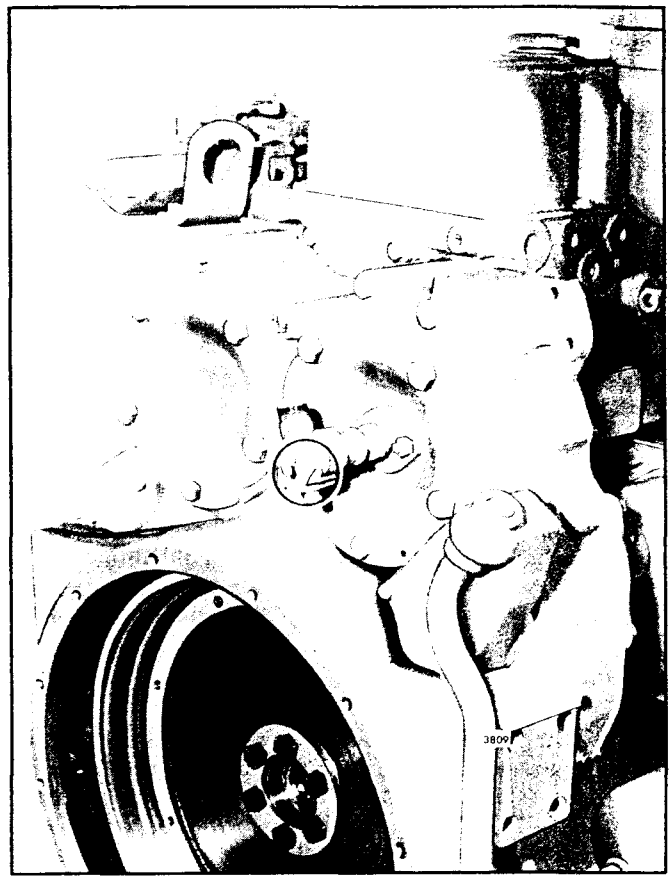
On D.C. generators, inspect the commutator and brushes every 500 hours or 15,000 miles. Clean the commutator every 2,000 hours or 60,000 miles, if necessary, with No. 00 sandpaper or a brush seating stone. After cleaning, reseat the brushes and blow out the dust.

On A.C. generators (alternators), the slip rings and brushes can be inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean slip rings. Hold the polishing cloth against the slip rings with the generator in operation and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them.

Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.

Item 16

Check the specific gravity of the electrolyte in each cell of the battery every 100 hours or 3,000 miles. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.



Item 17

Item 17

Lubricate the tachometer drive every 100 hours or 3,000 miles with an all purpose grease at the grease fitting. At temperatures above +30 °F., use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.

Item 18

Lubricate the throttle control mechanism every 200 hours or 6,000 miles with an all purpose grease at the grease fittings. At temperatures above +30 °F., use a No. 2 grade grease. Use a No. 1 grade grease below this temperature. Lubricate the clutch control levers and all other control mechanisms, as required, with engine oil.

Item 19

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating

mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

Item 20

New standard V-belts will stretch after the first few hours of operation. Run the engine for 15 *seconds* to seat the belts, then retension them. Retighten new fan drive, pump drive, battery-charging generator and other accessory drive belts after 1/2 hour or 15 miles and again after 8 hours or 240 miles of operation. Thereafter, check the tension of the drive belts every 200 hours or 6,000 miles and adjust, if necessary. Too tight a belt is destructive to the bearings of the driven part; a loose belt will slip.

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set; premature belt wear can result because of belt length variation. All belts in a matched belt set are within .032 " of their specified center distances.

Adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will depress the belt 1/2 " to 3/4 ". If belt tension gage BT-33-73FA or equivalent is available, adjust the belt tension as outlined in the Chart.

NOTE: When installing or adjusting an accessory drive belt, be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.

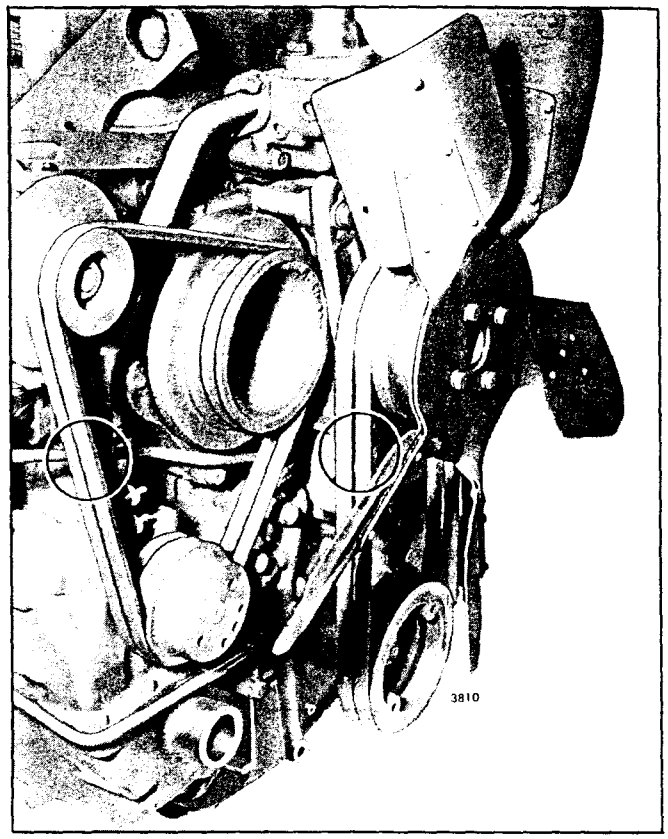
Item 21

Lubricate the overspeed governor, if it is equipped with a hinge-type cap oiler or oil cup, with 5 or 6 drops of engine oil every 500 hours. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Engine Model	Fan Drive		Generator Drive		
	2 or 3 Belts	Single Belt	Two 3/8" or 1/2" Belts	One 1/2" Belt	One Wide Belt*
2, 3, 4-53	40-50	—	40-50	50-70	40-50
6, 8V-53	60-80	80-100	40-50	50-70	40-50
All	For 3-point or triangular drive use a tension of 90-120.				

*Belt tension is 50-70 for a single premium high capacity belt (.785" wide) used to drive a 12 cfm air compressor.

BELT TENSION CHART (lbs/belt)



Item 20

Item 22

At a major engine overhaul, discard the bearings in the fan hub assembly used in radiator cooled engines. Pack the hub assembly, using new bearings, with Chevron BRB No. 2 grease or an equivalent performance grease.

Item 23

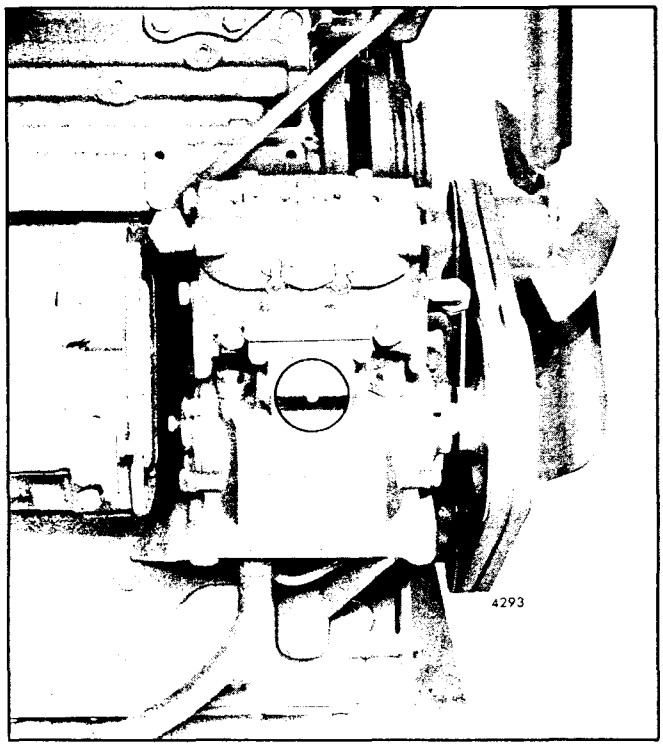
Check the shut-down system every 300 operating hours or each month to be sure it will function when needed.

Item 24

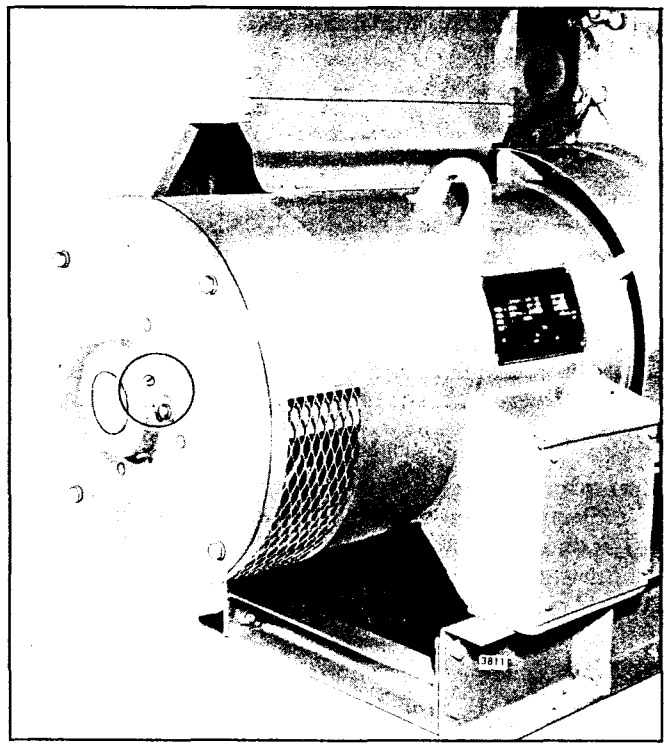
On engines equipped with a Hydrostarter, refer to Lubrication and Preventive Maintenance in Section 12.6.1.

Item 25

To clean either the hair or polyurethane type air compressor air strainer element, saturate and squeeze it in fuel oil, or any other cleaning agent that would not be detrimental to the element, until dirt free. Then



Item 25



Item 27

dip it in lubricating oil and squeeze it dry before placing it back in the air strainer.

For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available.

Item 26

There is no scheduled interval for performing an inspection on the Airesearch turbocharger. As long as the turbocharger is operating satisfactorily and there is no appreciable loss of power, no vibration or unusual noise and no oil leaks, only a periodic inspection is necessary (refer to Section 3.5).

Item 27

The power generator requires lubrication at only one point -- the ball bearing in the end frame.

If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade and viscosity *heavy-duty* oil as specified for the engine. Maintain the oil level to the line in the sight gage. *Do not overfill.* After adding oil, recheck the oil level after running the generator for several minutes.

If the bearing is grease lubricated, a new generator has sufficient grease for three years of normal service. Thereafter, it should be lubricated at one year intervals. To lubricate the bearing, remove the filler and relief plugs on the side and the bottom of the bearing reservoir. Add grease until new grease appears at the relief plug opening. Run the generator a few minutes to vent the excess grease; then reinstall the plugs.

The following greases, or their equivalents, are recommended:

Keystone 44H	Keystone Lubrication Co.
BRB Lifetime	Socony Vacuum Oil Co.
NY and NJ F926 or F927	NY and NJ Lubricant Co.

After 100 hours on new brushes, or brushes in generators that have not been in use over a long period, remove the end frame covers and inspect the brushes, commutator and collector rings. If there is no appreciable wear on the brushes, the inspection interval may be extended until the most practicable period has been established (not to exceed six months). To prevent damage to the commutator or the collector rings, do not permit the brushes to become shorter than 3/4 inch.

Keep the generator clean inside and out. Before removing the end frame covers, wipe off the loose dirt. The loose dirt and dust may be blown out with low

pressure air (25 psi maximum). Remove all greasy dirt with a cloth.

Item 28

Lubricate all of the power take-off bearings with an all purpose grease such as Shell Alvania No. 2, or equivalent. Lubricate sparingly to avoid getting grease on the clutch facing.

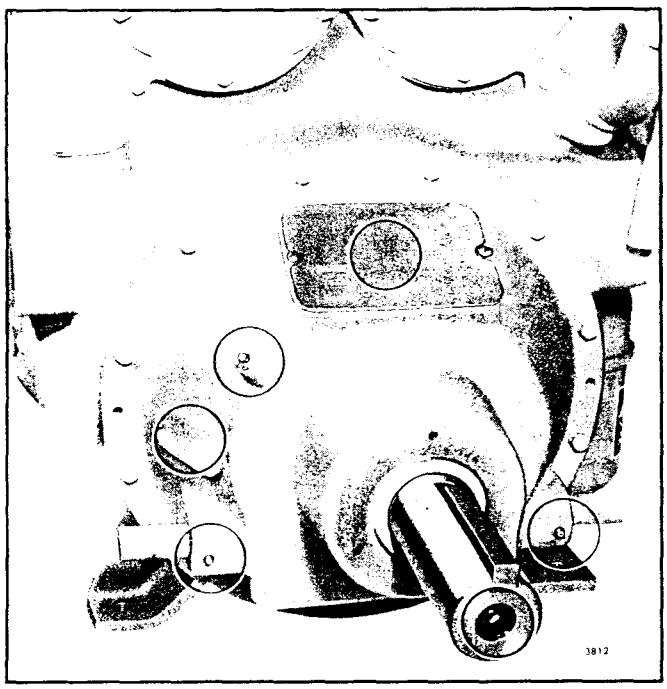
Open the cover on the side of the clutch housing (8 " and 10 " diameter clutch) and lubricate the clutch release sleeve collar through the grease fitting every 8 hours.

Lubricate the clutch drive shaft pilot bearing through the fitting in the outer end of the drive shaft (8 " and 10 " diameter clutch power take-offs) every 50 hours of operation. One or two strokes with a grease gun should be sufficient.

Lubricate the clutch drive shaft roller bearings through the grease fitting in the clutch housing every 50 hours under normal operating conditions (not continuous) and more often under severe operating conditions or continuous operation.

Lubricate the clutch release shaft through the fittings at the rear of the housing every 500 hours of operation.

Lubricate the clutch levers and links sparingly with



Item 28

Prevailing Ambient Temperature	Recommended Oil Specification
Above -10° F.	Hydraulic Transmission Fluid, Type C-2.
Below -10° F.	Hydraulic Transmission Fluid, Type C-2. Auxiliary preheat required to raise temperature in the sump to a temperature above -10° F.

OIL RECOMMENDATIONS

engine oil every 500 hours of operation. Remove the inspection hole cover on the clutch housing and lubricate the clutch release levers and pins with a hand oiler. To avoid getting oil on the clutch facing, do not over lubricate the clutch release levers and pins.

Check the clutch facing for wear every 500 hours. Adjust the clutch if necessary.

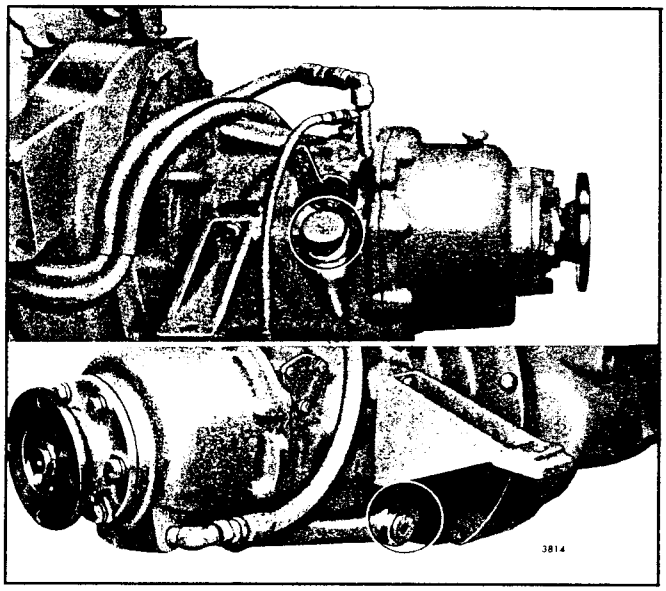
Item 29

Check the oil level in the Torqmatic converter and supply tank daily. The oil level must be checked while the converter is operating, the engine idling and the oil is up to operating temperature (approximately 200 °F). If the converter is equipped with an input disconnect clutch, the clutch must be engaged.

Check the oil level after running the unit a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" (see chart). *Do not overfill* the converter as too much oil will cause foaming and high oil temperature.

The oil should be changed every 500 hours of operation. Also, the oil should be changed whenever it shows traces of dirt or effects of high operating temperature as evidenced by discoloration or strong odor. If the oil shows metal contamination, refer to the separate manual covering the specific converter as this usually requires disassembly. Under severe operating conditions, the oil should be changed more often.

The converter oil breather, located on the oil level indicator (dipstick), should be cleaned each time the



Item 30

converter oil is changed. This can be accomplished by allowing the breather to soak in a solvent, then drying it with compressed air.

The full-flow oil filter element should be removed, the shell cleaned and a new element and gasket installed each time the converter oil is changed.

Lubricate the input clutch release bearing and ball bearing every 50 hours with an all purpose grease through the grease fittings provided on the clutch housing. This time interval may vary depending upon the operating conditions. Over-lubrication will cause grease to be thrown on the clutch facing, causing the clutch to slip.

Item 30

WARNER MARINE GEAR:

Check the oil level daily. Start and run the engine at idle speed for a few minutes to fill the lubrication system. Stop the engine. Then, immediately after stopping the engine, check the oil level in the marine gear. Bring the oil level up to the proper level on the dipstick. Use the same grade and viscosity *heavy-duty* oil as used in the engine. *Do not overfill.*

Change the oil every 200 hours. After draining the oil from the unit, clean the removable oil screen thoroughly before refilling the marine gear with oil.

TWIN DISC MARINE GEAR:

Check the oil level daily. Check the oil level with the engine running at low idle speed and the gear in neutral. Keep the oil up to the proper level on the dipstick. Use the same grade and viscosity *heavy-duty* oil as used in the engine.

Change the oil every 200 hours. Remove and clean the oil inlet strainer screen after draining the oil. The strainer is located in the sump at the lower end of the pump suction line. Reinstall the strainer and refill the marine gear with oil up to the full mark on the dipstick (approximately 5 quarts). Start the engine and, with the gear in neutral, run the engine at idle speed for three to five minutes. Then stop the engine and check the marine gear oil level. If necessary, add oil to bring it up to the full mark on the dipstick.

TROUBLE SHOOTING

Certain abnormal conditions which sometimes interfere with satisfactory engine operation, together with methods of determining the cause of such conditions, are covered on the following pages.

Satisfactory engine operation depends primarily on:

1. An adequate supply of air compressed to a sufficiently high compression pressure.

2. The injection of the proper amount of fuel at the right time.

Lack of power, uneven running, excessive vibration, stalling at idle speed and hard starting may be caused by either low compression, faulty injection in one or more cylinders, or lack of sufficient air.

Since proper compression, fuel injection and the proper amount of air are important to good engine performance, detailed procedures for their investigation are given as follows:

Locating a Misfiring Cylinder

1. Start the engine and run it at part load until it reaches normal operating temperature.

2. Stop the engine and remove the valve rocker cover(s).

3. Check the valve clearance.

4. Start the engine. Then, hold an injector follower down with a screw driver, thus preventing operation of the injector. If the cylinder has been misfiring, there will be no noticeable difference in the sound and operation of the engine. If the cylinder has been firing properly, there will be a noticeable difference in the sound and operation when the injector follower is held down. This is similar to short-circuiting a spark plug in a gasoline engine.

5. If the cylinder is firing properly, repeat the procedure on the other cylinders until the faulty one has been located.

6. Provided the injector operating mechanism of the faulty cylinder is functioning satisfactorily, remove the fuel injector and install a new one.

7. If installation of a new injector does not eliminate the misfiring, the compression pressure of the cylinder in question should be checked.

Checking Compression Pressure

Compression pressure is affected by altitude as follows:

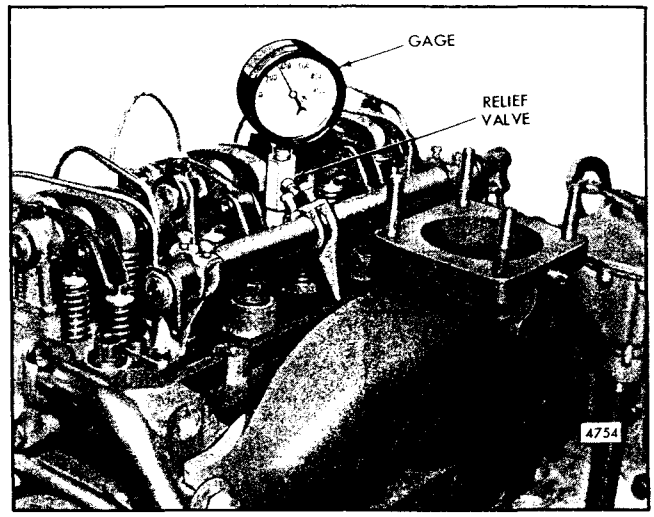


Fig. 1 - Checking Compression Pressure

Minimum Compression Pressure, psi		Altitude, Feet Above Sea Level
Std. Engine	"N" Engine	
430	540	0
400	500	2,500
370	465	5,000
340	430	7,500
315	395	10,000

Check the compression pressure as follows:

1. Start the engine and run it at approximately one-half rated load until normal operating temperature is reached.

2. Stop the engine and remove the fuel pipes from the injector and fuel connectors of the No. 1 cylinder.

3. Remove the injector and install the adaptor J 7915-02 and pressure gage and hose assembly J 6992 (Fig. 1).

4. Use a spare fuel pipe and fabricate a jumper connection between the fuel inlet and return manifold connectors. This will permit fuel from the inlet manifold to flow directly to the return manifold.

5. Start the engine and run it at a 600 rpm. Observe and record the compression pressure indicated on the gage.

Do not crank the engine with the starting motor to obtain the compression pressure.

6. Perform Steps 2 through 5 on each cylinder. The compression pressure in any one cylinder should be not less than 430 psi (540 psi for 53N engines) at 600 rpm. In additon, the variation in compression

pressures between cylinders must not exceed 25 psi at 600 rpm.

EXAMPLE: If the compression pressure readings were as shown in the following table, it would be evident that No. 3 cylinder should be examined and the cause of the low compression pressure be determined and corrected.

Cylinder	Gage Reading*
1	525 psi
2	520 psi
3	485 psi
4	515 psi

The above pressures are for an engine operating at an altitude near sea level.

Note that all of the cylinder pressures are above the low limit for satisfactory engine operation. Nevertheless, the No. 3 cylinder compression pressure indicates that something unusual has occurred and that a localized pressure leak has developed.

Low cylinder pressure may result from any one of several causes:

A. Piston rings may be stuck or broken. To determine the condition of the rings, remove the air box cover and inspect them by pressing on the rings with a blunt tool. A broken or stuck ring will not have a "spring- like" action.

B. Compression pressure may be leaking past the cylinder head gasket, the valve seats, the injector tube, or a hole in the piston.

Engine Out of Fuel

The problem in restarting the engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is then pumped from the primary fuel strainer and sometimes partially removed from the secondary fuel filter before the fuel supply becomes insufficient to sustain engine firing. Consequently, these components must be refilled with fuel and the fuel pipes rid of air in order for the system to provide adequate fuel for the injectors.

When an engine has run out of fuel, there is a definite procedure to follow for restarting it:

1. Fill the fuel tank with the recommended grade of fuel oil. If only partial filling of the tank is possible, add a minimum of ten gallons of fuel.

2. Remove the fuel strainer shell and element from the strainer cover and fill the shell with fuel oil. Install the shell and element.

3. Remove and fill the fuel filter shell and element with fuel oil as in Step 2.

4. Start the engine. Check the filter and strainer for leaks.

NOTE: In some instances, it may be necessary to remove a valve rocker cover and loosen a fuel pipe nut in order to bleed trapped air from the fuel system. Be sure the fuel pipe is retightened securely before replacing the rocker cover.

Primer J 5956 may be used to prime the entire fuel system. Remove the filler plug in the fuel filter cover and install the primer. Prime the system. Remove the primer and install the filler plug.

Fuel Flow Test

1. Disconnect the fuel return hose and hold the open end in a suitable container.

2. Start and run the engine at approximately 1200 rpm and measure the fuel flow from the return hose for one minute. At least 0.6 gallon of fuel should flow from the return hose per minute.

3. Be sure all of the connections between the fuel supply and the pump are tight so that no air will be drawn into the fuel system; then, immerse the end of the fuel hose in the fuel in the container. Air bubbles rising to the surface of the fuel will indicate a leak on the suction side of the pump.

Crankcase Pressure

The crankcase pressure indicates the amount of air that has passed between the oil control rings and the cylinder liner into the crankcase, most of which is clean air from the air box. A slight pressure in the crankcase is desirable to prevent the entrance of dust. A loss of engine lubricating oil through the breather tube, crankcase ventilator, or dipstick hole in the cylinder block is indicative of excessive crankcase pressure.

The causes of high crankcase pressure may be traced to excessive blow-by due to worn piston rings, a hole or crack in a piston crown, loose piston pin retainers, worn blower oil seals, defective blower, cylinder, or end plate gaskets, or excessive exhaust back pressure. Also, the breather tube or crankcase ventilator should be checked for obstructions.

The crankcase pressure may be checked with a manometer. The manometer should be connected to the oil level dipstick opening in the cylinder block. Check the readings obtained at various engine speeds with the *Engine Operating Conditions in Section 13.2.*

Exhaust Back Pressure

A slight pressure in the exhaust system is normal. However, excessive exhaust back pressure seriously affects engine operation. It may cause an increase in the air box pressure with a resultant loss of efficiency of the blower. This means less air for scavenging which results in poor combustion and higher temperatures.

Causes of high exhaust back pressure are usually a result of an inadequate or improper type of muffler, an exhaust pipe which is too long or too small in diameter, an excessive number of sharp bends in the exhaust system, or obstructions such as excessive carbon formation or foreign matter in the exhaust system.

The exhaust back pressure, measured in inches of mercury, may be checked with a manometer in the engine diagnosis test kit J 9531-01. Connect the manometer to the exhaust manifold by removing the 1/8" pipe plug which is provided for that purpose. If there is no opening provided, drill an 11/32" hole in the exhaust manifold companion flange; then tap the hole to accommodate a 1/8" pipe plug.

On turbocharged engines check the exhaust back pressure in the exhaust piping 6" to 12" from the rear face of the turbine. The tapped hole must be in a comparatively straight area for an accurate measurement.

Check the readings obtained at various speeds (at no-load) with the specifications in Section 13.2.

Air Box Pressure

Proper air box pressure is required to maintain sufficient air for combustion and scavenging of the burned gases. Low air box pressure is caused by a high air inlet restriction, damaged blower rotors, an air leak from the air box, such as leaking end plate gaskets, or a clogged blower air inlet screen. Lack of power or black or grey exhaust smoke are indications of low air box pressure.

High air box pressure can be caused by partially plugged cylinder liner ports.

To check the air box pressure, connect a manometer to an air box drain tube.

Check the readings obtained at various speeds with the *Engine Operating Conditions* in Section 13.2.

Air Inlet Restriction

Excessive restriction of the air inlet will affect the flow of air to the cylinders and result in poor combustion and lack of power. Consequently the restriction must be kept as low as possible considering the size and capacity of the air cleaner. An obstruction in the air inlet system or dirty or damaged air cleaners will result in a high blower inlet restriction.

The air inlet restriction may be checked with a water manometer connected to a fitting in the air intake ducting located 2" above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to the engine air inlet housing. The restriction at this point should be checked at a specific engine speed. Then, the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading.

The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

Check the normal air inlet vacuum at various speeds (at no-load) and compare the results with the *Engine Operating Conditions* in Section 13.2.

PROPER USE OF MANOMETER

The U-tube manometer is a primary measuring device indicating pressure or vacuum by the difference in the height of two columns of fluid.

Connect the manometer to the source of pressure, vacuum or differential pressure. When the pressure is imposed, add the number of inches one column of fluid travels up to the amount the other column travels down to obtain the pressure (or vacuum) reading.

The height of a column of mercury is read differently than that of a column of water. Mercury does not wet the inside surface; therefore, the top of the column has a convex meniscus (shape). Water wets the surface and therefore has a concave meniscus. A mercury column is read by sighting horizontally between the top of the convex mercury surface (Fig. 2) and the scale. A water manometer is read by sighting horizontally between the bottom of the concave water surface and the scale.

Should one column of fluid travel further than the other column, due to minor variations in the inside diameter of the tube or to the pressure imposed, the accuracy of the reading obtained is not impaired.

The manometer reading may be converted into other units of measurement by use of the pressure conversion chart.

PRESSURE CONVERSION CHART

1" water	=	.0735" mercury
1" water	=	.0361 psi
1" mercury	=	.491 psi
1" mercury	=	13.6" water
1 psi	=	27.7" water
1 psi	=	2.036" mercury

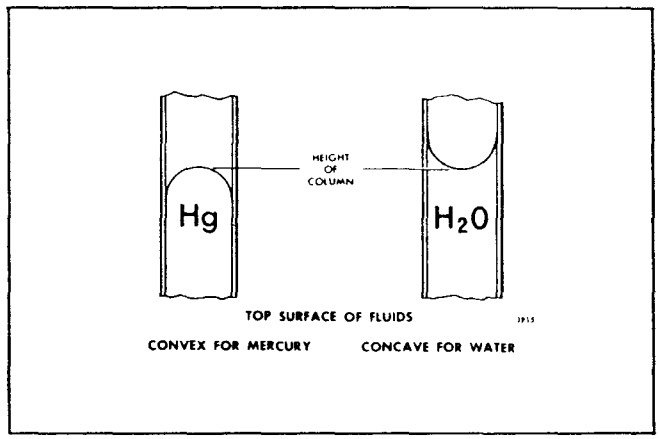


Fig. 2 - Comparison of Column Height for Mercury and Water Manometers

Chart 1

EXHAUST SMOKE ANALYSIS

CHECKS SHOULD BE MADE WITH WATER OUTLET TEMPERATURE AT 160°F. MINIMUM

BLACK OR GRAY SMOKE

Probable Causes

1. INCOMPLETELY BURNED FUEL
2. EXCESSIVE FUEL OR IRREGULAR FUEL DISTRIBUTION
3. IMPROPER GRADE OF FUEL

BLUE SMOKE

Probable Causes

4. LUBRICATION OIL NOT BURNED IN CYLINDER (BLOWN THROUGH CYLINDER DURING SCAVENGING PERIOD)

WHITE SMOKE

Probable Cause

5. MISFIRING CYLINDERS

SUGGESTED REMEDY

1. High exhaust back pressure or a restricted air inlet causes insufficient air for combustion and will result in incompletely burned fuel.

High exhaust back pressure is caused by faulty exhaust piping or muffler obstruction and is measured at the exhaust manifold outlet with a manometer. Parts causing high exhaust back pressure should be replaced.

Restricted air inlet to the engine cylinders is caused by clogged cylinder liner ports, air cleaner, or blower air inlet screen. These items should be cleaned. Check the emergency stop to make sure that it is completely open and readjust it if necessary.

2. Check for improperly timed injectors and improperly positioned injector rack control levers. Time the fuel injectors as outlined in *Fuel Injector Timing* and perform the appropriate governor tune-up to correct this condition.

Replace faulty injectors if this condition still persists after timing the injectors and performing the engine tune-up.

Lugging the engine will cause incomplete combustion and should be avoided. Operate the engine as outlined in the *Drivers Handbook.*

3. Check for the use of an improper grade of fuel. Consult the *Fuel Oil Specifications* for the correct fuel to use.

4. Check for internal lubricating oil leaks, and refer to the *High Lubricating Oil Consumption* chart.

5. Check for faulty injectors and replace as necessary.

Check for low compression and consult the *Hard Starting* chart.

The use of low cetane fuel will cause this condition and can be corrected by consulting and following the *Fuel Oil Specifications.*

Chart 2

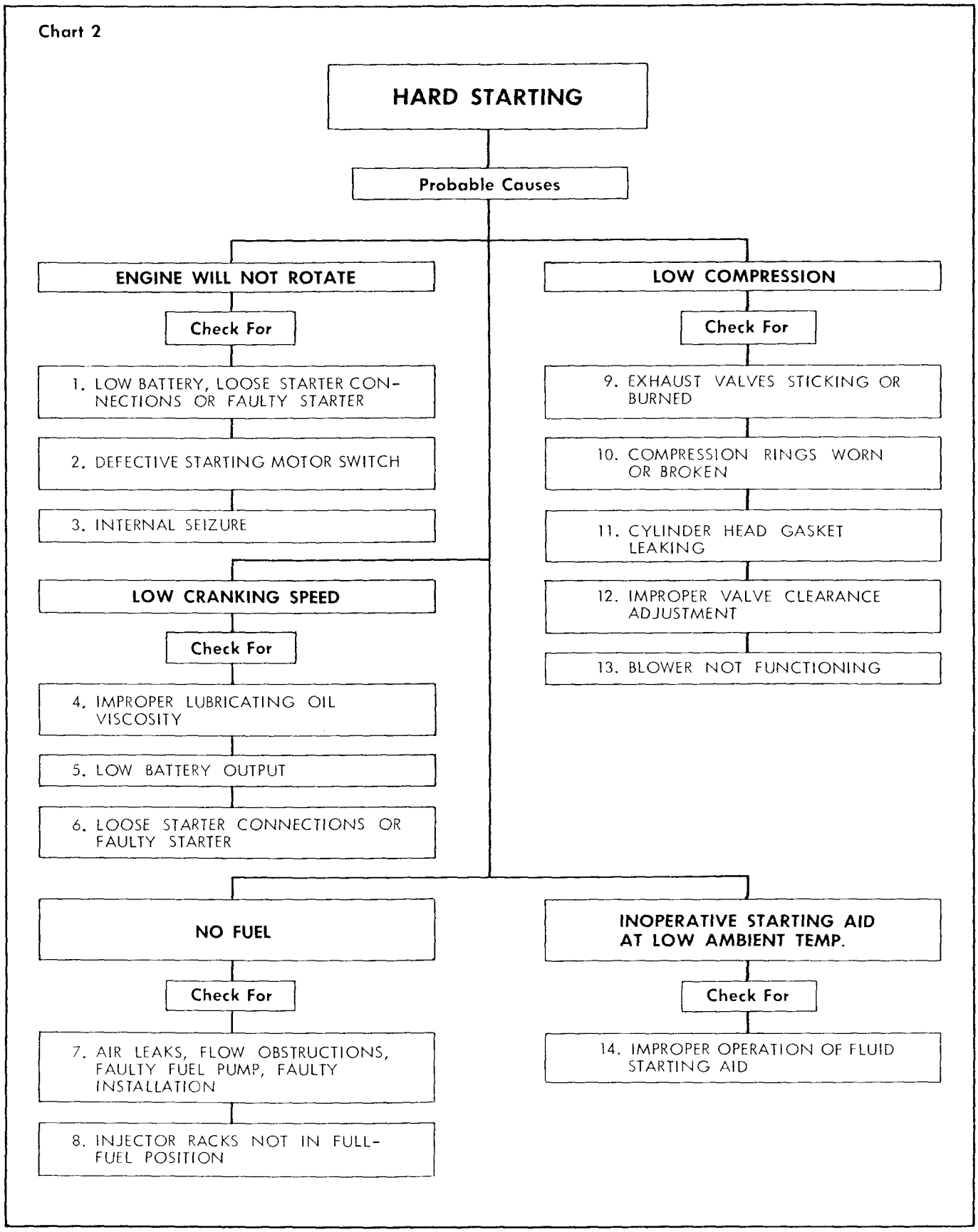

HARD STARTING
Probable Causes
ENGINE WILL NOT ROTATE
Check For
1. LOW BATTERY, LOOSE STARTER CONNECTIONS OR FAULTY STARTER
2. DEFECTIVE STARTING MOTOR SWITCH
3. INTERNAL SEIZURE
LOW CRANKING SPEED
Check For
4. IMPROPER LUBRICATING OIL VISCOSITY
5. LOW BATTERY OUTPUT
6. LOOSE STARTER CONNECTIONS OR FAULTY STARTER
NO FUEL
Check For
7. AIR LEAKS, FLOW OBSTRUCTIONS, FAULTY FUEL PUMP, FAULTY INSTALLATION
8. INJECTOR RACKS NOT IN FULL-FUEL POSITION
LOW COMPRESSION
Check For
9. EXHAUST VALVES STICKING OR BURNED
10. COMPRESSION RINGS WORN OR BROKEN
11. CYLINDER HEAD GASKET LEAKING
12. IMPROPER VALVE CLEARANCE ADJUSTMENT
13. BLOWER NOT FUNCTIONING
INOPERATIVE STARTING AID AT LOW AMBIENT TEMP.
Check For
14. IMPROPER OPERATION OF FLUID STARTING AID

Chart 2 (Cont'd.)

HARD STARTING (Cont'd.)

SUGGESTED REMEDY

1. Refer to Items 2 and 3 and perform the operations listed.

2. Replace the starting motor switch.

3. Hand crank the engine at least one complete revolution. If the engine cannot be rotated a complete revolution, internal damage is indicated and the engine must be disassembled to ascertain the extent of damage and the cause.

4. Use the proper viscosity lubricating oil grade as recommended in the *Lubricating Oil Specifications.*

5. Recharge the battery if a light load test indicates low or no voltage. Replace the battery if it is damaged or will not hold a charge.

Connect the leads properly after replacing the terminals that are damaged or corroded.

At low ambient temperatures, use of a starting aid will facilitate keeping the battery fully charged by reducing the cranking time.

6. Tighten the starter connections. Inspect the starter commutator and brushes for wear. Replace the brushes if badly worn and overhaul the starting motor if the commutator is damaged.

7. To check for air leaks, flow obstruction, faulty fuel pump or faulty installation, consult the *No Fuel or Insufficient Fuel* chart.

8. Inspect for governor-to-injector linkage binding that will prevent the governor from positioning the injector racks into the full-fuel position. Remove any bind found and readjust the governor and injector controls if necessary.

9. The cylinder head must be removed and overhauled to correct this condition.

10. Remove the air box covers and inspect the compression rings through the ports in the cylinder liners. Overhaul the cylinder assemblies if the rings are badly worn or broken.

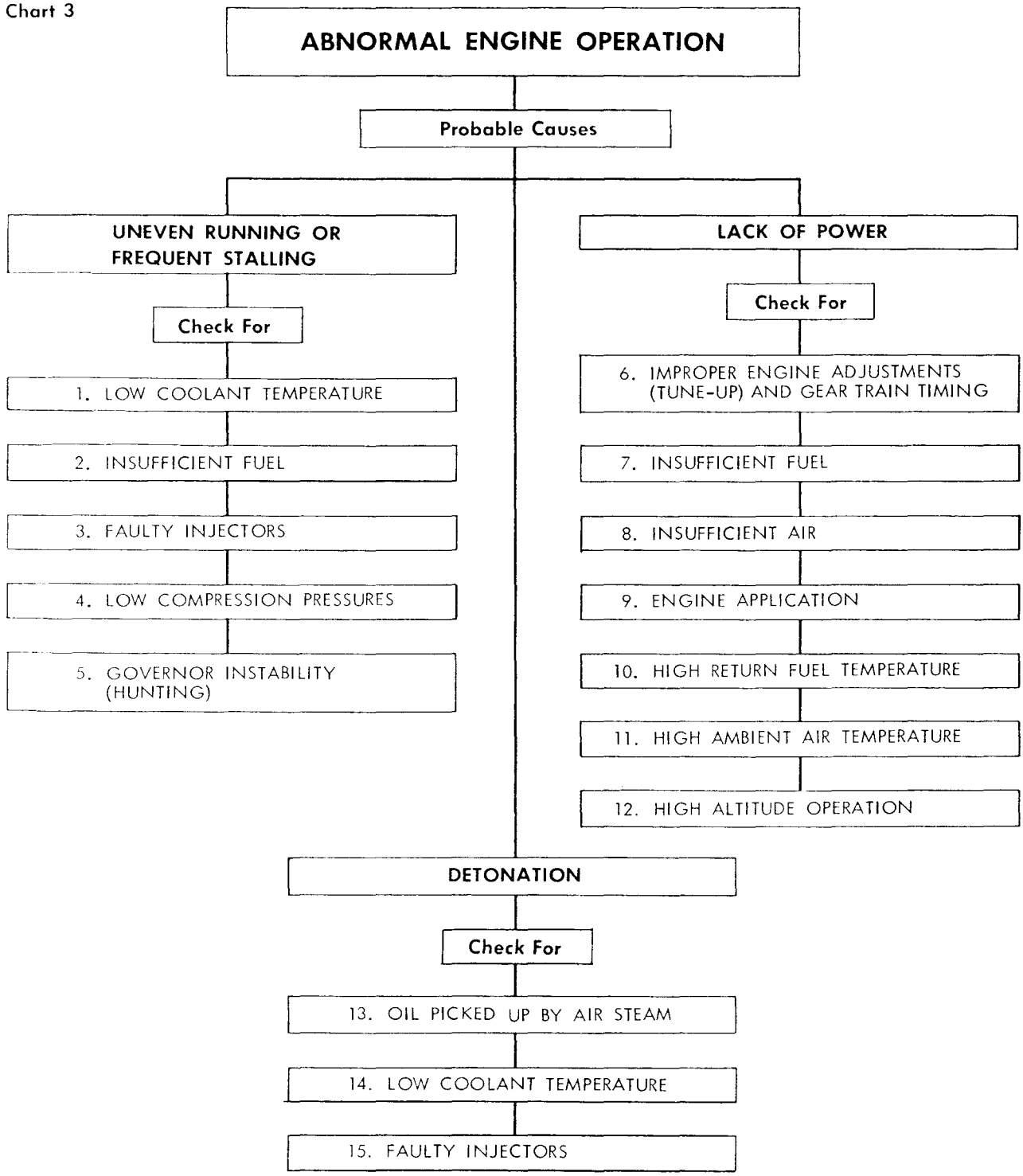
11. To check for compression gasket leakage, remove the radiator filler cap and operate the engine. A steady flow of gases from the coolant filler indicates either a cylinder head gasket is damaged or the cylinder head is cracked. Remove the cylinder head and replace the gaskets.

12. Check the exhaust valve clearance and adjust to the correct clearance.

13. Inspect the blower drive shaft and drive coupling. Replace damaged parts.

14. Operate the starting aid according to the instructions under *Cold Weather Starting Aids.*

Chart 3



SUGGESTED REMEDY

1. Watch the engine coolant temperature gage and if the temperature does not reach 160° to 185°F. while the engine is operating, consult the *Abnormal Engine Coolant Temperature* chart.

2. Check engine fuel spill back and if the return is less than .6 gallon per minute consult the *No Fuel or Insufficient Fuel* chart.

Chart 3 (Cont'd.)

ABNORMAL ENGINE OPERATION (Cont'd.)

SUGGESTED REMEDY

3. Check the injector timing and the position of the injector racks. If the engine was not tuned correctly, perform an engine tune-up. Erratic engine operation may also be caused by leaking injector spray tips. Replace the faulty injectors.

4. Check the compression pressures within the cylinder and consult the *Hard Starting* chart if compression pressures are low.

5. Erratic engine operation may be caused by governor-to-injector operating linkage binding or by faulty adjustments when performing the engine tune-up. These items may be corrected by performing the appropriate engine tune-up procedure as outlined for the governor.

6. The engine should be tuned whenever performance is not satisfactory.

Check the engine gear train timing. An improperly timed gear train will result in a loss of power due to the valves and injectors being actuated at the wrong time in the engine's operating cycle.

7. Perform a *Fuel Flow Test* and, if less than .6 gallon per minute is returning to the fuel tank, consult the *No Fuel or Insufficient Fuel* chart.

8. Check for damaged or dirty air cleaners and clean, repair or replace damaged parts.

Remove the air box covers and inspect the cylinder liner ports. If the ports are over 50% plugged, clean them.

When it is determined that the engine is not getting an adequate supply of air into the cylinders, resulting in poor combustion, check for damaged or dirty air cleaners, inadequate air supply to the engine compartment cylinder liner ports over 50% plugged, blower air intake obstructed or high exhaust back pressure. The faulty parts should be cleaned, repaired or replaced.

Check the compression pressures; if found low, consult the *Hard Starting* chart.

9. Incorrect operation of the engine may result in excessive loads on the engine. Operate the engine according to the approved procedures outlined in the *Drivers Handbook.*

10. Refer to Item 13 on Chart 4.

11. Check the ambient air temperature. A power decrease of .15 to .5 horsepower per cylinder, depending upon injector size, for each 10°F. temperature rise above 90°F. will occur. Relocate the engine air intake to provide a cooler source of air.

12. Engines lose horsepower with increases in altitude. The percentage of power loss is governed by the altitude at which the engine is operating.

13. Check oil bath air cleaners to see that they have been filled to the proper level with the same viscosity lubricating oil that is used in the engine.

Clean the air box and drain tubes to prevent accumulations that may be picked up by the air stream and enter the engine's cylinders.

Inspect the blower oil seals by removing the air inlet housing and watching through the blower inlet for oil radiating away from the blower rotor shaft oil seals while the engine is running. If oil is passing through the seals, overhaul the blower.

Check for a defective blower-to-cylinder block gasket. Replace the gasket if necessary. If the blower has been removed, install a new gasket.

14. Refer to Item 1 of this chart.

15. Check injector timing and the position of each injector rack. If the engine was not tuned-up correctly, perform an engine tune-up. If the engine is correctly tuned, the erratic operation may be caused by an injector check valve leaking, spray tip holes enlarged, or a broken spray tip. Replace all injectors found faulty.

Chart 4

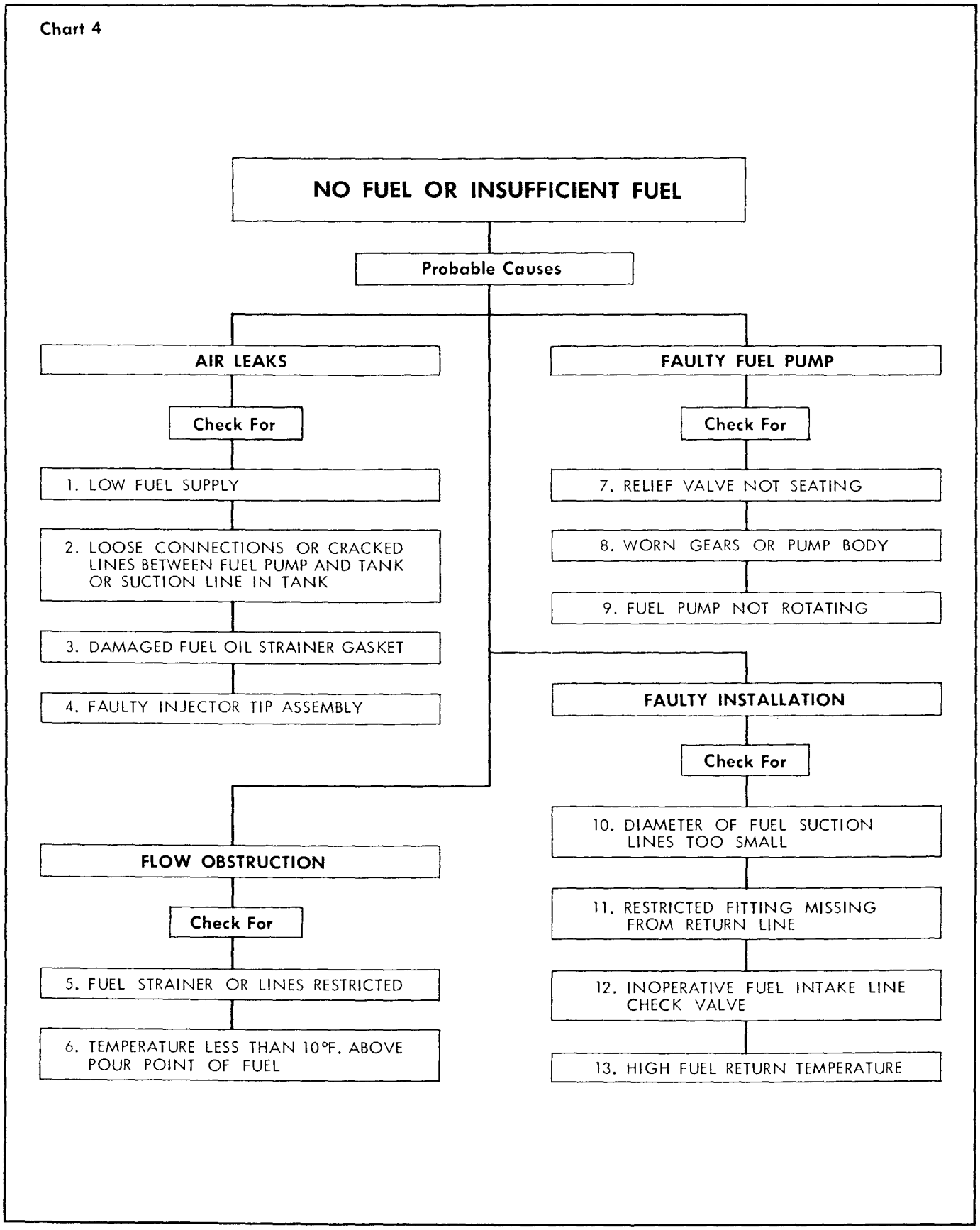

NO FUEL OR INSUFFICIENT FUEL
Probable Causes
AIR LEAKS
Check For
1. LOW FUEL SUPPLY
2. LOOSE CONNECTIONS OR CRACKED LINES BETWEEN FUEL PUMP AND TANK OR SUCTION LINE IN TANK
3. DAMAGED FUEL OIL STRAINER GASKET
4. FAULTY INJECTOR TIP ASSEMBLY
FLOW OBSTRUCTION
Check For
5. FUEL STRAINER OR LINES RESTRICTED
6. TEMPERATURE LESS THAN 10°F. ABOVE POUR POINT OF FUEL
FAULTY FUEL PUMP
Check For
7. RELIEF VALVE NOT SEATING
8. WORN GEARS OR PUMP BODY
9. FUEL PUMP NOT ROTATING
FAULTY INSTALLATION
Check For
10. DIAMETER OF FUEL SUCTION LINES TOO SMALL
11. RESTRICTED FITTING MISSING FROM RETURN LINE
12. INOPERATIVE FUEL INTAKE LINE CHECK VALVE
13. HIGH FUEL RETURN TEMPERATURE

Chart 4 (Cont'd.)

NO FUEL OR INSUFFICIENT FUEL (Cont'd.)

SUGGESTED REMEDY

1. The fuel tank should be filled above the level of the fuel suction tube.

2. Perform a *Fuel Flow Test* and, if air is present, tighten loose connections and replace cracked lines.

3. Perform a *Fuel Flow Test* and, if air is present, replace the fuel strainer gasket when changing the strainer element.

4. Perform a *Fuel Flow Test* and, if air is present with all fuel lines and connections assembled correctly, check for and replace faulty injectors.

5. Perform a *Fuel Flow Test* and replace the fuel strainer and filter elements and the fuel lines, if necessary.

6. Consult the *Fuel Oil Specifications* and use the fuel oil recommended.

7. Perform a *Fuel Flow Test* and, if inadequate, clean and inspect the valve seat assembly.

8. Replace the gear and shaft assembly or the pump body.

9. Check the condition of the fuel pump drive and blower drive and replace the defective parts.

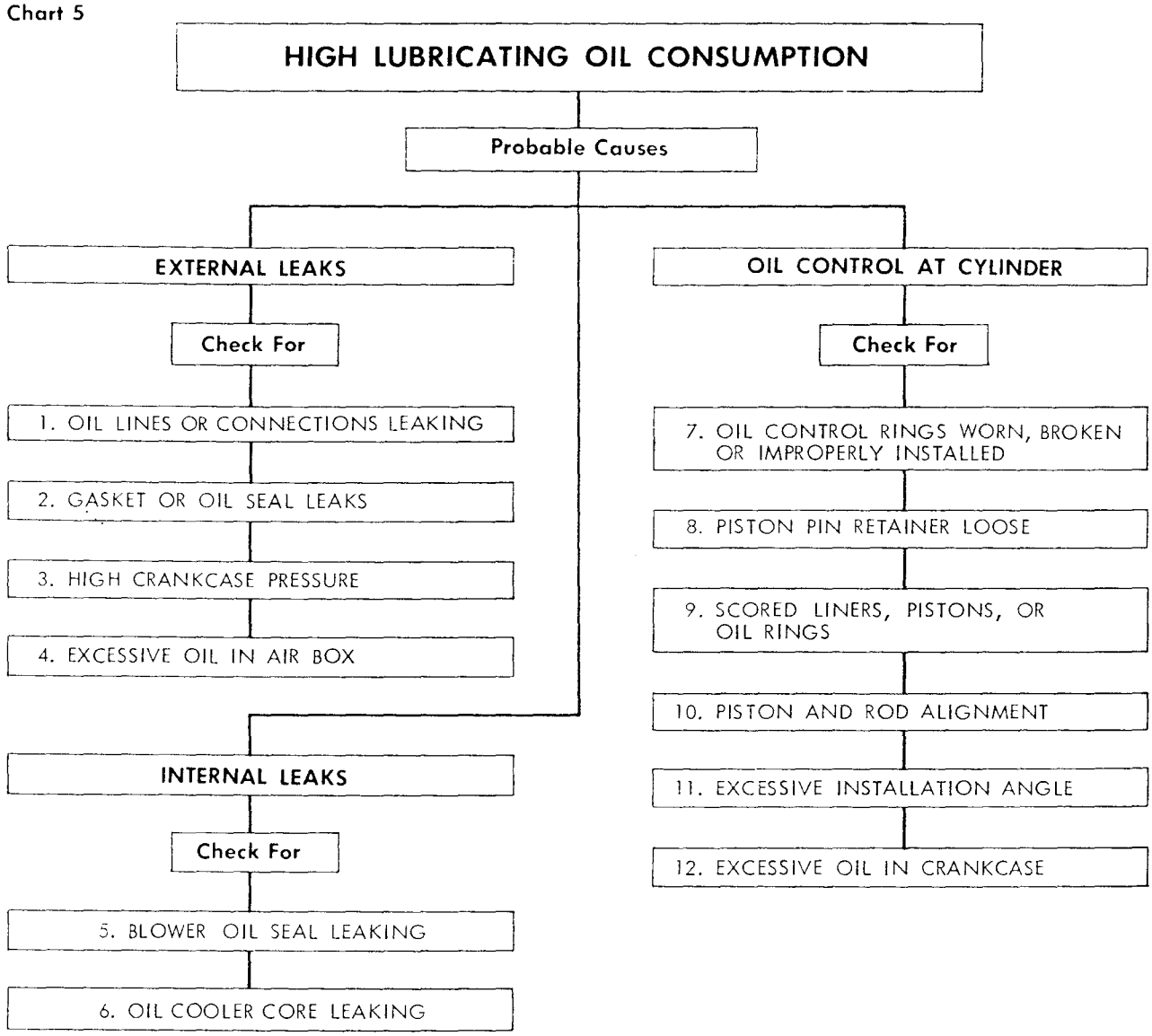
10. Replace with larger tank-to-engine fuel lines.

11. Install a restricted fitting in the return line.

12. Make sure that the check valve is installed in the line correctly; the arrow should be on top of the valve assembly or pointing upward. Reposition the valve if necessary. If the valve is inoperative, replace it with a new valve assembly.

13. Check the engine fuel spill-back temperature. The return fuel temperature must be less than 150°F. or a loss in horsepower will occur. This condition may be corrected by installing larger fuel lines or relocating the fuel tank to a cooler position.

Chart 5



SUGGESTED REMEDY

1. Tighten or replace the defective parts.

2. Replace defective gaskets or oil seals.

3. Refer to the *Excessive Crankcase Pressure* chart.

4. Refer to the *Abnormal Engine Operation* chart.

5. Remove the air inlet housing and inspect the blower end plates while the engine is operating. If oil is seen on the end plate radiating away from the oil seal, overhaul the blower.

6. Inspect the engine coolant for lubricating oil contamination; if contaminated, replace the oil cooler core. Then, use a good grade of cooling system cleaner to remove the oil from the cooling system.

7. Replace the oil control rings on the piston.

8. Replace the piston pin retainer and defective parts.

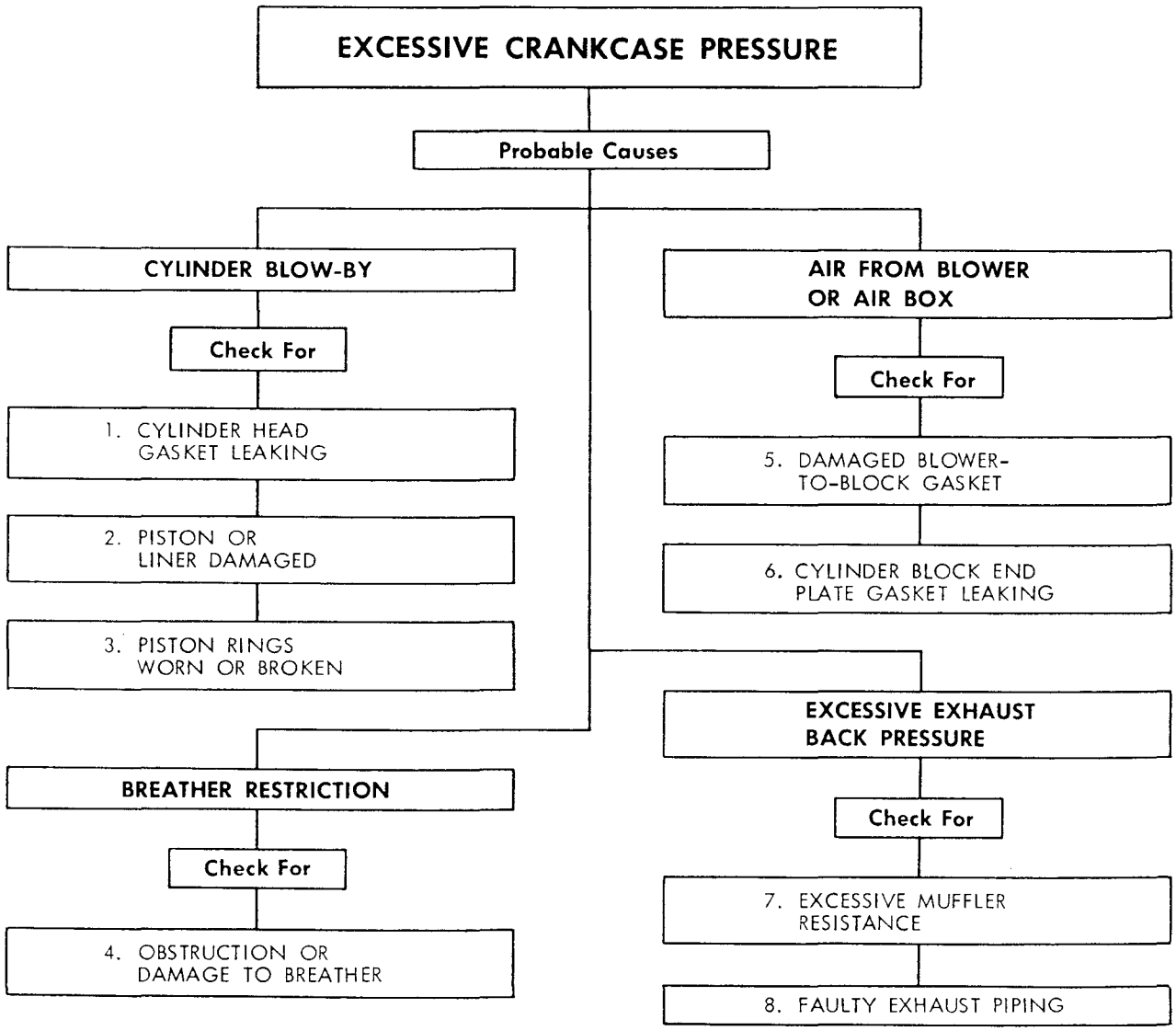
9. Remove and replace the defective parts.

10. Replace all worn and defective parts.

11. Decrease the installation angle.

12. Fill the crankcase to the proper level only.

Chart 6



SUGGESTED REMEDY

1. Check the compression pressure and, if only one cylinder has low compression, remove the cylinder head and replace the head gaskets.

2. Inspect the piston and liner and replace damaged parts.

3. Install new piston rings.

4. Clean and repair or replace the breather assembly.

5. Replace the blower-to-block gasket.

6. Replace the end plate gasket.

7. Check the exhaust back pressure and repair or replace the muffler if an obstruction is found.

8. Check the exhaust back pressure and install larger piping if it is determined that the piping is too small, too long or has too many bends.

Chart 7

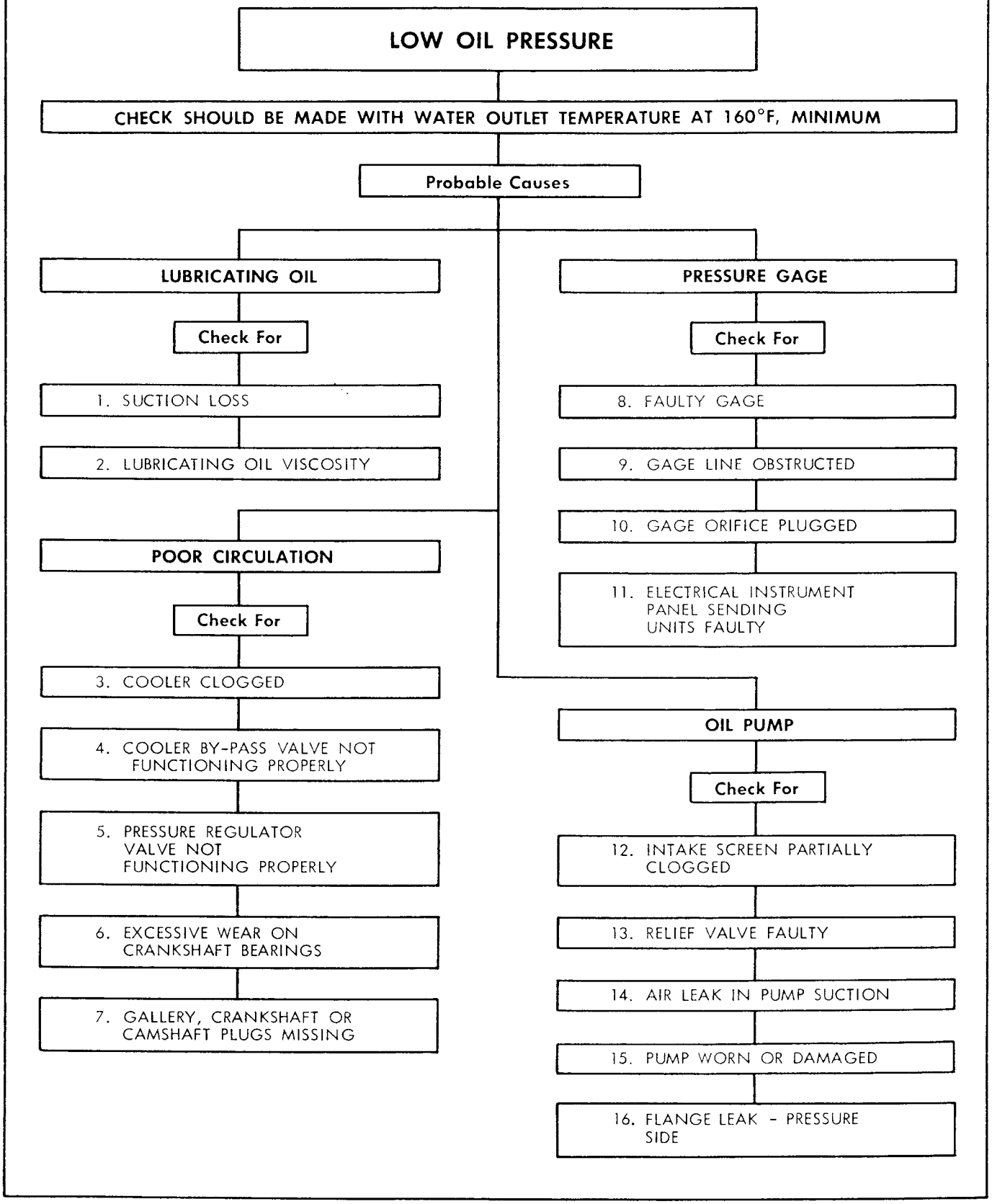

LOW OIL PRESSURE
CHECK SHOULD BE MADE WITH WATER OUTLET TEMPERATURE AT 160°F, MINIMUM
Probable Causes
LUBRICATING OIL
Check For
1. SUCTION LOSS
2. LUBRICATING OIL VISCOSITY
POOR CIRCULATION
Check For
3. COOLER CLOGGED
4. COOLER BY-PASS VALVE NOT FUNCTIONING PROPERLY
5. PRESSURE REGULATOR VALVE NOT FUNCTIONING PROPERLY
6. EXCESSIVE WEAR ON CRANKSHAFT BEARINGS
7. GALLERY, CRANKSHAFT OR CAMSHAFT PLUGS MISSING
PRESSURE GAGE
Check For
8. FAULTY GAGE
9. GAGE LINE OBSTRUCTED
10. GAGE ORIFICE PLUGGED
11. ELECTRICAL INSTRUMENT PANEL SENDING UNITS FAULTY
OIL PUMP
Check For
12. INTAKE SCREEN PARTIALLY CLOGGED
13. RELIEF VALVE FAULTY
14. AIR LEAK IN PUMP SUCTION
15. PUMP WORN OR DAMAGED
16. FLANGE LEAK - PRESSURE SIDE

Chart 7 (Cont'd.)

LOW OIL PRESSURE (Cont'd.)

SUGGESTED REMEDY

1. Check the oil and bring it to the proper level on the dipstick or correct the installation angle.

2. Wrong viscosity of lubricating oil being used; consult the *Lubricating Oil Specifications.*

Check for fuel leaks at the injector nut seal ring and fuel pipe connections. Leaks at these points will cause fuel oil dilution.

3. A plugged oil cooler is indicated by excessively high lubricating oil temperature. Remove and clean the oil cooler core.

4. Remove the by-pass valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.

5. Remove the pressure regulator valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.

6. Change the bearings. Consult the *Lubricating Oil Specifications* for the proper grade of oil to use and change the oil filters.

7. Replace missing plug(s).

8. Check the oil pressure with a reliable gage and replace the gage if found faulty.

9. Remove and clean the gage line; replace it if necessary.

10. Remove and clean the gage orifice.

11. Repair or replace defective electrical equipment.

12. Remove and clean the oil pan and oil intake screen; consult the *Lubricating Oil Specifications* for the proper grade of oil to use and change the oil filters.

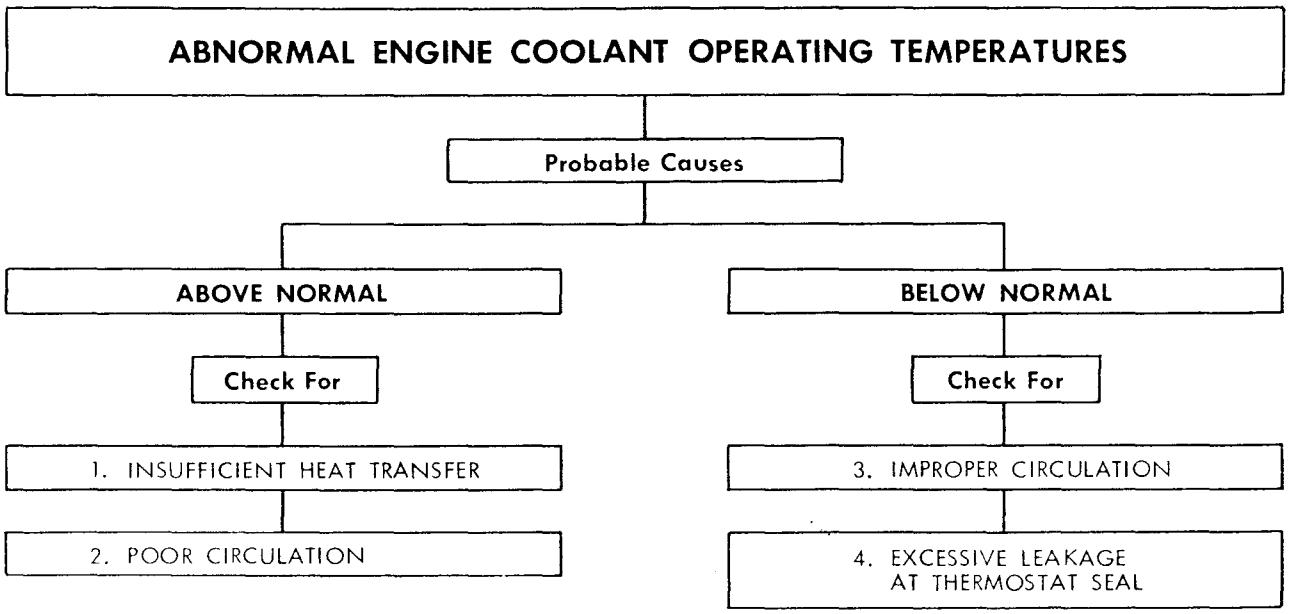
13. Remove and inspect the valve, valve bore and spring; replace faulty parts.

14. Disassemble the piping and install new gaskets.

15. Remove the pump, clean and replace defective parts.

16. Remove the flange and replace the gasket.

Chart 8



SUGGESTED REMEDY

1. The cooling system should be cleaned with a good cooling system cleaner and thoroughly flushed to remove scale deposits.

The exterior of the radiator core should be cleaned to open plugged passages permitting normal air flow.

Loose fan belts should be adjusted to the proper tension to prevent slippage.

Check for an improper size radiator or inadequate shrouding.

Repair or replace inoperative temperature-controlled fan.

2. Check the coolant level and fill to the filler neck if the coolant level is low.

Inspect for collapsed or disintegrated hoses. Replace all faulty hoses.

Thermostat may be inoperative. Remove, inspect and test the thermostat; replace if found faulty.

Check the water pump for a loose or damaged impeller.

Check the flow of water through the radiator. A clogged radiator will cause an inadequate supply of water on the suction side of the pump. Clean the radiator core.

Remove the radiator cap and operate the engine, checking for combustion gases in the cooling system. The cylinder head must be removed and inspected for cracks and the head gaskets replaced if combustion gases are entering the cooling system.

Check for an air leak on the suction side of the water pump. Replace defective parts.

3. The thermostat may not be closing. Remove, inspect and test the thermostat. Install a new thermostat if necessary.

Check for an improperly installed heater.

4. Excessive leakage of coolant past the thermostat seal(s) is a cause of continued low coolant operating temperature. when this occurs, replace the thermostat seal(s).

STORAGE

PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 days or less)

To protect an engine for a temporary period of time, proceed as follows:

1. Drain the engine crankcase.

2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.

3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

> **NOTE:** Do not drain the fuel system or the crankcase after this run.

4. Check the air cleaner and service it, if necessary, as outlined in Section 3.1.

5. If freezing weather is expected during the storage period, add a high boiling point type antifreeze solution in accordance with the manufacturer's recommendations. Drain the raw water system and leave the drain cocks open.

6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with air.

7. Seal all of the engine openings. The material used for this purpose must be waterproof, vaporproof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission, and priming the raw water pump, if used.

EXTENDED STORAGE (30 days or more)

When an engine is to be removed from operation for an extended period of time, prepare it as follows:

1. Drain and thoroughly flush the cooling system with clean, soft water.

2. Refill the cooling system with clean, soft water.

3. Add a rust inhibitor to the cooling system (refer to *Corrosion Inhibitors* in Section 13.3).

4. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.

5. Reinstall the injectors in the engine, time them, and adjust the valve clearance.

6. Circulate the coolant through the entire system by operating the engine until normal operating temperature is reached (160°F. to 185°F).

7. Stop the engine.

8. Remove the drain plug and completely drain the engine crankcase. Reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.

9. Fill the crankcase to the proper level with a 30-weight preservative lubricating oil MIL-L-21260, Grade 2 (P10), or equivalent.

10. Drain the engine fuel tank.

11. Refill the fuel tank with enough rust preventive fuel oil such as American Oil Diesel Run-In Fuel (LF-4089), Mobil 4Y17, or equivalent, to enable the engine to operate 10 minutes.

12. Drain the fuel filter and strainer. Remove the retaining bolts, shells and elements. Discard the used elements and gaskets. Wash the shells in clean fuel oil and insert new elements. Fill the cavity between the element and shell about two-thirds full of the same rust preventive compound as used in the fuel tank and reinstall the shell.

13. Operate the engine for 5 minutes to circulate the rust preventive throughout the engine.

14. Refer to Section 3.1 and service the air cleaner.

15. MARINE GEAR

a. Drain the oil completely and refill with clean oil of the proper viscosity and grade as is recommended. Remove, clean or replace the strainer and replace the filter element.

b. Start and run the engine at 600 rpm for 5 minutes so that clean oil can coat all of the internal parts of the marine gear. Engage the clutch to circulate clean oil through all of the moving parts.

NOTE: The performance of this step is not necessary on torque converter units.

16. TORQMATIC CONVERTER

a. Start the engine and operate it until the temperature of the converter oil reaches 150°F.

b. Remove the drain plug and drain the converter.

c. Remove the filter element.

d. Start the engine and stall the converter for twenty seconds at 1000 rpm to scavenge the oil from the converter. *Due to lack of lubrication, do not exceed the 20 second limit.*

e. Install the drain plug and a new filter element.

f. Fill the converter to the proper operating level with a commercial preservative oil which meets Government specifications MIL-L-21260, Grade 1. Oil of this type is available from the major oil companies.

g. Start the engine and operate the converter for at least 5 mintues at a minimum of 1000 rpm. Engage the clutch; then stall the converter to raise the oil temperature to 225°.

CAUTION: Do not allow the oil temperature to exceed 225°F. If the unit does not have a temperature gage, *do not stall the converter for more than thirty seconds.*

h. Stop the engine and permit the converter to cool to a temperature suitable to touch.

i. Seal all of the exposed openings and the breather with moisture-proof tape.

j. Coat all exposed, unpainted surfaces with preservative grease. Position all of the controls for minimum exposure and coat them with grease. The external shafts, flanges and seals should also be coated with grease.

17. POWER TAKE-OFF

a. With an all purpose grease such as Shell Alvania No. 2, or equivalent, lubricate the clutch throwout bearing, clutch pilot bearing, drive shaft main bearing, clutch release shaft, and the outboard bearings (if so equipped).

b. Remove the inspection hole cover on the clutch housing and lubricate the clutch release lever and link pins with a hand oiler. Avoid getting oil on the clutch facing.

c. If the unit is equipped with a reduction gear, drain and flush the gear box with light engine oil. If the unit is equipped with a filter, clean the shell and replace the filter element. Refill the gear box to the proper level with the oil grade indicated on the name plate.

18. TURBOCHARGER

The turbocharger bearings are lubricated by pressure through the external oil line leading from the engine cylinder block while performing the previous operations above and no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture resistant tape.

19. HYDROSTARTER SYSTEM

Refer to Section 12.6.1 for the lubrication and preventive maintenance procedure.

20. Apply a *non-friction* rust preventive compound to all exposed parts. If it is convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

CAUTION: Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip.

21. Drain the engine cooling system.

22. The oil may be drained from the engine crankcase if so desired. If the oil is drained, reinstall and tighten the drain plug.

23. Remove and clean the battery and battery cables with a baking soda solution and rinse them with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32°F.) dry place. Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.

24. Insert heavy paper strips between the pulleys and belts to prevent sticking.

25. Seal all of the openings in the engine, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

26. Clean and dry the exterior painted surfaces of the engine. Spray the surfaces with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

27. Cover the engine with a good weather-resistant tarpaulin or other cover if it must be stored outdoors. A clear plastic cover is recommended for indoor storage.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

PROCEDURE FOR RESTORING AN ENGINE TO SERVICE WHICH HAS BEEN IN EXTENDED STORAGE

1. Remove the valve rocker cover(s) and pour at least one-half gallon of oil, of the same grade as used in the crankcase, over the rocker arms and push rods.

2. Reinstall the valve rocker cover(s).

3. Remove the covers and tape from all of the openings of the engine, fuel tank, and electrical equipment. *Do not overlook the exhaust outlet.*

4. Wash the exterior of the engine with fuel oil to remove the rust preventive.

5. Remove the rust preventive from the flywheel.

6. Remove the paper strips from between the pulleys and the belts.

7. Check the crankcase oil level. Fill the crankcase to the proper level with the heavy-duty lubricating oil recommended under *Lubricating Oil Specifications* (Section 13.3).

8. Fill the fuel tank with the fuel specified under *Diesel Fuel Oil Specifications* (Section 13.3).

9. Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, fill the cooling system with a high boiling point type antifreeze solution (refer to Section 13.3).

10. Install and connect the battery.

11. Service the air cleaner as outlined in Section 3.1.

12. Power Generator

Prepare the generator for starting as outlined under *Operating Instructions* in Section 13.1.1.

13. Marine Gear

Check the marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.

14. TORQMATIC CONVERTER

a. Remove the tape from the breather and all of the openings.

b. Remove all of the preservative grease with a suitable solvent.

c. Start the engine and operate the unit until the temperature reaches 150°F. Drain the preservative oil and remove the filter. Start the engine and stall the converter for twenty seconds at 1000 rpm to scavenge the oil from the converter.

CAUTION: A Torqmatic converter containing preservative oil should only be operated enough to bring the oil temperature up to 150°F.

d. Install the drain plug and a new filter element.

e. Refill the converter with the oil that is recommended under *Lubrication and Preventive Maintenance.*

15. POWER TAKE-OFF

Remove the inspection hole cover and inspect the clutch release lever and link pins and the bearing ends of the clutch release shaft. Apply engine oil sparingly, if necessary, to these areas.

16. HYDROSTARTER

a. Open the relief valve on the side of the hand pump and release the pressure in the system.

b. Refer to the filling and purging procedures outlined in *Hydraulic Starting System* (Section 12.6.1). Then, drain, refill and purge the Hydrostarter system.

17. TURBOCHARGER

Remove the covers from the turbocharger air inlet and turbine outlet connections. Refer to the lubricating procedure outlined in *Preparation for Starting Engine First Time* in Section 13.1.

18. After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

NOTE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

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h. Remove the two bolts and pilots that were used to draw the rotor gears half-way on the rotor shafts.

i. Lubricate the threads of the rotor gear retaining bolts with engine oil.

j. Place a pilot on each rotor gear retaining bolt with the counterbored side facing away from the bolt head.

k. Thread the hex head bolt in the left-hand helix rotor shaft and the twelve point head bolt in the right- hand helix rotor shaft and draw the rotor gears into position tight against the shims and the bearing inner races as shown in Fig. 17. Tighten the bolts to 50-55 lb-ft torque.

l. Check the back lash between the rotor gears. The backlash should be .0005 " to .0025 " with new gears. Replace the gears if the backlash exceeds .0035 ".

13. Install the 3/8 "-24 x 2 " bolt with special flat washers in the right-hand helix rotor shaft at the front end of the blower. Tighten the bolt to 50-55 lb-ft torque.

14. Place the bearing retainer nut lock washer over the end of the left-hand rotor shaft with the tang in the inner diameter of the washer in the notch in the shaft. Then thread the bearing lock nut on the shaft. Tighten the lock nut to 50-60 lb-ft torque with spanner wrench J 21672-17.

15. Bend the tang of the lock washer over the notch of the bearing retainer nut.

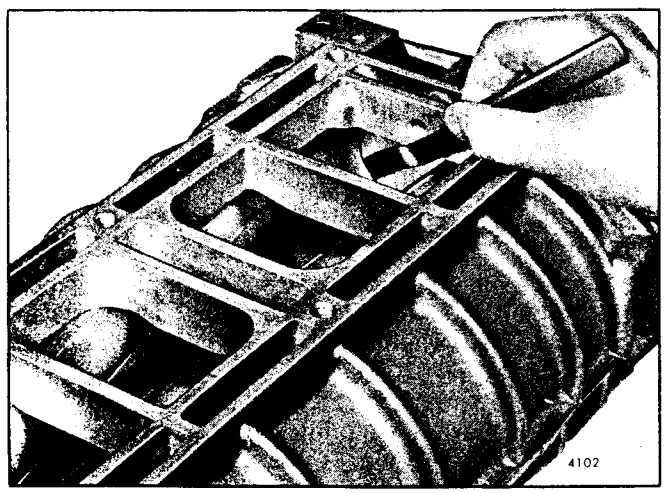


Fig. 21 - Measuring End Clearance Between Blower Rotors and End Plate

Timing Blower Rotors

After the blower rotors and rotor gears are installed, the blower rotors must be timed.

1. The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

2. If the left-hand helix gear is moved out, the right-hand helix rotor will turn clockwise when viewed from the gear end. If the right-hand helix gear is moved out, the left-hand helix rotor will turn counterclockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.

3. Moving the gears *out* or *in* on the rotor shafts is accomplished by adding or removing shims between the gears and the bearings.

4. The clearance between the rotor lobes may be checked with 1/2 " wide feeler gages in the manner shown in Fig. 18. When measuring clearances of more than .005 ", laminated feeler gages that are made up of .002 ", .003 " or .005 " feeler stock are more practical and suitable than a single feeler gage. Clearances should be measured from both the inlet and outlet sides of the blower.

5. A specially designed feeler gage set J 1698-02 for the blower clearance operation is available. Time the rotors as follows:

a. Time the rotors to pass an .008 " feeler gage at the closest point between the *trailing* edge of the right-hand helix rotor and the *leading* edge of the left-hand helix rotor ("CC" clearance) measured from both the inlet and outlet sides as shown in Figs. 18 and 21.

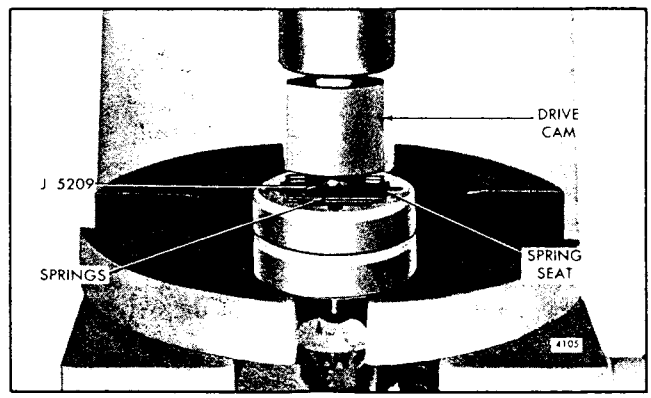


Fig. 22 - Inserting Blower Drive Cam in Springs

b. Then check the clearance between the *leading* edge of the right-hand helix rotor and the *trailing* edge of the left-hand helix rotor ("C" clearance) for the minimum clearance of .018 ". Rotor-to-rotor measurements should be taken 1 " from each end and at the center of the blower.

6. After determining the amount one rotor must be revolved to obtain the proper clearance, add shims back of the proper gear as shown in Fig. 20 to produce the desired result. When more or less shims are required, both gears must be removed from the rotors. Placing a .003 " shim in back of a rotor gear will revolve the rotor .001 ".

7. Install the required thickness of shims back of the proper gear and next to the bearing inner race and reinstall both gears. Recheck the clearances between the rotor lobes.

8. Determine the minimum clearances at points "A" and "B" shown in Fig. 19. Insert the feeler gages, as shown in Fig. 21, between the end plates and the ends of the rotors. This operation must be performed at the ends of each lobe, making 12 measurements in all. Refer to Fig. 19 for the minimum clearances.

9. Check the clearance between each rotor lobe and the blower housing at both the inlet and outlet side -- 12 measurements in all. Refer to Fig. 19 for the minimum clearances.

Attach Accessories to Blower

On the former blowers, the drive hub is attached to the left-hand helix gear with four bolts. On the current blowers, a new drive hub is used with three bolt holes and utilizing two steel plates. The plates are bolted between the left-hand helix rotor drive gear and the drive hub to provide a flexible drive connection. On former blowers, the right-hand helix rotor gear is separately interchangeable, but the current drive hub and attaching parts must be included to replace the left-hand helix rotor gear.

1. On the former blower, attach the blower drive hub to the left-hand helix rotor gear with four bolts. On the current blower, bolt two steel plates between the left-hand helix rotor drive gear and the drive hub. Tighten the bolts to 15-19 lb-ft torque.

2. If removed, install the blower drive hub oil seal in the groove in the outside diameter of the drive hub.

3. Attach the blower drive support assembly to the blower assembly as follows:

a. Affix a new gasket to the blower rear end plate. Then place the blower drive support assembly over the two dowel pins in the rear end plate and against the gasket.

b. Attach the blower drive support assembly to the rear end plate with six bolts, lock washers, plain washers and one socket head bolt. Tighten the bolts to 20-24 lb-ft torque.

4. Attach the governor assembly to the blower assembly as follows:

a. Affix a new gasket to the blower front end plate.

b. Position the governor assembly in front of the blower, then start the weight shaft straight into the end of the rotor shaft. If necessary, rotate the weight shaft or rotor shaft to align the splines. Now push the governor assembly on the dowel pins in the end plate and against the gasket.

c. Attach the governor to the front end plate with seven bolts and copper washers (two bolts inside and five outside). Tighten the bolts to 20-24 lb-ft torque.

Install Blower

1. Affix a new governor housing gasket (83), Fig. 10, to the cylinder block.

2. Affix a new blower drive support housing gasket (84) to the cylinder block. Also affix a new gasket to the cylinder block rear end plate.

NOTE: Use Scotch Grip Rubber adhesive No. 4300, or equivalent, on the governor housing and blower drive support housing gaskets to prevent them from slipping when the blower assembly is lowered into position.

3. Place the blower housing-to-cylinder block seal ring in the groove in the top of the cylinder block.

4. If removed, place a fuel rod cover tube hose and clamp on each fuel rod cover tube at the side of each cylinder head.

5. Thread eyebolts in two diagonally opposite tapped holes in the top of the blower housing. Then attach a rope sling and a chain hoist to the eyebolts as shown in Fig. 4.

6. Lift the blower assembly at a slight angle and position it over the top of the cylinder block. Then lower the assembly on the cylinder block and mesh the blower drive gear with the camshaft gear.

7. Install two 7/16 "-14 x 7-1/2 " bolts and special

washers in each blower end plate. Tighten the bolts to 60-65 lb-ft torque.

8. Install the two 7/16 "-14 x 7/8 " governor housing-to-cylinder block bolts and copper washers. Tighten the bolts to 46-50 lb-ft torque.

9. Install the five blower drive support housing-to-engine end plate bolts, lock washers and one plain washer. Tighten the bolts to 20-24 lb-ft torque.

10. If disassembled, install the springs and blower drive cam in the two blower drive coupling supports as follows:

a. Place the drive spring supports on a bench. Then place the drive spring seats inside the support.

b. Lubricate the springs with engine oil. Then place the spring packs, consisting of 15 leaves per pack, in between the spring seats as shown in Fig. 22.

c. Place the second drive spring support on top of the first drive spring support, then install the spring seats and spring packs in the second support as outlined in Steps "a" and "b" above.

d. Place the two drive spring supports, with springs, over a small opening in the bed of an arbor press so the spring seats and the ends of the spring packs will rest on the bed of the arbor press.

e. Place the blower drive cam, the protruding end of the cam down, over the end of the installer J 5209. Insert the tapered end of the installer in between the spring packs and under the ram of the press, then press the cam into place between the spring packs as shown in Fig. 22. Catch the installer by hand after it passes through the spring packs.

11. Attach the blower drive coupling supports to the blower drive gear as follows:

a. Insert the blower drive coupling supports through the opening in the rear face of the flywheel housing, with the protruding end of the drive cam facing the drive shaft (Fig. 1).

b. Align the bolt holes in the supports with the holes in the blower drive gear, then thread two bolts with flat washers in two diametrically opposite holes, finger tight only. Install the two remaining bolts finger tight only.

c. Insert the blower drive shaft, flat end first, through the blower drive cam and into the blower drive hub. Then tighten the two bolts with the flat washers to 8 - 10 lb-ft torque.

d. Check the blower drive shaft for alignment and freeness by sliding the shaft in and out of the splines in the drive hub and cam. If the drive shaft binds, loosen the two bolts with flat washers and move the blower drive support coupling slightly and retighten the bolts.

e. Remove the two bolts without the flat washers. Place the blower drive shaft retainer against the end of the blower drive support, then install the two bolts and tighten them to 8-10 lb-ft torque.

12. Affix a new gasket to the blower drive gear hole cover, then place the cover in position against the flywheel housing and install the five bolts and lock washers. Tighten the 5/16 "-18 bolts to 13-17 lb-ft torque and the 3/8 "-16 bolt to 20-24 lb-ft torque.

13. Slide the fuel rod cover tube hoses up on the cover tubes in the governor housing and tighten the hose clamps.

14. Install the governor fuel rods and connect them to the governor and injector rack control levers.

15. Place the governor cover on the governor housing and secure it in place with eight screws and lock washers.

16. Connect the fuel oil supply line to the fuel oil pump and the fuel oil filter.

17. Connect the fuel oil supply and return lines to the fuel manifold fittings in the cylinder heads.

18. Place the water by-pass tube with seal rings and flanges in between the two thermostat housings and secure it in place with four bolts and lock washers. Tighten the bolts to 7-9 lb-ft torque.

19. Connect the blower housing breather tube and hose to the breather housing with a hose clamp, then attach the tube clamp at the lower end of the tube to one of the water pump attaching bolts.

20. Attach the air compressor (if used) to the engine flywheel housing as follows:

a. Affix a new gasket to the bolting flange of the air compressor.

b. Install the air compressor drive coupling in the drive plate attached to the rear face of the camshaft gear.

c. Place the air compressor in position at the rear of the flywheel housing and guide the teeth on the drive coupling into the teeth in the drive plate on the air compressor, then push the air compressor against the flywheel housing. If necessary, rotate

the crankshaft to align the teeth of the drive coupling and the drive plate.

d. Install the four bolts and lock washers and tighten them to 71-75 lb-ft torque.

e. Connect the water inlet and outlet tubes to the air compressor. Then connect the oil supply line to the air compressor and the cylinder block.

21. If removed, attach the battery-charging generator mounting bracket to the top of the governor housing with four bolts and lock washers. Tighten the bolts to 30-35 lb-ft torque.

22. Attach the battery-charging generator to the mounting bracket. Install the generator drive belts, then tighten the generator mounting bolts and adjust the drive belt tension.

23. Use new gaskets and install a valve rocker cover on each cylinder head.

24. Attach a valve rocker cover breather tube to each rocker cover with a hose clamp, then secure the breather tube clamp at the lower end of each tube to the flywheel housing.

25. Place the blower screen and gasket assembly in position on top of the blower, with the screen side of the assembly toward the blower. Then place the air inlet adaptor on the blower screen. Install the six bolts and lock washers and tighten them to 16-20 lb-ft torque.

26. Affix a new gasket to the top of the air inlet adaptor, then place the air shut-down housing on top of the gasket. Install the six bolts and lock washers and tighten them to 16-20 lb-ft torque.

27. Connect the throttle control rods to the governor levers.

28. Attach any other accessories that were removed from the engine.

29. Adjust the governor and injector rack control levers as outlined in Section 14. Check for and repair any coolant or oil leaks detected when performing the tune-up.

TURBOCHARGER (Airesearch)

The TE0675 turbocharger (Figs. 1 and 2) is designed to increase engine efficiency and power output. Power to drive the turbocharger is extracted from the waste energy in the engine exhaust gas.

The turbocharger consists of a turbine wheel and shaft, a compressor wheel, a center housing which serves to support the rotating assembly, bearings, seals, a turbine housing and a compressor housing.

The turbine wheel is located in the turbine housing and is mounted on one end of the turbine shaft. The compressor wheel is located in the compressor housing and is mounted on the opposite end of the turbine wheel shaft to form an integral rotating assembly.

The rotating assembly consists of the turbine wheel and shaft assembly, thrust ring, thrust spacer, compressor wheel and wheel retaining nut. The rotating assembly is supported on two pressure lubricated bearings which are retained in the center housing by retaining rings. Internal oil passages are drilled in the center housing to provide lubrication to the turbine wheel shaft bearings and thrust bearing, thrust ring and thrust spacer.

The oil is sealed off from the compressor and the turbine by seal arrangements at both ends of the center housing. Oil drains from the center housing by gravity.

The turbine housing is a heat resistant alloy casting which encloses the turbine wheel and provides a flanged engine exhaust gas inlet and an axially-located turbocharger exhaust gas outlet. The turbine housing is bolted to the turbine end of the center housing, thus providing a compact and vibration free assembly.

The compressor housing which encloses the compressor wheel provides an ambient air inlet and a compressed air discharge outlet. The compressor housing is bolted to the compressor end of the center housing.

Operation

The turbocharger is mounted on the exhaust outlet flange of the engine exhaust manifold. After the engine is started, the exhaust gases flowing from the engine and through the turbine housing cause the turbine wheel and shaft to rotate (Fig. 3). The gases are discharged into the atmosphere after passing through the turbine housing.

The compressor wheel, which is mounted on the opposite end of the turbine wheel shaft, rotates with the turbine wheel. The compressor wheel draws the ambient air into the compressor housing, compresses the air and delivers it to the engine blower.

During operation, the turbocharger responds to the engine load demands by reacting to the flow of the engine exhaust gases. As the power output of the engine increases, the flow of exhaust gases increases and the speed and output of the rotating assembly increases proportionately, delivering more air to the engine blower.

Certain engines are equipped with an intercooler to

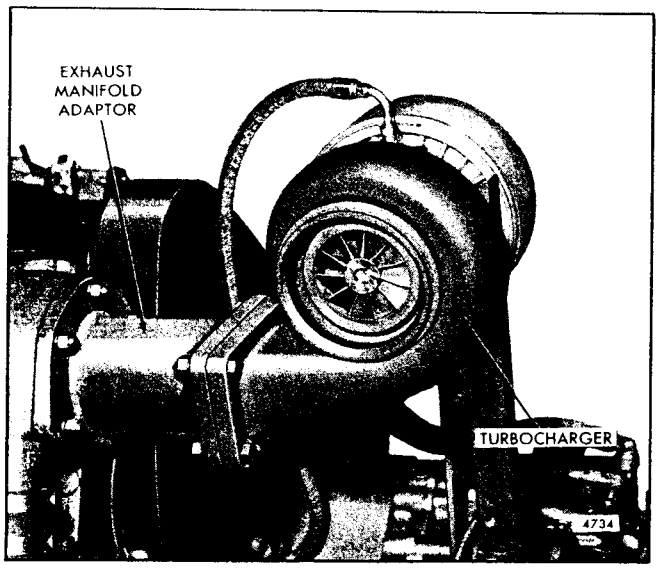


Fig. 1 - Turbocharger Mounting

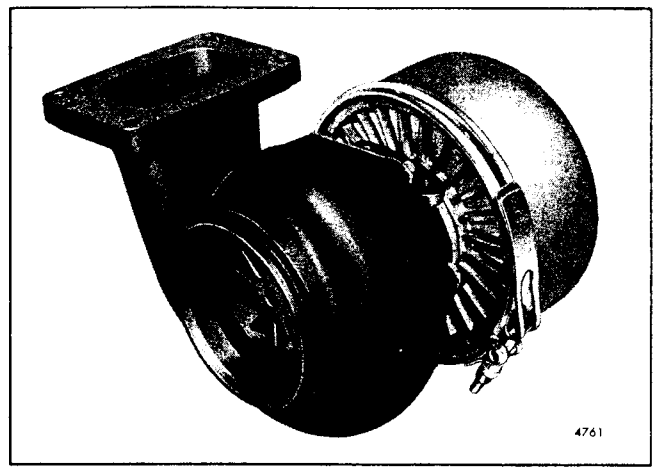


Fig. 2 - Turbocharger Assembly

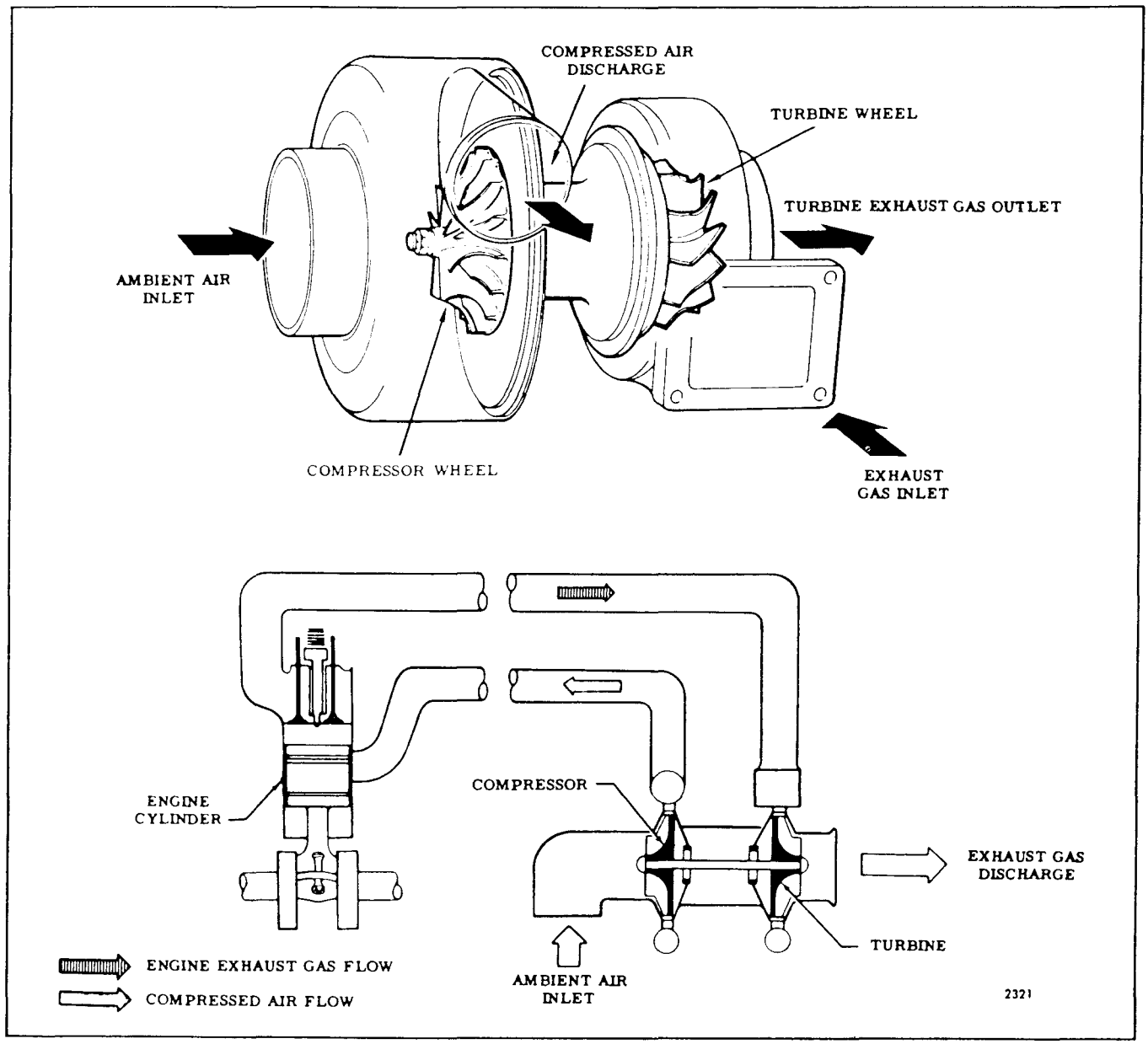


Fig. 3 - Schematic Flow Diagram

reduce the temperature of the discharge air from the turbocharger before it enters the engine blower (Section 3.5.2).

Lubrication

Lubricating oil for the turbocharger is supplied under pressure through an external oil line extending from the engine cylinder block to the top of the center housing. From the oil inlet in the center housing, the oil flows through the drilled oil passages in the housing to the shaft bearings, thrust ring, thrust bearing and thrust plate. The oil returns by gravity to the engine oil pan through an external oil line extending from the bottom of the turbocharger center housing to the side of the cylinder block.

Minimum oil flow to the turbocharger with the engine at idle is achieved at 10 psi with an oil temperature of 200 °F.

Before the initial engine start, when a new or overhauled turbocharger is installed, the turbocharger must be pre-lubricated as outlined under *Install Turbocharger*.

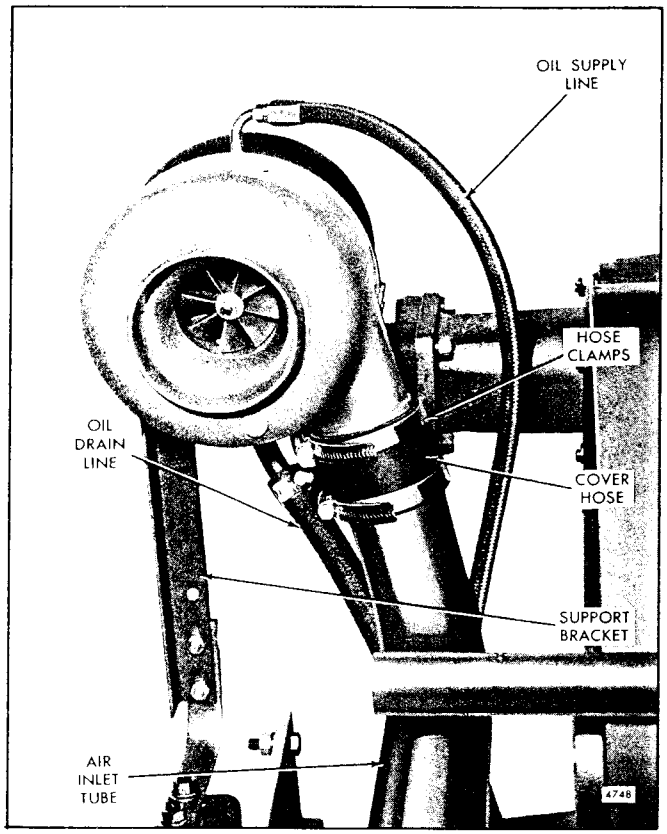


Fig. 4 - Turbocharger Support Bracket, Oil Lines and Air Inlet Tube

Periodic Inspection

A periodic inspection of the turbocharger should be made along with periodic engine inspection.

1. Inspect the oil inlet and oil return lines to make certain all of the connections are tight and the lines are not dented, restricting the flow of oil to and from the center housing.

> **CAUTION:** Be sure the oil lines are filled with oil. Refer to *Install Turbocharger.*

2. Inspect all of the air ducting and connections for leaks. Make the inspection both with the engine running and shut down. Check for leaks at the manifold connection, the turbine inlet and the exhaust manifold gasket.

> **CAUTION:** Do not operate the turbocharger if leaks are found in the ducting or if the air cleaner is not filtering efficiently. Dust leaking into the air ducting can damage the turbocharger and the engine.

3. Remove the air inlet duct and compressor housing and check for dirt or dust build-up. Remove all such foreign matter and determine and correct the cause. Refer to *Troubleshooting Turbocharger* in Section 3.0. Uneven deposits left on the compressor wheel can affect the balance and cause premature bearing failure.

> **NOTE:** It is not necessary to disassemble the turbocharger center housing and rotating assembly to remove dirt and dust build-up.

4. With the compressor housing removed, push the compressor wheel toward the turbine end and turn the rotating assembly by hand. Check for binding or rubbing. Listen carefully for unusual noises. If binding or rubbing is evident, remove the turbocharger for disassembly and inspection.

Remove Turbocharger

1. Refer to Fig. 4 and remove the turbocharger support bracket.

2. Disconnect the oil supply line and the oil drain line from the turbocharger.

3. Cover the end of each oil inlet and oil outlet line and the air inlet and exhaust outlet openings on the engine to prevent the entrance of foreign material.

4. Loosen the two hose clamps securing the cover hose to the turbocharger and the air inlet tube and slide the cover hose down over the inlet tube.

5. Remove the four bolts, nuts and lock washers securing the turbocharger to the exhaust manifold adaptor and remove the turbocharger and gasket. Refer to Fig. 1.

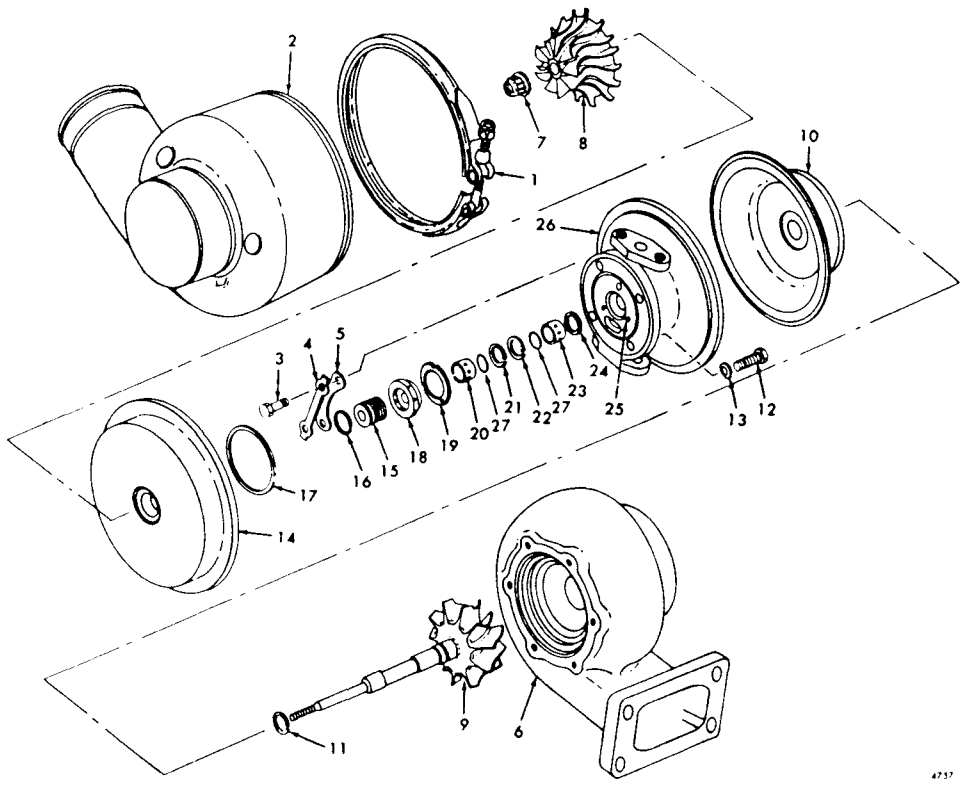
Disassemble Turbocharger

Clean the exterior of the turbocharger with a non-caustic cleaning solvent before disassembly, then proceed as follows:

> **CAUTION:** Exercise care when removing the center and turbine housings to prevent damage to the compressor or turbine wheel.

1. Loosen the "V" band coupling (1) securing the compressor housing (2) to the backplate assembly (14) and remove the compressor housings and "V" band.

2. Remove the eight bolts (3) securing the four lockplates (4) and turbine housing clamps (5) to the center housing (26) and turbine housing (6). Remove the turbine housing from the center housing.



1. Coupling--"V" Band
2. Housing--Compressor
3. Bolt
4. Lockplate
5. Clamp--Turbine Housing
6. Housing--Turbine
7. Nut--Self-Locking
8. Wheel--Compressor
9. Shaft--Turbine Wheel Assembly
10. Shroud--Turbine Wheel
11. Ring--Piston
12. Screw
13. Lockplate
14. Backplate Assembly
15. Spacer--Thrust
16. Ring--Piston
17. Ring--Seal
18. Collar--Thrust
19. Bearing--Inboard Thrust
20. Bearing
21. Ring--Retaining
22. Ring--Retaining
23. Bearing
24. Ring--Retaining
25. Pin--Groove
26. Housing--Center
27. Spacer

Fig. 5 - Turbocharger Details and Relative Location of Parts

NOTE: Tap the housing with a soft headed hammer if force is needed for removal.

3. Position the turbine wheel (9) of the center housing assembly in a suitable holding fixture (Fig. 6).

4. Remove the wheel nut (7) from the shaft.

CAUTION: To prevent the possibility of bending the turbine wheel shaft, remove the compressor wheel nut from the shaft with a double universal socket and tee handle.

5. Place the center housing and rotating assembly in a oven, furnace or hot oil bath that has been preheated to 350 °F.-375 °F. for no longer than 10 minutes.

6. Remove the compressor wheel (8) from the wheel shaft assembly (9).

7. Withdraw the wheel shaft assembly (9) and wheel shroud (10) from the center housing.

8. Remove the piston seal (11) from the wheel shaft assembly (9).

9. Remove the screws (12) and lock tabs (13) securing the backplate assembly (14) to the center housing (26) and remove the backplate assembly.

10. Remove the seal ring (17) from the groove in the center housing.

11. Remove the thrust spacer (15) and piston ring (16) from the backplate assembly.

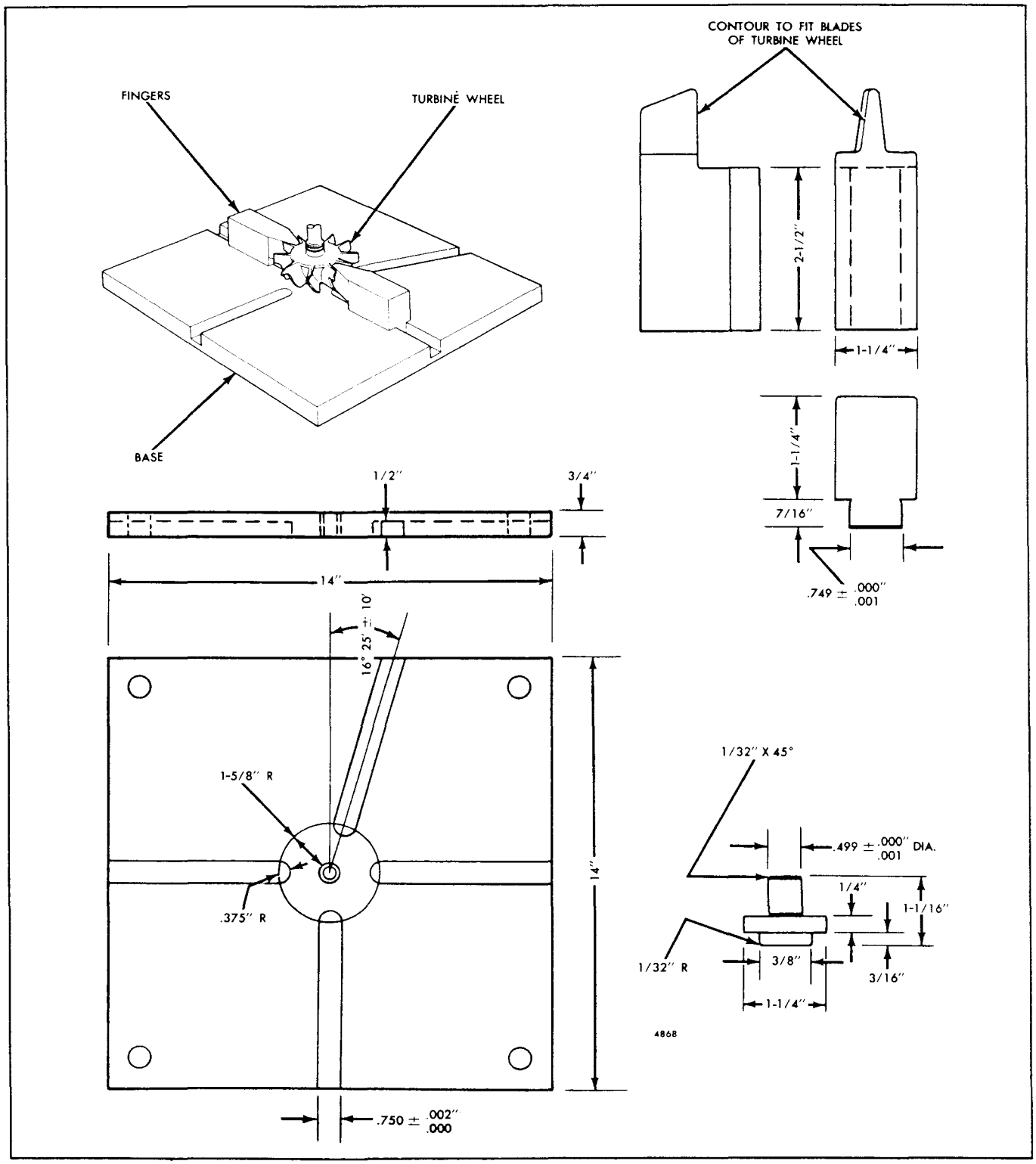


Fig. 6 - Turbocharger Holding Fixture

12. Remove the thrust collar (18), inboard thrust bearing (19), bearing (20), spacer (27) if used, and retaining ring (21) from the center housing.

13. Remove the retaining ring (22), spacer (27) if used, bearing (23) and retaining ring (24) from the center housing.

Cleaning

Before cleaning, inspect all of the parts for signs of burning, rubbing or other damage which might not be evident after cleaning.

Soak all of the parts in a non-caustic cleaning solvent for about 25 minutes. After soaking, use a stiff bristle brush and remove all dirt particles. Dry all of the parts thoroughly.

Inspection

Inspect all of the parts for signs of damage, corrosion or deterioration. Check for nicked, crossed or stripped threads.

Visually check the turbine wheel for signs of rubbing. Also check the turbine wheel vanes for worn or feathered edges.

Inspect the shaft for signs of scoring, scratches or seizures with the bearings.

Check the compressor wheel for signs of rubbing or damage from foreign material. Check to see that the wheel bore is not galled. The wheel must be free of dirt and other foreign material.

Inspect the seal parts for signs of rubbing or scoring of the running faces.

Inspect the housing for contact with the rotating parts. The oil and air passages must be clean and free of obstructions.

Minor surface damage may be burnished or polished. Use a silicone carbide abrasive cloth for aluminum parts or a crocus abrasive cloth for steel parts.

Replace the bearings and thrust washer if they show signs of nicks, scores, shellac deposits or foreign material imbedment. It is recommended that when one bearing needs replacement that both rotor shaft bearings be replaced at the same time. The current bearing and spacer are serviced only as a kit.

Assemble Turbocharger

Check each part prior to installation to ensure cleanliness. As the parts are assembled, cover the openings to prevent entry of dirt or other foreign material.

Refer to Fig. 5 for parts orientation and proceed as follows:

1. Lubricate the bearings (20 and 23) with clean engine oil.

2. Install a new retaining ring (24), bearing (23), spacer (27) and new retaining ring (22) in the turbine housing end of the center housing (26).

3. Install a new retaining ring (21), spacer (27) and bearing (20) in the center housing.

4. Install a new piston ring (16) on the thrust spacer (15) and gently insert the spacer into the backplate assembly (14).

> **CAUTION:** Do not force the piston ring into place.

5. Position the inboard thrust bearing (19) against the center housing with the hole and cut-outs in the bearing in alignment with the pins (25) in the center housing.

6. Install the thrust collar (18) snugly against the thrust bearing (19). Lubricate the thrust collar and bearing with clean engine oil.

7. Install a new seal ring (17) in the groove in the backplate assembly (14).

8. Align the oil feed holes in the center housing (26) and the backplate assembly and install the backplate, using four bolts (12) and new lockplates (13). Tighten the bolts to 75-90 **lb-in** torque and bend the lockplate tangs up against the side of the bolt heads.

9. Install a new piston ring (11) on the wheel shaft assembly (9).

10. Position the wheel shroud (10) against the center housing (26) and insert the wheel shaft assembly (9) through the wheel shroud and into the center housing.

> **CAUTION:** Be careful not to scuff or scratch the bearings when installing the shaft. Do not use force to compress the piston ring into place. A gentle rocking and pushing action will allow the piston ring to seat and the shaft to bottom. A thin tool may be used as an aid in compressing the piston ring if difficulty is encountered.

11. Heat the compressor wheel in an oven or hot oil bath to 325-375 °F. for no more than 10 minutes.

12. Position the turbine wheel (9) of the center housing assembly in the holding fixture (Fig. 6).

13. Position the compressor wheel over the shaft and install the wheel retaining nut. Tighten the nut to 120 **lb-in** torque. After the compressor wheel has cooled to room temperature, remove the retaining nut.

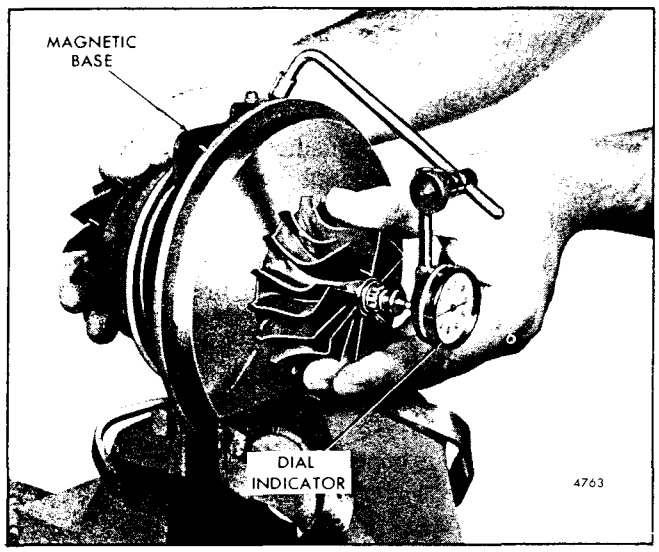


Fig. 7 - Checking Bearing Axial End Play

14. Check the face of the retaining nut and the wheel face to make sure they are smooth and clean. Lightly oil the shaft threads and washer face and reinstall the nut. Tighten the nut to 18-20 **lb-in** torque. Continue to tighten until the shaft increases in length .008 "-.009 ".

CAUTION: Tighten the retaining nut in such a manner so as not to impose a bending load on the shaft.

15. Check bearing axial end play:

a. Clamp the center housing assembly in a bench vise equipped with soft jaws as shown in Fig. 7.

b. Fasten the dial indicator and magnetic base (J 7872) to the center housing so that the indicator tip rests on the end of the rotating shaft on the compressor side.

c. Move the shaft axially back and forth by hand. The total indicator reading should be between .004 " and .007 ". If the dial indicator readings do not fall within the specified limits, repair or replace the rotating assembly.

16. Position the turbine housing (6) against the center housing (26) and secure it in place with four clamps (5), four lockplates (4) and eight bolts (3). Tighten the bolts to 160-190 **lb-in** torque. Bend the lockplate tabs up against the flat on the bolt heads.

17. Position the compressor housing (2) against the center housing (26) and secure it in place with the "V" band coupling (1). Tighten the nut on the coupling to 30-45 **lb-in** torque.

18. After assembly, push the rotating assembly as far as possible from the turbine end. Then rotate the assembly and check for bind. Push the rotating assembly in the opposite direction and repeat the check.

19. Check shaft radial movement:

a. Position the magnetic base J 7872-2 with the swivel adaptor J 7872-3 on the flat surface of the turbine housing inlet flange as shown in Fig. 8.

b. Fasten the extension rod J 22758 to the dial indicator J 8001-3 and attach the dial indicator to the swivel adaptor.

c. Insert the extension rod into the oil drain tube mounting pad opening so that it is against the wheel shaft and is perpendicular to the shaft.

CAUTION: Make sure the extension rod does not make contact with the sides of the center housing, otherwise it will be impossible to obtain an accurate reading.

d. Grasp each end of the rotating assembly and, applying equal pressure at each end, move the rotating shaft first toward and then away from the dial indicator, creating a transverse movement in the shaft. The dial indicator displacement should be more than .003 " and less than .007 ". If the displacement does not fall within the specified limits, disassemble and repair or replace the rotating assembly.

20. If it is to be stored, lubricate the turbocharger internally and install protective covers on all openings.

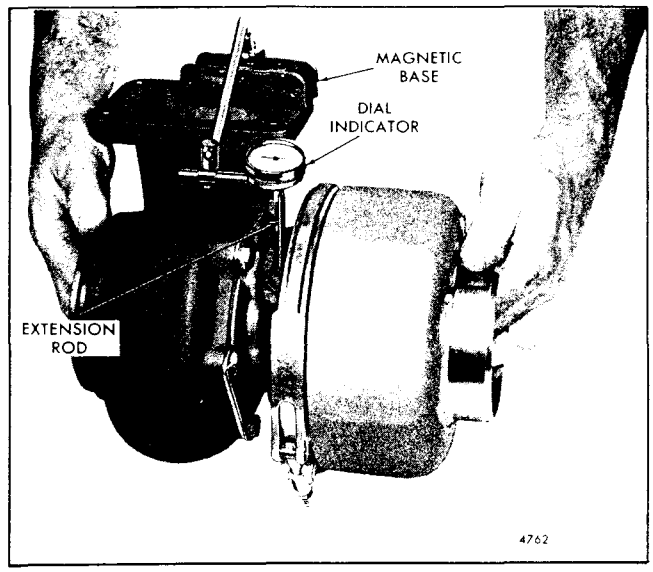


Fig. 8 - Checking Shaft Radial Movement

Install Turbocharger

If a turbocharger is to be installed on a new or overhauled engine, operate the engine for approximately one hour *before* the turbocharger is installed. This must be done to ensure that no foreign material is carried from the engine into the turbocharger lubrication system.

1. Position the turbocharger, using a new gasket, against the exhaust manifold adaptor and secure it in place with four bolts, lock washers and nuts (Fig. 1).

2. Slide the cover hose (Fig. 4) over the end of the turbocharger air outlet opening and tighten the two hose clamps.

3. Install the turbocharger support bracket.

4. Install the oil drain line from the opening in the bottom side of the center housing (Fig. 4) to the cylinder block.

5. Attach the oil inlet line at the cylinder block.

6. Before starting the engine, make sure that there is lubricating oil in the turbocharger.

a. Clean the area around the oil inlet opening, then pour about four ounces of engine oil in the oil inlet opening of the center housing. Turn the rotating assembly by hand to coat the bearings, thrust ring and thrust bearing with oil.

b. Fill the oil supply line with lubricating oil.

c. Use a socket wrench on the wheel nut to keep the compressor wheel from turning and start the engine.

d. As soon as oil appears at the end of the oil supply line, connect the oil supply line to the center housing (Fig. 4).

NOTE: The oil pressure should be at a minimum of 10 psig.

e. After the line is connected, release the compressor wheel.

7. Check all ducts and gaskets for leaks.

8. Operate the engine at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, shut down immediately and correct the cause.

NOTE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

TURBOCHARGER INTERCOOLER

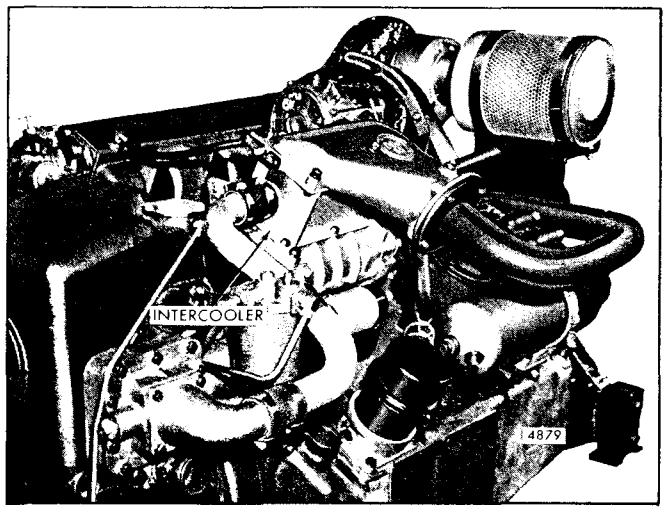


Fig. 1 - Turbocharger Intercooler Mounting

The turbocharger intercooler is mounted on the air inlet side of the engine blower and is used to reduce the temperature of the compressed air from the turbocharger before the air enters the engine blower. This permits a more dense charge of air to be delivered to the engine. The cooling is accomplished by the raw water from the heat exchanger passing through the cells of the intercooler core. The compressed air enters the intercooler via the air inlet housing and circulates past the cooler core of the intercooler.

Remove Intercooler

1. Drain the raw water system.

2. Loosen the two hose clamps on the hose connecting the raw water inlet tube to the inlet end of the intercooler (Fig. 1).

3. Remove the four 5/16 "-18 x 1 " bolts and lock washers that retain the air inlet tube flange to the air inlet housing.

4. Disconnect the connection between the outlet end of the intercooler and the raw water discharge line.

5. Disconnect the manual shutdown, if used.

6. Remove the six bolts, nuts, washers and lock washers that retain the air inlet housing to the intercooler and remove the air inlet housing and the screen and gasket assembly.

NOTE: The bolts are not all the same length and their location should be noted during removal to facilitate installation.

7. Remove the six bolts and lock washers that retain the intercooler to the blower and remove the intercooler. Note the location of the two shorter bolts.

8. Remove the gasket from the side of the blower.

Clean Intercooler

Check all of the intercooler tubes to be sure they are free of obstructions.

If the tubes contain dirt or any other foreign material, they can be cleaned with a small brush or by use of a suitable solvent cleaning solution. Flush the core thoroughly with water to remove the solvent.

Install Intercooler

1. Affix a new gasket to the side of the blower.

2. Mount the intercooler assembly on the blower with the six bolts and lock washers and tighten the bolts to 16-20 lb-ft torque.

3. Affix a new air inlet screen and gasket assembly on the intercooler.

4. Mount the air inlet housing on the intercooler with the six bolts, nuts, washers and lock washers and tighten the nuts to 35-39 lb-ft torque.

5. Affix a new gasket on the air inlet housing flange and secure the air inlet tube flange to the air inlet housing with the four 5/16 "-18 x 1 " bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

6. Connect the raw water inlet tube to the inlet end of the intercooler with the hose and clamps. Tighten the clamps securely.

7. Connect the raw water discharge line to the outlet end of the cooler.

8. Connect the manual shutdown, if used.

9. Fill the raw water system. Then start the engine and check for air or water leaks.