GM DIESEL

TUNE-UP, TROUBLE SHOOTING AND MAINTENANCE INFORMATION

ENGINE TUNE-UP PROCEDURES

Approximately 100 hours after the initial start, or after an engine overhaul, and thereafter at 1000 hour intervals, check the various engine adjustments and make the necessary corrections.

Three types of governors are used. Since each governor has different characteristics, the tune-up procedure varies accordingly. The three types are:

1. Limiting speed mechanical.
2. Variable speed mechanical.
3. Hydraulic.

The mechanical engine governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double weight limiting speed governor. A single weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor, or injectors have been replaced or overhauled, then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine.

To tune-up an engine completely, all of the adjustments are made by following the applicable tune-up sequence given below after the engine has reached the normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

Tune-Up Sequence for Mechanical Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rod.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Adjust the speed droop.
7. Adjust the maximum no-load speed.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders, and eventually burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting which is close enough to the specified clearance to prevent damage to the valves when the engine is started.

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment— Two Valve Cylinder Head (Cold Engine)

1. Place the speed control lever in the no-fuel position.

2. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft or camshaft bolt at the front of the engine, do not turn the engine in a left-hand direction of rotation as the bolt will be loosened.

3. Loosen the push rod lock nut.

4. Place a .012" feeler gage, J 9708, between the the valve stem and the rocker arm, see Fig. 1. Adjust the push rod to obtain a smooth pull on the feeler gage.

5. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.

6. Recheck the clearance. At this time, if the adjustment is correct, the .010" gage will pass freely between the end of the valve stem and the rocker arm and the .012" will not pass through.

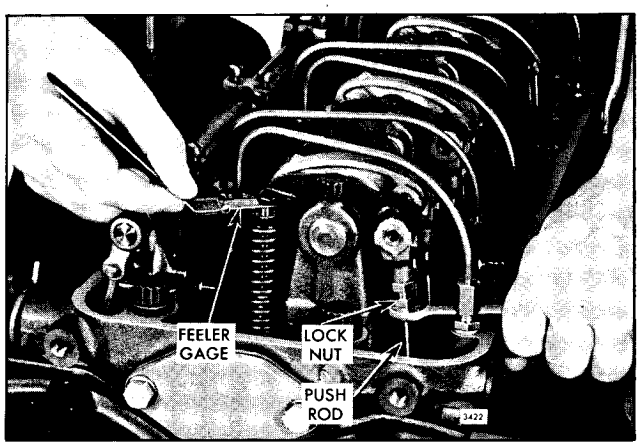


Fig. 1 - Adjusting Valve Clearance

7. Check and adjust the remaining valves in the same manner as outlined above.

Exhaust Valve Clearance Adjustment— Two Valve Cylinder Head (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance, when running at full load, may become insufficient.

With the engine at normal operating temperature (160^{o}-185^{o}F.) recheck the exhaust valve clearance with feeler gage J 9708. At this time, if the valve clearance is correct the .008" gage will pass freely between the end of the valve stem and the rocker arm and the .010" gage will not pass through. Readjust the push rod, if necessary.

Exhaust Valve Clearance Adjustment— Four Valve Cylinder Head (Cold Engine)

1. Place the speed control lever in the no-fuel position.

2. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft or camshaft bolt at the front of the engine, do not turn the engine in a left-hand direction of rotation as the bolt will be loosened.

3. Loosen the push rod lock nut.

14.1 EXHAUST VALVE CLEARANCE ADJUSTMENT

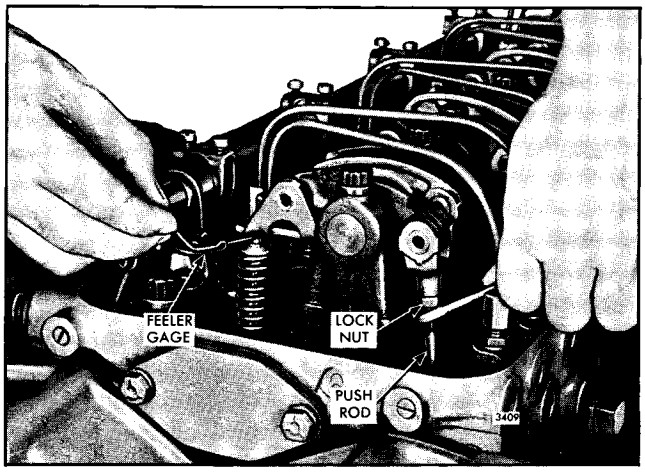


Fig. 2 - Adjusting Valve Clearance

4. Place a .027" feeler gage, J 9708, between the end of one valve stem and the rocker arm bridge, Fig. 2. Adjust push rod to obtain a smooth pull on the feeler gage.
5. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.
6. Recheck the clearance. At this time, if the adjustment is correct, the .025" gage will pass freely between the end of one valve stem and the rocker arm bridge, and the .027" gage will not pass through. Readjust the push rod if necessary.

Exhaust Valve Clearance Adjustment— Four Valve Cylinder Head (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become insufficient.

With the engine at normal operating temperature (.160°-185°F.) recheck the exhaust valve clearance with gage J 9708. At this time if the valve clearance is correct the .023" gage should pass freely between the end of one valve stem and the rocker arm bridge and the .025" feeler gage should not. Readjust as necessary.

FUEL INJECTOR TIMING

To properly time the injectors, the injector follower must be adjusted to a definite height in relation to the injector body.

All injectors can be timed during a full revolution of the crankshaft.

1. Place the stop lever in the NO FUEL position.

2. Rotate the crankshaft in the direction of engine rotation, until the exhaust valves are fully depressed on the particular cylinder to be timed.

   CAUTION: Left-hand turning engines should not be barred in the direction of rotation by use of wrench on crankshaft bolt.

3. Place the small end of injector timing gage (see chart below for correct timing gage) in hole provided in the top of the injector body, with the flat of the gage toward the injector follower as shown in Fig. 1.

Injector	Timing Dimension	Tool Number
35 (Reefer Car)	1.508	J 8909
35	1.484	J 1242
40	1.484	J 1242
45	1.484	J 1242
S40	1.460	J 1853
S45	1.460	J 1853
S50	1.460	J 1853

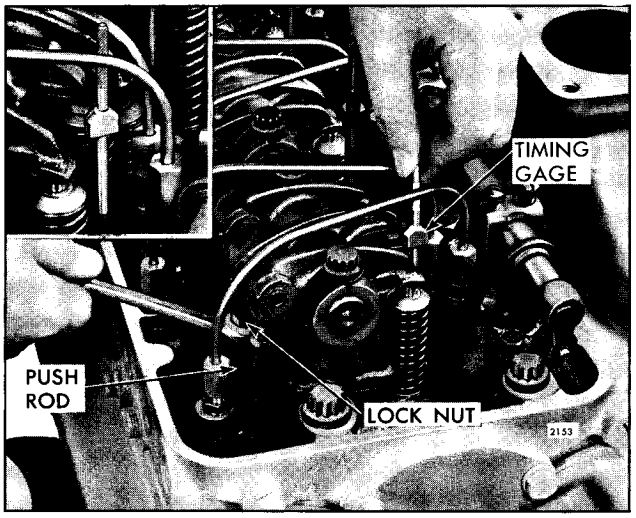


Fig. 1 - Timing Fuel Injector

4. Loosen the push rod lock nut.

5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the lock nut. Check adjustment and readjust if necessary.

7. Time the remaining injectors as outlined in steps 1 through 6.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (IN-LINE ENGINE)

After timing the fuel injectors and adjusting the exhaust valves, adjust an engine with a limiting speed mechanical governor as follows:

Adjust Governor Gap

With the engine at operating temperature, the governor gap may be adjusted as follows: Ordinarily, adjustment is required when the governor has been repaired or replaced.

1. Remove the high speed spring retainer cover.
2. Back out the buffer screw until it extends 5/8" beyond the governor housing.
3. Remove the valve rocker cover.
4. Start the engine and adjust the idle speed screw to obtain an idle of 450 r.p.m., see Fig. 5.

   NOTE: The recommended idle speed is 450 r.p.m., but may vary with special engine applications.

5. Shut the engine down and remove the governor cover.
6. Start the engine and control the speed manually by operating the injector control tube lever. Engine speed should be between 800 and 1000 r.p.m.

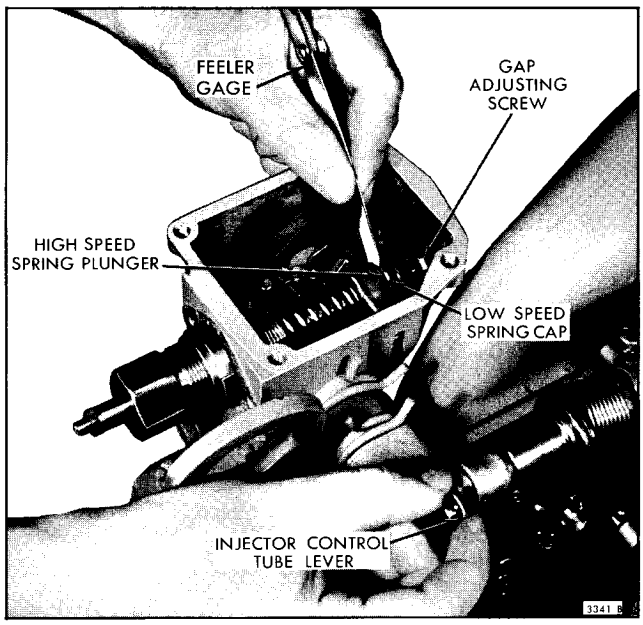


Fig. 1 - Adjusting Governor Gap - Tool J 3172

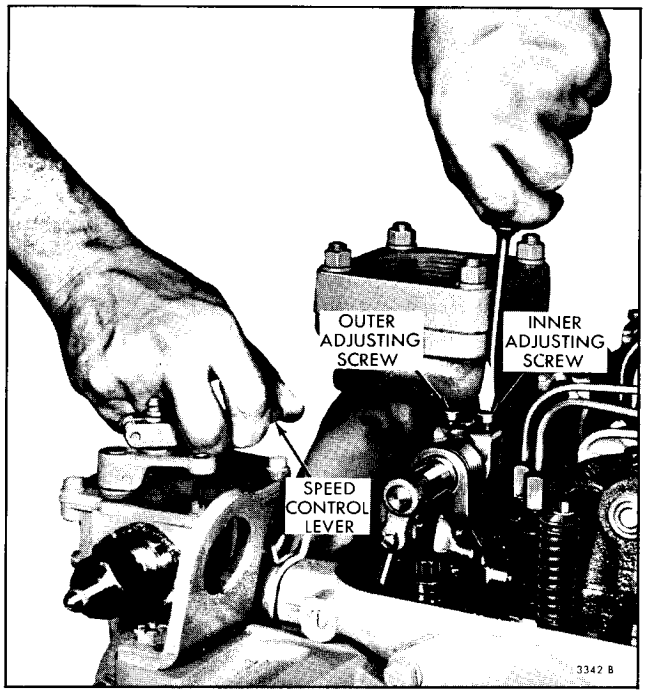


Fig. 2 - Positioning the Rear Injector Rack Control Lever

7. Check the gap between the low speed cap and the high speed spring plunger with a .0015" feeler gage. If gap setting is incorrect, reset the gap adjusting screw, Fig. 1.
8. Install the governor cover. The governor cover should be placed on the housing with the pin of the speed control lever projecting into the slot of the differential lever.
9. Install the screws and lockwashers finger tight. Pull the cover away from the engine and tighten the screws. This step will properly locate the cover on the governor housing.

Position Injector Rack Control Levers

Properly positioned injector rack control levers with the engine at FULL LOAD will result in the following:

Speed control lever at the maximum speed position.

Governor low speed gap closed.

High speed spring plunger on the seat in the governor control housing.

Injector fuel control racks in the FULL FUEL position.

14.3.1 LIMITING SPEED GOVERNOR ADJUSTMENT

Adjust the rear injector rack control lever, Fig. 2, first to establish a guide for adjusting the remaining injector rack control levers.

1. Refer to Fig. 2 and disconnect any linkage attached to the speed control lever.

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

3. Move the speed control lever to the FULL FUEL position as shown in Fig. 2. Turn the inner adjusting screw down on the rear injector rack control lever until a step up in effort is noted. This will place the rear 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 until they are tight.

   The above step should 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 as previously described.

4. To be sure of proper rack adjustment, the following check should be performed.

   Hold the speed control lever in the FULL FUEL position. Press down on the injector rack causing the rack to rotate. The setting is sufficiently tight if the injector rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct, back off the outer adjusting screw slightly and tighten the inner adjusting screw.

   The setting is too tight if, when moving the speed control lever from the idle to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (stop under the governor cover). This will result in a step up in effort to move the speed control lever to its maximum speed 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.

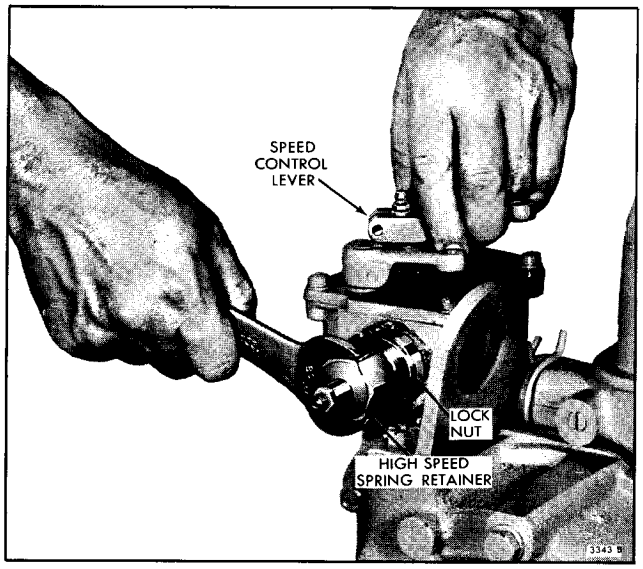


Fig. 3 - Adjusting Maximum No-Load Engine Speed

5. Manually hold the rear injector rack control lever in the full fuel position. Turn down the inner adjusting screw on the injector rack control lever of the adjacent injector until the injector rack 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 adjusting screws until they are tight.

6. Recheck the rear injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while adjusting the adjacent injector. If the rack of the rear injector has become loose, back off slightly 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.

7. Position the remaining control rack levers as outlined in items 5 and 6.

Adjust Maximum No-Load Engine Speed—Industrial Units

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 unit name plate, the maximum no-load speed may be set as follows:

1. Loosen the lock nut, Fig. 3, and back off the high speed spring retainer approximately five turns.

2. With the engine at operating temperature and no-load on the engine, place the speed control lever in the FULL FUEL position. Turn the high speed spring retainer IN until the engine is operating at the recommended no-load speed.

   The best method of determining the engine r.p.m. is with hand tachometer.

3. Hold the high speed retainer and tighten the lock nut.

Adjust Maximum No-Load Engine Speed—Vehicle Units

1. Start the engine and after it attains operating temperature remove the load from engine.

2. Place the engine speed control lever in the Full Fuel position and note the engine speed.

3. Stop the engine and if necessary, refer to Fig. 4 and adjust the engine to the desired No-Load speed as follows:

   a. Remove the high speed spring retainer, high speed spring and plunger.

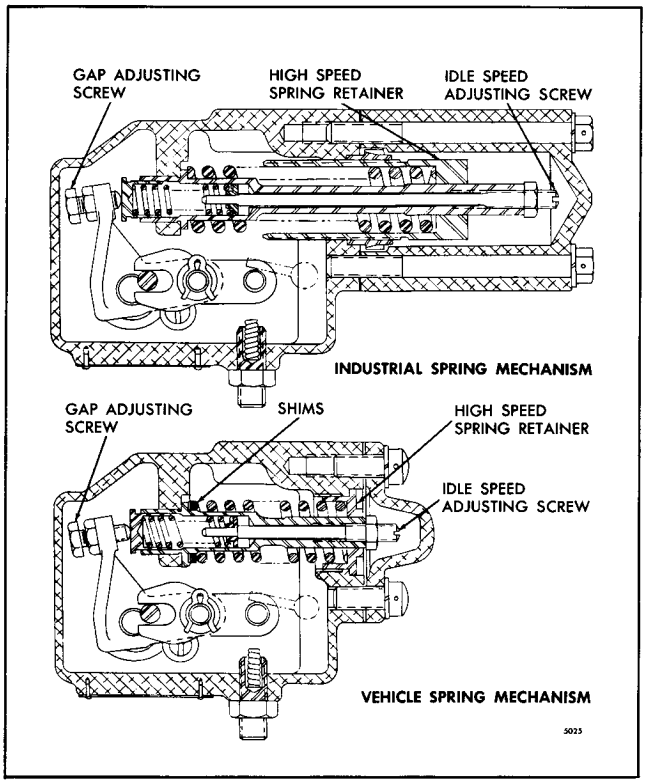


Fig. 4 - Differences Between Industrial and Vehicle Spring Assemblies

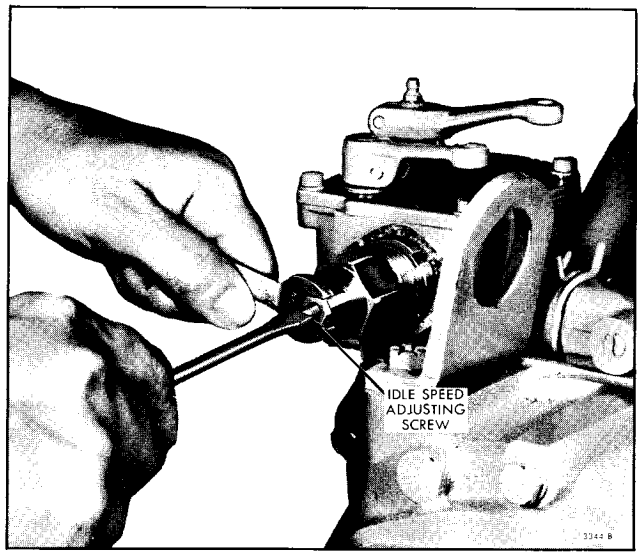


Fig. 5 - Adjusting Engine Idle Speed

CAUTION: Be careful not to jar the assembly while it is being removed to prevent the low speed spring and cap from dropping into the governor.

   b. Remove the high speed spring from the high speed plunger and add or remove shims as required to establish the desired engine No-Load speed.

   NOTE: Shims are available in .010" and .078" thickness. For each .010" in shim added, the engine speed will be increased approximately 10 r.p.m.

   c. Replace the high speed spring on the high speed plunger and assemble the spring assembly into the governor housing. Install the spring retainer in the governor housing and tighten securely.

   d. Start the engine and recheck the engine No-Load speed. Repeat steps a, b and c as is necessary to establish the No-Load speed.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. With the engine running at normal operating temperature and with buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw, Fig. 5, until the engine idles at the recommended idle speed.

   The recommended idle speed is 450 r.p.m. but may vary with special engine applications.

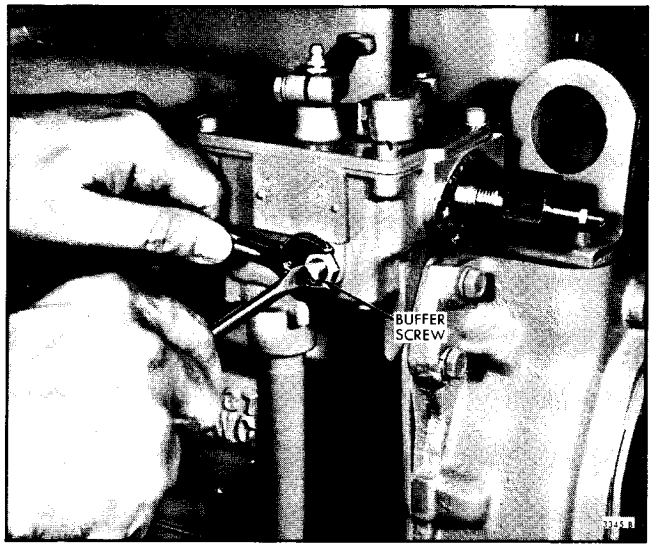


Fig. 6 - Adjusting the Buffer Screw

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

3. Install the high speed spring cover and retain with two bolts.

Adjust Buffer Screw

1. Set the maximum no-load speed and idle speed (engine at normal operating temperature).

2. With the engine at idle speed, screw IN the buffer screw, Fig. 6, so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

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

3. Recheck the maximum no-load speed. If it has increased more than 25 r.p.m. from the maximum speed attained in step 1, back off the buffer screw until the increase is less than 25 r.p.m.

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

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (V-Type Engine)

The limiting speed mechanical governor assembly is mounted near the rear of 6V-53 engines, between the flywheel housing and the blower (Fig. 1). The governor is driven by the right blower rotor drive gear. The left blower rotor drive gear is driven by a shaft, which passes through the governor housing, from the engine gear train. There are two types of limiting speed governor assemblies. One type is generally used in industrial applications and the other is generally used in vehicles. The only difference between the governors is in the spring mechanism (Fig. 5).

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

Adjust Governor Gap

With the engine at operating temperature, set the governor gap as follows:

1. With the engine stopped, remove the two bolts and withdraw the governor high speed spring retainer cover.

2. Back out the buffer screw until it extends 9/16" to 5/8" from the surface of the governor housing.

   CAUTION: Do not back the buffer screw out beyond the limits given, or the control link lever may disengage the differential lever.

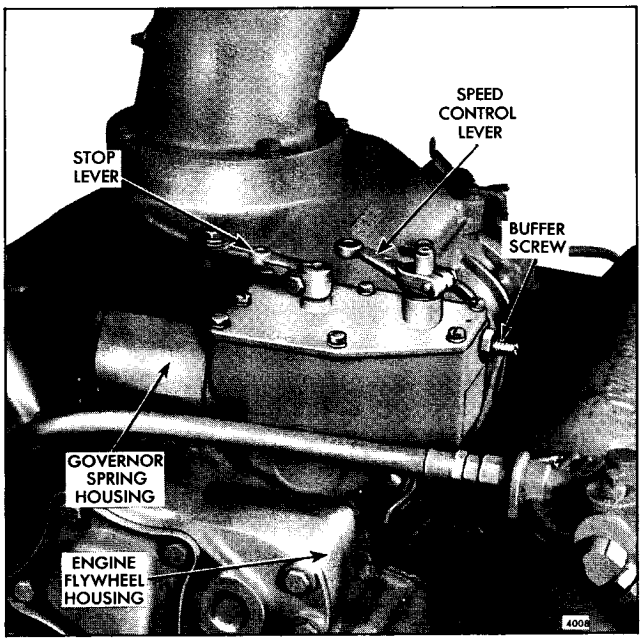


Fig. 1 - Limiting Speed Governor Mounting

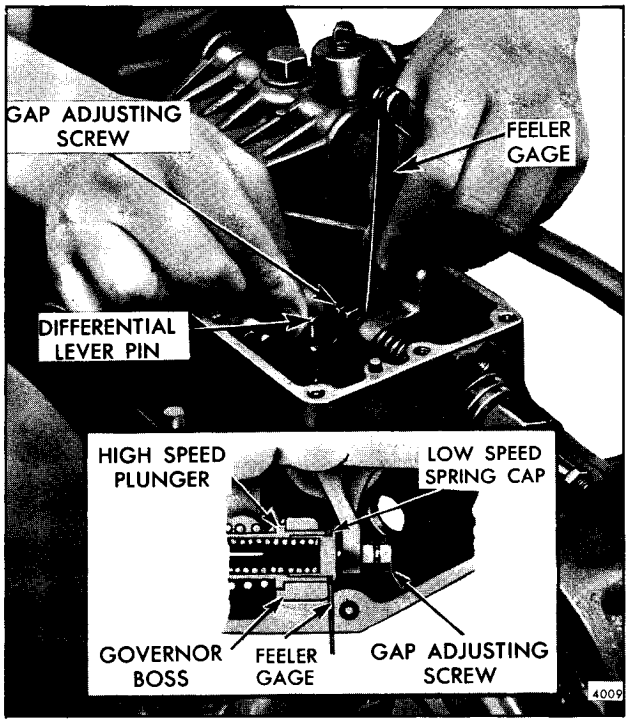


Fig. 2 - Checking Governor Gap

3. Start the engine and loosen the idle speed adjusting screw lock nut. Then, adjust the idle screw (Fig. 6) to obtain the desired idle speed.

4. Stop the engine and remove the governor cover and the engine rocker covers.

5. Start and run the engine, between 800 and 1000 rpm, by manual operation of the differential lever.

   CAUTION: Do not overspeed the engine.

6. Check the gap between the low speed spring cap and the high speed spring plunger with a .0015" feeler gage. If the gap setting is incorrect, reset the gap adjusting screw (Fig. 2).

7. Hold the gap adjusting screw and tighten the lock nut.

8. Recheck the gap and readjust if necessary.

14.3.2 LIMITING SPEED GOVERNOR ADJUSTMENT

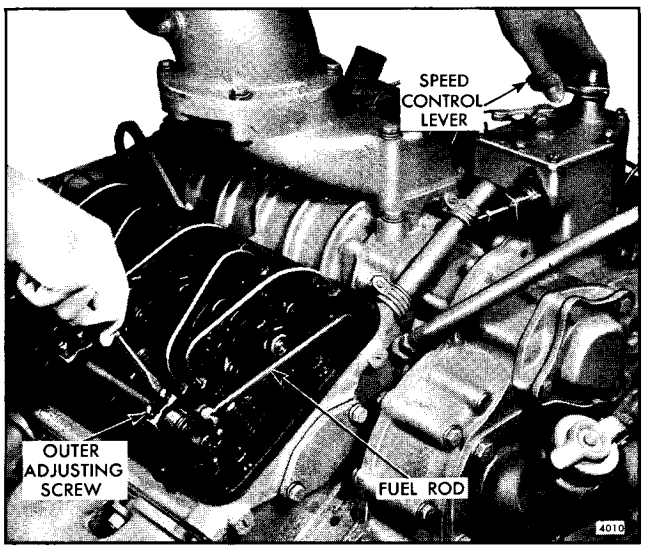


Fig. 3 - Positioning No. 3L Injector Rack Control Lever

9. Stop the engine and reinstall the governor cover.

Position Injector Rack Control Levers

Properly positioned injector rack control levers with the engine at FULL LOAD will result in the following:

Speed control lever at the maximum speed position.

Governor low speed gap closed.

High speed spring plunger on the seat in the governor control housing.

Injector fuel control racks in the FULL-FUEL position.

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

1. Disconnect the linkage attached to the speed control lever.

2. Turn the idle speed adjusting screw until about 1/2" of the screw projects from the lock nut.

   NOTE: This adjustment lowers the tension of the low speed spring so it can be compressed, while closing the low speed gap, without bending the fuel rods.

3. If not already done, back out the buffer screw as outlined in Item 2 under "Adjust Governor Gap".

4. Remove the valve rocker covers. Then, remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

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

6. Move the speed control lever to the maximum speed position; hold it in that position with light finger pressure. Turn the inner adjusting screw of the No. 3L injector rack control down, as shown in Fig. 3, until a step-up in effort is noted. This will place the No. 3L injector 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 until they are tight.

   The above step should result in placing the governor linkage and control tube assembly in the same positions they will attain while the engine is running at full load as previously described.

7. To be sure of the proper rack adjustment, perform the following check.

   Hold the speed control lever in the maximum speed 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, back off the outer adjusting screw slightly and tighten the inner adjusting screw.

   The setting is too tight if, when moving the speed control lever from the idle to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (stop under the governor cover). This will result in a step-up in effort to move the speed control lever to its maximum speed position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is 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 injector rack control lever.

10. Insert the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Repeat the check on the 3L and 3R injector rack control levers as outlined in step 7. Carefully observe and eliminate any deflection which occurs 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 and turn down the inner adjusting screw of the No. 2L injector rack control lever until the injector rack of the 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 until they are tight.

12. Recheck the No. 3L injector rack to be sure 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 the No. 2L 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.

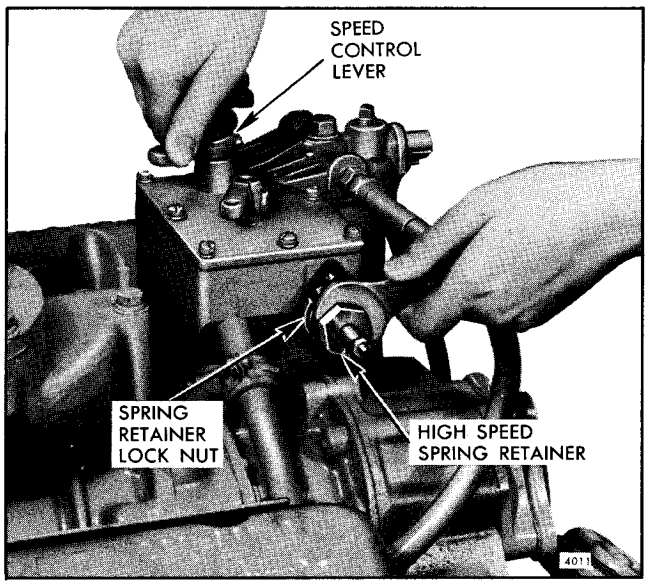


Fig. 4 - Adjusting Maximum No-Load Engine Speed

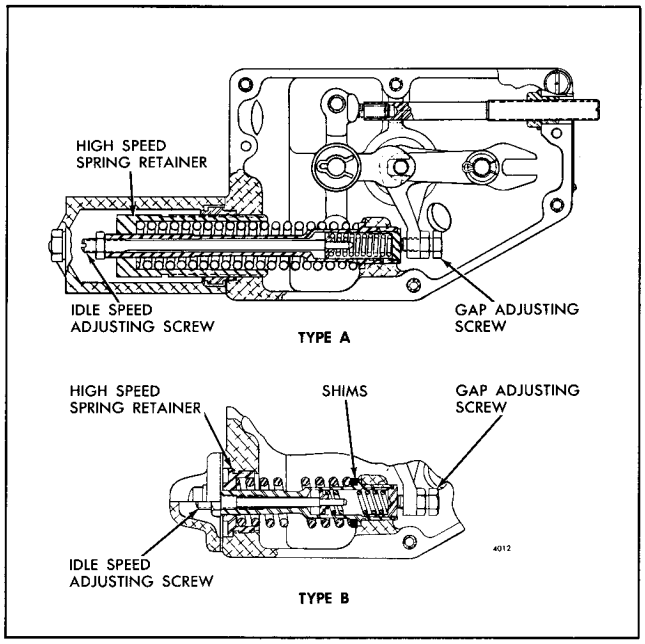


Fig. 5 - Governor Spring Assemblies

13. Position the No. 1L injector rack control lever as outlined in the two steps above.

14. Position No. 2R and 1R injector racks as outlined above for the left cylinder bank.

15. Turn the idle speed adjusting screw in until it projects 3/16" from the lock nuf to permit starting of the engine.

16. Replace the engine rocker covers.

Adjust Maximum No-Load Engine 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 unit name plate, set the maximum no-load speed as outlined below.

TYPE A GOVERNOR SPRINGS (Fig. 5):

1. Loosen the lock nut and back off the high speed spring retainer several turns. Then, start the engine and increase the speed slowly. If the speed exceeds the required no-load speed before the speed control lever reaches the end of its travel, back off the spring retainer a few additional turns.

14.3.2 LIMITING SPEED GOVERNOR ADJUSTMENT

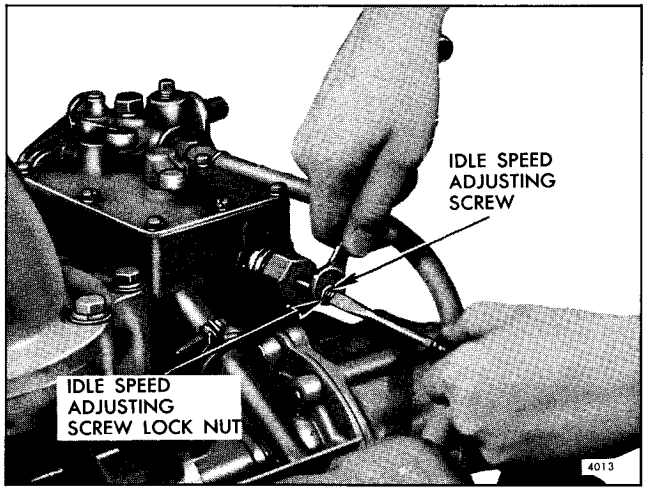


Fig. 6 - Adjusting Engine Idle Speed

2. With the engine at operating temperature and no-load on the engine, place the speed control lever in the maximum speed position. Turn the high speed spring retainer in (Fig. 4) until the engine is operating at the recommended no-load speed. The best method of determining the engine rpm is with a hand tachometer.

3. Hold the spring retainer and tighten the lock nut.

TYPE B GOVERNOR SPRINGS (Fig. 5):

1. Start the engine and, after it reaches normal operating temperature, remove the load from the engine.

2. Place the speed control lever in the maximum speed position and note the engine speed.

3. Stop the engine and, if necessary, adjust the no-load speed as follows:

   a. Remove the high speed spring retainer, high speed spring, and plunger assembly.

      CAUTION: To prevent the low speed spring and cap from dropping into the governor, be careful not to jar the assembly while it is being removed.

   b. Remove the high speed spring from the high speed spring plunger and add or remove shims as required to establish the desired engine no-load speed.

      NOTE: Shims are available in .010" and .078" thickness. For each .010" in shims added, the engine speed will be increased approximately 10 rpm.

   c. Replace the high speed spring on the high speed spring plunger and install the spring assembly in the governor housing. Install the spring retainer and tighten it securely.

   d. Start the engine and recheck the no-load speed. Repeat the procedure as necessary to establish the no-load speed required.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (Fig. 6) until the engine idles at the recommended idle speed.

   The recommended idle speed is 500-600 rpm, but may vary with the engine application. If the engine has a tendency to stall during deceleration, install a new buffer screw. The current buffer screw uses a heavier spring and restricts the travel of the differential lever to the off (no-fuel) position.

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

3. Install the high speed spring retainer cover.

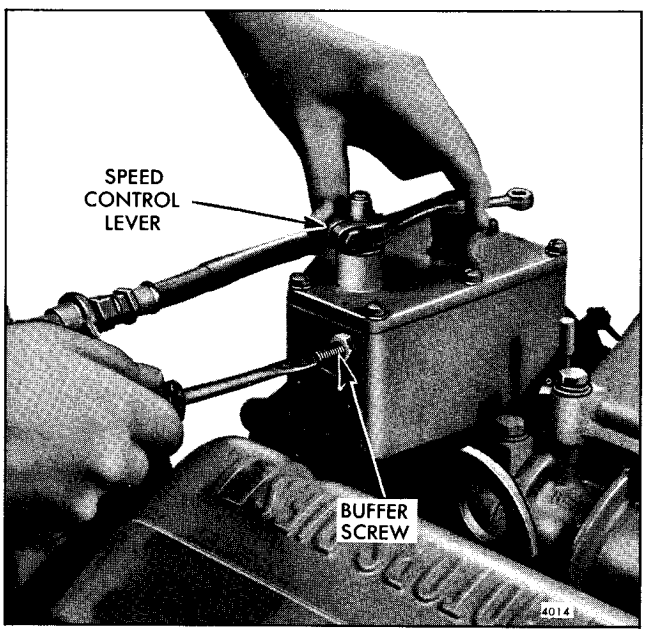


Fig. 7 - Adjusting Buffer Screw

Adjust Buffer Screw

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

1. With the engine running at normal operating temperature, turn the buffer screw in (Fig. 7) so it contacts the differential lever as lightly as possible and still eliminates the engine roll.

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

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

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

Adjust engines with a variable speed mechanical governor assembly after adjusting the exhaust valves and timing the fuel injectors as follows:

Position Injector Rack Control Levers

The setting of the injector control racks govern the quantity of fuel injected into each cylinder. All injectors of an engine must be set to inject the same quantity of fuel into each cylinder, to ensure equal distribution of the load.

The injector racks should be set as follows:

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

2. Loosen all inner and outer rack control lever adjusting screws, Fig. 1. Check each rack control lever to ascertain that it is loose on the control tube.

3. Lift upward on bell crank, as shown in Fig. 2, moving 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 down outer adjusting screw until it bottoms on control tube, then tighten alternately both inner and outer screws to retain adjustment.

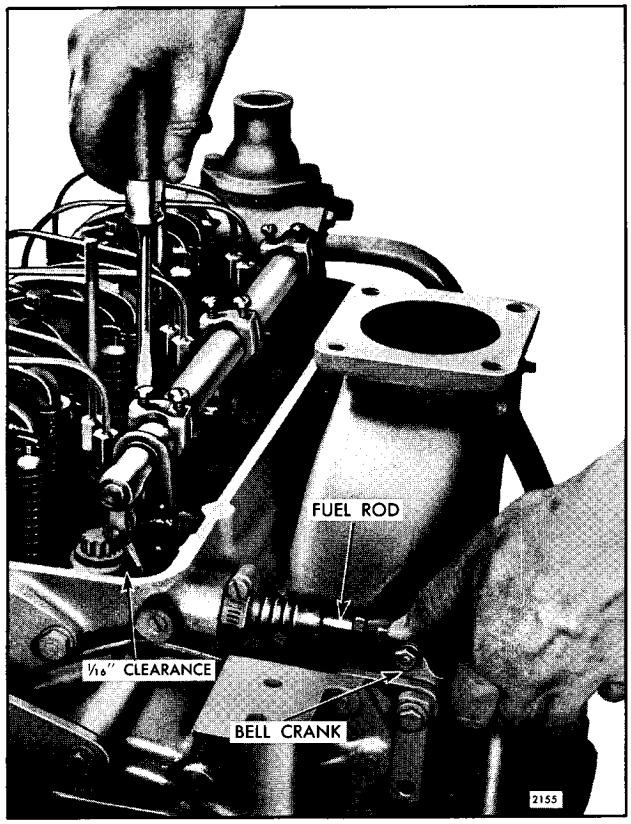


Fig. 2 - Setting Fuel Rod to Cylinder Head Clearance

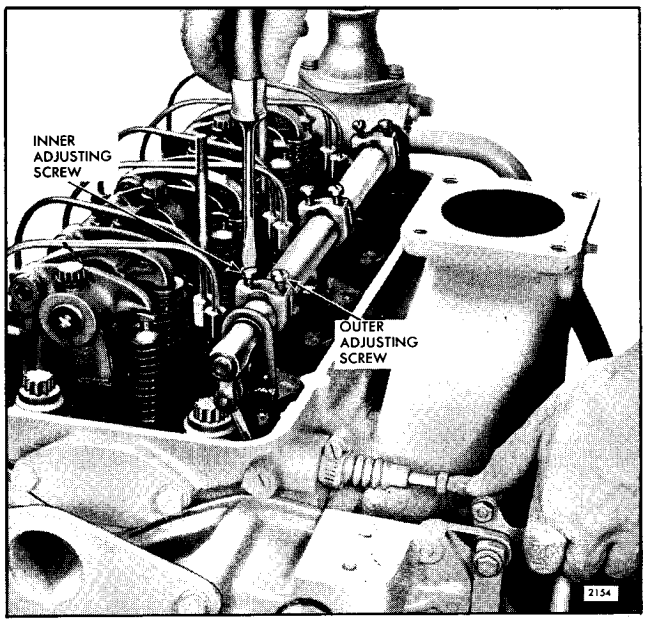


Fig. 1 - Positioning Injector Rack Control Lever

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

5. Recheck the rear injector rack to be sure that 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 slightly the inner adjusting screw on the adjacent injector rack control lever and tighten outer adjusting screw to retain adjustment.

When the settings are correct, the racks of

both injectors will be snug on the ball end of their respective rack control levers.

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

Adjust Governor Linkage

1. Check travel of bell crank as shown in Fig. 3. The vertical arm of the bell crank should move an equal distance on either side of center when moving the fuel injector racks from FULL FUEL to NO FUEL positions. The bell crank is positioned by loosening the fuel rod lock nut, then after removing fuel rod ball joint from bell crank, turn ball joint assembly on fuel rod until the fuel rod is the correct length to give the bell crank the correct travel. Replace ball joint assembly on bell crank and tighten lock nuts securely to retain adjustment.

2. Advance governor rocker shaft lever to the maximum fuel position and retain. The rocker shaft lever can be held in the FULL FUEL position by advancing the governor speed control lever to its maximum speed position, see Fig. 6, or by turning down the idle speed adjusting bolt until the rocker shaft lever is held at the end of its travel.

   NOTE: Back out the maximum speed adjusting bolt only as far as necessary, to permit the idle speed adjusting bolt to move the rocker shaft lever to the end of its travel.

3. Hold injector control racks in the FULL FUEL position, then adjust the length of the vertical link assembly, by turning the ball and socket assembly on to the link assembly, until it can be connected to the bell crank lever, as shown in Fig. 4, without compressing the spring, in the vertical assembly, more than 1/32".

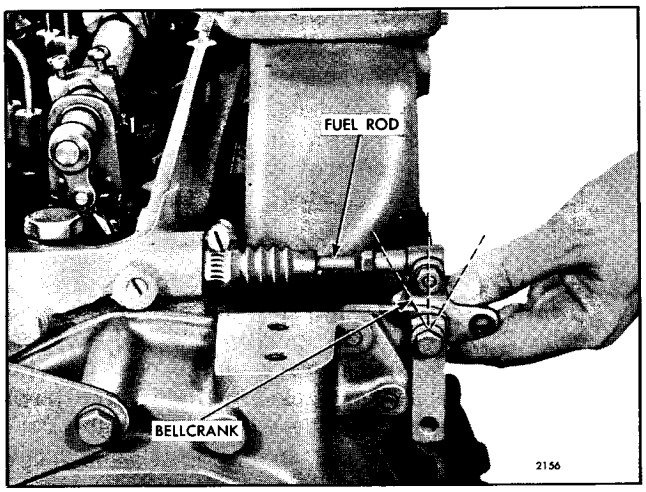


Fig. 3 - Adjusting Fuel Rod Length

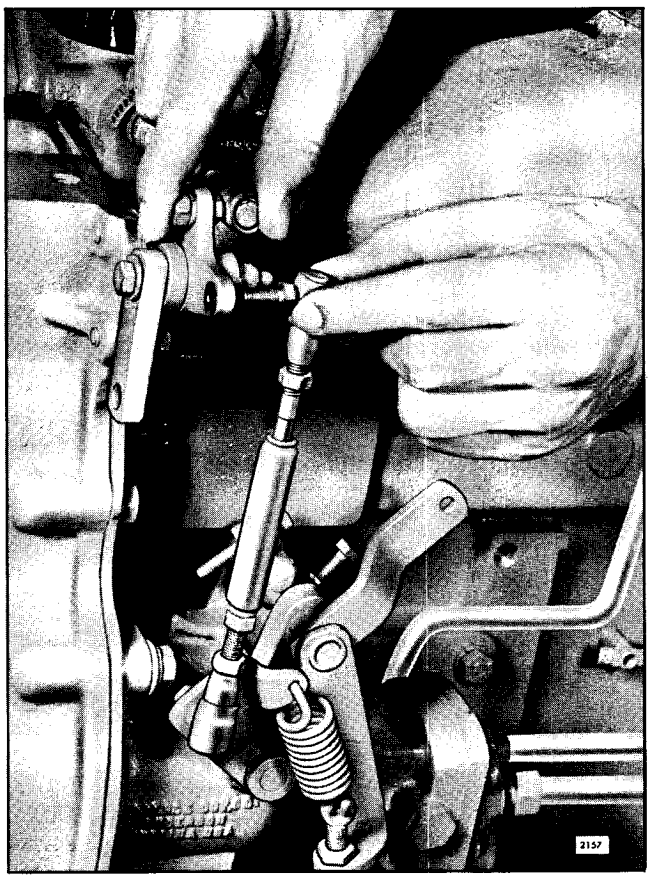


Fig. 4 - Adjusting Length of Vertical Link

4. Check injector racks to be sure governor holds the injector racks in the FULL FUEL position.

5. Back out idle speed adjusting bolt, see Fig. 7.

6. Place speed control lever in the minimum speed position and force injector racks to their NO FUEL position, then check for interference between the rocker shaft lever and the vertical link assembly. No interference should occur.

   NOTE: If the spring in the vertical link assembly is compressed more than 1/32" interference may occur with the rocker shaft lever.

7. Adjust speed adjusting spring eye bolt until the speed control lever is at the center of the eye bolt's threads. Secure adjustment by tightening nuts on eyebolt.

8. Back out buffer bolt until it is within 1/16" to 1/8" of the governor speed control shaft.

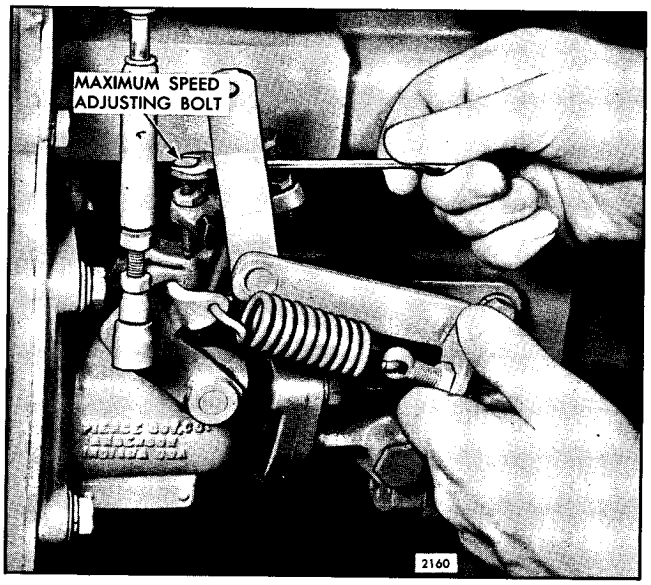


Fig. 5 - Adjusting Maximum Speed

Adjust Maximum No-Load Speed

1. Start engine and move speed control lever to the FULL SPEED position.

   NOTE: Do not overspeed engine.

2. Adjust maximum speed adjusting bolt, Fig. 5, until the desired no-load speed is obtained.

3. Tighten maximum speed adjusting bolt lock nut to retain adjustment.

Adjust Engine Speed Droop

With the engine operating at maximum speed, depress linkage to injector control tube to cause a speed decrease of several hundred r.p.m. Release linkage and observe hunting when governor returns engine to the maximum speed setting. If engine stabilizes in less than three surges, droop may be excessive. If engine does not stabilize in five surges, the droop may be insufficient. The speed droop may be set as follows:

1. Speed droop excessive, engine surges less than three times, increase tension of speed adjusting spring. See Fig. 6.

   Speed droop insufficient, engine surges more than five times, decrease tension of speed adjusting spring.

   NOTE: Make sure eye, of eye bolt, is in a horizontal position to avoid twisting spring.

2. Reset maximum engine no-load speed, if necessary, as outlined in "Adjust Maximum Engine No-Load Speed."

3. Check speed droop. The engine speed should be stable when the governor speed droop is 7 1/2% to 10% of the full-load speed. Thus, an engine operating at 2000 r.p.m. full load, the speed droop should be 150 to 200 r.p.m. Therefore, the engine no-load speed, in this case, must be set between 2150 to 2200 r.p.m.

Adjust Engine Idle Speed

1. Back out buffer bolt, if necessary, until it is within 1/16" to 1/8" of the governor speed control shaft.

2. Start the engine and adjust idle speed adjusting bolt, as shown in Fig. 7, to obtain the desired idle speed.

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

Adjust Buffer Bolt

1. Loosen buffer bolt lock nut and, with the engine operating at idle speed, screw buffer bolt down, see Fig. 8, until the buffer bolt just touches

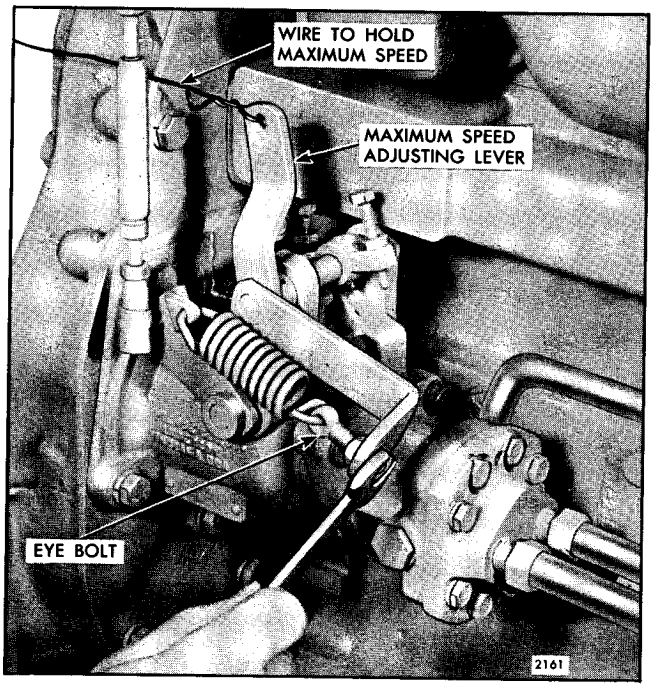


Fig. 6 - Adjusting Engine Droop

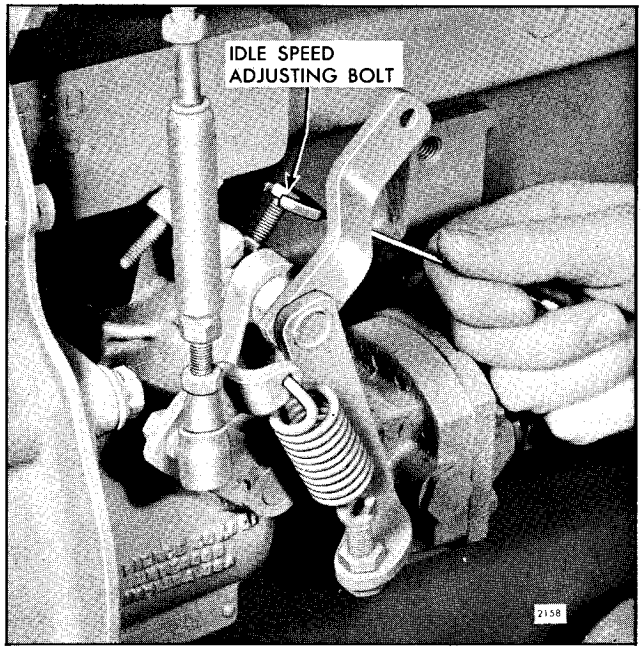


Fig. 7 - Adjusting Engine Idle Speed

buffer spring, in the governor, and engine roll is eliminated.

NOTE: Do not raise engine speed more than 20 r.p.m. with the buffer bolt.

2. Tighten lock nut on buffer bolt to retain adjustment.

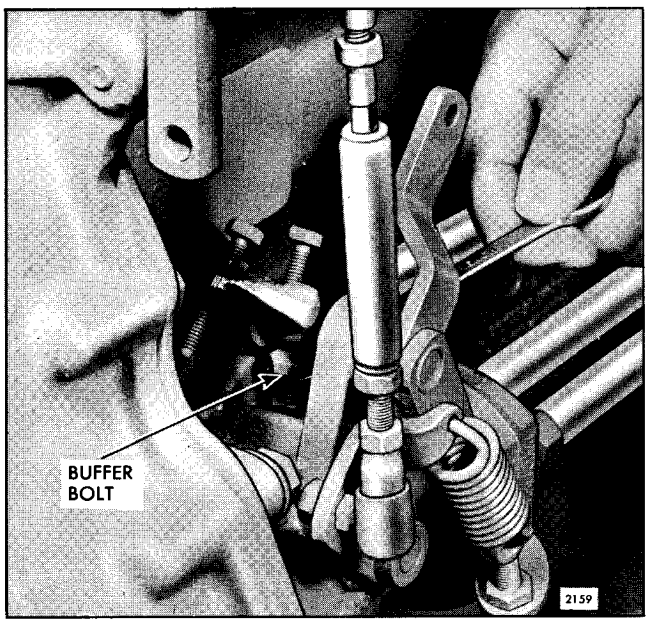


Fig. 8 - Adjusting Buffer Bolt

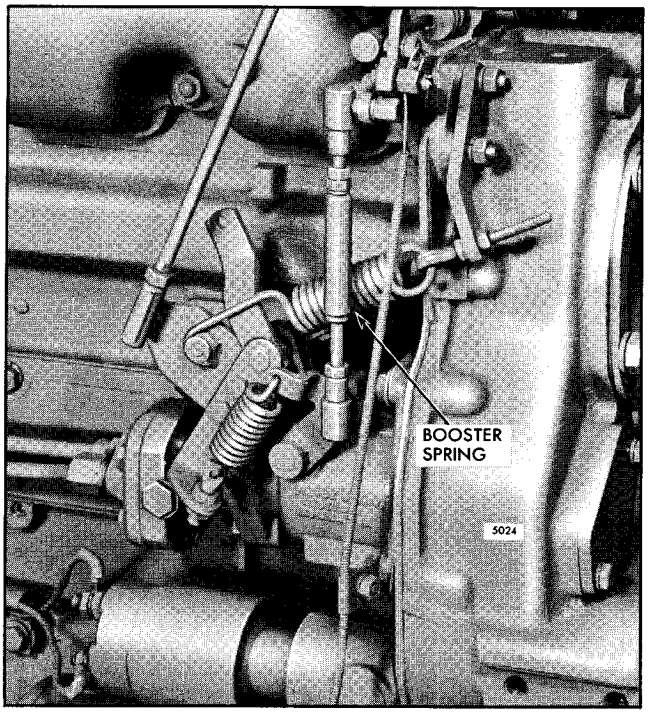


Fig. 9 - Adjusting Booster Spring

Adjust Governor Booster Spring

The governor booster spring, is used on some units to reduce the force necessary to move the governor throttle lever from the idle speed position to the maximum speed position. The booster spring should be adjusted as follows:

1. Reduce the tension on the booster spring, if not previously performed, to the minimum, by backing off the outer nut, see Fig. 9.
2. Adjust eye bolt in its slot so that an imaginary center line drawn through the booster spring will align with an imaginary outer line drawn through the speed adjusting shaft. Secure lock nuts on eye bolt to retain adjustment.
3. Move governor speed adjusting lever from the idle position to the maximum speed position, noting the force required.
4. To reduce the force required to move the governor speed adjusting lever, back off on the inner eye bolt nut and tighten the outer eye bolt nut increasing the booster spring tension.

   NOTE: before tightening the eye bolt nuts, reposition the booster spring as in Step 2.

   The setting is correct when the governor speed adjusting lever can be moved from the idle speed to maximum speed position, while the engine is operating, with a fairly constant force and when released will return to the idle speed position.

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

After timing the fuel injectors and adjusting the exhaust valves, adjust engines with an exposed linkage variable speed governor as follows:

Preliminary Governor Adjustments

1. Clean the governor movable linkage, removing all the foreign material.

2. Lubricate all the movable linkage, ball joints and bearing surfaces with clean engine oil to ensure complete freedom of movement.

3. Back out the buffer screw, shown in Fig. 1, until it projects 9/16" from the governor boss.

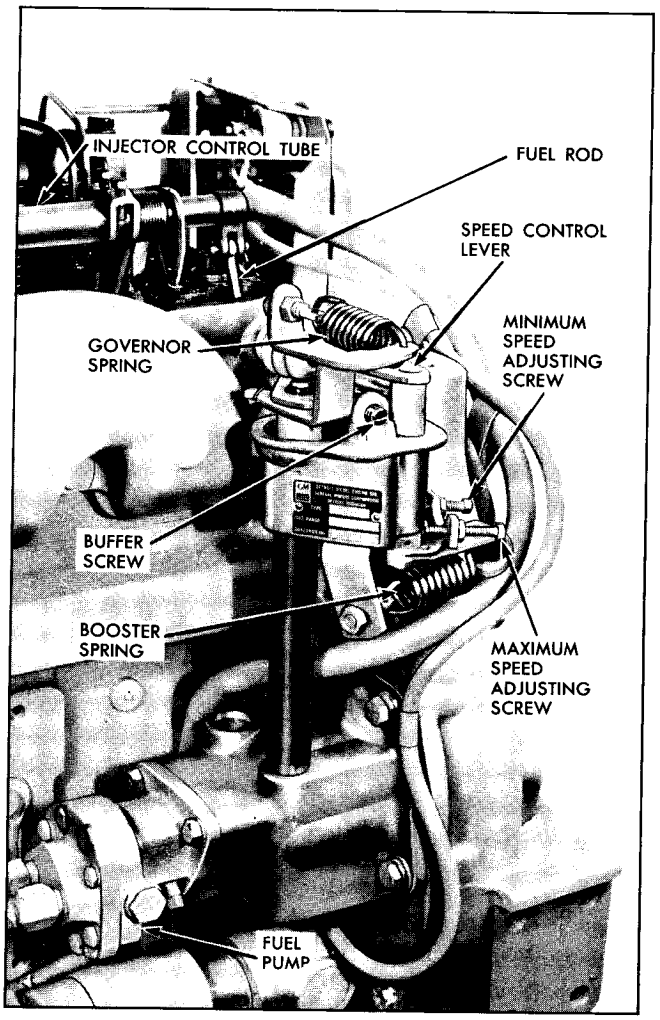


Fig. 1 - Variable Speed Open Linkage Type Governor Mounted on an Engine

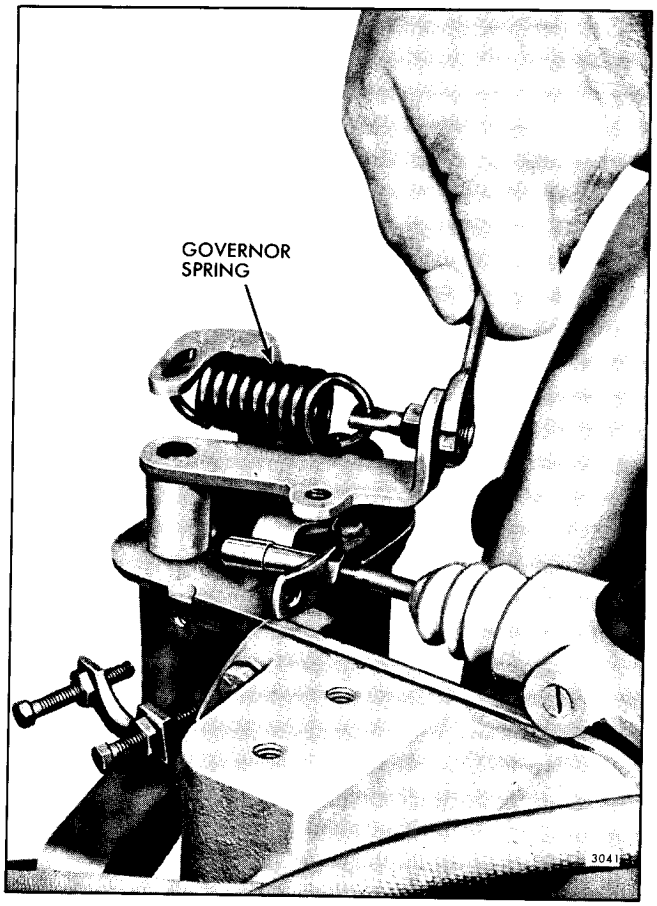


Fig. 2 - Adjusting Governor Spring Eye Bolt

4. Back off the tension of the booster spring, shown in Fig. 1, until the eye bolt is flush with the nut.

Adjust Governor Spring Tension

1. Adjust the governor spring eye bolt, see Fig. 2, until 1/8" of threads projects from the nut to the end of eye bolt.

2. Tighten the eye bolt nuts to retain the adjustment.

NOTE: This setting of the eye bolt will produce approximately 7% droop in engine speed from No-Load to Full-Load.

Position Injector Rack Control Levers

1. Disconnect the fuel rod ball joint socket, shown in Fig. 4, from the ball of the governor operating shaft lever.

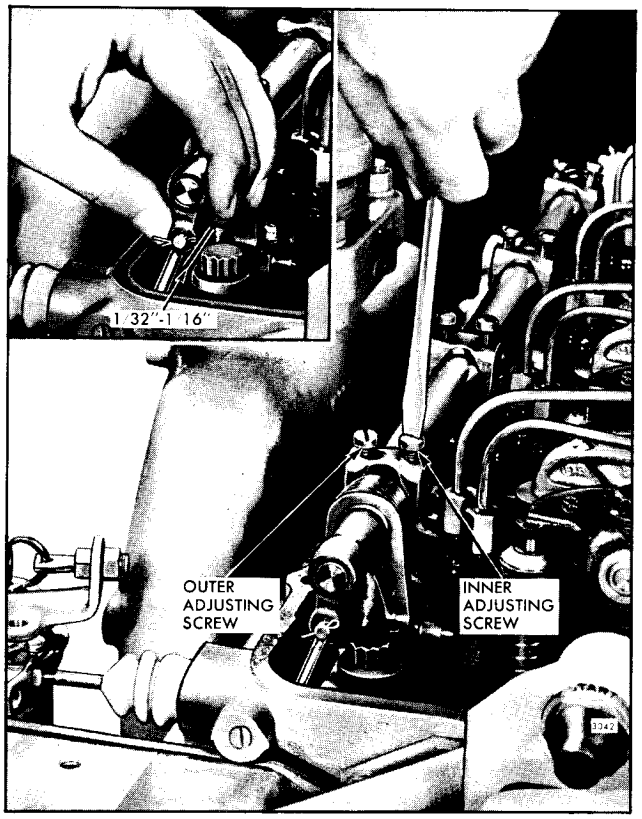


Fig. 3 - Adjusting Injector Rack Adjusting Screws

2. Adjust the injector rack adjusting screws on the rear cylinder until both screws are equal in height, see Fig. 3, and tight on the control tube.

3. Move the rear injector rack into the Full-Fuel position and note the clearance between the fuel rod and the cylinder head bolt head. The clearance should be 1/32" or more. If necessary, readjust the injector rack adjusting screws until a clearance of at least 1/32" to 1/16" exists. Tighten the adjustment screws to retain adjustment.

4. Loosen the lock nut, retaining the ball joint socket on the fuel rod. Hold the fuel rod in the Full-Fuel position and adjust the fuel rod socket, see Fig. 4, until it is aligned and will slide onto the ball of the governor operating shaft lever while retaining the governor operating shaft lever ball in the Full-Fuel position. Tighten the fuel rod lock nut, to retain the adjustment, after positioning the shut-down cable clip.

   NOTE: After assembling the socket on the ball of the governor operating shaft lever, push the rod end towards the engine and ascertain that the injector control rack is in the Full-Fuel position.

5. Manually hold the rear injector control rack in the Full-Fuel position and turn down the inner adjusting screw of the adjacent injector control lever until it 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 adjusting screws until tight.

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

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

   When the settings are correct, the racks of both injectors will be snug on the ball end of their respective rack control levers.

Adjust Engine Idle Speed

1. Start the engine and adjust the Idle speed adjusting screw, see Fig. 5, to obtain the desired Idle speed.

   NOTE: The minimum Idle speed is 500 r.p.m. on units with two valve

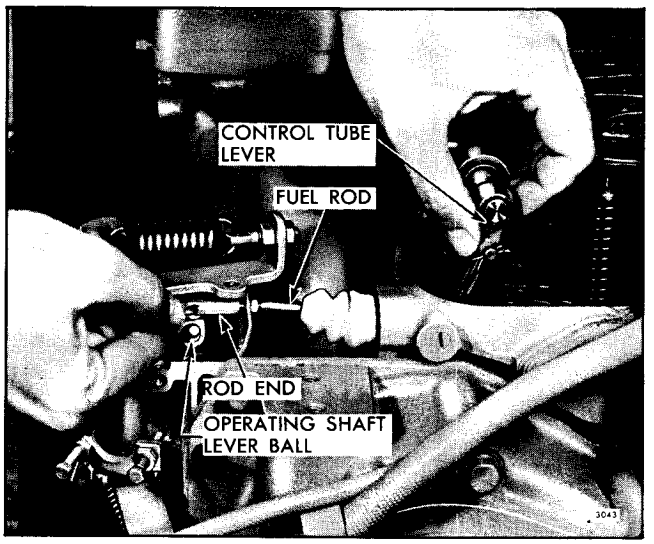


Fig. 4 - Adjusting Fuel Rod Length

cylinder heads and 550 r.p.m. on units with four valve cylinder heads.

2. Hold the Idle speed adjusting screw and tighten the lock nut securely.

Adjust Maximum No-Load Speed

1. Move the governor speed control lever, with the engine running, to the maximum speed position.

   NOTE: Do not overspeed the engine.

2. Adjust the maximum speed adjusting screw, see Fig. 6, until the desired No-Load speed is obtained.

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

Adjust Buffer Screw

1. With the engine running, screw in the buffer screw, see Fig. 7, until the spring just contacts the governor operating shaft lever and the roll is eliminated.

   NOTE: Do not raise the engine Idle speed more than 20 r.p.m. with the buffer screw. Check the maximum No-Load engine speed to see that it has not been increased over 25 r.p.m. by the buffer screw setting.

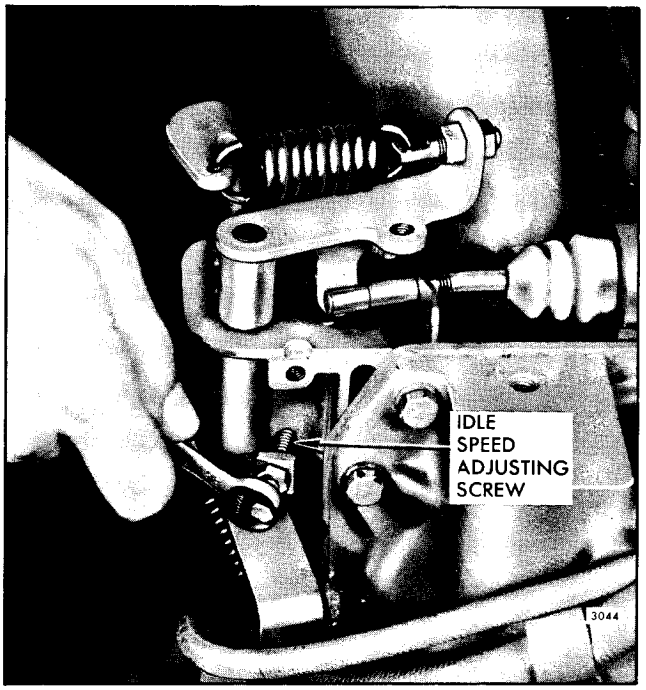


Fig. 5 - Adjusting Idle Speed

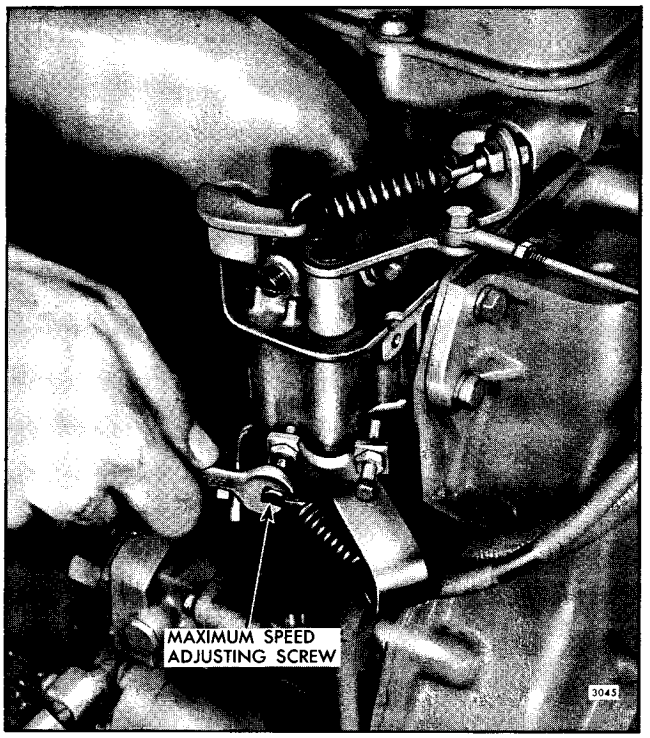


Fig. 6 - Adjusting Maximum No-Load Engine Speed

Adjust Governor Booster Spring

The governor booster spring is used on some units to reduce the force necessary to move the governor speed control from the Idle speed position to the maximum speed position. The booster spring should be adjusted as follows:

1. Reduce the tension on the booster spring, if not previously performed, to the minimum, by

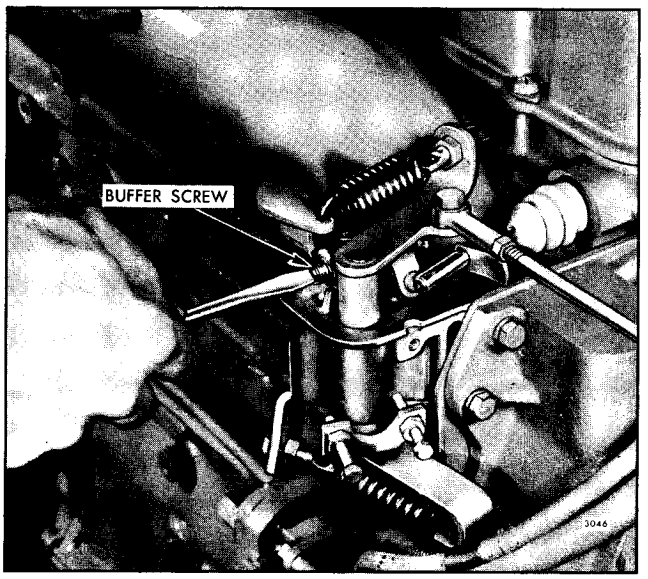


Fig. 7 - Adjusting Buffer Screw

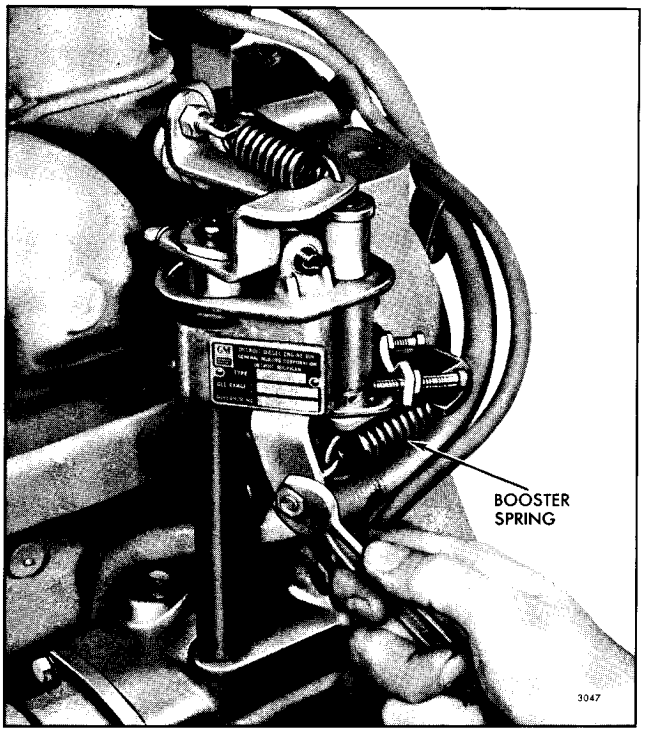


Fig. 8 - Adjusting Booster Spring

backing off the outer nut, see Fig. 8, until the threaded end of the booster spring eye bolt is flush with the end of the nut.

2. Adjust the eye bolt in its slot so that an imaginary center line drawn through the booster spring will align with an imaginary center line drawn through the throttle shaft. Secure the lock nuts on the eye bolt to retain the adjustment.

3. Move the speed control lever from the Idle position to the maximum speed position, noting the force required.

4. To reduce the force required to move the governor speed control, back off on the inner eye bolt nut and tighten the outer eye bolt nut increasing the booster spring tension.

   NOTE: Before tightening the eye bolt nuts, reposition the booster spring as in Step 2.

   The setting is correct when the speed control lever can be moved from the Idle speed to the Maximum speed position, while the engine is operating, with a fairly constant force and when released will return to the Idle speed position.

Adjust Engine Speed Droop

The adjustment of the governor spring tension outlined in "Adjust Governor Spring Tension" will result in approximately 7% droop from the Maximum No-Load speed to Full-Load speed. This is the optimum droop setting for most applications, however, the droop may be changed as necessary for the particular application.

1. Lower the droop by Increasing the governor spring tension.

2. Raise the droop by Decreasing the governor spring tension.

It should be noted, however, that a change in the governor spring tension will result in changing the engine Idle and Maximum speeds making their readjustment necessary.

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

After timing the fuel injectors and adjusting the exhaust valves, adjust an engine with an enclosed linkage variable speed governor as follows:

Adjust Governor Gap

1. With the engine stopped, remove the governor cover.
2. Place speed control lever, Fig. 1 in the maximum speed position.
3. Insert a .006" feeler gage between the spring plunger, and the plunger guide. 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.
4. Hold the adjusting screw and tighten the lock nut. Recheck gap and if necessary reset.
5. Install governor cover. The governor cover should be placed on the governor housing with the pin of the stop lever projecting into the slot of the differential lever and the cover screws tightened in the following manner:

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

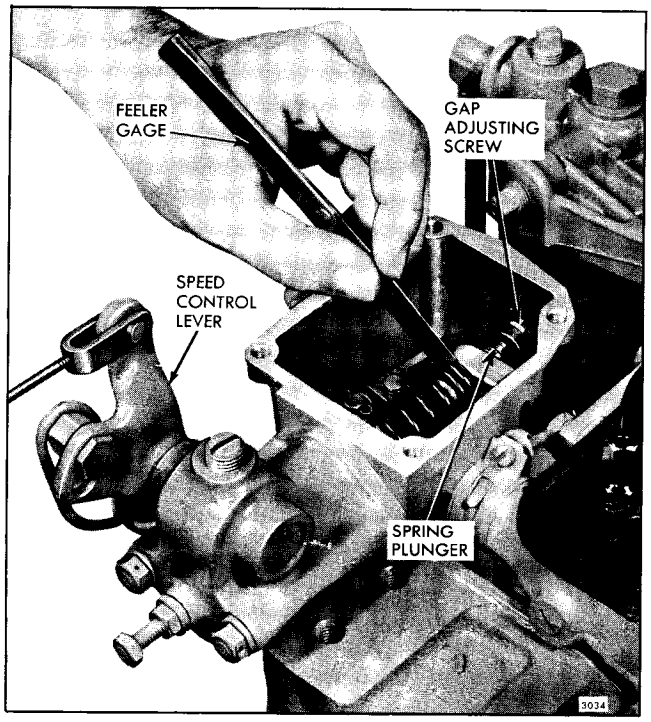


Fig. 1 - Adjusting Governor Gap

Fig. 2 - Positioning the Rear Injector Rack Control Lever

   b. Pull cover assembly away from engine to take up slack around cover retaining screws.

   NOTE: This step is necessary since no dowels project from the governor housing to locate the cover.

   c. Tighten cover attaching screws while performing step "b".

Position Injector Rack Control Levers

The position of the injector 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, Fig. 2 first to establish a guide for adjusting the remaining injector rack control levers.

1. Refer to Fig. 2 and disconnect any linkage attached to the stop lever.
2. Loosen the lock nut, Fig. 4, and back out the buffer screw approximately 5/8".
3. Loosen all the inner and outer injector rack adjusting screws. Be sure all the injector rack

control levers are free on the injector control tube.

4. Move stop lever to the RUN position and the speed control lever to the maximum speed position as shown in Fig. 2. Turn the inner adjusting screw down until a slight movement of the control tube is observed or a step up in effort is noted. This will place the rear 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 until they are tight.

   The above step should 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.

5. To be sure of proper rack adjustment, the following check should be performed:

   Hold the stop lever in the RUN position. Press down on the injector rack with a screw driver on 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, 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 governor control lever reaches the end of its travel. This will result in a step up in effort 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 rack is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

6. Manually hold the rear injector rack control lever in the full fuel position and turn down the inner adjusting screw on the injector rack control lever of the adjacent injector until the injector rack 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 adjusting screws until tight.

7. Recheck the rear injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while adjusting the adjacent injector. If the rack of the rear injector has become loose, back off slightly the inner adjusting screw on the adjacent injector rack control lever. Tighten outer adjusting screw.

8. Position the remaining control rack levers as outlined in items 6 and 7.

   When the settings are correct the racks of all injectors must be snug on the ball end of their respective rack control levers.

Adjust Maximum No-Load Speed

The maximum No-Load speed on units equipped with variable speed governor assemblies varies with the Full-Load operating speed desired, as shown in the following chart.

ENGINE SPEED DROOP

Full Load R.P.M.	R.P.M. DROOP RANGE	
	Engines with 2 Valves/Cylinder	Engines with 4 Valves/Cylinder
2800	---	175-200
2500	---	150-175
2200	160-185	125-150
2000	150-175	120-145
1800	130-155	120-145
1600	120-145	115-140

EXAMPLE: If the Full-Load speed is to be 2200 r.p.m. and the engine has four exhaust valves per cylinder then the No-Load speed setting should be between 2325 and 2350 r.p.m. to ensure the governor will move the injector racks into their FULL FUEL position at the desired FULL 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. 5 and disconnect the booster spring and retracting spring.

2. Remove the two bolts and withdraw the variable speed spring housing and variable speed spring plunger located inside spring housing.

3. Refer to Table I and determine the stops or shims required for the desired Full-Load speed for in-line engines with Two Valve Cylinder Heads.

TABLE I
TWO VALVE CYLINDER HEAD

Full Load Speed	Stops		Shims
	Solid Ring	Split Ring	
1200-1400	1	2	As Required
1401-1800	1	1	As Required
1801-2350	1	0	As Required
2351-2200	0	0	As Required

Refer to Table II and determine the stops or shims required for the desired Full-Load speeds for in-line engines with Four Valve Cylinder Heads.

TABLE II
FOUR VALVE CYLINDER HEAD

Full Load Speed	Stops		Shims
	Solid Ring	Split Ring	
1200-1575	1	2	As Required
1576-2025	1	1	As Required
2026-2625	1	0	As Required
2626-2800	0	0	As Required

4. Install the variable speed spring housing and recheck the maximum No-Load speed.

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

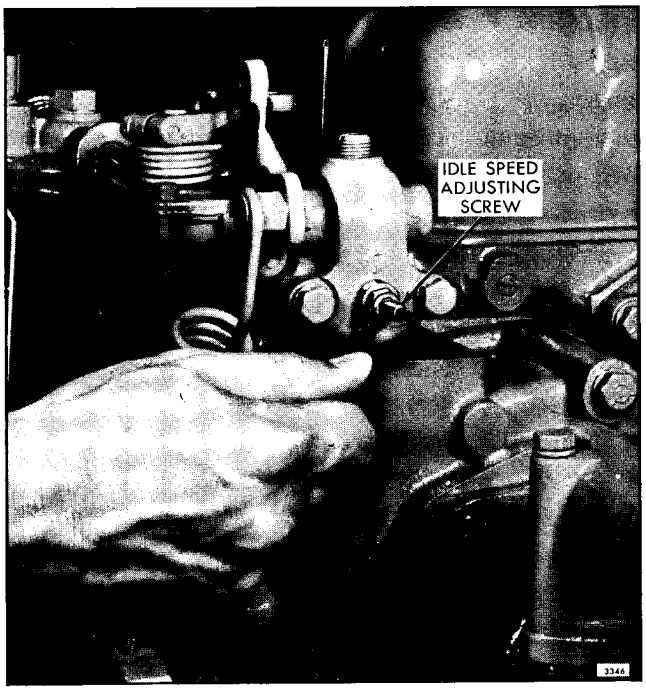


Fig. 3 - Adjusting Idle Speed

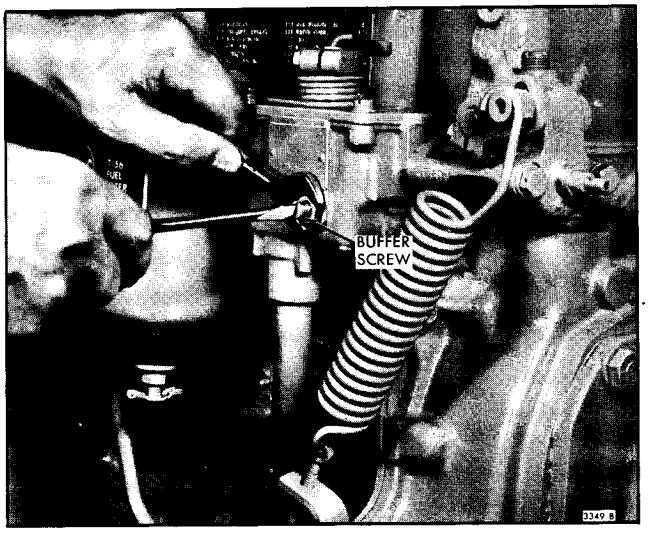


Fig. 4 - Adjusting Buffer Screw

Governor shims are available in .010 and approximately .078" in thickness.

NOTE: If the maximum No-Load speed is raised or lowered more than 50 r.p.m. by the installation or removal of the governor shims, the governor gap should be rechecked, as previously outlined in "Adjust Governor Gap." If re-adjustment of the governor gap is required, the position of the injector racks must be rechecked.

Adjust Idle Speed

With the maximum No-Load speed properly adjusted, the idle speed may be adjusted as follows:

1. Start the engine and with stop lever in the RUN position place the speed control lever in IDLE position as shown in Fig. 3.

2. With the engine operating loosen lock nut and turn idle adjusting screw until engine idles at the recommended idle speed.

   The recommended idle speed is 500 r.p.m. for engines with two exhaust valves per cylinder and 550 r.p.m. for units with four exhaust valves per cylinder, but may vary with special engine applications.

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

14.4.3 VARIABLE SPEED GOVERNOR ADJUSTMENT

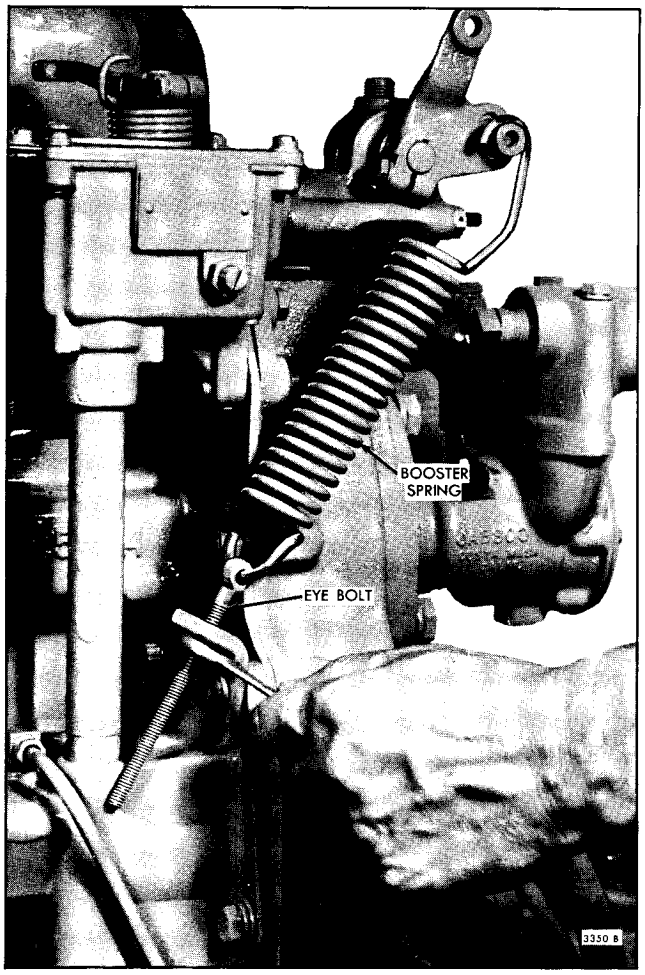


Fig. 5 - Adjusting Booster Spring

Adjust Buffer Screw

With the idle speed properly adjusted, the buffer screw may be adjusted as follows:

1. With the engine at idle speed, screw IN the buffer screw, Fig. 4, so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

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

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

Adjust Booster Spring

With the idle speed set, the booster spring is adjusted as follows:

1. Refer to Fig. 5 and loosen the booster spring retaining nut on speed control lever. Loosen the nut and lock nut on the eye bolt at the opposite end of the booster spring.

2. Move the bolt up or down in the slot of the speed control lever until the center of the bolt is on or slightly below 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 full throttle and release. The speed control lever should return to the idle position. If it does not, reduce the booster spring tension. If it does, 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 to operate the speed control lever.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (Tractor Type)

After timing the fuel injectors and adjusting the exhaust valves, adjust engines with a variable speed mechanical governor as follows:

Position Injector Rack Control Levers

The setting of the injector control racks govern the quantity of fuel injected into each cylinder. All injectors of an engine must be set to inject the same quantity of fuel into each cylinder, to ensure equal distribution of the load.

The injector racks should be set as follows:

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

2. Loosen all inner and outer rack control lever adjusting screws. Check each rack control lever to ascertain that it is loose on the control tube.

3. Position the adjusting screws of the rear cylinder, Fig. 1, until both screws are equal in height and tight on the control tube.

4. Check for at least 1/16'' clearance between the the fuel rod and the boss in the cylinder head. This is done by lifting upward on bell crank lever until the injector control rack is in the FULL FUEL position.

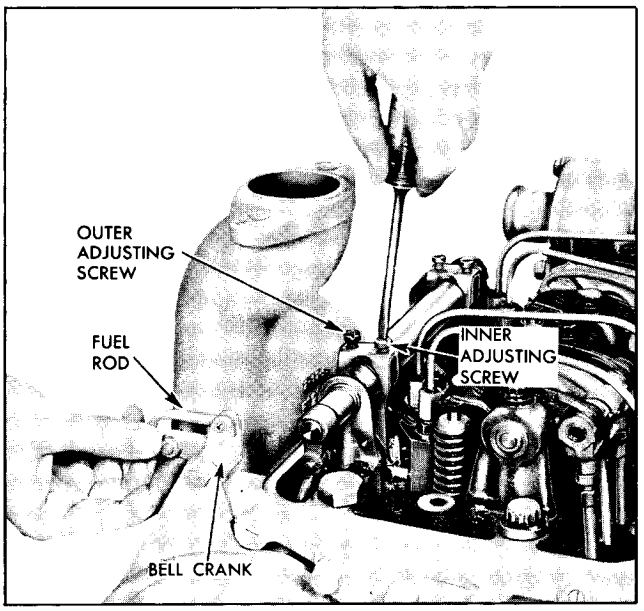


Fig. 1 - Positioning Injector Rack Control Levers

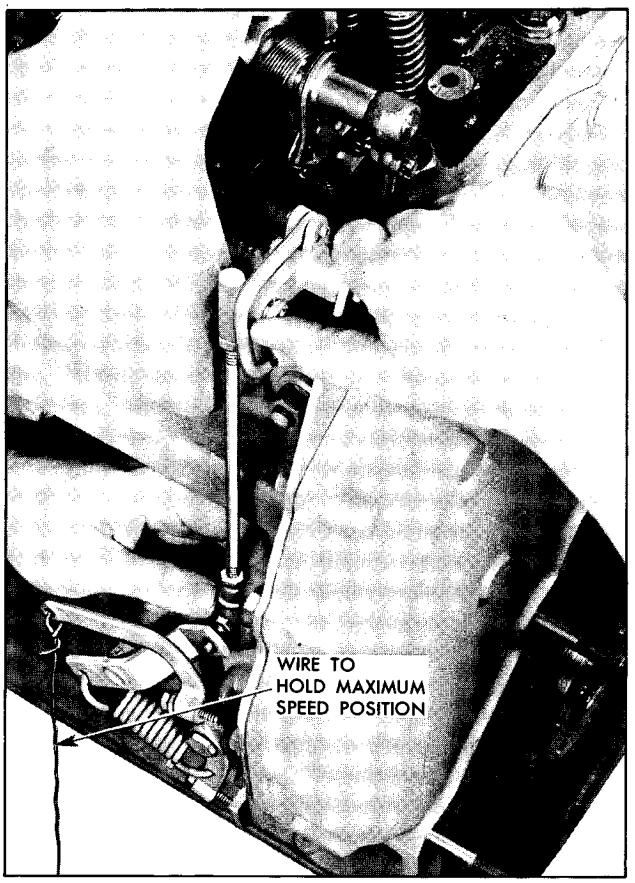


Fig. 2 - Adjusting Length of Vertical Link

If the clearance is insufficient, loosen outer control rack adjusting screw, Fig. 1, and tighten inner adjusting screw until a clearance of 1/16'' is present. Tighten both inner and outer adjusting screws.

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

6. Recheck the rear injector rack to be sure that 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 slightly the inner adjusting

14.4.4 TRACTOR TYPE GOVERNOR ADJUSTMENT

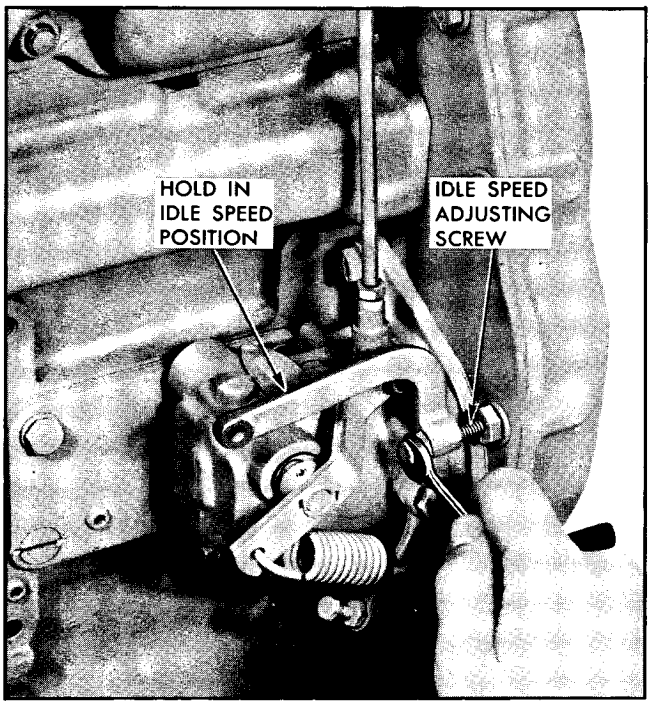


Fig. 3 - Adjusting Idle Speed

screw on the adjacent injector rack control lever and tighten adjustment with the outer adjusting screw.

To check the tightness of an injector control rack move with the control tube lever into the FULL FUEL position and press straight down on the rack with a screw driver. The rack should return to its original position.

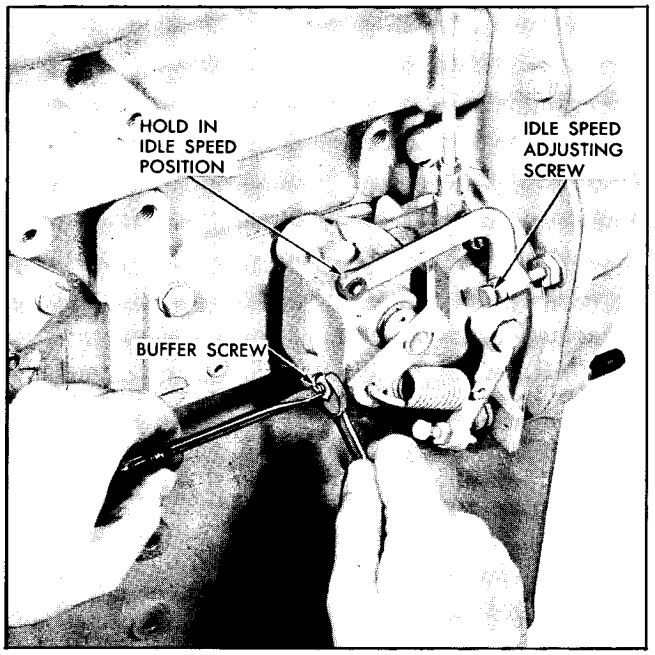


Fig. 4 - Adjusting Buffer Screw

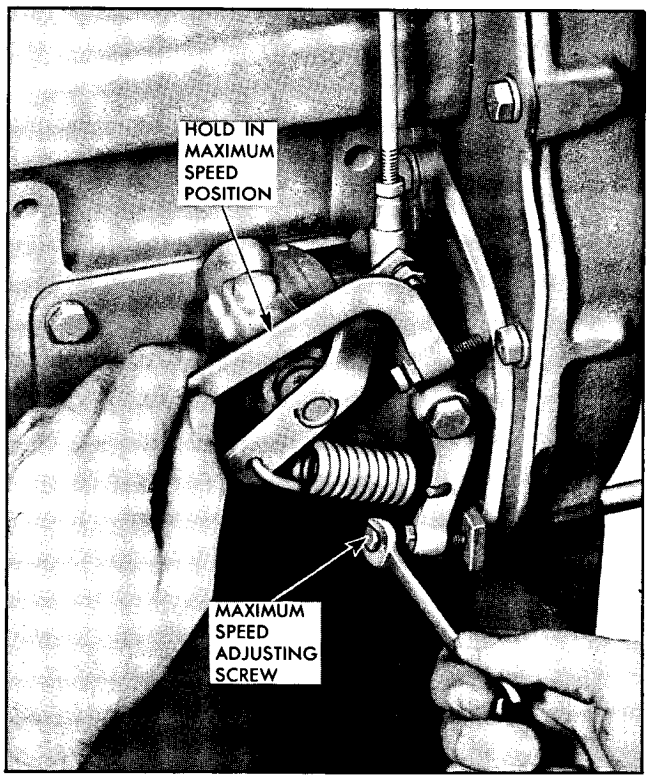


Fig. 5 - Adjusting Maximum No-Load Speed

Adjust Governor Linkage

1. Advance governor rocker shaft lever to the maximum fuel position and retain. The rocker shaft lever can be held in the FULL FUEL position after backing out the buffer screw, see Fig. 4, by advancing the governor speed control lever to its maximum speed position.
2. Hold injector control racks in the FULL FUEL position, then adjust the length of the vertical link assembly, by turning the ball and socket assembly onto the link assembly, until it can be connected to the rocker shaft lever. See Fig. 2.
3. Check injector racks to be sure governor holds the racks in the FULL FUEL position.

Adjust Engine Idle Speed

1. Back out buffer screw.
2. Start engine and adjust idle speed adjusting screw, Fig. 3, to obtain the desired idle speed.

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

Adjust Buffer Screw

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

   NOTE: Do not raise engine speed more than 20 r.p.m. with the buffer screw.

2. Tighten lock nut of buffer screw to retain adjustment.

Adjust Maximum No-Load Speed

1. Move speed control lever, with engine running, to obtain the desired maximum no-load speed. It may be necessary to back out the maximum speed adjusting bolt to obtain the desired speed.

   NOTE: Do not overspeed engine.

2. Adjust maximum speed adjusting bolt, Fig. 5, to the desired no-load speed obtained in step one.
3. Tighten maximum speed adjusting bolt lock nut to retain adjustment.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (V-TYPE ENGINE)

The variable speed mechanical governor assembly is mounted near the rear of 6V-53 engines, between the flywheel housing and blower, as shown in Fig. 1. The governor is driven by the right blower rotor drive gear. The left blower rotor drive gear is driven by a shaft, that passes through the governor housing, from the engine gear train.

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

Adjust Governor Gap

With the engine stopped, the governor gap may be set as follows:

1. Remove the governor cover.
2. Place the speed control lever in the MAXIMUM SPEED position.
3. 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.
4. Hold the adjusting screw and tighten the lock nut. Check the gap. If necessary readjust.
5. 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.

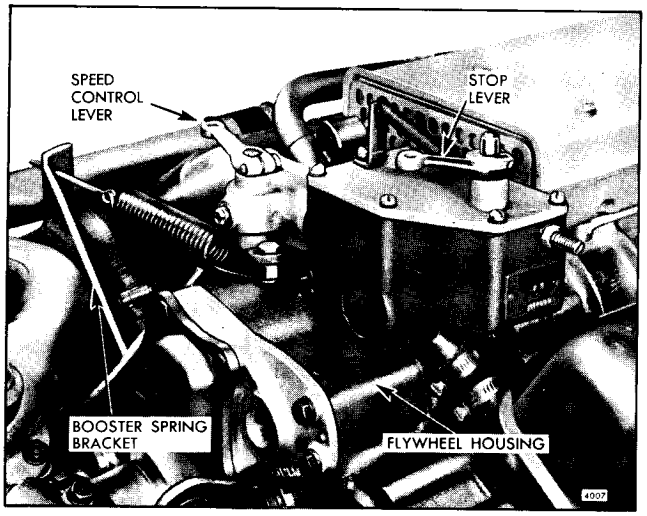


Fig. 1 - Variable Speed Governor Mounting

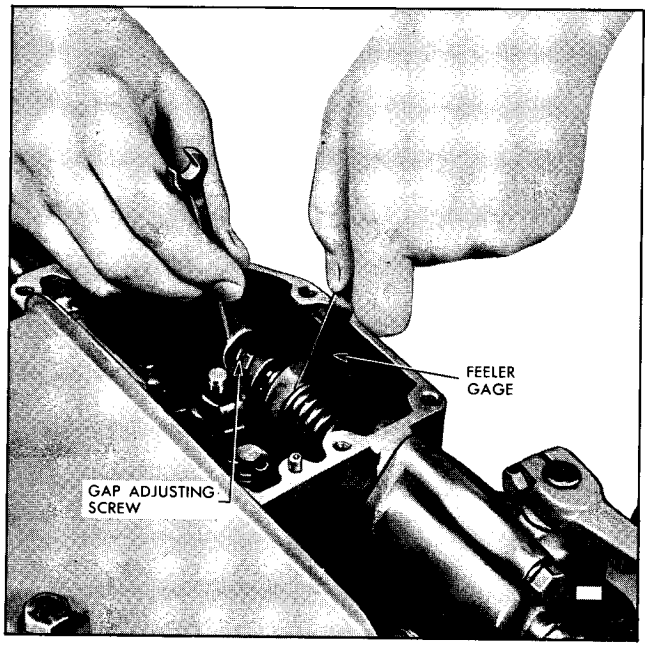


Fig. 2 - Adjusting Governor Gap

The letters R or L indicate the injector location in the right or left cylinder bank, 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 injector rack control levers.

1. Disconnect any linkage attached to the governor levers.
2. Loosen the buffer screw lock nut and back out the buffer screw approximately 3/4".
3. Remove the valve rocker covers.
4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.
5. Loosen all the inner and outer injector rack control lever adjusting screws on both cylinder heads. Be sure all the injector rack control levers are free on the injector control tubes.

14.4.5 VARIABLE SPEED GOVERNOR ADJUSTMENT

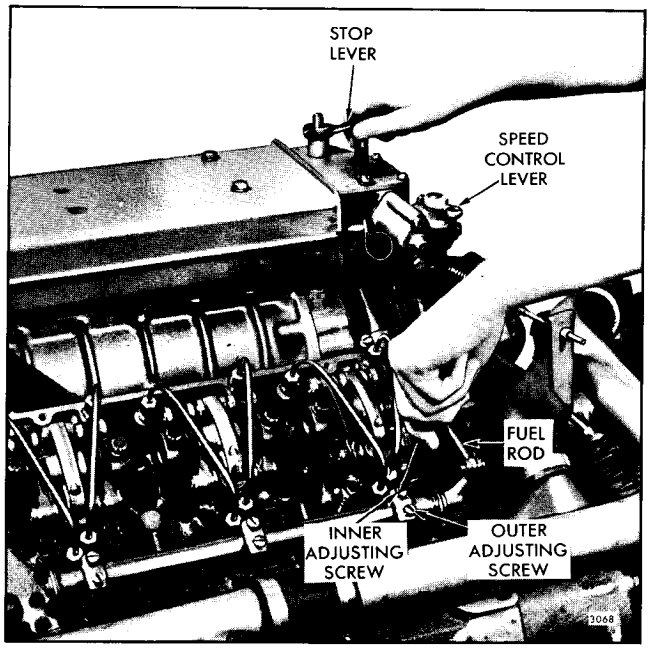


Fig. 3 - Positioning No. 3L Injector Rack Control Lever

6. Move speed control lever to the MAXIMUM SPEED position.

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

   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.

8. To be sure of proper rack adjustment, the following check can be performed.

   Hold the stop lever in the RUN position. 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, 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 governor stop lever reaches the end of its travel. This will result in a step up in effort 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 inner adjusting screw slightly and tighten the outer adjusting screw.

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

10. Insert clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position No. 3R injector rack control lever as previously outlined in Step 7 for the No. 3L injector rack control lever.

11. Insert the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Repeat the check on the 3L and 3R injector rack control lever as outlined in Step 8.

    Carefully observe and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

12. Manually hold No. 3L injector rack in the FULL FUEL position and turn down inner adjusting screw of No. 2L injector rack control lever until the injector rack of No. 2L injector has moved into the FULL FUEL position. Turn outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

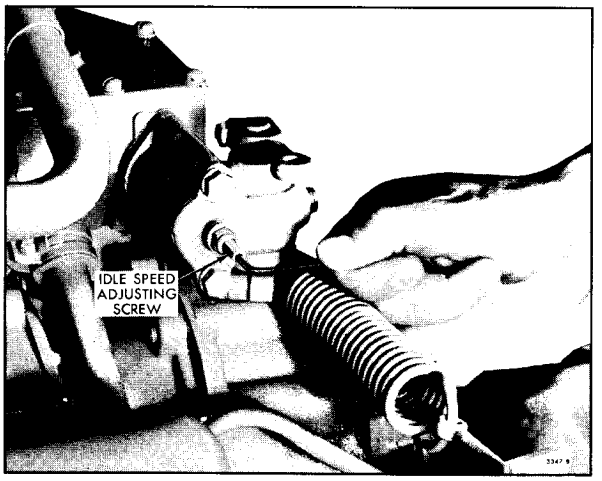


Fig. 4 - Adjusting Idle Speed

13. Recheck No. 3L injector rack to be sure that it has remained snug on the ball end of the rack control lever while positioning No. 2L injector rack. If the rack of No. 3L injector has become loose, back off slightly the inner adjusting screw on No. 2L injector rack control lever. Tighten 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.

14. Position 1L injector rack control lever as outlined in Steps 12 and 13.

15. Position No. 2R and 1R injector racks as outlined above for the left cylinder bank in Steps 12 through 14.

16. Replace the engine rocker covers.

Adjust Maximum No-Load Speed

The maximum No-Load speed varies with the Full-Load operating speed desired, as shown in the following chart.

ENGINE SPEED DROOP

Full Load R.P.M.	R.P.M. DROOP RANGE
2800	140-165
2200	125-150
1600	115-140

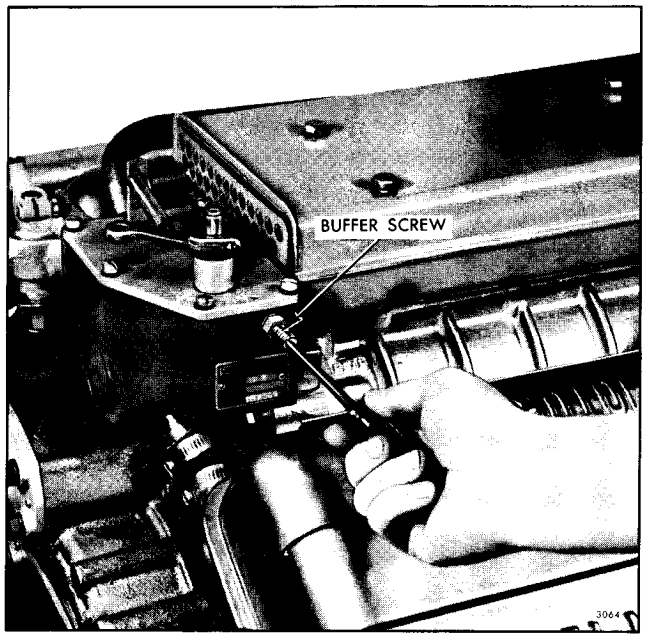


Fig. 5 - Adjusting Buffer Screw

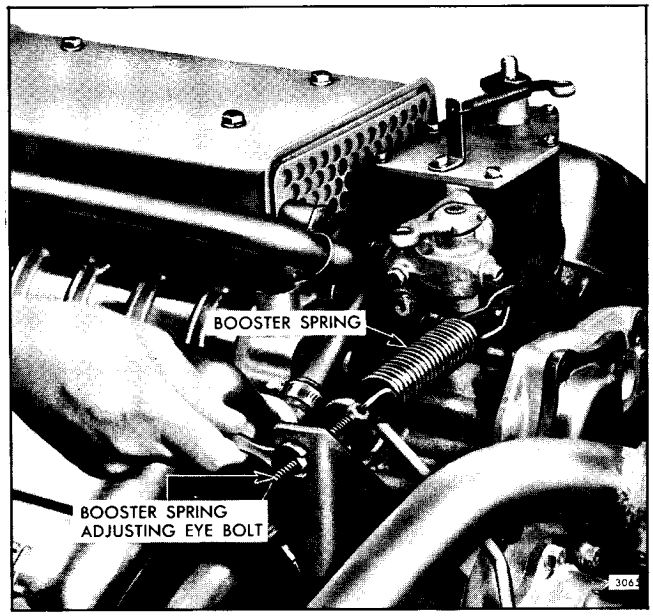


Fig. 6 - Adjusting Booster Spring

EXAMPLE: If the Full-Load speed is to be 2200 r.p.m., then the No-Load speed setting should be between 2325 and 2350 r.p.m. to ensure the governor will move the injector racks into their FULL FUEL position at the desired FULL 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 booster spring and the retracting spring.

2. Remove the two bolts and withdraw the variable speed spring housing and the variable speed spring plunger located inside the spring housing.

3. Refer to the Table and determine the stops or shims required for the desired Full-Load speed.

6V-53 ENGINES

Full Load Speed	Stops		Shims*
	Solid Ring	Split Ring	
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 the shims to obtain the necessary operating speed. For each .001" in shims added the operating speed will increase approximately 2 r.p.m.

Governor shims are available in .010" and approximately .078" in thickness.

> **NOTE:** If the maximum No-Load speed is raised or lowered more than 50 r.p.m. by the installation or removal of the governor shims, the governor gap should be rechecked, as previously outlined in "Adjust 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

With the maximum no-load speed properly adjusted, the idle speed may be adjusted 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 idle speed adjusting screw lock nut. Turn the idle speed adjusting screw, Fig. 4, until the engine idles at the recommended idle speed.

   The recommended idle speed is 550 r.p.m., but may vary with special engine applications.

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

Adjust Buffer Screw

With the idle speed properly adjusted, the buffer screw may be adjusted as follows:

1. With engine at idle speed, screw IN buffer screw, Fig, 5, so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

   > **NOTE:** Do not raise the engine idle speed more than 15 r.p.m. with the buffer screw.

2. Hold buffer screw and tighten lock nut.

Adjust Booster Spring

With the idle speed set, the booster spring is adjusted as follows:

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

2. Move the bolt up or down in the slot of speed control lever until the center of the bolt is on or slightly below 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 full throttle and release. The speed control lever should return to idle position. If it does not, reduce the booster spring tension. If it does, 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.

HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

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 engines having a hydraulic governor assembly 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 until both screws are equal in height and tight on the control tube. Check the fuel rod to cylinder head bolt or to cylinder head casting, below 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 cylinder head casting, re-adjust the screws to obtain the 1/16" clearance.

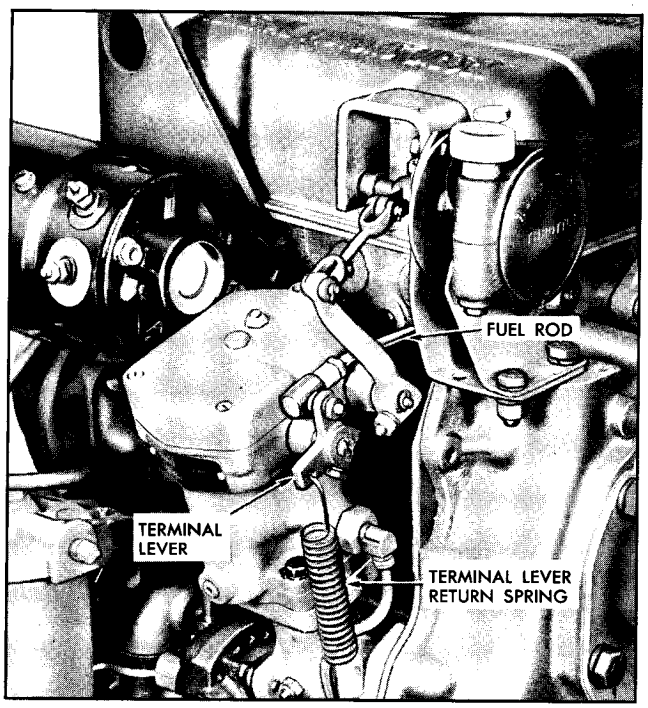


Fig. 1 - Hydraulic Governor Mounted on Series 53 Engine

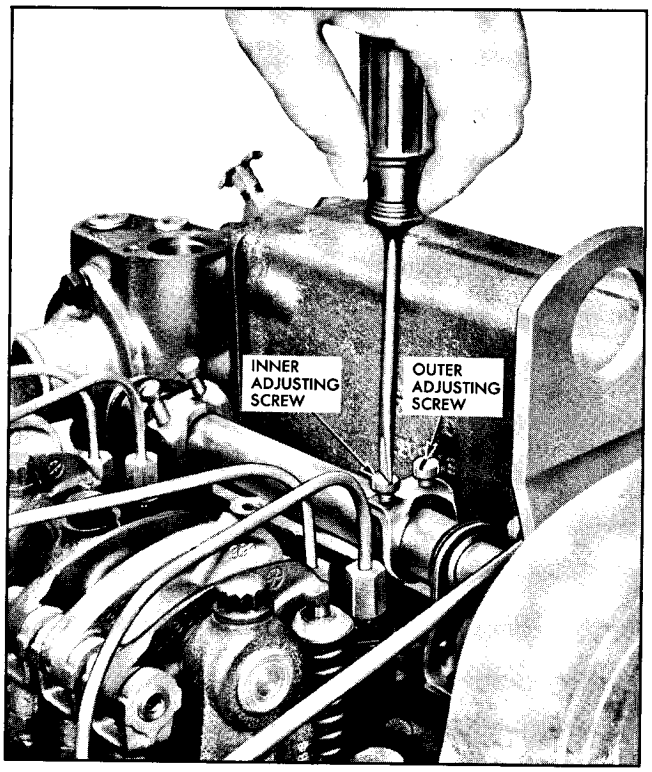


Fig. 2 - Adjusting Height of Rack Control Lever Adjusting Screws

2. Remove governor terminal lever return spring.

3. Remove fuel rod ball joint from terminal shaft lever and terminal lever from terminal shaft.

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

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

   NOTE: It will be necessary to slide terminal lever partially off the shaft to attach fuel rod ball joint to terminal lever.

6. Hold the terminal lever in the FULL FUEL position and loosen the inner adjusting screw 1/8

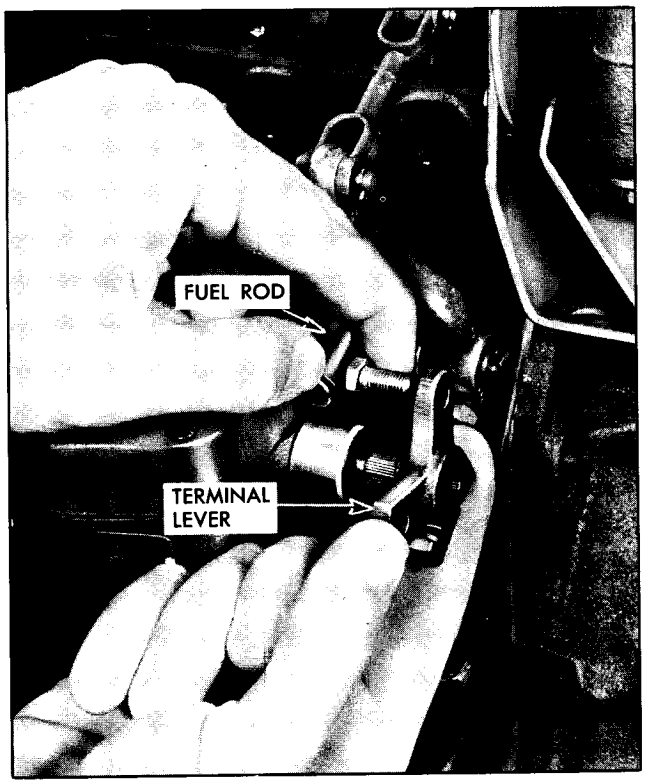


Fig. 3 - Adjusting Length of Fuel Rod

of a turn and 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 clevis pin between the fuel rod and the injector control tube lever.

   NOTE: Located under the control lever is a cylinder head oil drain back hole which should be covered when removing the fuel rod clevis pin to prevent its loss and possible damage to the engine.

8. Manually hold the rear injector in the FULL FUEL position and turn down 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 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 until tight.

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 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 items 8 and 9.

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

12. Install 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, the fuel rod, injector rack control levers and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start engine and run 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 lock nut and back off maximum speed adjusting screw, shown in Fig. 5, approximately 5/8''.

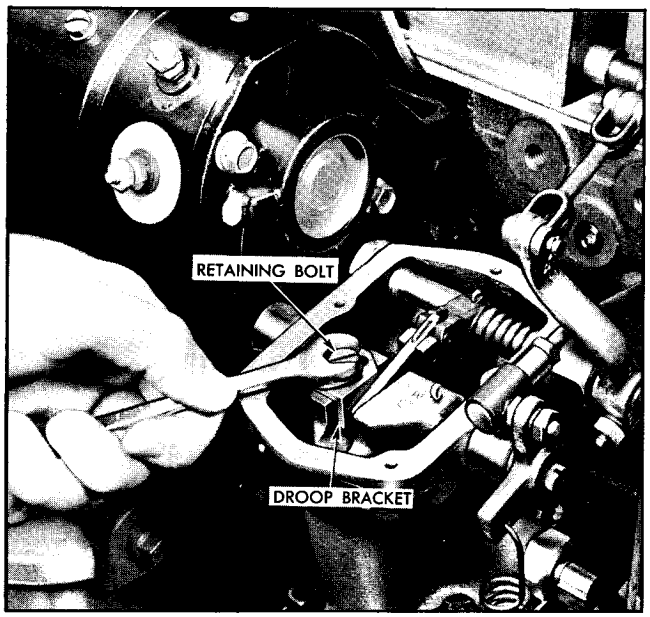


Fig. 4 - Adjusting Droop Bracket

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

5. With the throttle in 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 engine speed after 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 engine and again loosen droop bracket retaining bolt and move droop adjusting bracket IN toward the engine. Tighten bolt. To increase the speed droop, move droop adjusting bracket OUT, away from 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 engine no-load and full-load speeds shown in the following table.

Full-Load	No-Load
50 cycles 1000 r.p.m.	52.5 cycles 1050 r.p.m.
60 cycles 1200 r.p.m.	62.5 cycles 1250 r.p.m.
50 cycles 1500 r.p.m.	52.5 cycles 1575 r.p.m.
60 cycles 1800 r.p.m.	62.5 cycles 1875 r.p.m.

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

8. Install governor cover.

Adjust Maximum No-Load Speed

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

1. With engine operating at no-load, adjust engine speed until engine is operating at approximately 10% higher than the rated full-load speed.

2. Turn maximum speed adjusting screw, Fig. 5, in until engine is operating approximately 8% above the rated full-load speed.

3. Hold screw and tighten maximum speed adjusting screw lock nut.

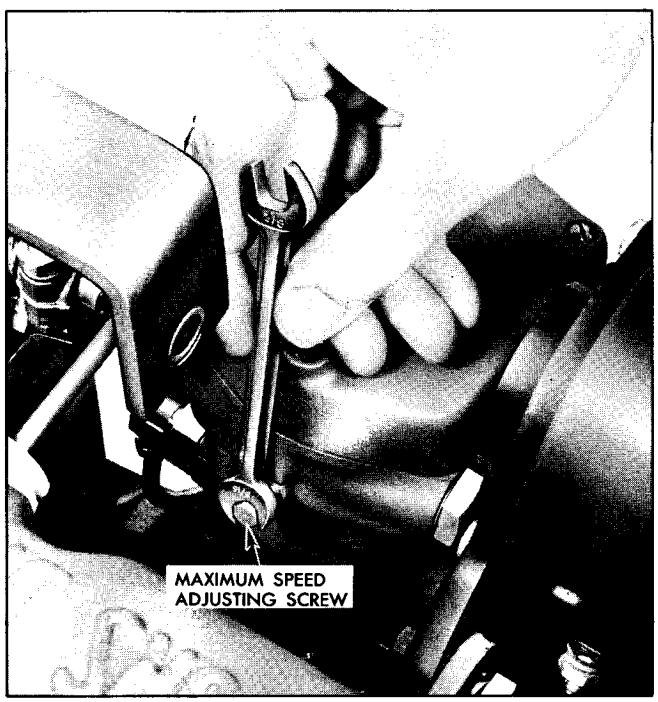


Fig. 5 - Adjusting Maximum Engine Speed

ENGINE TUNE-UP PROCEDURES

Approximately 100 hours or 3,000 miles after the initial start, or after an engine overhaul, and thereafter at 1000 hour or 30,000 mile intervals, check the various engine adjustments and make the necessary corrections.

Three types of governors are used. Since each governor has different characteristics, the tune-up procedure varies accordingly. The three types are:

1. Limiting speed mechanical.
2. Variable speed mechanical.
3. Hydraulic.

The mechanical engine governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double weight limiting speed governor. A single weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor, or injectors have been replaced or overhauled, then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine (see Section 14.1).

To tune-up an engine completely, all of the adjustments, except the valve bridge adjustment on four valve cylinder heads, are made by following the applicable tune-up sequence given below, after the engine has reached the normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

> **NOTE:** The exhaust valve bridges on the four valve cylinder head are adjusted at the time the cylinder head is installed on the engine and, until wear occurs, no further adjustment is required. When wear is evident, perform a complete valve bridge adjustment as outlined in Section 1.2.2.

The tune-up procedures apply to the individual engines of multiple engine units as well as to the single engine units. However, the throttle linkage of multiple engine units must be adjusted after the individual engines have been tuned-up.

Tune-Up Sequence for Mechanical Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).
9. Adjust the fuel modulator (if used).

> **NOTE:** The steps necessary to adjust an engine with a fuel modulating governor are covered in Section 14.5.

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rod.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Compensation adjustment (PSG governors only).
7. Adjust the speed droop.
8. Adjust the maximum no-load speed.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders, and eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will insure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

ENGINES WITH TWO VALVE CYLINDER HEADS

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Place the governor throttle control lever in the NO-FUEL position.

2. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation as the bolt will be loosened.

3. Loosen the push rod lock nut.

4. Place a .013" feeler gage, tool J 9708, between the valve stem and the rocker arm (see Fig. 1). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

5. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.

6. Recheck the clearance. At this time, if the adjustment is correct, the .011" feeler gage, J 9708, will pass freely between the valve stem and the rocker arm, but the .013" feeler gage will not pass through.

7. Check and adjust the remaining valves in the same manner as outlined above.

Exhaust Valve Clearance Adjustment (Hot Engine)

Maintaining the normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become insufficient.

With the engine at normal operating temperature (160°-185°F.), recheck the exhaust valve clearance with feeler gage J 9708. At this time, if the valve clearance is correct, the .008" feeler gage will pass freely between the valve stem and the rocker arm, but the .010" gage will not pass through.

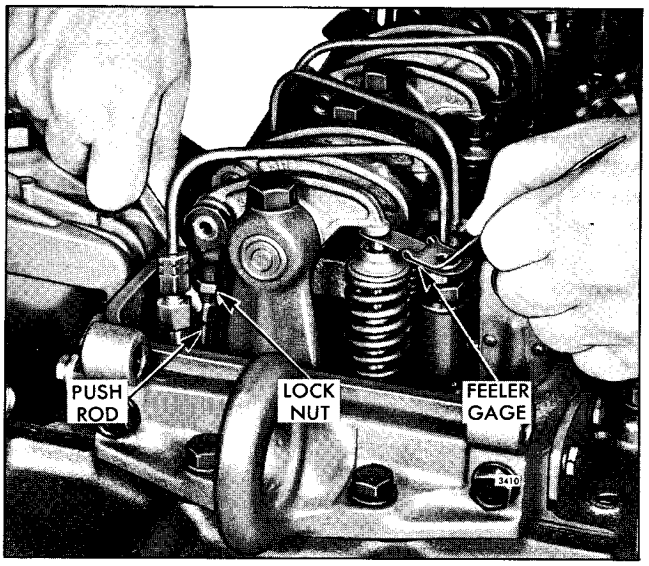


Fig. 1 - Adjusting Valve Clearance

14.1 EXHAUST VALVE ADJUSTMENT

ENGINES WITH FOUR VALVE CYLINDER HEADS

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. Until wear occurs, no further adjustment is required on the exhaust valve bridges. When wear is evident, make the necessary adjustments as outlined in Section 1.2.2.

The exhaust valve clearance is always adjusted at the push rod. DO NOT DISTURB THE EXHAUST VALVE BRIDGE ADJUSTING SCREW.

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Place the governor throttle control lever in the NO-FUEL position.
2. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation as the bolt will be loosened.
3. Loosen the push rod lock nut.
4. Place a .017" feeler gage, tool J 9708, between the end of the valve stem and the valve bridge adjustment screw (spring-loaded bridge only) or between the valve bridge and the valve rocker arm pallet (unloaded bridge only) -- see Figs. 2 and 3. Adjust the push rod to obtain a smooth "pull" on the feeler gage.
5. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.
6. Recheck the clearance. At this time, if the adjustment is correct, the .015" feeler gage, J 9708, will pass freely between the valve stem and the adjustment screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .017" feeler gage will not pass through.
7. Check and adjust the remaining valves in the same manner as outlined above.

Exhaust Valve Clearance Adjustment (Hot Engine)

Maintaining the normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become insufficient.

With the engine at normal operating temperature (160°-185°F.), recheck the exhaust valve clearance with feeler gage J 9708. At this time, if the valve clearance is correct, the .013" feeler gage must pass freely between the valve stem and the valve bridge adjusting screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .015" feeler gage must not pass through. Readjust the push rod if necessary.

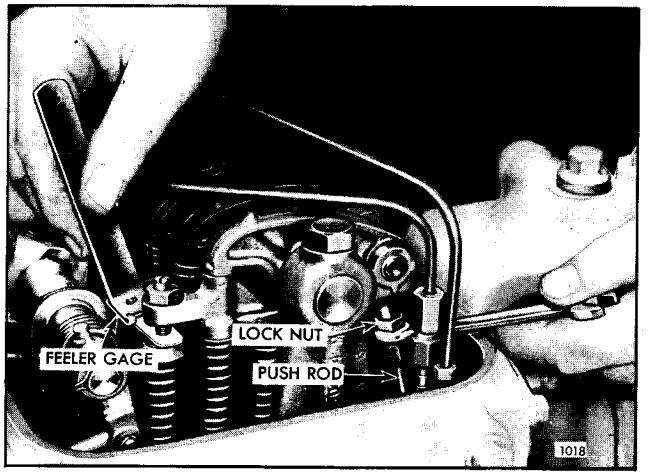


Fig. 2 - Adjusting Valve Clearance (Spring-Loaded Valve Bridge)

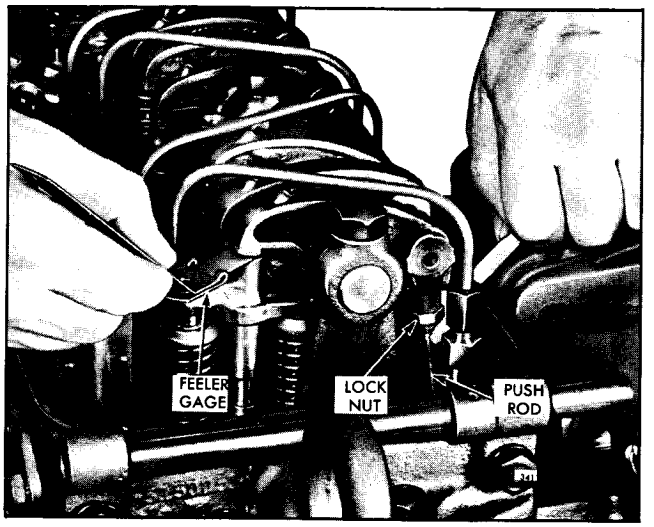


Fig. 3 - Adjusting Valve Clearance (Unloaded Valve Bridge)

TIMING FUEL INJECTORS

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed, in firing order sequence, during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the engine firing order.

Use the proper timing gage as indicated in the following chart.

INJECTOR TIMING GAGE CHART

Injector	Timing Gage Dimension	Timing Gage Tool Number
50	1.484"	J 1242
TV55	1.484"	J 1242
HV55	1.484"	J 1242
55E	1.460"	J 1853
N55	1.460"	J 1853
S55	1.460"	J 1853
60	1.484"	J 1242
TV6	1.484"	J 1242
DF6	1.484"	J 1242
HV6	1.484"	J 1242
6E6	1.460"	J 1853
6E8	1.460"	J 1853
6S8	1.484"	J 1242
60E	1.460"	J 1853
HE6	1.460"	J 1853
N60	1.460"	J 1853
S60	1.460"	J 1853
N65	1.460"	J 1853
S65	1.460"	J 1853
70	1.460"	J 1853
HV7	1.460"	J 1853
N70	1.460"	J 1853
S70	1.460"	J 1853
80	1.460"	J 1853
HV8	1.460"	J 1853
N80	1.460"	J 1853
S80	1.460"	J 1853
90	1.460"	J 1853
HV9	1.460"	J 1853
S90	1.460"	J 1853

Time Fuel Injector

1. Place the governor control lever in the NO-FUEL position.
2. Rotate the crankshaft until the exhaust valves are fully depressed on the particular cylinder to be timed.

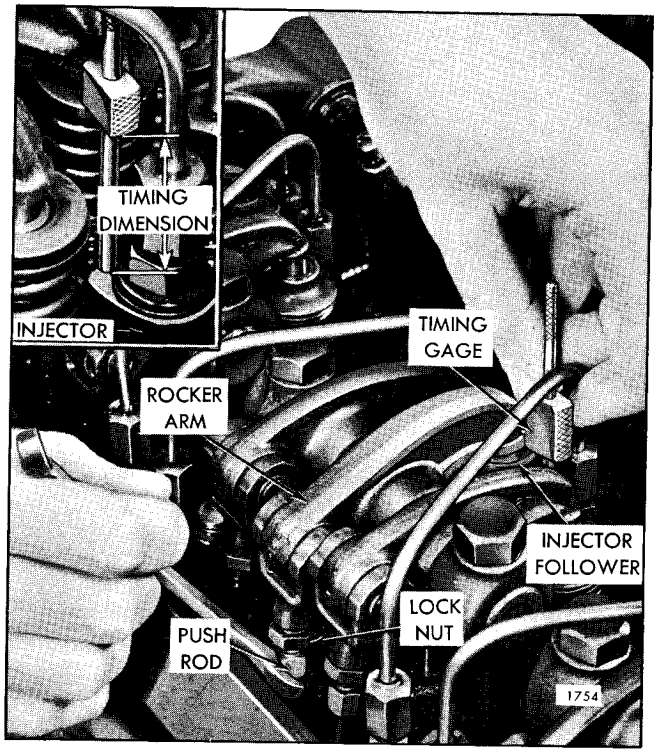


Fig. 1 - Timing Fuel Injectors

CAUTION: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation as the bolt will be loosened.

3. Place the small end of the injector timing gage in the hole provided in the top of the injector body, with the flat of the gage toward the injector follower (see Fig. 1).
4. Loosen the push rod lock nut.
5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.
6. Hold the push rod and tighten the lock nut. Check the adjustment and, if necessary, readjust the push rod.
7. Time the remaining injectors in the same manner as outlined in items 1 through 6.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust engine Single and Double Weight Limiting Speed Mechanical Governor Assemblies after adjusting the exhaust valves and timing the fuel injectors as follows:

Adjust the Governor Gap—Single Weight Governor

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

1. With the engine stopped, remove two bolts and withdraw the governor high speed spring retainer cover.

2. Start the engine. Then loosen the idle speed adjusting screw lock nut (56), see Fig. 2. Turn the idle speed adjusting screw (55) to obtain the recommended idle speed. The recommended idle speed is 550 rpm for single weight governors, but may vary with special engine applications.

3. With the engine stopped, remove the governor cover.

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

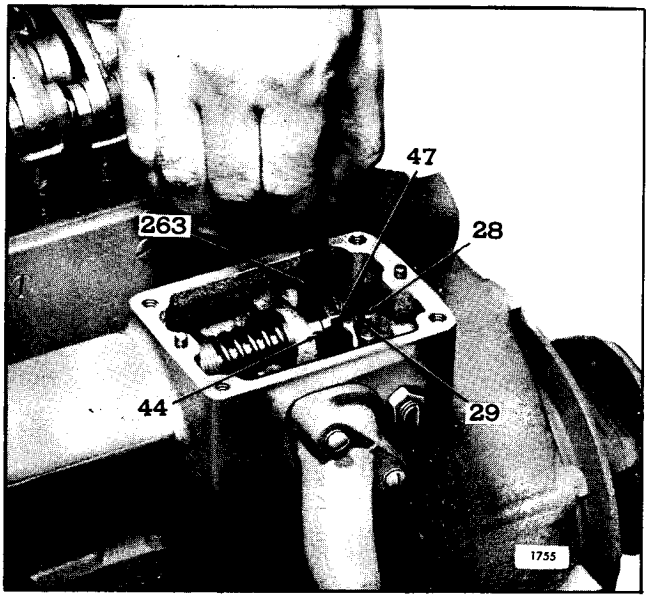


Fig. 1 - Adjusting Governor Gap

28. Screw--Gap Adjusting
29. Lock Nut
44. Plunger--High Speed Spring
47. Cap--Low Speed Spring
263. Gage--Governor Gap-Tool J 5407

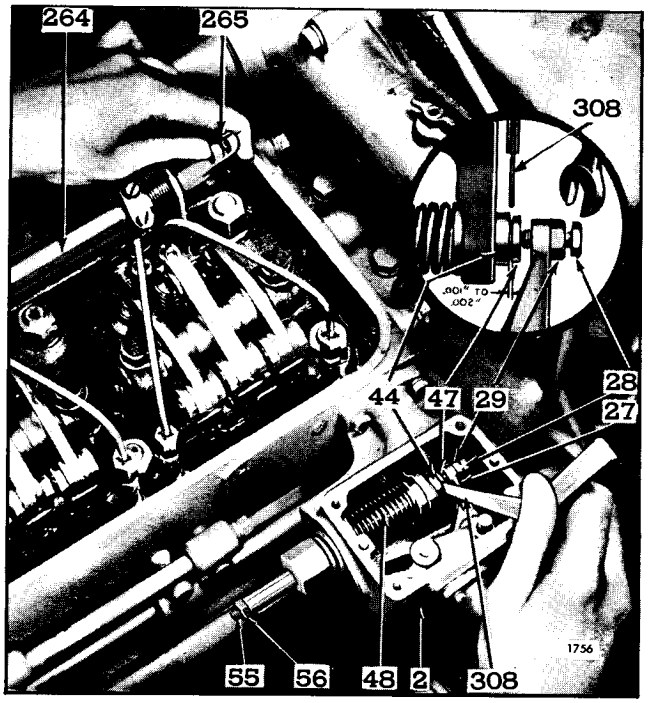


Fig. 2 - Adjusting Governor Gap

2. Housing--Governor Control
27. Lever--Operating Shaft
28. Screw--Gap Adjusting
29. Lock Nut
44. Plunger--High Speed Spring
47. Cap--Low Speed Spring
48. Spring--High Speed
55. Screw--Idle Speed Adjusting
56. Lock Nut
264. Tube--Injector Control
265. Lever--Injector Control Tube
308. Feeler Gage Set--Tool J 3172

5. Check the gap between the low speed spring cap (47) and the high speed spring plunger (44) with tool J 5407 (.170") as shown in Fig. 1.

6. If required, loosen the lock nut (29) and turn the gap adjusting screw (28) until a slight drag is felt on the gage.

7. Hold the adjusting screw and tighten the lock nut.

8. Recheck the gap and readjust if necessary.

9. Install the fuel rod between the governor and injector control tube lever.

10. Install the governor cover.

Adjust the Governor Gap—Double Weight Governor

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

14.3 LIMITING SPEED GOVERNOR ADJUSTMENT

1. With the engine stopped, remove the two bolts and withdraw the governor high speed spring retainer cover.

2. Start the engine. Then loosen the idle speed adjusting screw lock nut (56) see Fig. 2. Turn the idle speed adjusting screw (55) to obtain the recommended idle speed. The recommended idle speed is 450 rpm for double weight governors, but may vary with special engine applications.

3. Remove the governor cover.

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

5. Start and run the engine between 800 and 1000 rpm by manual operation of the control tube lever.

   CAUTION: Do not overspeed the engine.

6. Check the gap between the low speed spring cap and the high speed plunger with a .0015" feeler gage. If the gap setting is incorrect, reset the gap adjusting screw.

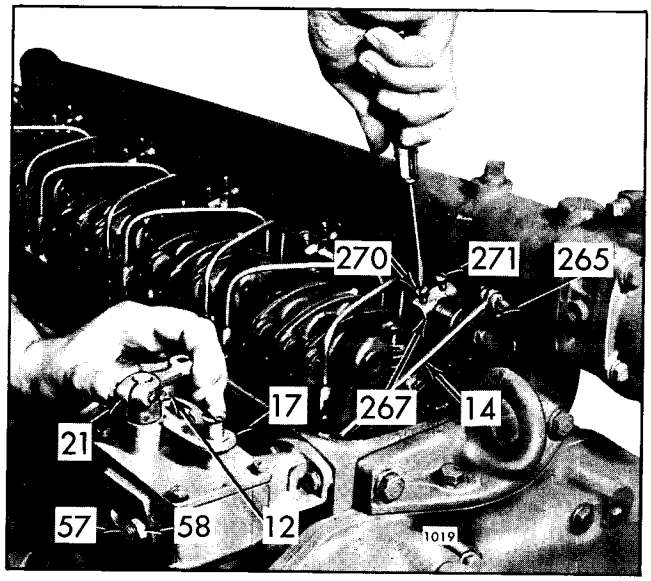


Fig. 3 - Positioning No. 1 Injector Rack Control Lever

12. Lever--Throttle Control
14. Rod--Fuel
17. Cam--Cover
21. Lever--Governor Control
57. Screw--Buffer
58. Lock Nut
265. Lever--Injector Control Tube
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)

7. Hold the gap adjusting screw and tighten the lock nut.

8. Recheck the governor gap, with the engine operating between 800 and 1000 rpm by placing a screw driver between the gap adjusting screw and the governor housing and manually forcing the gap closed. If the setting is correct, the .0015" movement can be seen.

   NOTE: The gap closing can be easily seen if a drop of oil is placed into the gap just before it is closed.

9. Stop the engine and install the fuel rod between the differential lever and the control tube lever.

10. Install the governor cover.

Proceed with "Position Injector Control Racks-Engines Not Using a Fuel Modulator" if unit does not have a fuel modulator.

Position Injector Rack Control Levers—Engines Using Fuel Modulator

The position of the injector 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. When adjusting the fuel control racks be sure no interference is encountered from the fuel modulator. This may be assured by loosening the fuel modulator lever "U" bolt and moving the modulator lever along the injector control tube to avoid contact with modulator cam or adjacent cylinder head stud nut.

NOTE: When the modulator lever is in position, it may strike the cylinder head stud nut when the rack is moved toward the OFF position. The NO FUEL position is reached before this contact takes place and should therefore cause no concern.

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

1. Refer to Fig. 3 and disconnect any linkage attached to the governor control lever (21).

2. Loosen the lock nut (58) and back out the buffer screw (57) approximately 5/8".

3. Refer to Fig. 6 and loosen the idle speed adjusting screw lock nut (56) and back out the idle speed adjusting screw (55) until 9/16" of thread protrudes beyond the lock nut.

NOTE: This lowers the tension on the low speed spring permitting the governor gap to close completely when performing step 5 without overcoming the control tube fuel modulating torsion spring.

4. Loosen all the inner adjusting screws (270) and outer adjusting screws (271), as shown in Fig. 3. Be sure all the control levers (267) are free on the injector control tube.

5. Move the governor control lever (21) to the FULL FUEL position as shown in Fig. 3. Turn the inner adjusting screw down until a step up of effort is noted. This will place the No. 1 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 until tight.

6. Check the setting of the No. 1 injector rack by moving the governor control lever towards the NO FUEL position while holding the governor to control tube link, with a light finger pressure, in a direction towards the governor. This pressure will retain the low speed spring gap in the closed position when the throttle control lever is moved from the full speed position toward the idle position. A proper rack setting will be indicated by an immediate corresponding movement of the No. 1 injector rack from the FULL FUEL position when the governor control lever is moved away from the FULL SPEED position.

7. If no immediate corresponding movement of the injector rack is observed in step 6, back off the inner adjusting screw approximately 1/8 of a turn and tighten the outer 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 6.

   NOTE: Performing steps 5, 6 and 7 will result in placing the governor linkage and control tube assembly in the same positions they will attain while the engine is running at full load. These positions are:

   a. Throttle control lever-at full speed position.

   b. Governor gap-closed.

   c. High speed spring plunger-on its seat in the governor control housing.

   d. Injector fuel control racks are within .005" of the maximum fuel position (measured at clevis end of injector control tube lever).

8. Remove the clevis pin between the fuel rod and the injector control tube lever (265), Fig. 3.

9. Manually hold the No. 1 injector in the FULL FUEL position. Do not hold the end of the control tube.

   Hold the No. 1 injector lever, and turn down the inner adjusting screw (270) of the No. 2 injector until the injector rack of the No. 2 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 (271) down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until they are tight.

10. 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. 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.

11. Position the remaining control rack levers as outlined in Items 9 and 10.

12. Insert the clevis pin between the fuel rod and the injector control tube lever (265), Fig. 3.

13. Reset the idle speed adjusting screw until it projects 3/8" beyond the lock nut. Tighten the lock nut.

Position Injector Rack Control Levers— Engine Not Using a Fuel Modulator

The position of the injector 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. Properly positioned injector rack control levers will result in the following:

Speed control lever at a maximum speed position.

Governor low speed gap closed.

14.3 LIMITING SPEED GOVERNOR ADJUSTMENT

High speed spring plunger on the seat in the governor control housing.

Injector racks in the full fuel position.

Adjust the No. 1 injector rack control lever (267), Fig. 3, first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the speed control lever.

2. Remove the valve rocker cover.

3. Loosen the idle speed adjusting screw lock nut and back out the idle speed adjusting screw until 1/2" of the threads project from the lock nut when the nut is against the high speed plunger.

4. Loosen the lock nut (58) and back out the buffer screw approximately 5/8".

5. Loosen all the inner (270) and outer (271) adjusting screws. Be sure all control levers are free on the injector control tube.

6. Move the speed control lever to the maximum speed position as shown in Fig. 3. Hold the lever in that position with light finger pressure. Turn the inner adjusting screw on the No. 1 injector rack control lever down until a slight movement of the control tube is observed or a step up in effort is noted. This will place the No. 1 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 until tight.

   NOTE: The above step should result in placing the governor linkage and control tube assembly in the same position that they will obtain while the engine is running at full load.

7. To be sure the control lever is properly adjusted, the following check should be performed.

   Hold the speed control lever in the maximum speed 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 injector rack returns to its original position.

   If the rack does not return to its original position, it is too loose. To correct, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

   The setting is too tight if when moving the speed control lever from the idle to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover.) This will result in a step up in effort required to move the speed control lever to the end of its travel. To correct this condition, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

8. Manually hold the No. 1 injector in the full fuel position and turn down the inner adjusting screw of the No. 2 injector until the injector rack 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 adjusting screws until tight.

9. Recheck the No. 1 injector rack to be sure that it has remained snug on the ball end of the injector 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 No. 2 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. Reset the idle speed adjusting screw until it projects 3/8" beyond the lock nut. Tighten the lock nut.

    NOTE: Remove the "C" clamp from the fuel rod of units having a yield link.

Adjust Maximum No-Load Engine Speed— Engines With Dual Range Mechanical Governors

After positioning the injector rack control levers, with the buffer screw backed out, set the governor maximum speeds as follows:

With the spring housing mounted on the governor with both the piston and sleeve assembled as illustrated in Fig. 4, and the low maximum speed adjusting screw extending from the spring housing cover approximately 3/4" beyond the lock nut, proceed as follows:

NOTE: To stop air leakage between the piston and the sleeve, coat the

mating threads with P.O.B. No. 3 sealant or equivalent.

CAUTION: Do not apply air pressure to the spring housing until ready to perform Step 1.g.

1. Set high maximum no-load speed.
   a. Start the engine and position the engine throttle in the maximum speed position.
   b. Loosen the lock nut and turn the low maximum speed adjusting screw inward until the desired no-load high maximum speed is obtained.
   c. Stop the engine and remove the spring housing.
   d. Remove the piston and sleeve from the spring housing.
   e. Turn the piston on the sleeve until the piston is flush to 1/64" below the end of the spring housing when the piston and sleeve is placed into the spring housing and held tight against the adjustment screw.
   f. Replace the piston and sleeve in the spring housing and assemble the spring housing to the governor.
   g. Start the engine and position the engine throttle in the maximum speed position and apply air pressure to the governor cylinder.

   NOTE: To overcome the tension of the governor high speed spring, 50 p.s.i. air pressure will be required in the governor cylinder.

   h. Back out the adjustment screw 1/4". If the piston is adjusted correctly, the engine will operate at the recommended high maximum no-load speed set.
   i. Remove the air pressure from the governor cylinder.
   j. Make a minor adjustment on the piston, if necessary, to establish the exact speed desired.
2. Set the low maximum no-load engine speed.
   a. Adjust the low maximum speed adjusting screw, with the engine operating and governor control lever held in the FULL FUEL position, until the desired low maximum speed is obtained. Turn the screw inward to increase or out to decrease the engine speed.
   b. Tighten the lock nut and recheck the engine speed.
3. Check both high maximum and low maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 or 2.

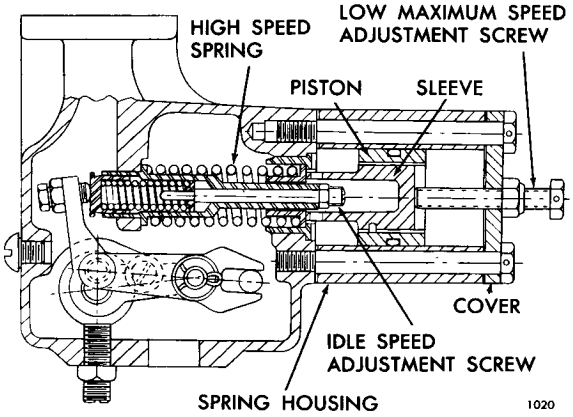


Fig. 4 - Dual Range Governor and Piston Assembly

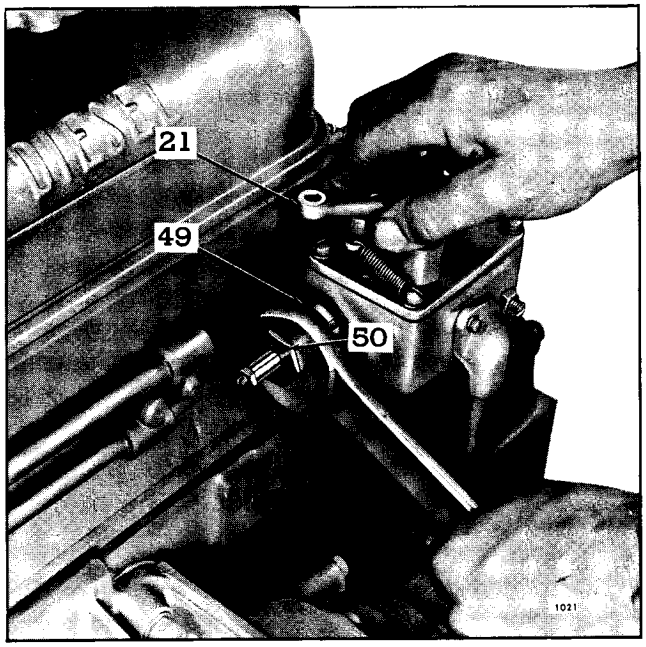


Fig. 5 - Adjusting Maximum No-Load Speed

21. Lever--Governor Control
49. Lock Nut--Spring Retainer
50. Retainer--High Speed Spring

Adjust Maximum No-Load Engine Speed— Engines Without Dual Range Mechanical Governors

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 unit name plate, the maximum no-load speed may be set as follows:

1. Loosen the lock nut (49), Fig. 5, and back off the high speed spring retainer (50) approximately five turns.

2. With the engine at operating temperature and no-load on the engine, place the control lever (21) in the FULL FUEL position. Turn the high speed spring retainer IN until the engine is operating at the recommended no-load speed.

   The best method of determining the engine rpm is with the aid of an accurate hand tachometer.

3. Hold the spring retainer (50) and tighten lock nut (49).

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. Refer to Fig. 4 and remove the spring housing to uncover the idle speed adjusting screw on dual range governors.

2. With the engine at normal operating temperature and with the buffer screw (57), Fig. 6, backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (55) until the engine is operating at approximately 15 rpm below the recommended idle speed.

   The recommended idle speed is 550 rpm for single weight governors and 450 rpm for double weight governors, but may vary with engine applications.

3. Hold the idle screw and tighten the lock nut (56).

4. Install the high speed spring retainer and retain with the two bolts.

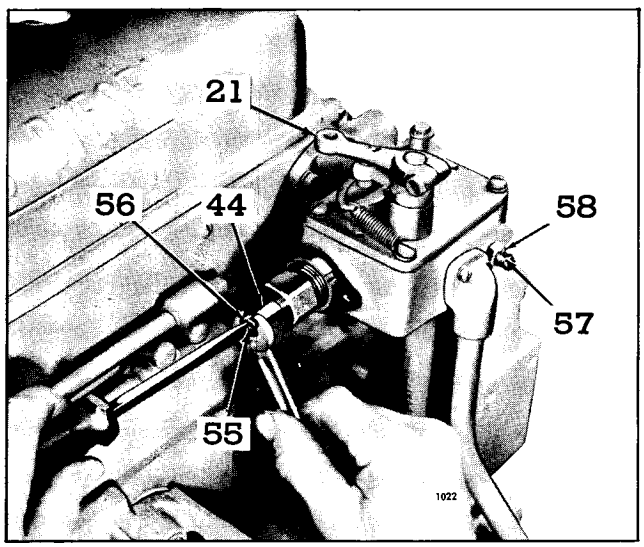


Fig. 6 - Adjusting Engine Idle Speed

21. Lever--Governor Control
44. Plunger--High Speed Spring
55. Screw--Idle Speed Adjusting
56. Lock Nut
57. Screw--Buffer
58. Lock Nut

Adjust Buffer Screw

Set maximum no-load speed and idle speed (engine at normal operating temperature).

With the idle speed set at approximately 15 rpm below the recommended idle speed, the buffer screw may be set as follows:

1. Turn the buffer screw (57) in until the engine is operating at the recommended idle speed.

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

2. On the 71E and 71T engines, recheck the maximum no-load speed. If it has increased more than 25 rpm from the top speed attained in Step 1, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the lock nut (58).

Adjust Fuel Modulator—Engines With Fuel Modulator

After completing the adjustment of the engine governor, adjust the fuel modulator, if the engine is so equipped, according to the following procedure.

1. Relocate the fuel modulator lever and roller assembly in its original position opposite the cam, so that cam is centrally located on the roller. Tighten the "U" bolt nuts until the lever and roller assembly is snug on the control tube. This will not only permit the adjustment of the lever, but will retain the adjustment until the roller and lever assembly can be securely tightened.

2. Hold the fuel modulating piston and cam in the high speed position by applying not less than 20 p.s.i. air pressure to the piston or by prying the cam out with a screw driver.

3. Hold the injector rack in the FULL FUEL position.

4. While holding the cam and the injector rack, move the fuel modulating lever and roller assembly until the roller contacts the cam. Carefully tighten the clamping nuts on the "U" bolt alternately to avoid changing the position of the roller against the cam.

Check Fuel Modulator Setting

1. Pry the fuel modulating cam out with a screw driver.

2. Move the injector control tube to FULL FUEL position.

3. Release the pressure on the screw driver slightly and allow the cam to move in slightly. If properly set, the roller of the fuel modulating lever and roller assembly will rotate as soon as the cam moves. Repeat this check several times to ensure the proper setting was not disturbed while tightening the "U" bolt clamping nuts.

Adjust Fuel Shut-Off Air Cylinder Linkage Engines With Fuel Shut-Off Cylinder Assembly

After completing the adjustment of the engine governor, adjust the linkage between the air shut-off cylinder and the injector fuel control tube lever according to the following procedure.

1. Place the governor control lever into the full speed position. The movement of the control lever to the full speed position will move the injector racks to the FULL FUEL position.

2. Loosen the lock nuts on the air cylinder fuel shut-off rod and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in the end of the control tube shut-off lever. Then shorten the rod one complete turn of the turnbuckle and tighten lock nuts.

Adjusting the rod in this manner will permit the engine's governor to move the injector fuel control racks into the FULL FUEL position without coming to the end of the slot in the end of the air cylinder fuel shut-off rod.

LIMITING SPEED MECHANICAL GOVERNOR, INJECTOR RACK CONTROL AND THROTTLE CONTROL ADJUSTMENT (Diesel Railcar Engine)

The limiting speed governor controls the engine idle speed and maximum speed. Intermediate speeds are dependent on the throttle control lever position and the load on the engine.

The electrically-operated throttle control lever is attached to the governor throttle shaft and is operated by two solenoids (see Fig. 1) which are electrically connected to the remote throttle controller. The throttle control lever is also connected, through the governor mechanism, to the injector control racks in such a manner as to move the racks to a predetermined position when the lever is moved between the idle and full-fuel positions.

The remote throttle controller has five positions -- OFF, 1, 2, 3, and 4. Position 1 is the engine idle speed position and position 4 is maximum power.

When the throttle controller is moved to position 2, the No. 1 solenoid is energized and moves the throttle control operating beam away from the solenoids around point "A" as a fulcrum (see Fig. 6). This moves the throttle lever away from the solenoids and allows more fuel to enter the cylinders.

When the throttle controller is moved to position 3, solenoid No. 1 is de-energized and solenoid No. 2 is energized, moving the beam away from the solenoids around point "B" as a fulcrum. Arm "X" is longer than arm "Y" (see Fig. 6) and, since the plunger of solenoid No. 1 moved for position 2, then the throttle control lever moves farther in position 3 and admits additional fuel to the cylinders.

Both solenoids are energized when the throttle controller is moved to position 4; this places the throttle control lever in the maximum fuel position.

When both solenoids are de-energized, the throttle control lever moves to the IDLE position (not to the OFF position).

When the PARAR (Portuguese for stop) button on the control cabinet cover is pushed IN, the governor shut-down solenoid becomes energized and moves the shut-down lever, which in turn, moves the injector control rack to the OFF position. The stop button must be held in until the engine stops.

Before proceeding with the governor and throttle linkage adjustments, perform the following steps:

1. Set the railcar hand brake and the air brake.

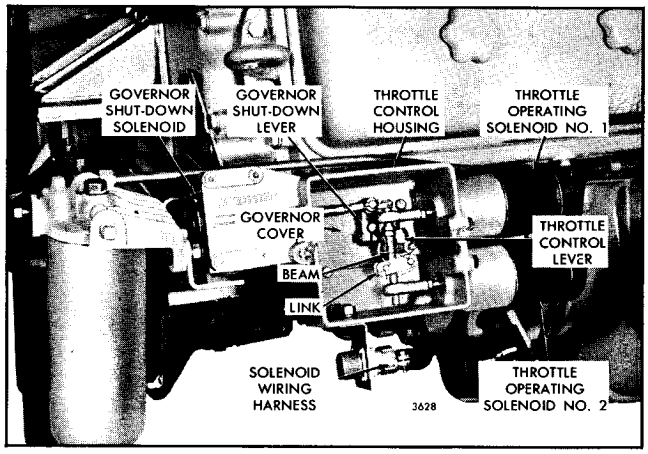


Fig. 1 - Throttle Control Linkage Arrangement

2. Remove the generator fuse, which is located in the regulator locker.

Preliminary Throttle Linkage Adjustment

A preliminary throttle linkage adjustment should be made to establish a starting point, if the governor or throttle linkage has been reconditioned or replaced, by adjusting the geometry of the linkage to a position where most of the adjustment will be established before proceeding with the final engine governor and throttle adjustments.

Refer to Fig. 6 and perform the preliminary throttle linkage adjustment as follows:

1. If the governor has been repaired or replaced, check the governor gap before the throttle control housing is installed.

2. Loosen the clamping bolt on the governor shut-down lever.

3. Loosen the throttle control lever clamping bolt. Then, loosen the lock nut on both throttle control rod ends.

4. Loosen both lock nuts and thread the throttle control operating beam up so the plain end is just inside of the No. 2 throttle control rod end bearing. Tighten the lock nuts on the beam.

5. Adjust both throttle control rod ends so the threaded end of the beam is approximately 5°-10° from the vertical (away from the solenoids). Tighten the control rod lock nuts.

6. Energize both solenoids. Then, with a wrench

14.3.3 GOVERNOR AND THROTTLE CONTROL ADJUSTMENT

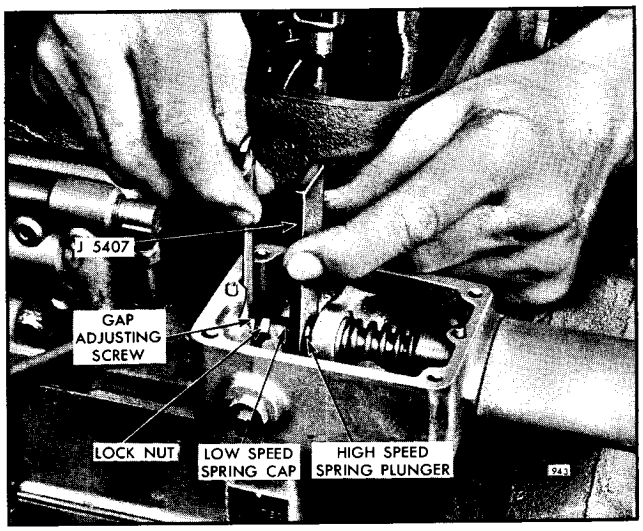


Fig. 2 - Adjusting Governor Gap

on the lubrication fitting, rotate the throttle control shaft to the full-fuel position and tighten the clamping bolt. De-energize the solenoids.

Adjust Governor Gap

If the governor has been reconditioned or replaced, adjust the gap as follows:

1. Start and warm-up the engine to the normal operating temperature. Then, stop the engine and remove the governor high speed spring retainer cover.

2. Start the engine. Then, loosen the idle speed adjusting screw lock nut (see Fig. 2). Turn the idle speed adjusting screw to attain a speed of 840-850 rpm (at no-load). Then, tighten the lock nut.

3. Stop the engine and remove the throttle control housing, solenoids, and governor cover as an assembly (refer to Section 2.9.2).

4. Remove the valve rocker cover. Then, remove the fuel rod from the governor differential lever and the injector control tube lever.

5. Check the gap between the low speed spring cap and the high speed spring plunger with gage J 5407 (.170"). If necessary, loosen the lock nut and turn the gap adjusting screw until a slight drag is felt on the gage.

6. Hold the adjusting screw and tighten the lock nut. Then, recheck the gap. If necessary, re-adjust the gap.

7. Install the fuel rod.

8. Install the throttle control housing, solenoids, and governor cover (refer to Section 2.9.2).

Position Injector Rack Control Levers

Properly positioned injector rack control levers will result in the following:

Throttle control lever at the maximum speed position.

Governor low speed gap closed.

High speed spring plunger on the seat in the governor control housing.

Injector racks in the full-fuel position.

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

1. Disconnect the linkage attached to the throttle control lever. Then, disconnect the control rod from the governor shut-down lever.

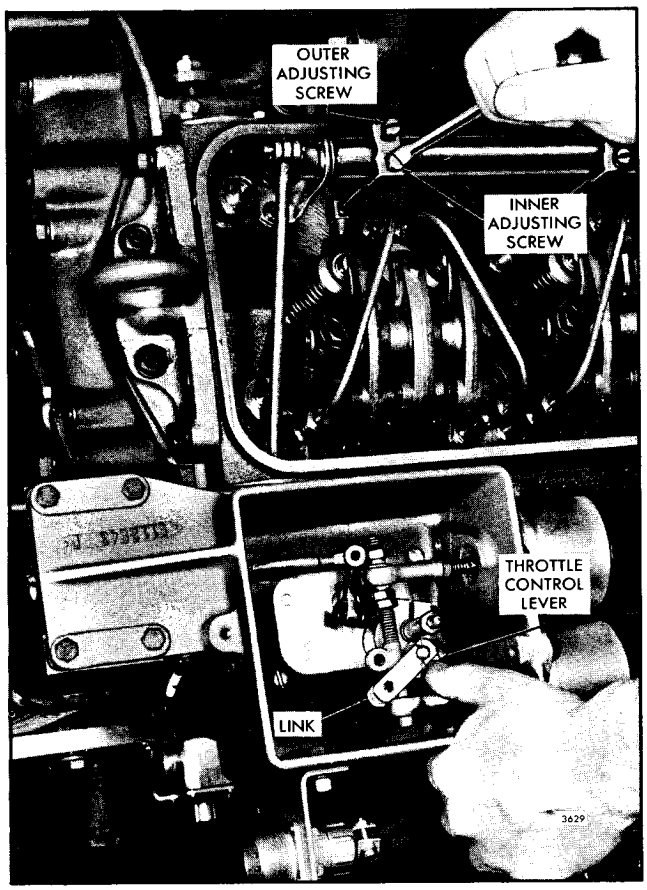


Fig. 3 - Positioning No. 1 Injector Rack Control Lever

2. Loosen the lock nut and back out the idle speed adjusting screw until 1/2" of the threads project from the lock nut when the nut is against the high speed plunger.

3. Loosen the lock nut and back out the buffer screw approximately 5/8".

4. Loosen all the inner and outer rack control lever screws. All of the control levers must be free on the injector control tube.

5. Hold the throttle control lever in the FULL-FUEL position and turn the inner adjusting screw down on the No. 1 injector rack control lever (see Fig. 3) until a slight movement of the injector control tube lever is observed or a step-up in effort is noted. This will place the No. 1 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 until they are tight.

   NOTE: Step 5 will place the governor linkage and the injector control tube assembly in the same position they will attain when the engine is running at full load.

6. Hold the throttle control lever in the maximum speed position and check for a slight rotating movement of the injector control rack. If the rack is too loose, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

   The setting is too tight if, when moving the throttle control lever from the idle to the maximum speed position, the injector rack becomes tight before the throttle control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step-up in effort required to move the throttle lever to the end of its travel. To correct this condition, back off the inner adjusting screw slightly and tighten the outer screw slightly.

7. Disconnect the fuel rod from the injector control tube lever and hold the No. 1 injector manually in the full-fuel position and turn down the inner adjusting screw of the No. 2 injector until the injector rack 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 until they are tight.

8. Recheck the No. 1 injector rack to be sure it has remained snug on the ball end of the injector 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 will be snug on the ball end of their respective rack control levers.

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

10. Connect the fuel rod to the injector control tube lever.

11. Reset the idle speed adjusting screw until it projects 3/8" beyond the lock nut. Then, tighten the lock nut.

Adjust Maximum No-Load Engine Speed

The governor is properly adjusted before the engine leaves the factory. However, if the governor has been reconditioned or replaced, to ensure the engine will not exceed the specified no-load speed, set the maximum no-load speed as follows:

1. Loosen the lock nut and back off the high speed spring retainer approximately five turns.

2. With the engine running at normal operating

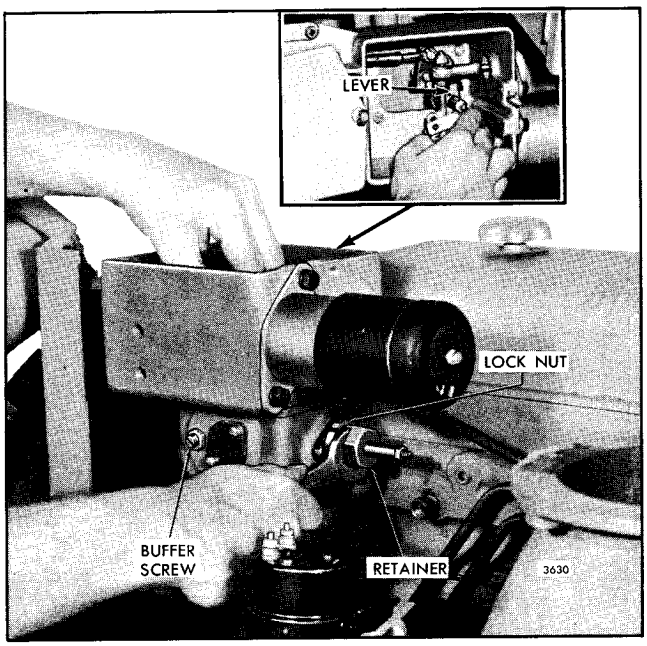


Fig. 4 - Adjusting Maximum No-Load Speed

temperature and no load, place the throttle control lever in the maximum speed position. Then, turn the high speed spring retainer (see Fig. 4) until the engine is running at 2250-2280 rpm.

3. Hold the spring retainer and tighten the lock nut.

Adjust Idle Speed

With the maximum no-load speed properly set, adjust the idle speed as follows:

1. With the engine at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (see Fig. 5) until the engine is running at approximately 15 rpm below the specified idle speed.

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

3. Install the high speed spring retainer cover.

Adjust Buffer Screw

With the idle speed set at approximately 15 rpm below the recommended idle speed, adjust the buffer screw as follows:

1. Run the engine at idle speed and turn the buffer screw in until the engine is running at 840-850 rpm idle speed. Do not raise the engine speed more than 15 rpm with the buffer screw.

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

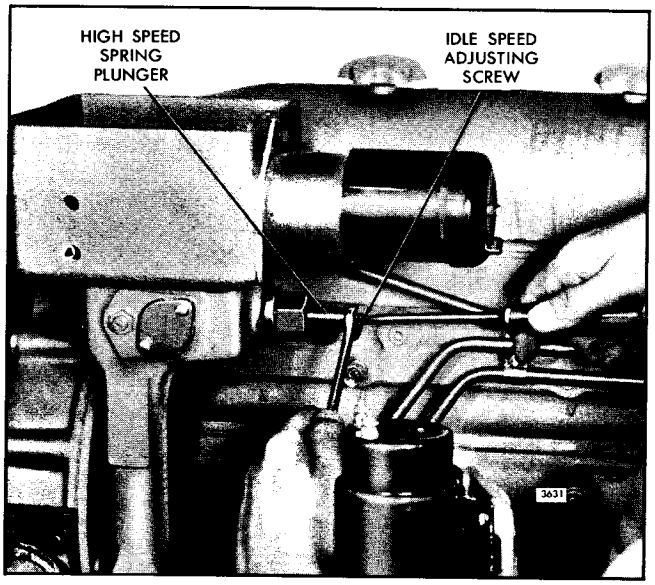


Fig. 5 - Adjusting Engine Idle Speed

3. Recheck the maximum no-load speed.

4. Stop the engine and connect the linkage to the throttle control lever.

Adjust Governor Shut-Down Solenoid

After the governor adjustments have been made, refer to Figs. 1 and 6 and adjust the governor shut-down lever as follows:

1. If the governor shut-down solenoid was previously removed, insert the solenoid plunger through the opening in the throttle control housing and thread the control rod end approximately four turns on the end of the plunger. Then, install the four bolts, lock washers, and nuts which secure the solenoid to the throttle control housing. Do not tighten the bolts.

2. Place the end of the control rod end over the pin in the governor shut-down lever. Then, tighten the solenoid attaching bolts and nuts. Install the washer and spring retainer on the control lever pin to secure the control rod end.

3. Loosen the shut-down control lever clamping bolt and loosen the lever on the terminal shaft.

4. Place the injector racks in the NO-FUEL position and turn the shut-down control lever shaft counterclockwise until interference is encountered.

5. Move the injector racks to the FULL-FUEL position by energizing the throttle control operating solenoids; then, tighten the shut-down control lever clamping bolt.

6. With the injector racks still in the FULL-FUEL position, loosen the lock nut and turn the shut-down solenoid plunger counterclockwise approximately one and one-half (1-1/2) turns. Then, check for movement of the shut-down control lever by pushing it back towards the solenoid. The lever and plunger should have approximately 1/16" travel. When the setting is correct, tighten the lock nut on the plunger.

7. De-energize the throttle operating control solenoids and start the engine to check the operation of the shut-down solenoid.

NOTE: When the shut-down solenoid is de-energized, the injector racks should be able to move to the FULL-FUEL position. When the solenoid is energized, the injector racks should be in the NO-FUEL position.

8. Install the valve rocker cover.

Adjust Throttle Controls

Check and adjust the throttle controls for the proper idle and maximum no-load speeds as follows:

1. Set the railcar hand brake and air brakes.

2. Remove the generator fuse from the regulator locker, if not previously removed.

3. Remove the plug from the receptacle on the transmission wiring harness.

4. Start and warm-up the engine until the normal operating temperature has been reached.

5. Check the throttle controls as outlined under "Preliminary Throttle Linkage Adjustment"

   NOTE: As a safety precaution while making the following tests, a second man, familiar with the car controls, should stay in the cab, or the wheels of the railcar should be securely blocked to prevent movement of the car if the brakes fail to hold.

6. Check the free engine speeds with the throttle linkage connected to the throttle control lever.

   a. Note the engine idle speed. If the speed is above 850 rpm, turn the throttle control operating solenoid plungers into the rod end bearings (refer to Fig. 6). If the speed is below 840 rpm, adjust the speed as outlined under "Adjust Idle Speed".

   b. Move the throttle controller to Position No. 3 and check the maximum engine speed. If the speed is above or below the desired setting (2250-2280 rpm), readjust the speed as outlined under "Adjust Maximum No-Load Speed".

7. Move the throttle controller to the NEUTRAL position and stop the engine.

8. Install the plug in the receptacle on the transmission wiring harness.

9. Start the engine and place the throttle controller in Position No. 4. The engine speed should be 1760 ± 75 rpm with the transmission stalled. If the engine speed falls short of the specified speed, recheck the maximum free engine speed. If the maximum free engine speed is correct, the engine may not be developing full power.

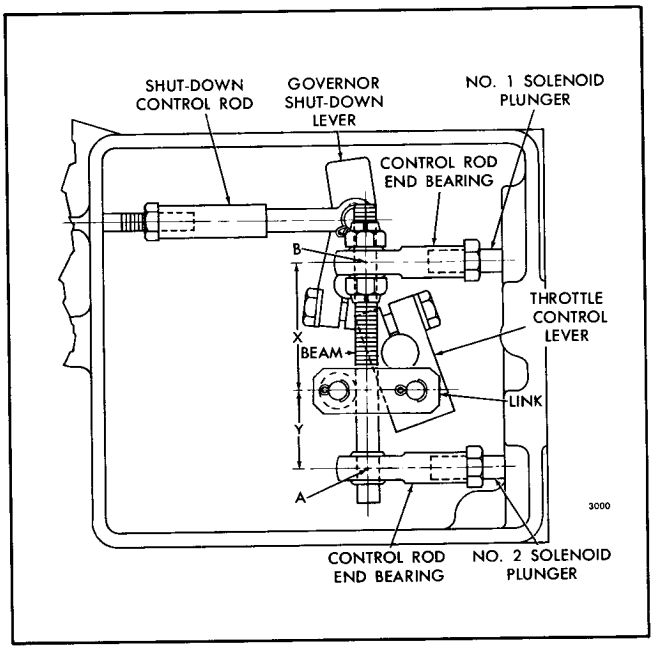


Fig. 6 - Throttle Control Linkage Adjustment Diagram

CAUTION: Do not operate the engine with the controller in Position No. 4 longer than 30 seconds with the transmission stalled. The drive oil temperature should not exceed 265°F. Any temperature in excess of this may be harmful to the torque converter of the transmission.

NOTE: All engine speeds except no-load idle (840-850 rpm), idle stall (800 ± 5 rpm), and maximum stall (1760 ± 75 rpm) may be varied to suit the operating conditions. However, the maximum no-load engine speed must not exceed 2250-2280 rpm.

10. Do not install the generator fuse in the regulator locker until the engine intermediate speed adjustments are performed.

Adjust Engine Intermediate Speeds

The engine intermediate speeds may be adjusted so the engine or engines will be synchronized in their operation as follows:

1. With the hand and air brakes set, and the car wheels blocked or a second man in the cab, start and warm-up the engine until the normal operating temperature has been reached.

2. Place the direction control handle (in the engineers cab) in the forward position. Then, check and adjust the engine speeds with the transmission stalled, as follows:

a. Controller in Position No. 1: check engine idle speed (800-810 rpm) with the transmission stalled.

b. Controller in Position No. 2: check engine speed (1050 ± 10 rpm) with the transmission stalled.

c. Controller in Position No. 3: check engine speed (1340 ± 50 rpm) with the transmission stalled.

d. Controller in Position No. 4: check engine speed (1760 ± 75 rpm) with the transmission stalled.

CAUTION: Do not operate the engine in excess of 30 seconds in the higher throttle positions to prevent the drive oil temperature from exceeding 265°F, otherwise the transmission high oil temperature switch will shut the engine down. Temperature in excess of 265°F may cause damage within the transmission.

NOTE: If the engine maximum speed is low or excessively high with the transmission stalled, refer to "Trouble Shooting--Transmission" in Section 9.9.0 and "Trouble Shooting--Engine" in Section 15.2.

3. Place the throttle controller in Position No. 2 and adjust the engine speed, if necessary, by increasing or decreasing the angle of the beam about point "A" as a fulcrum (see Fig. 6) until a speed of 1050 ± 10 rpm is obtained. To increase the speed, decrease the angle of the beam; to decrease the speed, increase the beam angle. Slight adjustments in the speed may be made by adjusting the beam upward to increase the speed, or downward to decrease the speed.

   CAUTION: Use care in adjusting the beam so it does not come out of the No. 2 control rod end bearing.

4. Place the throttle controller in Position No. 3 and check the engine speed (1340 ± 50 rpm).

   NOTE: The engine speeds (with the transmission stalled) in Positions No. 2 and No. 3 may be varied from the settings given above, if desired, to suit the existing operating conditions. It should be noted, due to the construction of the throttle linkage, if the No. 3 speed is increased, the No. 2 speed will be decreased and, if the No. 2 speed is increased, the No. 3 speed will be decreased.

5. Repeat all of the above steps on the second engine. The speeds at the No. 2 controller position should be within 10 rpm on each of the two engines.

6. Install the generator fuse in the regulator locker.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust engines with variable speed mechanical governors after adjusting the exhaust valves and timing the fuel injectors.

Adjust Governor Gap

With the engine stopped, the governor gap may be set as follows:

1. Remove the governor cover.
2. Place the speed control lever (21), Fig. 1, in the FULL FUEL position.
3. Insert a .006" feeler gage between the spring plunger (45) and the plunger guide (37). If required, loosen the lock nut (29) and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.
4. Hold the adjusting screw and tighten the lock nut. Check the gap, and reset it, if necessary.
5. Install the governor cover.

Position Injector Rack Control Levers

The position of the injector control rack levers must be correctly set in relation to the governor.

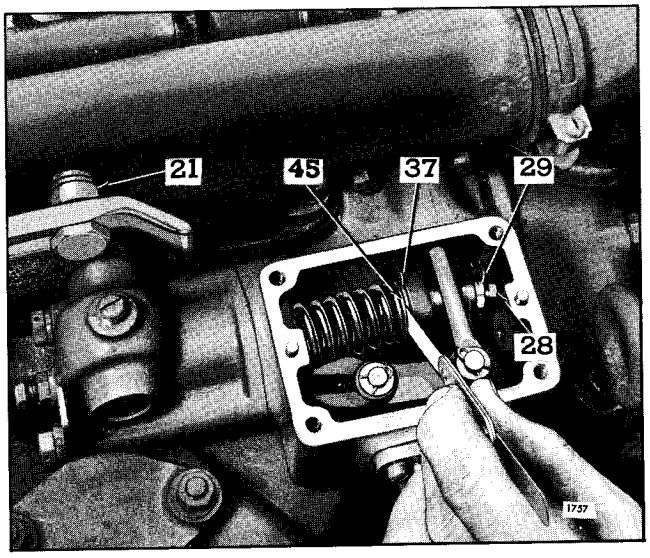


Fig. 1 - Adjusting Governor Gap

21. Lever--Speed Control
28. Screw--Gap Adjusting
29. Lock Nut
37. Guide--Plunger
45. Plunger--Variable Speed Spring

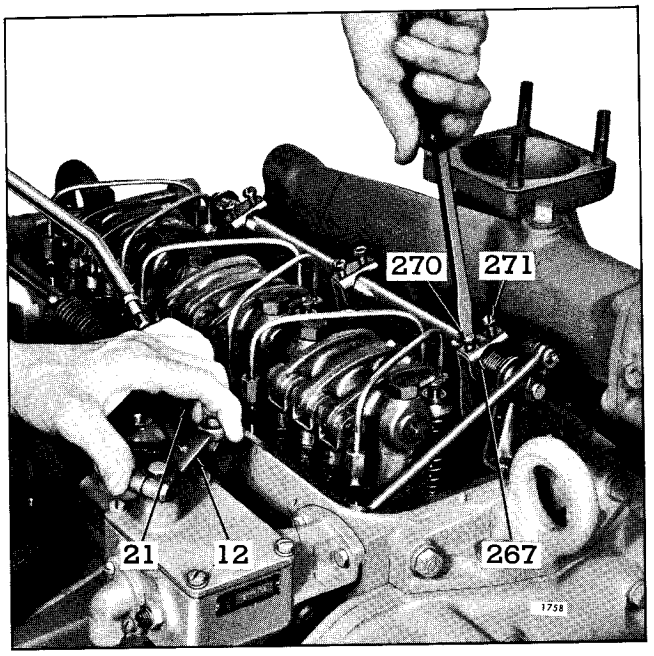


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

12. Lever--Governor Control
21. Lever--Speed Control
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)

Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers with the engine at full load will result in the following:

Speed control lever at the maximum speed position.

Stop lever in the RUN position.

High speed spring plunger is within .005" to .007" of its seat in the governor control housing.

Injector fuel control racks in the full fuel position.

NOTE: The cross link equalizer spring must be removed from multiple engine units before performing the individual engine tune-up. See "Throttle Adjustment for Load Equalization on Twin or Quad Units With Variable Speed Mechanical Governors" for procedure on removing cross link equalizer spring.

14.4 VARIABLE SPEED GOVERNOR ADJUSTMENT

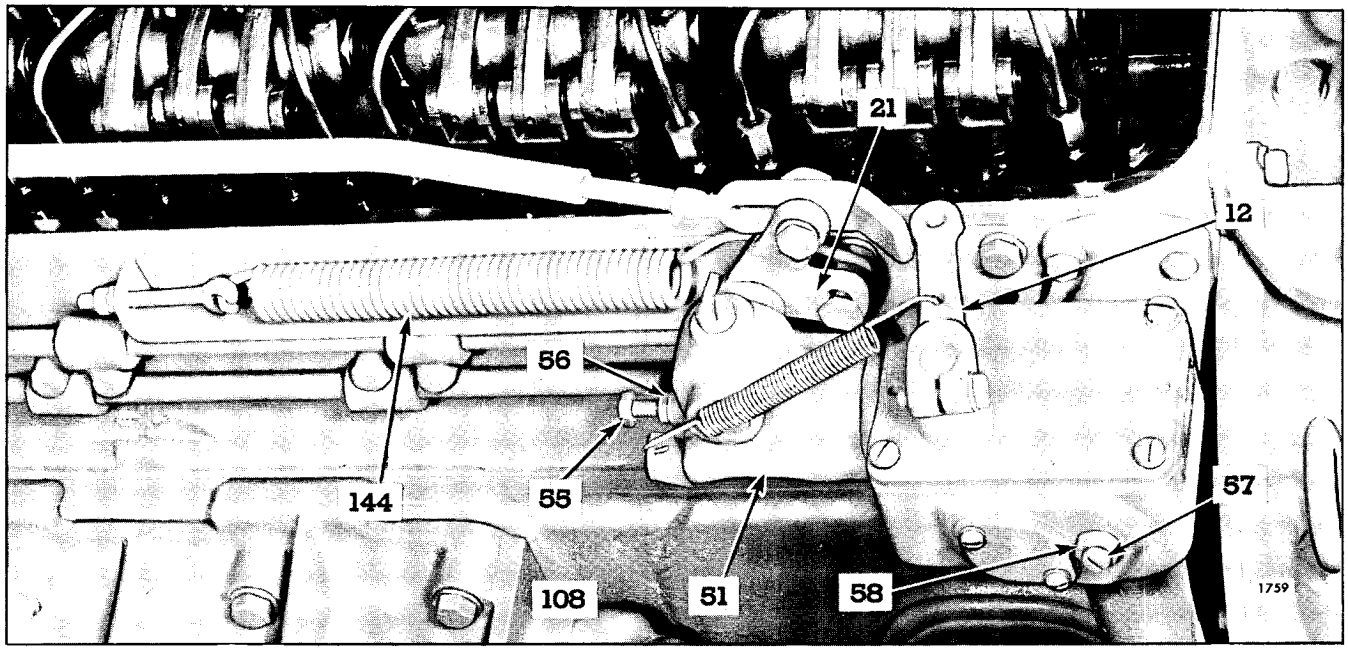


Fig. 3 - Buffer and Idle Speed Adjusting Screw

12. Lever--Governor Control
21. Lever--Speed Control
51. Housing--Variable Speed Spring
55. Screw--Idler Speed Adjusting
56. Lock Nut
57. Screw--Buffer
58. Lock Nut
108. Spring--Lever Retracting
144. Spring--Variable Speed Booster

Adjust the No. 1 injector rack control lever (267) Fig. 2 first, to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the stop lever.

2. Loosen the lock nut (58) Fig. 3, and back out the buffer screw (57) approximately 5/8".

3. Loosen all the inner and outer adjusting screws shown in Fig. 2. Be sure all the injector rack control levers are free on the injector control tubes.

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

5. Move the stop lever to the run position. Hold in that position with light finger pressure. Turn the inner adjusting screw of the No. 1 injector rack control lever down until a step up in effort is noted. This will place the No. 1 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: The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

6. To be sure the control lever is properly adjusted, the following check should be performed.

   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 injector rack returns to its original position.

   If the rack does not return to its original position, it is too loose. To correct, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

   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 as determined by the stop under the governor cover. This will result in a step up in effort required to move the stop lever to the end of its travel. To correct this condition, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

7. Manually hold the No. 1 injector rack in the

full fuel position and turn down the inner adjusting screw (270) Fig. 2 of the No. 2 injector until the injector rack has moved into full fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw (271) down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

8. Recheck the No. 1 injector rack to be sure that it has remained snug on the ball end of the rack control lever while positioning the No. 2 injector rack. If the rack of the No. 1 injector has become loose, back off slightly the inner adjusting screw on No. 2 injector control lever. Tighten the outer adjusting screw.

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

Adjust Maximum No-Load Speed

The maximum no-load speed on engines equipped with variable speed governors must not be less than 125 rpm or more than 150 rpm above the recommended full load speed.

With a hand tachometer, determine the maximum no-load speed of the engine then, make the following adjustments, if required:

1. Refer to Fig. 3 and disconnect the booster spring.

2. Remove the two bolts and withdraw the variable speed spring housing (51) and the variable speed spring plunger inside the spring housing.

3. Refer to Table 1 and determine the stop or shim required for the desired full load speed for engines with two valve cylinder heads.

TABLE 1
SERIES 71 ENGINES TWO VALVE CYLINDER HEADS

Full Load Speed	Stops	Shims
1200 to 1425 rpm	2	Up to .325"
1426 to 1825 rpm	1	Up to .325"
1826 to 2100 rpm	0	Amount Required to get necessary speed.

Refer to Table 2 and determine the stops or shims required for the desired full-load speeds for engines with four valve cylinder heads.

TABLE 2
SERIES 71 ENGINES FOUR VALVE CYLINDER HEADS

Full Load Speed	Stops	Shims
1450 to 1800 rpm	2	Amount required to get necessary speed
1801 to 2250 rpm	1	
2251 to 2450 rpm	0	

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" shim added, the operating speed will increase approximately 1 rpm. Governor shims are available in .010" and approximately .078".

NOTE: If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of the governor shims, the governor gap should be rechecked.

If re-adjustment of the governor gap is required, the position of the injector racks must be rechecked.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. Place the speed control lever in the idle position and the stop lever in the run position as shown in Fig. 3.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the lock nut (56) and turn the idle speed adjusting screw (55) until the engine is operating at approximately 15 rpm below the recommended idle speed.

   The recommended idle speed is 500-600 rpm but may vary with the engine application.

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

Adjust Buffer Screw

With the idle speed set at approximately 15 rpm below the recommended idle speed, the buffer screw may be set as follows:

14.4 VARIABLE SPEED GOVERNOR ADJUSTMENT

1. Turn the buffer screw (57) in until the engine is operating at the recommended idle speed. Do not raise the engine 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 adjusted, the booster spring is adjusted as follows:

1. Refer to Fig. 3 and loosen the booster spring retaining nut on the speed control lever (21). Loosen the nut and lock nut on the eye bolt at the opposite end of the spring (144).

2. Move the bolt up or down in the slot of the lever (21) until the center of the bolt is on or slightly below 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 (21) to the maximum speed position and release. The speed control lever should return to the idle position. If it does not, reduce the booster spring tension. If it does, 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 to operate the speed control lever.

FUEL MODULATING GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Prior to adjustment, the service man should read the following instructions, study the illustrations, and familiarize himself with the general design, nomenclature and location of various parts. Refer to Fig. 1 for all nomenclature references in the following text.

Governor adjustments should not be performed until the following engine tune-up procedures have been accomplished.

1. Start the engine and operate it at part throttle until engine is warmed up and the water temperature is at least 160°F.
2. Adjust the exhaust valve clearance.
3. Time the injectors - use a timing gage and adjust the follower height as described under "Time Fuel Injectors" in this manual.

Adjustment Sequence

The following 7 basic steps in setting a fuel modulating type governor must be performed in the order listed. Any deviation from this order may result in an improperly adjusted governor.

1. Set the fuel modulating spring tension.
2. Set the low speed spring gap.
3. Check the fuel modulating gap closing space.
4. Set the fuel modulating cam.
5. Set the injector racks.
6. Set the no load high speed.
7. Set the idle speed.

Only Settings 1, 3 and 4 are new and peculiar to the fuel modulating governor. Steps 2, 5, 6 and 7 are the same or similar to those of the limiting speed governors, however, the following adjustment procedures should be thoroughly studied and carefully followed.

The seven basic settings are set forth in bold face type in the following pages. The adjustments required before each of these seven settings can be made are set forth prior to each setting and are listed as "Preliminary Adjustment".

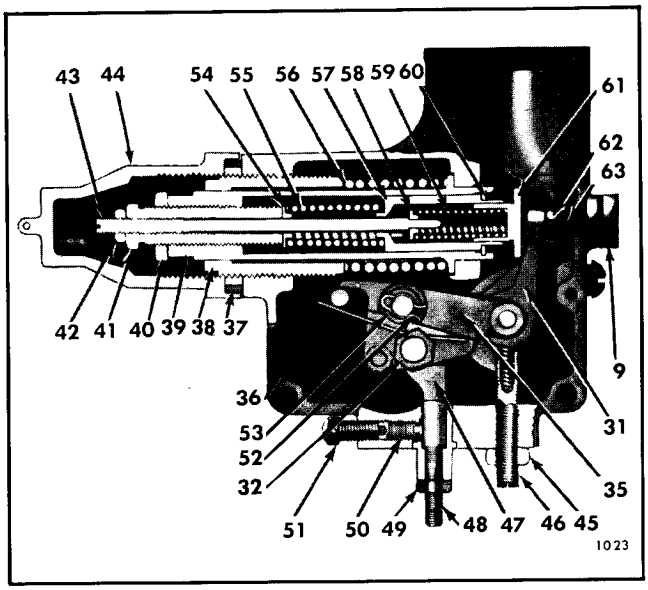


Fig. 1—Fuel Modulating Governor Spring

9. Housing Plug
31. Operating Lever
32. Torsion Spring Screw
35. Differential Lever
36. Torsion Spring
37. High Speed Lock Nut
38. High Speed Adjusting Screw
39. High Speed Spring Plunger
40. Modulating Screw Lock Nut
41. Modulating Speed Adjusting Screw
42. Idle Speed Screw Lock Nut
43. Idle Speed Adjusting Screw
44. Adjustment Cover
45. Buffer Screw Lock Nut
46. Buffer Screw
47. Modulating Cam
48. Cam Adjusting Screw
49. Screw Lock Nut
50. Cam Lock Screw
51. Plugging Screw
52. Retaining Spring Pin
53. Washer
54. Modulating Spring Seat
55. Modulating Spring
56. High Speed Spring
57. Modulating Spring Plunger
58. Low Speed Spring Seat
59. Low Speed Spring
60. Retainer Ring
61. Low Speed Spring Cap
62. Lock Nut
63. Low Speed Gap Adjusting Screw

No. 1—Fuel Modulating Spring Tension Setting

Preliminary Adjustment

A. Remove the governor adjustment cover (44), Fig. 1, control housing cover, housing plug (9) and copper gasket. Disconnect the governor external control linkage and remove the cylinder head cover.

B. Loosen the idle speed screw lock nut (42) and back out idle screw (43) until the low speed spring (59) exerts no pressure on the low speed spring cap (61). This may be determined by moving the low speed cap in and out. Use care not to back the screw out too far as it is possible

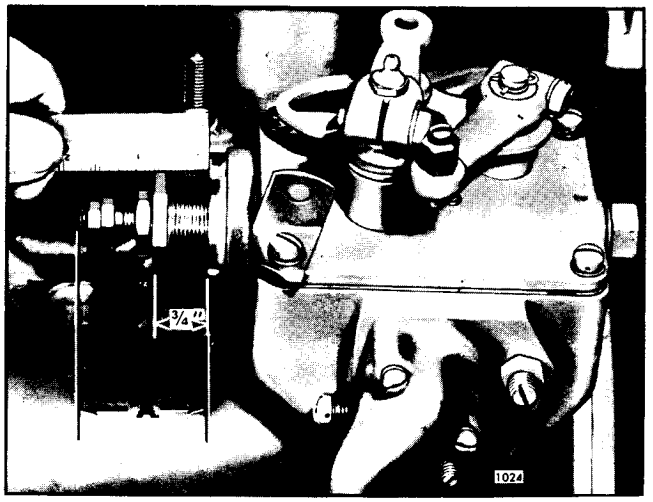


Fig. 2 - Preliminary Adjustment of Low and High Speed Springs

to turn it completely out of the low speed spring seat (58).

NOTE: If the type of fuel modulating spring (55) is not known (70, 95, 150, 175 or 225 lbs. per inch), consult the Chart on Fuel Modulating Governors, RPM, and Springs in section 2.7.1. The type of spring is identified by color code (and must be known) before proceeding with preliminary adjustment "C" below.

C. Loosen the high speed lock nut (37) and turn the high speed adjusting screw (38) into the body until the flats on the end of the high speed spring plunger (39) are fully exposed.

D. Loosen the modulating screw lock nut (40) and turn the screw (41) out by hand until the modulating plunger (57) may be moved back toward the high speed plunger 1/16" before touching the spring.

Adjustment No. 1

Turn the screw (41) in by hand until resistance indicates the spring has forced the plunger forward to contact the retainer ring (60). Repeat as necessary until sure that plunger is just contacting the ring with no tension on the spring, then turn the modulating adjusting screw (41) in 1/3 of a turn (two flats). Lock the adjusting screw in position with the lock nut (40).

CAUTION: The high speed plunger (39) and the fuel modulating spring adjusting screw (41) should both be held securely in position with two wrenches when tightening the fuel modulating adjusting screw lock nut (40) to prevent screw and plunger relationship from being disturbed.

No. 2—Low Speed Spring Gap Setting

Preliminary Adjustment

A. Reset the idle adjusting screw (43) to 2" projection ("A" in Fig. 2) and replace the control housing cover. Secure it with the two screws.

CAUTION: Be sure that the throttle shaft pin is positioned between the torsion spring (36) and end of the differential lever.

B. Start the engine and make a preliminary idle speed setting by setting the speed at 385 rpm with the low speed screw (43) and advancing the speed to 400 rpm by turning in the buffer screw (46). Tighten the low speed lock nut (42).

C. Stop the engine.

D. Remove the governor control housing cover and lever assembly. Remove the cover gasket. Disconnect the link rod between the differential lever and injector control tube lever, then remove the link through the governor.

E. Thread the buffer screw (46) outward 4 or 5 turns.

F. Loosen the cam adjusting screw lock nut (49). Remove the plugging screw (51), and use an Allen wrench to loosen the cam lock screw (50) approximately 1/8 turn to permit the cam to be

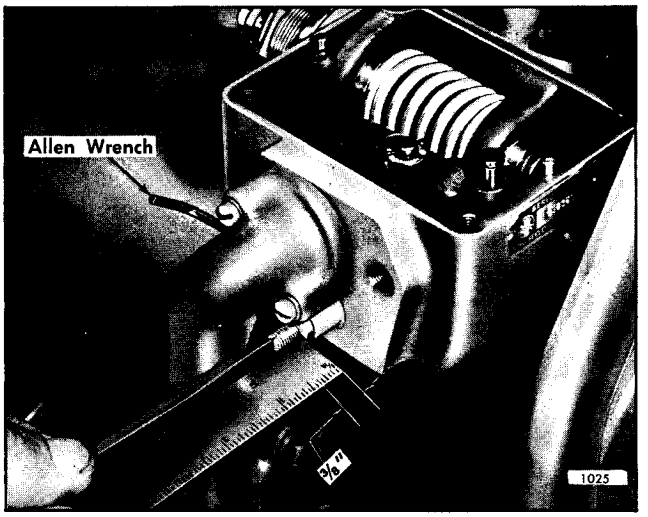


Fig. 3 - Preliminary Adjustment of Modulating Cam

moved in and out without allowing it to turn in housing.

G. Thread the cam adjusting screw (48) into the housing until the screw extends 3/8" beyond the lock nut when the nut is against the sleeve, Fig. 3. Tighten the cam lock screw with the Allen wrench to hold the cam in position until adjusted later.

H. Start the engine and operate it between 600 and 700 rpm checking with the tachometer.

NOTE: Governor to control tube link is removed and engine speed must be controlled by hand or temporary adjustable link and spring at control lever tube, Fig. 4.

Adjustment No. 2

Check the gap between the low speed spring cap (61) and modulating spring plunger (57) with a .0015" feeler gage, Fig. 5.

If the gap is not within .001"-.002" at 600-700 rpm loosen the lock nut (62) and turn the low speed gap adjusting screw (63) as necessary to obtain the proper gap. Tighten the lock nut (62) and recheck the gap.

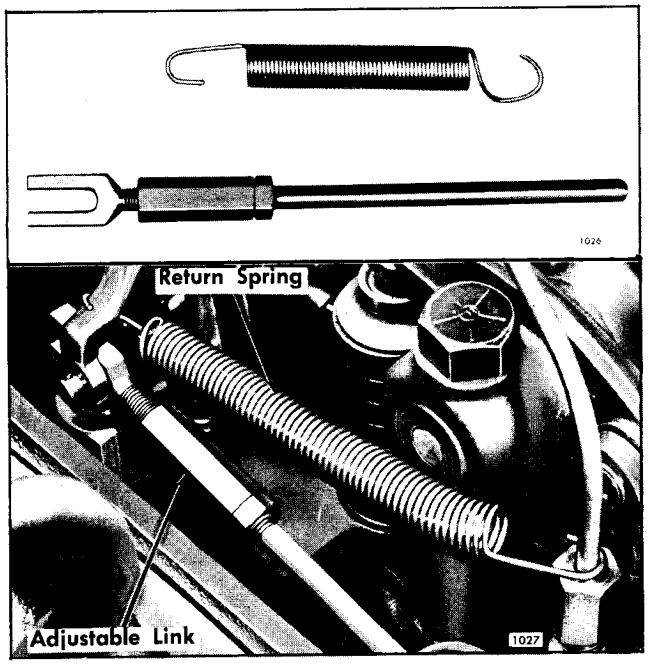


Fig. 4 - Injector Rack with Adjustable Link and Spring Installed

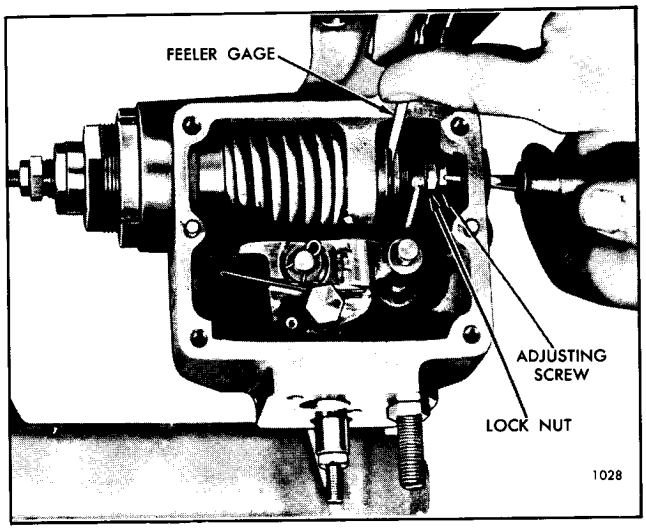


Fig. 5 - Low Speed Spring Gap Adjustment

No. 3—Checking Fuel Modulating Gap Closing

Preliminary Adjustment

A. If an adjustable link has been used, it should be removed, Fig. 4.

B. Install the control link between the differential lever and injector control tube lever. The link is secured at the governor end with a flat washer and retaining spring pin. A straight pin and cotter pins are used at control tube. The link must be free with no binding.

C. Start the engine and control the speed manually by exerting force against the torsion spring (36) with a finger.

CAUTION: Care must be exercised to avoid overspeeding engine.

Adjustment No. 3

Advance the engine speed gradually until the low speed spring cap (61) contacts the high speed plunger (39). Do not exceed 2100 rpm. The gap closing speed should be checked with a .0015" feeler gage between the mating surface of (61) and (39), and will vary according to following table:

Fuel Modulator Spring Chart

F.M. Spring	Closing Speed Range
225#/inch-WHITE	1950-2040
175#/inch-GREEN	1850-1940
150#/inch-BROWN	1750-1840
70#/inch-YELLOW . . .	1525-1625

14.5 FUEL MODULATING GOVERNOR ADJUSTMENT

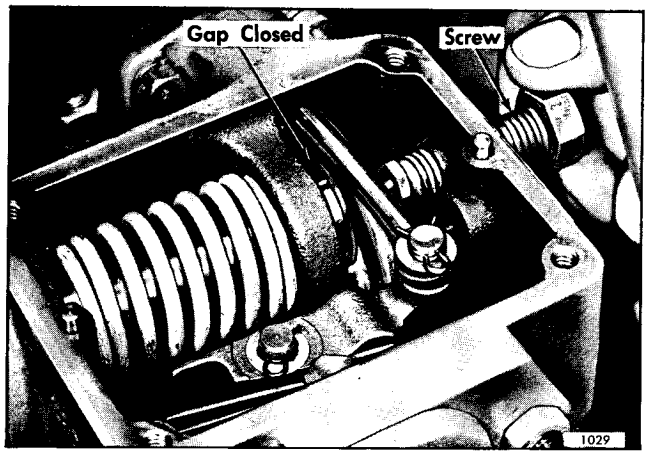


Fig. 6 - Closing Modulator Gap with Special Screw

If the closing speed does not fall within the correct range then recheck setting No. 1 - or preliminary "B" to setting No. 2 - or check for the correct fuel modulating spring.

If, after rechecking the adjustments as indicated above, the closing speed still does not fall within the specified range, the modulating spring should be replaced.

No. 4—Fuel Modulating Cam Setting

Preliminary Adjustment

A. Stop the engine.

B. Set the high speed adjusting screw (38) to extend 3/4" beyond the high speed screw lock nut (37) when the nut is tight against the housing, Fig. 2.

C. Temporarily install the cap screw (1/2"-13 x 2") into the front of the control housing and thread the screw inward until the gap between the low speed cap (61) and high speed spring plunger (39) just closes, Fig. 6, be careful that the high speed spring plunger is not moved.

D. Loosen the inner and outer adjusting screws at each control rack lever until each lever is free on the control tube.

E. Install the cover to the governor control housing gasket. Install the control housing cover assembly being sure that throttle shaft pin is between the differential lever (35) and torsion spring (36). Secure the cover with the four screws and lock washers.

Adjustment No. 4

Use an Allen wrench and loosen the cam lock screw (50) only enough (1/8 turn) to permit turning the cam adjusting screw (48) with the fingers. If the lock screw is backed out further, the cam may be released and turned by its own weight out of the operating position.

With the control lever in the full throttle position, Fig. 7, thread the cam adjusting screw (48) outward with the finger tips until the cam (47) can be felt bottoming against roller on the bottom of the differential lever (35). Thread the cam adjusting screw outward an additional 1/8 turn to provide positive engagement between the differential lever roller and cam. After making contact, it may be necessary to turn the screw very slightly IN or OUT to produce the final 1/64" clearance illustrated in Fig. 7 which is required after the Allen screw has been tightened. Tighten the lock nut (49); also install the plugging screw (51).

> **CAUTION:** The adjustment of the modulating cam is extremely important and must be carefully and accurately performed.

No. 5—Injector Rack Setting

Preliminary Adjustment

A. Manually hold the control lever in the full throttle position, Fig. 8.

B. Loosen all the inner and outer injector rack adjusting screws.

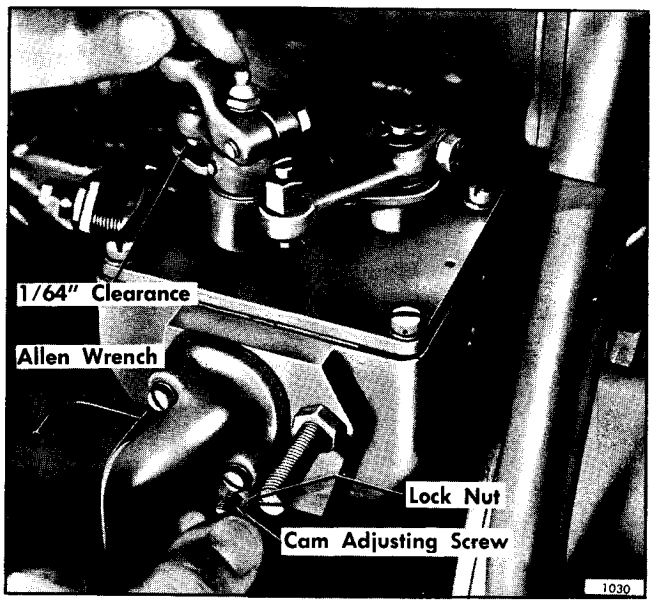


Fig. 7 - Modulating Cam Adjustment

Adjustment No. 5

A. Turn down the inner adjusting screw of the No. 1 injector rack control lever. Adjust the No. 1 injector rack lever, Fig. 8, so that a very light finger tip pressure at the coupling will produce a tendency to roll, but the coupling should not be loose.

B. Turn down the outer adjusting screw until it bottoms on the control tube. After the outer adjusting screw has bottomed, tighten the inner and outer adjusting screws alternately until the injector control lever is held firmly in position.

> **CAUTION:** Do not set No. 1 or any other rack too tight as this will produce clearance between the cam and differential roller and will result in delay and reduction of the fuel modulating action.

Holding the injector control tube lever for "feel" adjust the remaining control rack couplings, Fig. 9. Adjust the No. 2 rack control lever so that it has the same "feel" as the No. 1 coupling. Repeat this procedure on all the remaining racks. That is, compare the No. 3 rack with No. 1, etc., making certain no other injector is tighter than No. 1.

No. 6—No-Load High Speed Setting

Preliminary Adjustment

A. Remove the temporarily installed cap screw, then install the control housing plug (9), with gasket.

B. Loosen the high speed adjusting screw lock nut if tight.

C. Install the cylinder head cover.

Adjustment No. 6

Start the engine and move the throttle lever toward the FULL FUEL position while observing the tachometer. Avoid overspeeding the engine more than 100 rpm above the desired speed.

Fig. 8 - Adjusting No. 1 Rack to Governor

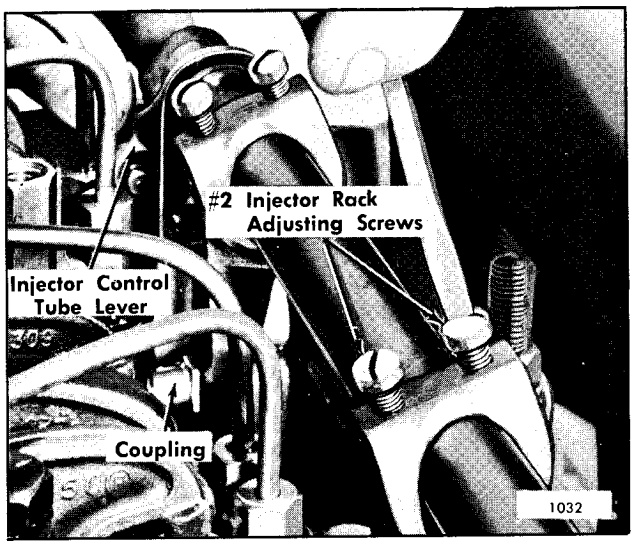


Fig. 9 - Adjusting No. 2 Rack to No. 1 Rack

Turn the high speed adjusting screw (38) until the desired no-load maximum speed is obtained with the throttle lever in a wide open position, Fig. 10. Lock the nut (37).

No. 7—Idle Speed and Buffer Screw Setting

Adjustment No. 7

With the engine running at idle speed, observe the engine rpm at the tachometer, then loosen the lock nut (42) and thread the idle adjusting screw (43) IN to increase or OUT to decrease until 385 engine rpm is obtained, Fig. 11. Tighten the lock nut.

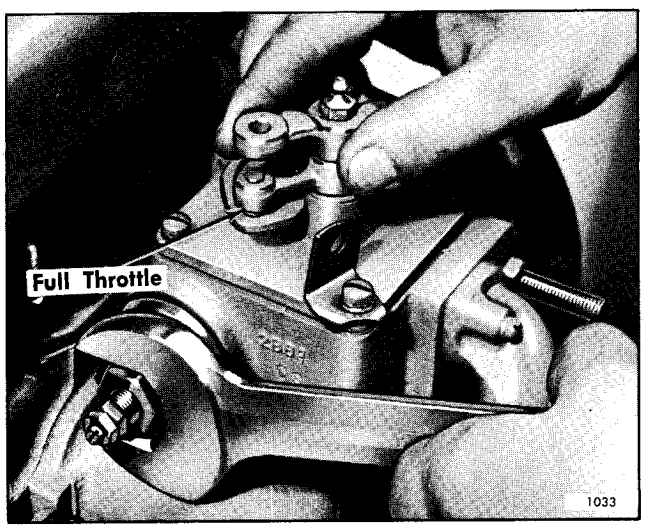


Fig. 10 - Adjusting High Speed

14.5 FUEL MODULATING GOVERNOR ADJUSTMENT

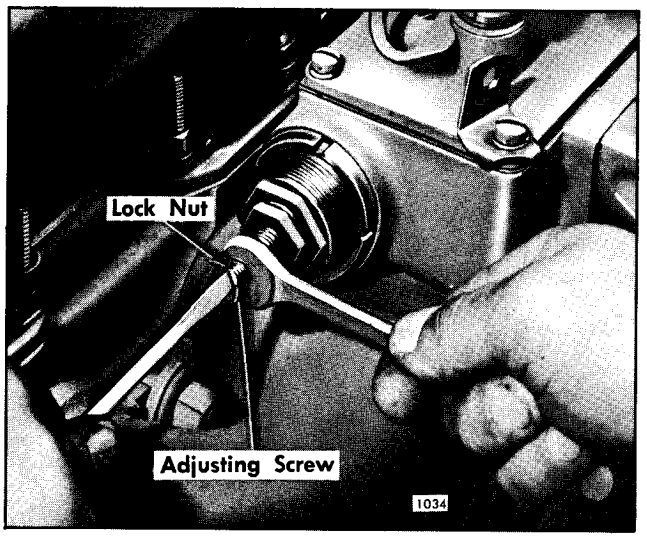


Fig. 11 - Adjusting Idle Speed

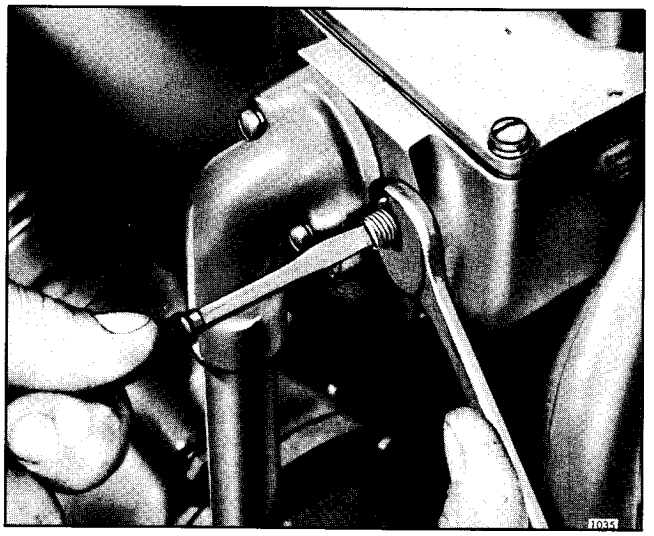


Fig. 12 - Adjusting Buffer Screw

With the engine running at idle speed, thread the buffer screw (46) in until the "surge" or "roll" of the engine just disappears, but not higher than 400 rpm. Any variation from this speed will affect fuel modulating action.

Do not raise the engine speed more than 20 rpm with the buffer screw, otherwise it may not be possible to stop the engine. Hold the screw (46) and tighten the lock nut, Fig. 12. Stop and start the engine several times to be sure of its stopping.

Install Removed Parts

1. Install and tighten the governor adjustment cover (44).

2. Connect the throttle control rod to the throttle control lever at the governor cover.

3. Connect the linkage to the engine stop lever at the governor cover.

Adjust Fuel Shut-Off Air Cylinder Linkage—Engines Having Fuel Shut-Off Air Cylinder Assembly

After completing the adjustment of the engine governor, adjust the linkage between the air shut-off cylinder and the injector fuel control tube lever according to the following procedure.

1. Place the governor control lever into the full speed position. The movement of the control lever to the full speed position will move the injector racks to the FULL FUEL position.

2. Loosen the lock nuts on the air cylinder fuel shut-off rod and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in end of the control tube shut-off lever. Then shorten the rod one complete turn of the turnbuckle and tighten the lock nuts.

Adjusting the rod in this manner will permit the engine's governor to move the injector fuel control racks into the FULL FUEL position without coming to the end of the slot in the end of the air cylinder fuel shut-off rod.

CONSTANT SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust the engine constant speed mechanical governor assembly after adjusting the exhaust valves and timing the fuel injectors as follows:

Governor Gap Setting

To obtain proper performance, the governor gap must be correctly set. This is the clearance between the operating speed spring plunger and the gap adjusting screw. Adjust the governor gap in accordance with the following procedure.

1. Remove the governor cover and lever assembly.
2. Remove the connecting link between the governor and injector control tube lever.
3. Check the governor gap. The governor gap is set at .0015" with the engine stopped. Insert a .0015" feeler gage between the operating speed spring plunger and the gap adjusting screw.
4. Loosen the lock nut and adjust the gap adjusting screw until the gap is .0015", see Fig. 1.
5. Hold the gap adjusting screw to prevent changing the setting, and tighten the lock nut.
6. Recheck the gap and readjust it if necessary.

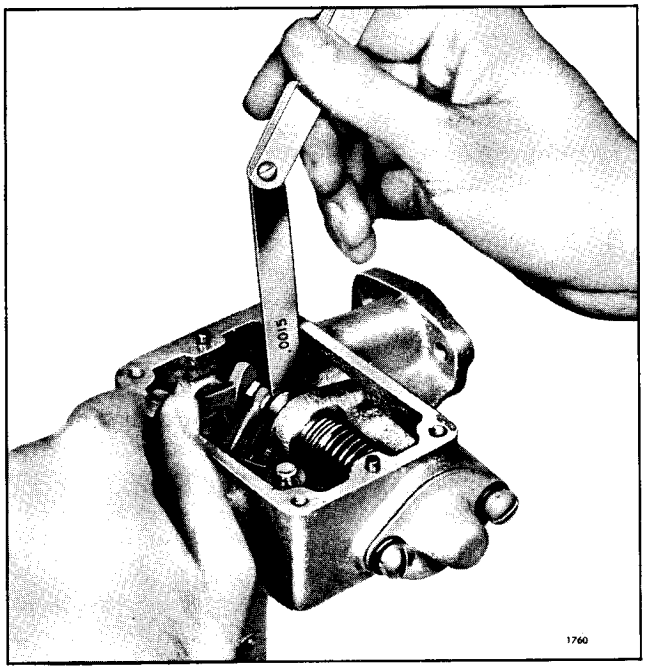


Fig. 1 - Adjusting Governor Gap

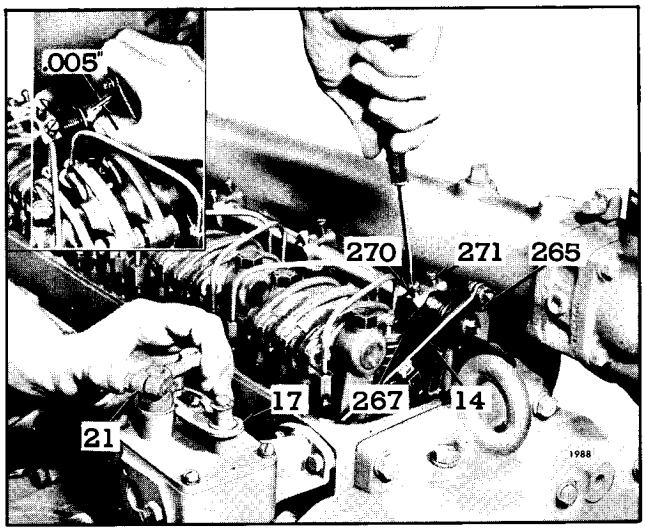


Fig. 2 - Positioning No. 1 Injector Control Rack Lever

14. Rod--Fuel
17. Cam--Cover
21. Lever--Governor Control
265. Lever--Injector Control Tube
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)

7. Install the link between the governor and the injector control tube lever.

Position Injector Control Racks

The position of the injector 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 (267) first to establish a guide for adjusting the remaining injector rack control levers.

1. Refer to Fig. 2 and disconnect any linkage attached to the control lever (21).
2. Loosen all the inner adjusting screws (270) and outer adjusting screws (271) as shown in Fig. 2. Be sure all the control levers (267) are free on the injector control tube.
3. Move the control lever (21) to the maximum speed position as shown in Fig. 2. Turn the inner adjusting screw down until a step up in effort is noted. This will place the No. 1 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 until they are tight.

4. With the governor control lever held in the maximum speed position, check for a slight movement of the injector control tube lever. This movement should not exceed .005".

5. 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 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 within .005" of the maximum fuel position (measured at the clevis end of injector control tube lever).

6. Remove the clevis pin between the fuel rod and the injector control tube lever (265).

7. Manually hold the No. 1 injector in the FULL FUEL position and turn down the inner adjusting screw (270) of the No. 2 injector until the injector rack of the No. 2 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 (271) down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until they are tight.

8. 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 No. 2 injector. If the rack of the No. 1 injector has become loose, back it off slightly on the inner adjusting screw on the No. 2 injector rack control lever. Tighten the outer adjusting screw.

   When the settings are correct, the racks of both injectors must be snug on the pin of their respective rack control levers.

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

10. Insert the clevis pin between the fuel rod and the injector control tube lever (265).

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 unit name plate, the maximum no-load speed may be set as follows:

1. Start and warm up the engine.

2. With the engine disconnected from the load, start the engine and observe the engine speed. Be sure the governor 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 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 WOODWARD SG GOVERNOR AND INJECTOR CONTROL RACK ADJUSTMENT

Adjust engines with a hydraulic governor assembly after adjusting the exhaust valves and timing the fuel injectors as follows:

Adjust Fuel Rod

1. Remove governor cover. Refer to Fig. 2 and loosen all inner adjusting screws (270) and outer adjusting screws (271). Be sure all control levers (267) are free on the injector control tube.

2. Loosen fuel rod lock nut (16), Fig. 1, and remove fuel rod knob.

3. Turn lock nut to a position so that 3/16" of the fuel rod extends beyond the nut. Install fuel rod knob and tighten lock nut.

Position Injector Rack Control Levers

With fuel rod properly adjusted, the rack control levers may be adjusted as follows:

1. Turn outer adjusting screw (271), Fig. 2, in until a slight movement of the injector control tube lever (265) is observed. Tighten inner adjusting screw (270).

2. Pull out on fuel rod and check for 1/32" to 1/16" movement.

   If movement exceeds that specified, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

   If movement is less than that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten inner adjusting screw.

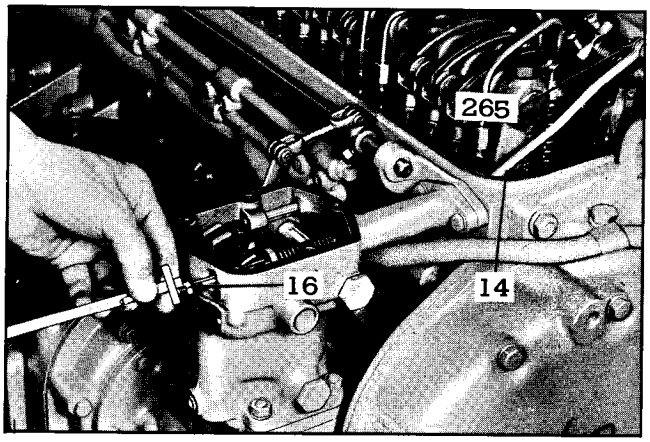


Fig. 1 - Adjusting Fuel Rod

14. Rod-Fuel
16. Lock Nut
265. Lever-Injector Control Tube

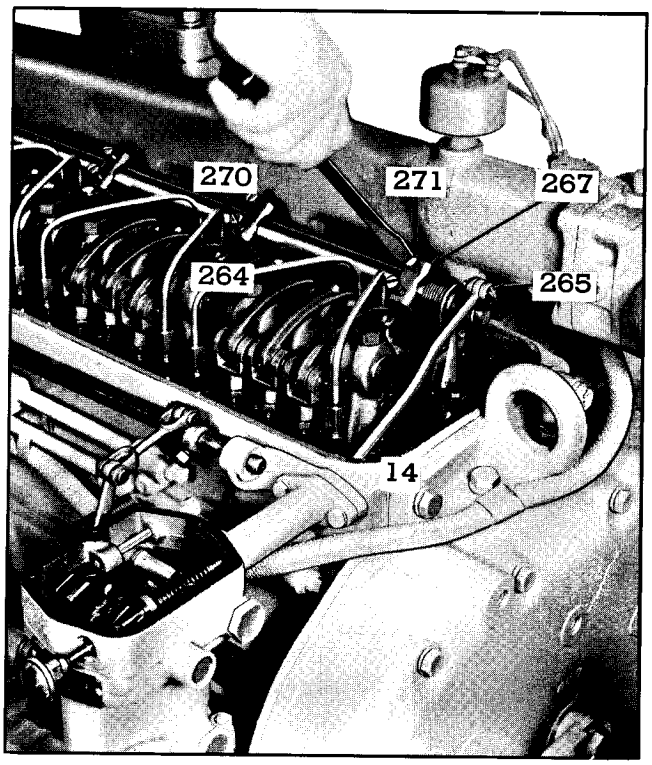


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

14. Rod-Fuel
264. Tube-Injector Control
265. Lever-Injector Control Tube
267. Lever-Injector Rack Control
270. Screw-Control Lever Adjusting (Inner)
271. Screw-Control Lever Adjusting (Outer)

3. Disconnect fuel rod (14) from injector control tube lever (265).

4. Holding onto clevis at end of injector control tube, position the number 1 injector in the FULL FUEL position and screw down the inner adjusting screw of number 2 injector until the injector control lever for that injector contacts the injector body. This may be felt at the clevis end by a slight movement as contact is made.

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

5. Make sure the rack remains snug on the pin of the rack control lever at No. 1 injector.

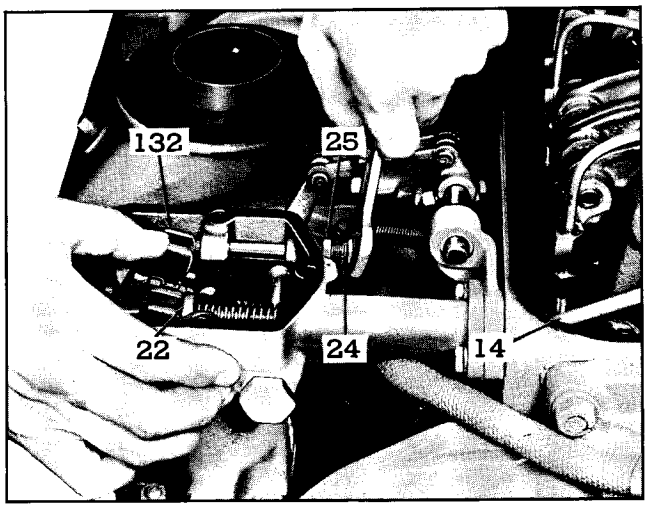


Fig. 3 - Adjust Load Limit

14. Rod-Fuel
22. Collar-Fuel Rod
24. Screw-Load Limit Adjusting
25. Lock Nut
132. Lever-Terminal

If the rack of No. 1 injector has become loose, back off slightly on the inner adjusting screw at No. 2 injector rack control lever. Tighten outer adjusting screw.

When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers.

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

When the settings are correct, the racks of all injectors must be snug on the pins of the rack control levers when control tube lever is held in the FULL FUEL position.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be re-adjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place fuel rod (14) and terminal lever (132) in the FULL FUEL position as shown in Fig. 3.

2. Loosen lock nut (25). Turn adjusting screw (24) until a .020" space exists between the fuel rod collar (22) and the terminal lever (132). Hold screw and tighten lock nut.

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, the fuel rod, injector control rack levers, and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start engine and run 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 lock nut (73), Fig. 5, and back off maximum speed adjusting screw (72) approximately 5/8".

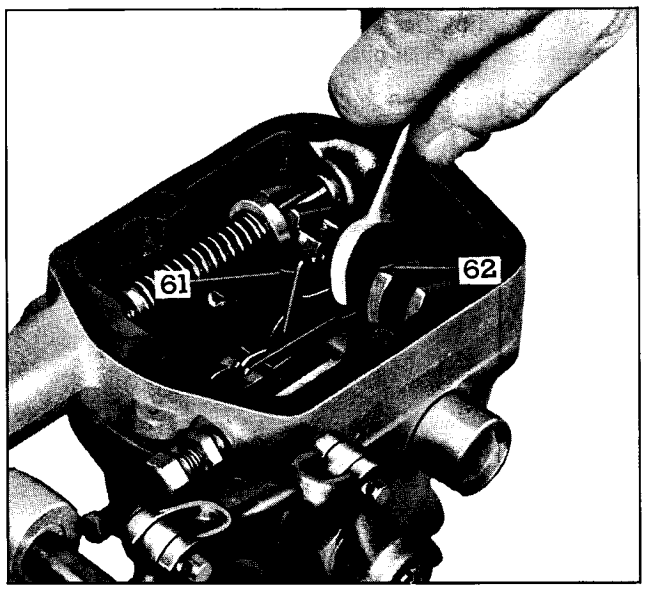


Fig. 4 - Adjusting Speed Droop

61. Bracket
62. Bolt

4. Refer to Fig. 4 and loosen droop adjusting bolt (62). Move bracket (61) so that bolt is midway between ends of slot in bracket. Tighten bolt.

   Be sure the bracket remains on the shoulder of the terminal lever.

5. With the throttle in 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 re-adjust the engine speed to the correct full load speed.

7. Remove the rated load and note engine speed after 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 engine and again loosen bolt (62) and move droop adjusting bracket IN toward the engine. Tighten bolt. To increase the speed droop, move droop adjusting bracket OUT, away from 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 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

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

Adjust Maximum No-Load Speed

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

1. With engine operating at no-load, adjust engine speed until engine is operating at approximately 10% higher than the rated full-load speed.

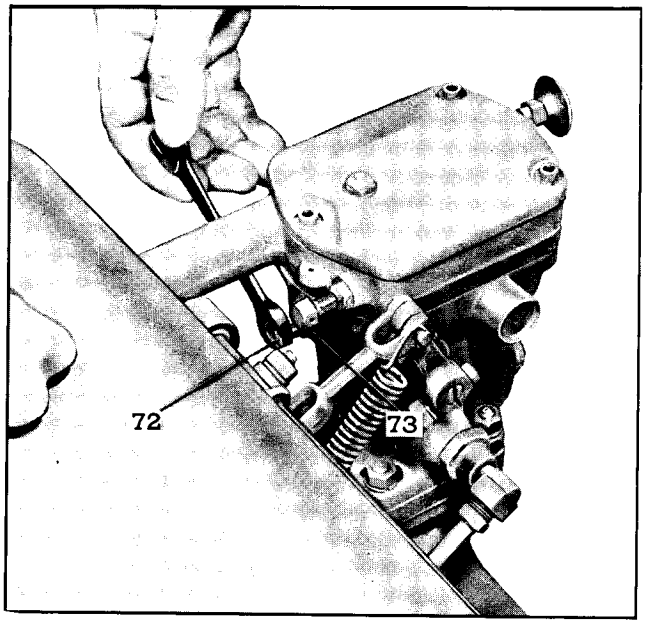


Fig. 5 - Adjusting Maximum No-Load Speed

72. Screw-Maximum Speed Adjusting 73. Lock Nut

2. Turn maximum speed adjusting screw (72), Fig. 5, in until engine is operating approximately 8% above the rated full-load speed.

3. Hold screw and tighten lock nut (73). Install governor cover.

GOVERNORS WITH SYNCHRONIZING MOTOR

On some hydraulic governors, a reversible electric synchronizing motor is mounted on the governor cover, see Fig. 6. This motor permits close adjustment of engine speed by remote control. This feature is especially valuable when synchronizing two generators from a central control panel.

When the two-way control switch for the unit on the central control panel is closed by the operator, the motor shaft turns the governor speed adjusting shaft by means of the reduction gear and slip coupling. The direction of rotation (clockwise or counterclockwise) is dependent upon the position of the switch. When the desired engine speed is indicated on a tachometer or frequency meter on the panel, the operator returns the switch to the "OFF" position.

Should switch be held in the "Lower Speed" position too long, the synchronizing motor will continue to lower the unit speed until it ultimately shuts the engine down. Should switch be held too long in the "Raise Speed" position, the motor will turn the governor shaft until the shaft strikes the maximum speed adjusting screw, after which the

14.7 HYDRAULIC WOODWARD SG GOVERNOR ADJUSTMENT

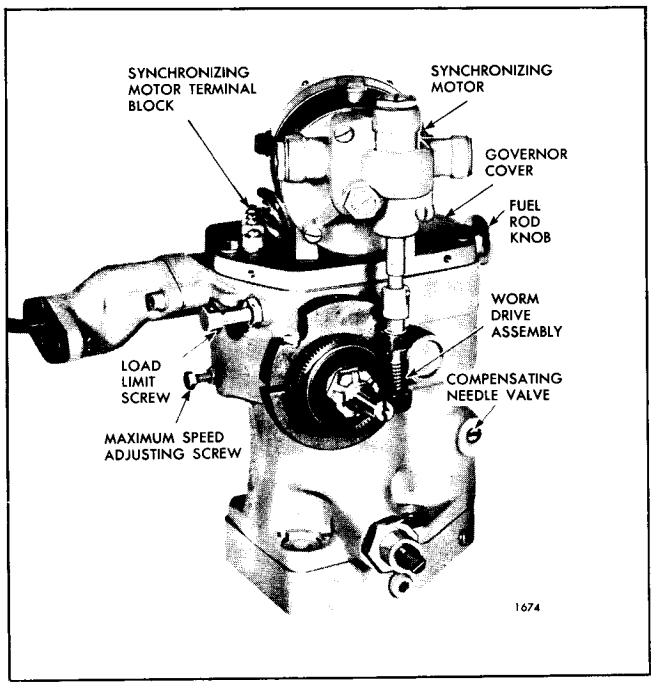


Fig. 6 - Typical Synchronizing Motor Mounting and Drive Assembly

clutch will slip and the motor will continue to run at a slightly reduced speed without further effect.

The adjustments on the governor equipped with a synchronizing motor are the same as on units without a synchronizing motor. The synchronizing motor is used in place of the vernier throttle control knob to raise and lower the engine speed.

The governor cover and motor assembly must be removed when setting the engine droop. The desired engine speeds may be obtained by manually turning the worm drive while the cover is removed.

HYDRAULIC WOODWARD PSG GOVERNOR AND INJECTOR CONTROL RACK ADJUSTMENT

Adjust engines with hydraulic governor assemblies after adjusting the exhaust valves and timing the fuel injectors as follows:

Adjust Fuel Rod

1. Remove governor cover. Refer to Fig. 1 and loosen all inner adjusting screws (62) and outer adjusting screws (63). Be sure all control levers (64) are free on the injector control tube.
2. Loosen fuel rod lock nut (66), and remove fuel rod knob.
3. Turn lock nut to a position so that 3/16" of the fuel rod extends beyond the nut. Install fuel rod knob and tighten lock nut.

Position Injector Rack Control Levers

With fuel rod properly adjusted, the rack control levers may be adjusted as follows:

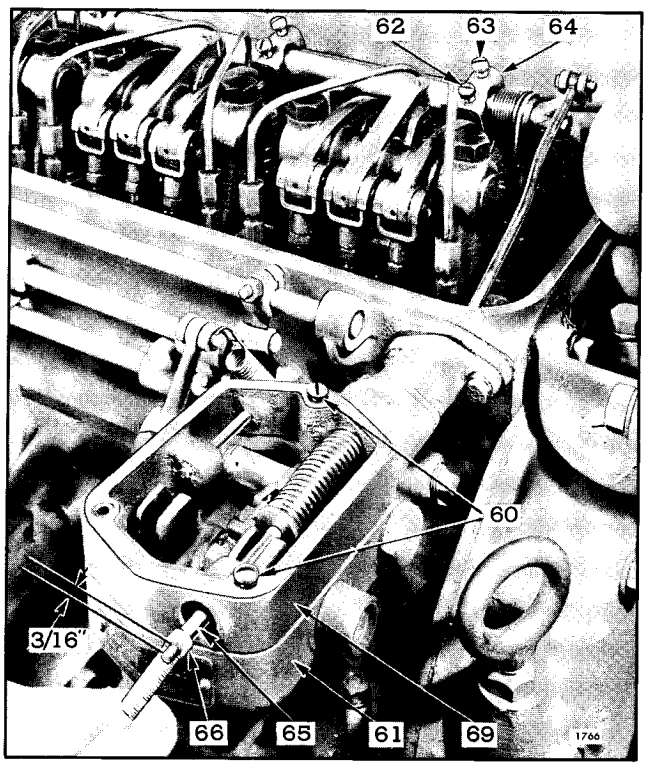


Fig. 1 - Adjusting Fuel Rod

60. Screw-Subcap to Housing
61. Housing-Governor
62. Adjusting Screw-Inner
63. Adjusting Screw-Outer
64. Lever-Injector Rack Control
65. Fuel Rod
66. Lock Nut-Fuel Rod Knob
69. Subcap-Governor

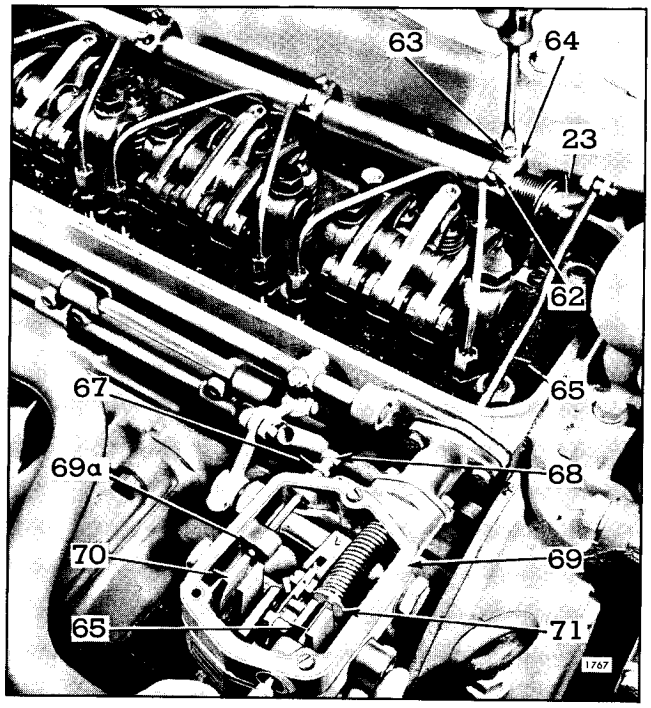


Fig. 2 - Positioning No. 1 Injector Rack

23. Lever-Injector Control Tube
62. Adjusting Screw-Inner
63. Adjusting Screw-Outer
64. Lever-Injector Rack Control
65. Fuel Rod
67. Lock Nut-Maximum Fuel Adjusting Screw
68. Screw-Maximum Fuel Adjusting
69. Subcap-Governor
69a. Boss-Governor Subcap
70. Lever-Terminal
71. Collar-Fuel Rod

1. Turn outer adjusting screw (63), Fig. 2, in until a slight movement of the injector control tube lever (23) is observed. Tighten inner adjusting screw (62).
2. Pull out on fuel rod and check for 1/32" to 1/16" movement.

   If movement exceeds that specified, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

   If movement is less than that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten inner adjusting screw.
3. Disconnect fuel rod (65) from injector control tube lever (23).
4. Holding onto clevis at end of injector control tube, position the number 1 injector in the FULL FUEL position and screw down the inner

adjusting screw of number 2 injector until the injector control lever for that injector contacts the injector body. This may be felt at the clevis end by a slight movement as contact is made.

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

5. Make sure the rack remains snug on the pin of the rack control lever at No. 1 injector.

   If the rack of No. 1 injector has become loose, back off slightly on the inner adjusting screw at No. 2 injector rack control lever. Tighten outer adjusting screw.

   When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers.

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

   When the settings are correct, the racks of all injectors must be snug on the pins of the rack control levers when control tube lever is held in the FULL FUEL position.

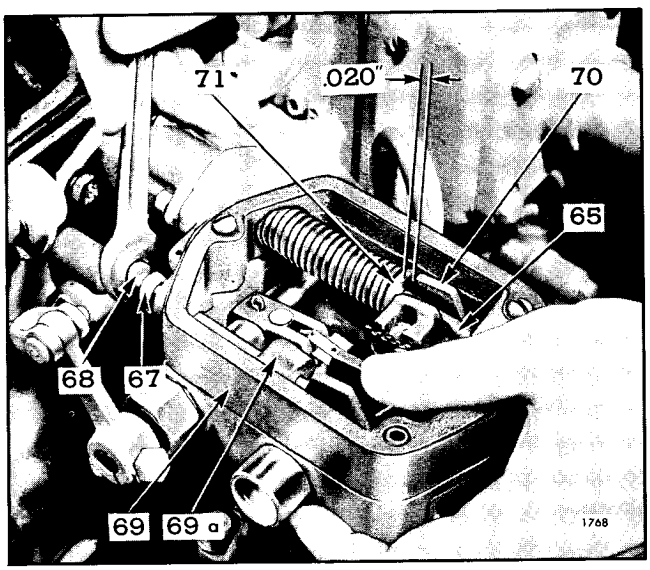


Fig. 3 - Setting Maximum Fuel Adjusting Screw (Load Limit)

65. Fuel Rod
67. Lock Nut-Maximum Fuel Adjusting Screw
68. Screw-Maximum Fuel Adjusting
69. Subcap-Governor
69a. Boss-Governor Subcap
70. Lever-Terminal
71. Collar-Fuel Rod

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be re-adjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place fuel rod (65) and terminal lever (70) in the FULL FUEL position as shown in Fig. 3.

2. Loosen lock nut (67). Turn adjusting screw (68) until a .020" space exists between the fuel rod collar (71) and the terminal lever (70). Hold screw and tighten lock nut.

Compensation Adjustment

After the temperature of the engine and the oil supplied to the governor reach their normal operating values, adjust the governor compensation, without load in the engine, as follows:

1. Open the compensating needle valve, Fig. 6, two or three turns with a screw driver and allow the engine to "hunt" or "surge" for about one-half minute to bleed trapped air from the governor oil passages.

2. Gradually close the needle valve until "hunting" just stops. Do not go beyond this position. Check the amount of needle valve opening by closing the valve completely, noting the amount required to close. Open the valve to the previously determined opening at which "hunting" stopped. Test action by manually disturbing engine speed. Engine should return promptly to original steady speed with only a small overshoot. The correct needle valve setting will be between 1/8 and 1/2 turn open.

It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change.

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.

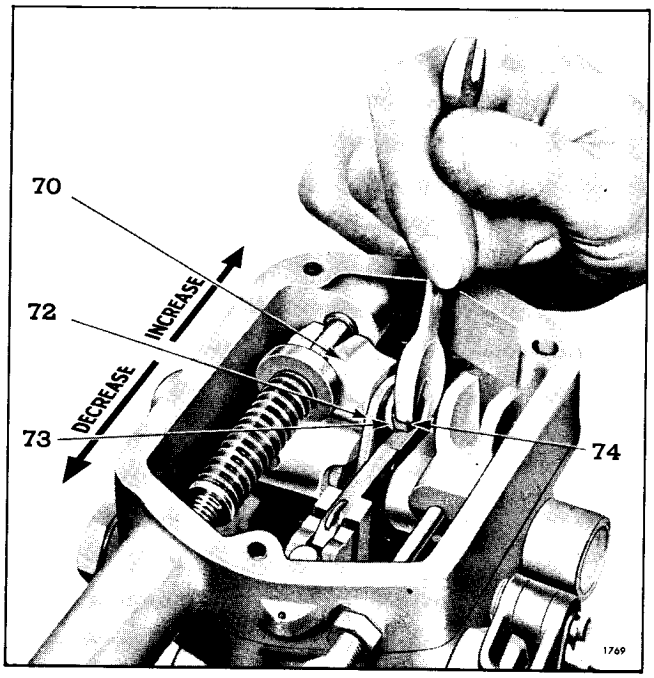


Fig. 4 - Adjusting Speed Droop

70. Lever-Terminal
72. Bracket-Droop Adjusting
73. Washer-Droop Adjusting Screw
74. Screw-Droop Adjusting

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

1. Start engine and run 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 lock nut (76), Fig. 5, and back off maximum speed adjusting screw (75) approximately 5/8''.

4. Refer to Fig. 4 and loosen droop adjusting bolt (74). Move bracket (72) so that bolt is midway between ends of slot in bracket. Tighten bolt.

   Be sure the bracket remains on the shoulder of the terminal lever.

5. With the throttle in 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 engine speed after 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 engine and again loosen bolt (74) and move droop adjusting bracket IN toward engine. Tighten bolt. To increase the speed droop, move droop adjusting bracket OUT, away from engine.

The speed droop in governors which control engines driving generators in parallel should 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 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

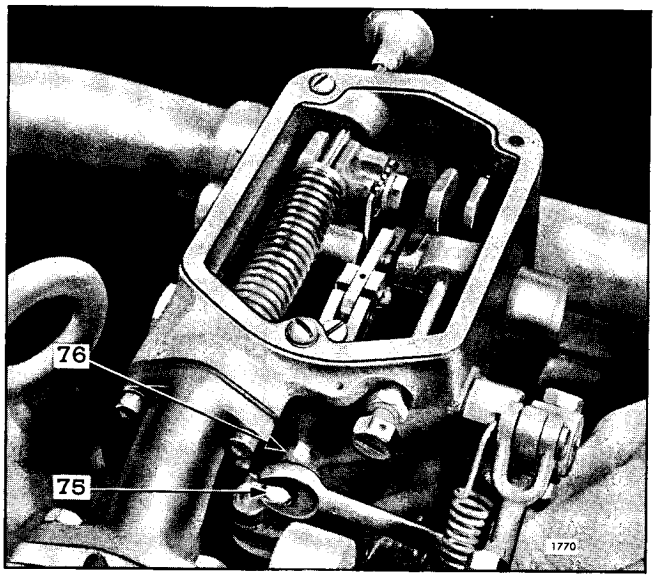


Fig. 5 - Setting Maximum Speed Adjusting Screw

75. Screw-Maximum Speed Adjusting
76. Lock Nut-Maximum Speed Adjusting Screw

14.8 HYDRAULIC WOODWARD PSG GOVERNOR ADJUSTMENT

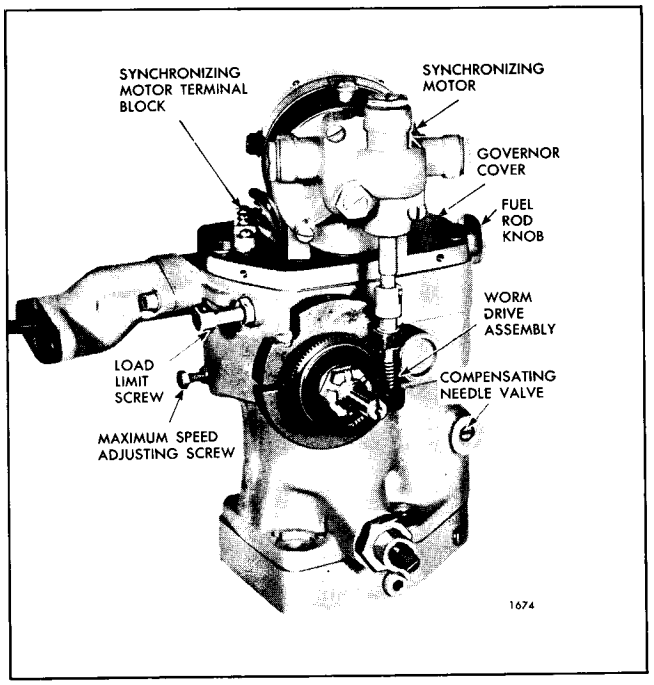


Fig. 6 - Typical Synchronizing Motor Mounting and Drive Assembly

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

A single engine unit equipped with an isochronous type hydraulic governor may operate at a constant frequency by setting the governor droop to zero. However, when operating generator units in parallel, the governor of each unit must be set with an equal amount of droop for stable operation and proper division of load.

If required the zero droop setting may be carried out by performing steps 1 through 7 as outlined, except adjust for zero droop instead of 3% to 5% stated.

Adjust Maximum No-Load Speed

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

1. With engine operating at no-load, adjust engine speed until engine is operating at approximately 10% higher than the rated full-load speed.

2. Turn maximum speed adjusting screw (75), Fig. 5, in until engine is operating approximately 8% above the rated full-load speed.

3. Hold screw and tighten lock nut (76). Install governor cover.

Governors with Synchronizing Motor

On some hydraulic governors, a reversible electric synchronizing motor is mounted on the governor cover. This motor permits close adjustment of engine speed by remote control. This feature is especially valuable when synchronizing two generators from a central control panel.

When the two-way control switch for the unit on the central control panel is closed by the operator, the motor shaft turns the governor speed adjusting shaft by means of the reduction gear and slip coupling. The direction of rotation (clockwise or counterclockwise) is dependent upon the position of the switch. When the desired engine speed is indicated on a tachometer or frequency meter on the panel, the operator returns the switch to the "OFF" position.

Should switch be held in the "Lower Speed" position too long, the synchronizing motor will continue to lower the unit speed until it ultimately shuts the engine down. Should switch be held too long in the "Raise Speed" position, the motor will turn the governor shaft until the shaft strikes the maximum speed adjusting screw, after which the clutch will slip and the motor will continue to run at a slightly reduced speed without further effect.

The adjustments on the governor equipped with a synchronizing motor are the same as on units with-

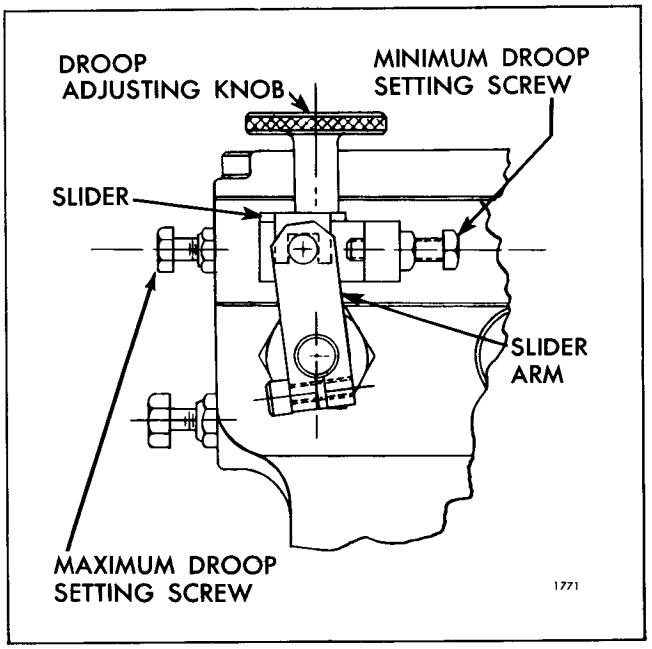


Fig. 7 - External Droop Control on PSG Isochronous Governor

out a synchronizing motor. The synchronizing motor is used in place of the vernier throttle control knob to raise and lower the engine speed.

The governor cover and motor assembly must be removed when setting the engine droop. The desired engine speeds may be obtained by manually turning the worm drive while the cover is removed.

Governors with External Droop Control

Some PSG governors have an external adjustable droop control to enable droop adjustment without the removal of the governor cover. Units, having a governor with this feature, may be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit should have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, the load should be shifted to the incoming unit and its governor droop bracket moved to zero droop. The outgoing unit can then be adjusted to maximum droop, removed from the line and stopped. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjustment of governor droop by the external adjustable droop control should be performed as follows:

1. Start engine, and run at approximately one-half the rated full load speed until the lubricating oil temperature stabilizes.
2. Remove load from engine.
3. Back off needle valve to release any air that may be trapped in the system. Turn needle valve in slowly to reduce governor hunting. The correct needle valve setting will be between 1/8 and 1/2 turn open.
4. Back out minimum and maximum droop setting screws.
5. Loosen droop adjusting knob, Fig. 7, and move slider all the way in toward the engine, and then tighten knob.
6. Loosen lock nut on maximum speed adjusting screw and turn screw out until 5/8'' of threads are exposed.
7. With engine operating at the recommended full load speed, apply the full rated load and recheck engine speed. If required, readjust engine to full load speed by means of the synchronizing motor.
8. Remove load and note engine speed. If zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the drop adjusting knob and set the slider to a reduced droop position.
9. When the desired minimum droop setting is reached, loosen lock nut and turn minimum droop setting screw inward until it contacts droop linkage within the governor. This will be felt by a step up of resistance while turning adjusting screw. Lock adjusting screw.
10. Loosen droop adjusting knob and slide droop bracket in a direction to increase droop. Perform steps 7 and 8 to check droop until the desired maximum droop is attained.
11. When the desired maximum droop setting is reached, loosen lock nut and turn maximum droop setting screw inward until it contacts droop slider arm. Lock adjusting screw.
12. Recheck the minimum and maximum droop setting as outlined in steps 7 and 8 and adjust adjustment screws if necessary until the correct settings are attained.
13. Adjust maximum no-load speed.

DUAL HYDRAULIC WOODWARD SGT GOVERNORS AND INJECTOR CONTROL RACK ADJUSTMENTS

A dual hydraulic governor assembly is used on certain torque converter applications for the Series 71 engine. This governor consists of 2 sets of flyweights and pilot valve assemblies that are interconnected to operate a single servo piston. One set of flyweights are driven by the engine. The other set is driven through a flexible shaft by the output shaft. The governor assembly used on a particular engine may have either single, Fig. 1, or dual, Fig. 3, speed control levers.

The single-lever type governor control lever is attached to the output shaft governor speed adjusting shaft, see Fig. 1. The engine and output shaft governor speed adjusting shaft arms are linked together by a "slip-joint" link as depicted in Fig. 2. The single governor control lever has two distinct arcs of travel. In the first arc of travel (used to get the r.p.m. at which the operator wishes the engine to run), the control lever moves the engine governor speed adjusting shaft arm between the engine idle and full speed positions. In the second arc of travel (used to set the r.p.m. at which the operator wishes the output shaft to run), the output shaft governor speed adjusting shaft arm "picks-up" the output shaft governor floating lever assembly by means of the pin located at the lower end of the arm. The movement of the governor control lever in the second arc of travel is opposed by the "slip-joint" linkage spring.

The dual lever type governor assembly has one of the two control levers, of the two lever control, attached to the engine governor speed adjusting shaft and is used to control the engine governor, the other is attached to the output shaft governor speed adjusting shaft and is used to control the output shaft governor, see Fig. 3.

The path of oil within both types of governor assemblies is from the pump through the engine governor pilot valve to the output shaft governor pilot valve, then to a single common servo piston. The servo piston operates a terminal lever which in turn controls the position of the fuel rod connected to the injector racks.

The engine governor no-load speed setting must be equal to the no-load output shaft speed setting plus the amount of engine speed increase over output shaft speed plus the engine governor droop.

When it is necessary to stop the engine, pull outward (away from the engine) on the fuel rod knob, shown in Figs. 1 and 3.

Adjustment

The following linkage and governor adjustments should be made with the engine stopped. Before adjusting the governor, be sure that adjustment is necessary; the injector racks, injector control tube, and remote throttle control linkage should be checked for freedom of movement, excess play or binding. Adjustments should be made only after the engine has reached normal operating temperature.

Fuel Rod Adjustment (Engine Not Running)

Figures 2 and 4 give the nomenclature of the parts in their approximate location and relation to each other. The following adjustments are made with the valve cover off.

1. Loosen adjusting screws in all injector rack control levers so that all levers move freely.
2. Remove the governor cover.
3. Loosen fuel rod lock nut and unscrew shut-down knob and rod extension. See inset Figs. 1 and 3.
4. Turn lock nut so that 3/16" to 1/4" of the fuel rod extends beyond nut.
5. Replace fuel rod extension and knob, and tighten extension against lock nut.

Position Injector Rack Control Levers (Engine Not Running)

With fuel rod properly adjusted, the rack control levers may be adjusted as follows:

1. Turn outer adjusting screw of No. 1 injector rack control lever in until a slight movement of the injector control tube lever is observed. Tighten inner adjusting screw.
2. Pull out on fuel rod and check for 1/32" to 1/16" movement.

   If movement exceeds that specified, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

   If movement is less than that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten inner adjusting screw.
3. Remove clevis pin and disconnect fuel rod from injector control tube lever.

14.9 DUAL HYDRAULIC GOVERNOR ADJUSTMENT

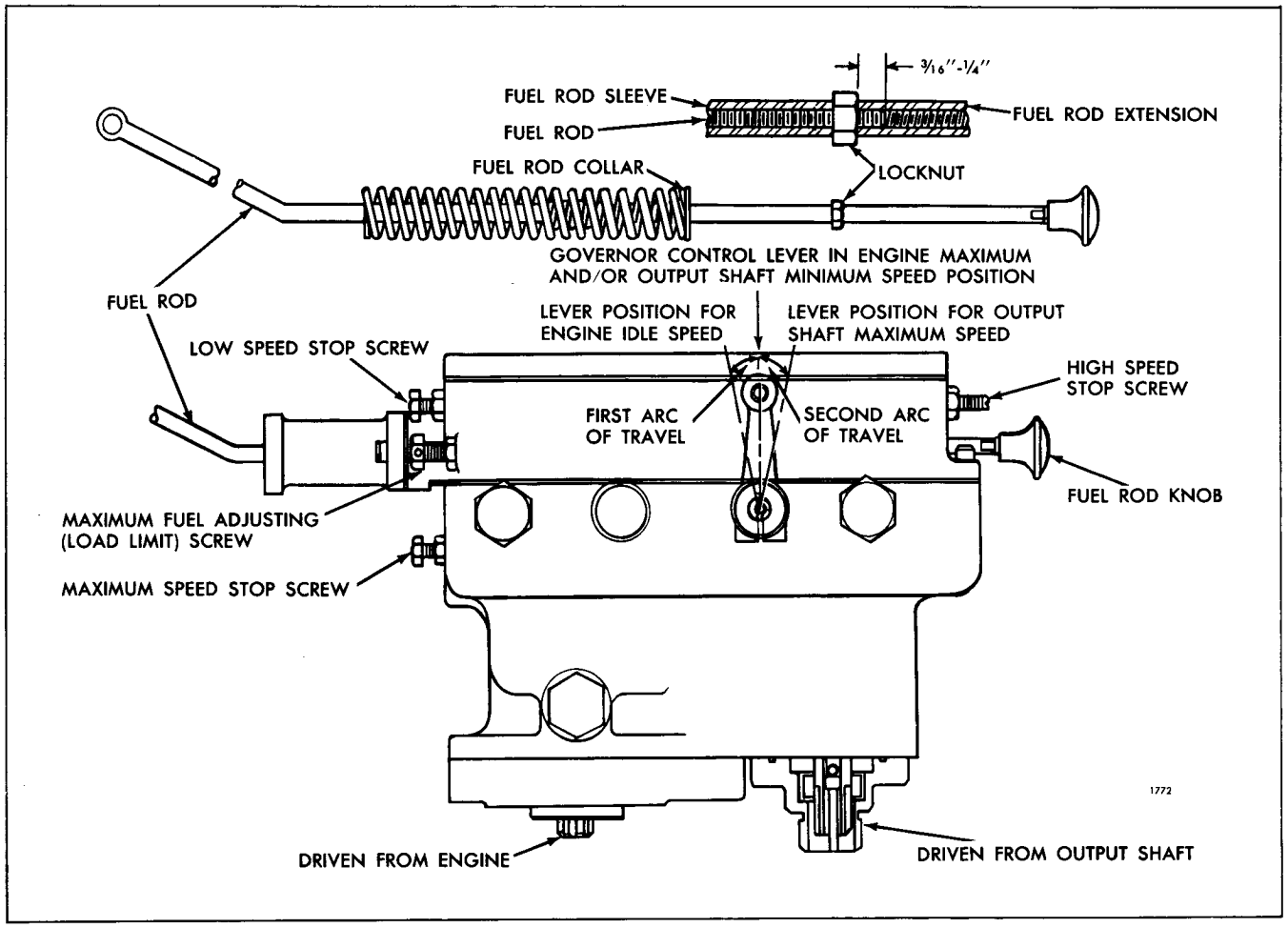


Fig. 1 - Single Lever Dual Hydraulic Governor

4. Holding onto clevis at end of injector control tube, position the No. 1 injector in the FULL FUEL position and screw down inner adjusting screw of No. 2 injector until the rack tightens on pin of rack control lever. This may be felt at the clevis end by a slight movement as contact is made.

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

5. Recheck No. 1 injector rack to be sure it has remained snug on the pin of the rack control lever while positioning No. 2 injector rack. While holding the injector control tube in the FULL FUEL position, press straight down on the rack with a screw driver. The rack should return to its original position with a rotary movement.

   If the rack of No. 1 injector has become loose, back off slightly on the inner adjusting screw of No. 2 rack control lever. Tighten outer adjusting screw.

   When No. 2 rack has the same motion as No. 1, repeat the operation on remaining injector racks, using No. 1 rack as a guide.

6. Connect fuel rod to injector control tube lever and replace clevis pin; clevis pin must rotate freely. Replace valve rocker cover.

Maximum Fuel Adjustment (Engine Not Running)

1. Place fuel rod and terminal in FULL FUEL position. (Some improvised method may be employed to hold the fuel rod in position).
2. Loosen maximum fuel adjusting screw lock nut and turn screw in until .020" gap exists between terminal lever and fuel rod collar.
3. Release fuel rod and tighten lock nut. Clearance must not exceed .020" to obtain FULL FUEL position of injector racks.

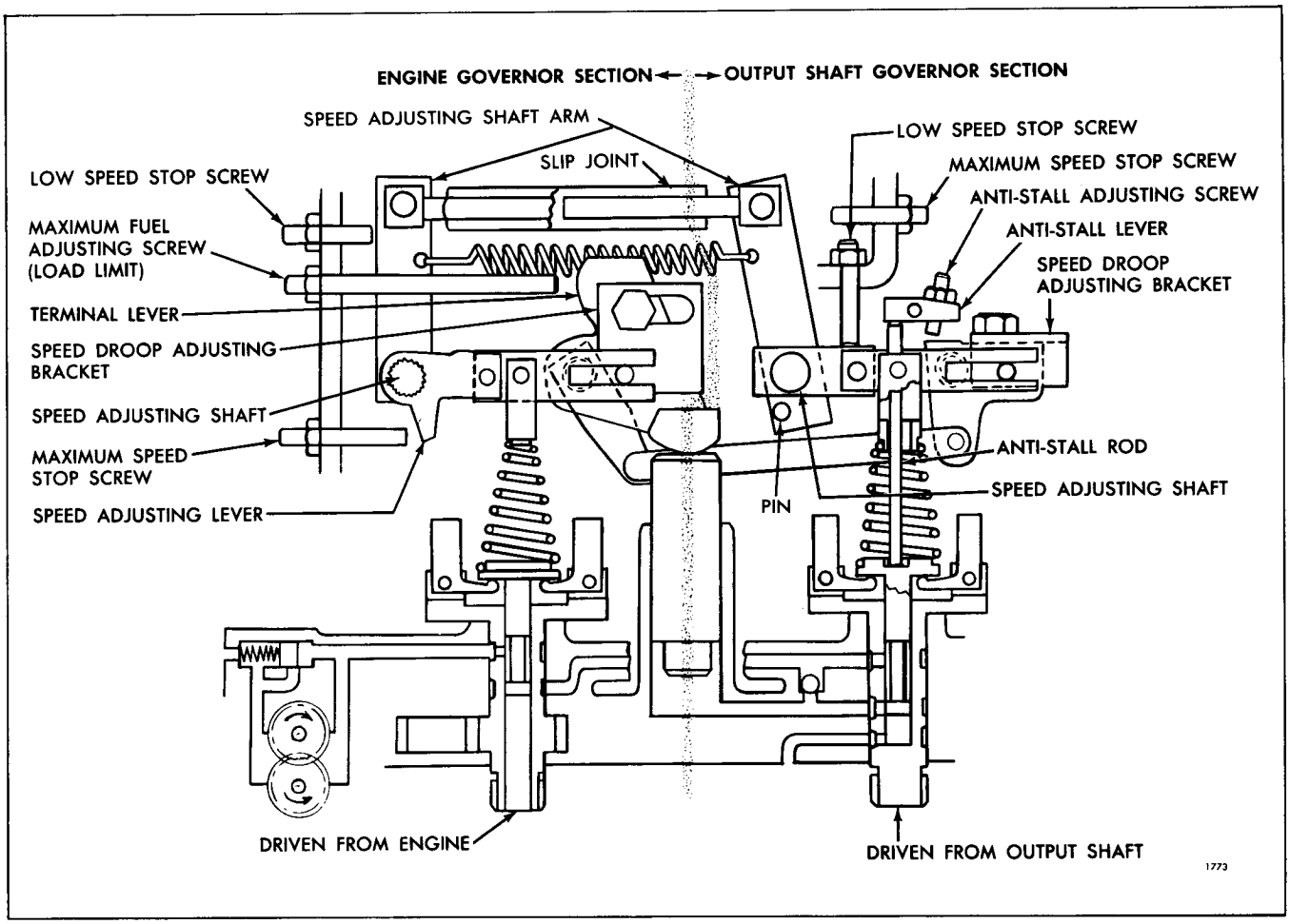


Fig. 2 - Schematic Diagram of Single Lever Governor Assembly

Before adjusting engine governor, the following steps must be performed:

1. Loosen lock nut and back out output shaft governor maximum speed stop screw until it extends approximately 1" from face of lock nut when nut is tight against housing.

2. Back out output shaft governor anti-stall adjusting screw until 1/2" of threads project from anti-stall lever.

3. Loosen output shaft governor low speed stop screw lock nut and run screw down until 5/16" of threads project from upper face of lock nut when nut is tight against governor body. The weights of the output shaft governor ball head assembly should be fully collapsed. This ensures control of the engine by the engine governor since tension on the output shaft governor speeder spring will hold the output shaft governor pilot valve plunger in an open position, thus permitting the oil passing through the engine governor pilot valve to actuate the servo piston.

4. Disconnect output shaft governor drive shaft at governor.

5. Position engine governor droop bracket so that adjusting screw is an equal distance from both ends of slot.

Adjust Engine Governor (Engine Running)

1. Start and thoroughly warm up engine.

2. Loosen lock nut on engine governor maximum speed stop screw, and back out screw until 5/8" of screw projects from face of lock nut when nut is tight against governor body.

3. Position governor control lever, using remote throttle control, so that the engine is running at the specified maximum no-load speed, usually

14.9 DUAL HYDRAULIC GOVERNOR ADJUSTMENT

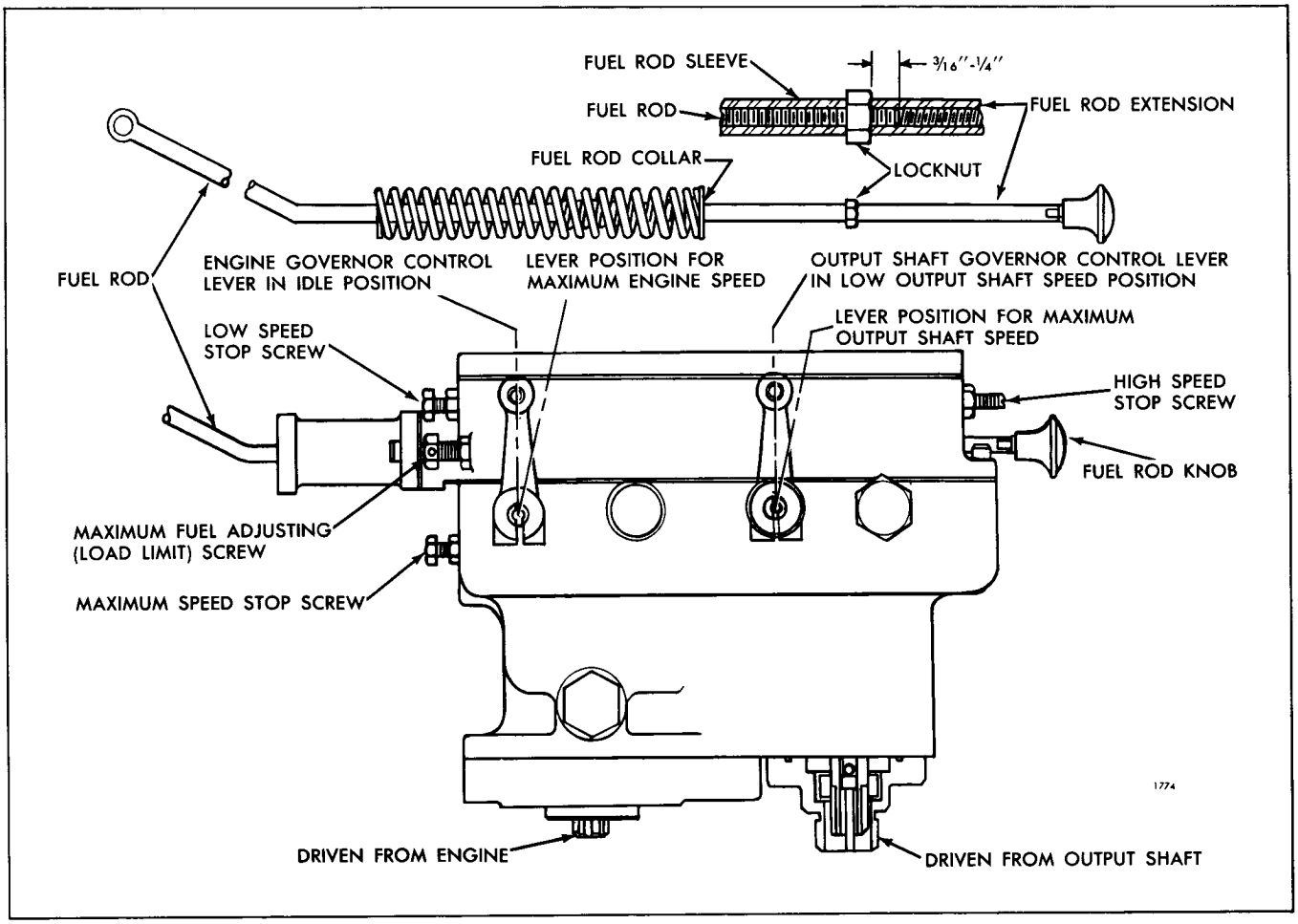


Fig. 3 - Two Lever Dual Hydraulic Governor Assembly

shown on the unit name plate. Then turn in the maximum speed stop screw until it contacts the speed adjusting lever. Tighten lock nut.

4. Loosen lock nut on engine governor low speed stop screw and run screw out until 3/4" of screw projects from governor body when nut is tight against governor body.

5. Position governor control lever, using remote throttle control, so that the engine is running at the specified no-load (minimum) speed (idle). Then, turn in low speed stop screw until it contacts the governor speed adjusting shaft arm. Tighten lock nut.

   NOTE: Idle speed should be at least 500 r.p.m.

6. Adjust the governor speed droop bracket, if necessary, to obtain the minimum droop to stabilize engine. A decreasing engine speed, as load is picked up, and an increasing speed as load is dropped off is called droop. Insufficient droop will cause "hunting" or "surging" and result in an unstable engine. It must be remembered however, that a stable engine may surge three or four times before stabilizing. Moving droop bracket toward engine decreases, and away from engine increases amount of droop. Stop engine.

Adjust Output Shaft Governor (Engine Running)

1. Connect flexible drive shaft to output shaft governor. Start engine; then ascertain that the ball head assembly of the output shaft governor is turning.

2. On single lever type governor assemblies, position governor control lever, using remote throttle control, in engine maximum speed position.

   On two-lever type governor assemblies,

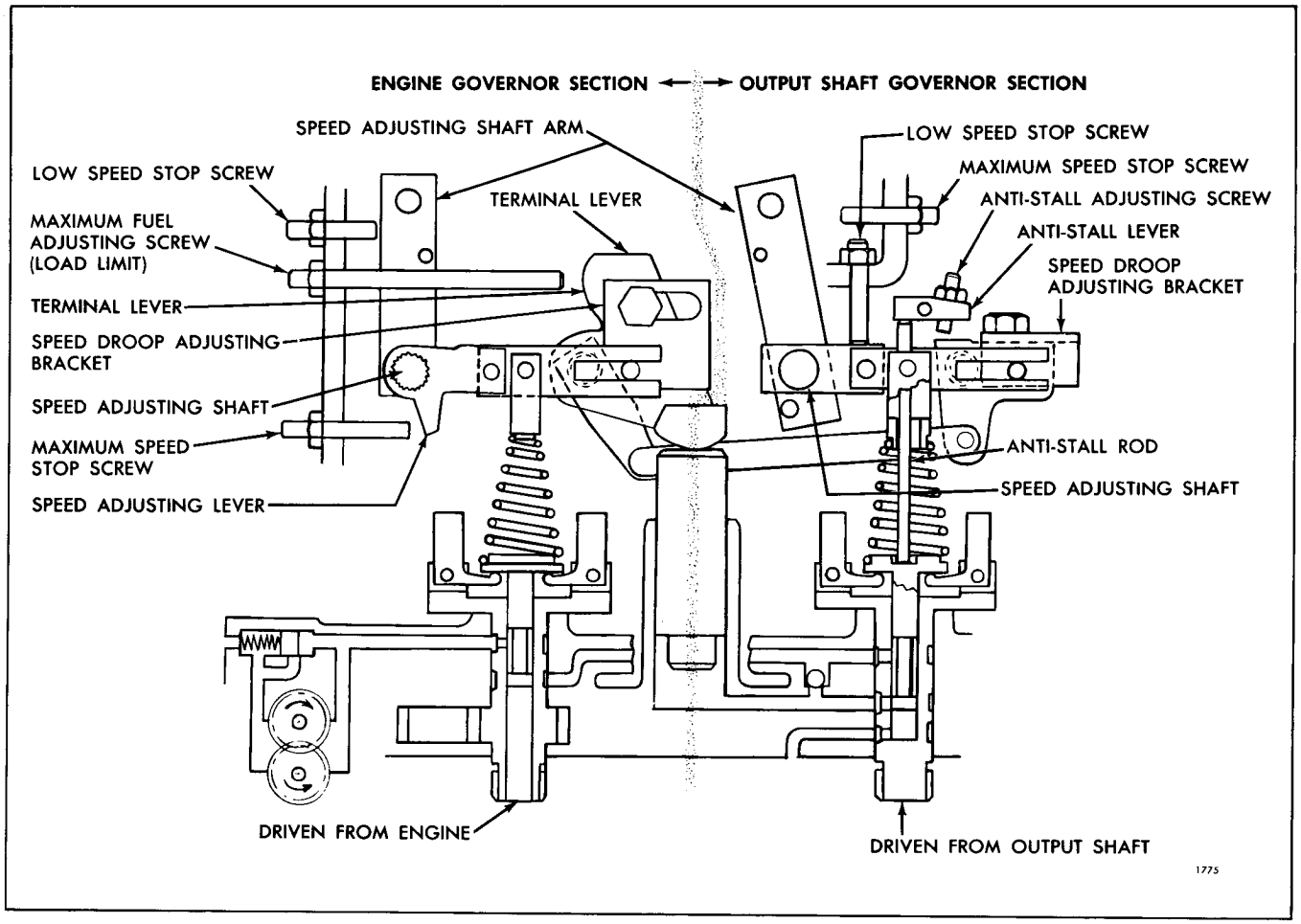


Fig. 4 - Schematic Diagram of Two Lever Governor Assembly

position engine governor control lever, using remote throttle control, in maximum engine speed position.

3. Adjust the output shaft governor speed droop bracket, if necessary, to stabilize the engine. Moving bracket toward engine decreases and away from engine increases amount of droop.

4. On single lever type governor assemblies, position governor control lever, using remote throttle control, in the output shaft minimum speed position.

   On dual lever type governor assemblies, position output shaft governor control lever, using remote throttle control, in the low output shaft speed position.

5. Loosen output shaft governor low speed stop screw lock nut and back out the screw until the desired minimum output shaft no-load speed is obtained. Tighten lock nut.

Dual governor assemblies with the "single" control lever incorporating the "slip-joint" linkage, may have the linkage adjusted to provide a "lag" or "dwell" between the throttle position at which the no-load maximum engine r.p.m. is reached and the throttle position at which the output shaft speed begins to increase (as the governor control lever is moved toward the output shaft maximum speed position). This "lag" is usually governed by the type of application (or provided for the convenience of the operator), and permits movement of the control lever toward full output shaft position, for a short distance, without a corresponding change in output shaft speed. The "slip-joint" may be lengthened or shortened by loosening the lock nut and turning the turnbuckle until the desired adjustment is made. Lengthening the linkage will decrease and shortening the linkage will increase the "lag".

6. On single lever type governor assemblies, position governor control lever, using remote throttle control, so that the output shaft is

running at the maximum speed desired (usually shown on one of the unit name plates); then run in output shaft governor maximum speed stop screw until it contacts the output shaft governor speed adjusting shaft arm. Tighten lock nut.

On dual lever type governor assemblies, position output shaft governor control lever, using remote throttle control, so that the output shaft is running at the maximum speed desired (usually shown on one of the unit name plates). Then, turn in output shaft governor maximum speed stop screw until it contacts the output shaft governor speed adjusting shaft arm. Tighten lock nut.

7. On single lever type governor assemblies, position governor control lever, using remote throttle control, in minimum speed position. Then, turn in anti-stall screw until anti-stall lever just contacts the anti-stall rod. This can be checked by lightly pressing the outer end of the anti-stall lever (side opposite screw) with a screw driver. The screw will be adjusted correctly when a slight increase in output shaft speed is noted when the lever is depressed slightly with screw driver.

   On dual lever type governor assemblies, position output shaft governor control lever, using remote throttle control, in minimum speed position. Then, turn in anti-stall screw until anti-stall lever just contacts the anti-stall rod. This can be checked by lightly pressing the outer end of the anti-stall lever (side opposite screw) with a screw driver. The screw will be adjusted correctly when a slight increase in output shaft speed is noted when the lever is depressed slightly with screw driver.

8. Replace governor cover.

MECHANICAL PIERCE OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

On certain Series 71 engine units equipped with a torque converter, it is sometimes desirable to maintain a constant output shaft speed regardless of engine speed or load fluctuations. The Pierce mechanical type output shaft governor, Fig. 1, is used for this purpose.

The governor is located at the rear of the engine and may be driven by the output shaft of the torque converter, or belt driven by a pulley on the torque converter output shaft. If the governor is belt driven, an internal oil sump is provided for lubrication, but if it is gear driven by the torque converter output shaft the lubrication is through an external line from the torque converter to the governor.

On some applications where a very low speed is required, such as in structural steel setting, the governor may be equipped with an overrule lever which allows the operator to decrease the speed of the output shaft to zero or slightly above, depending on the load on the output shaft. The overrule lever is necessary because the output shaft governor will not function at very low output shaft speeds. If the operator moves the overrule lever, the ball bearing roller contacts the linkage operating lever, moving it towards the IDLE position, thereby reducing the torque converter output shaft speed as desired. Whenever the engine is to be shut down, the governor overrule lever should be positioned to move the engine governor throttle control lever into its IDLE position. The engine may then be shut down by moving the engine governor shut-off lever into the STOP position.

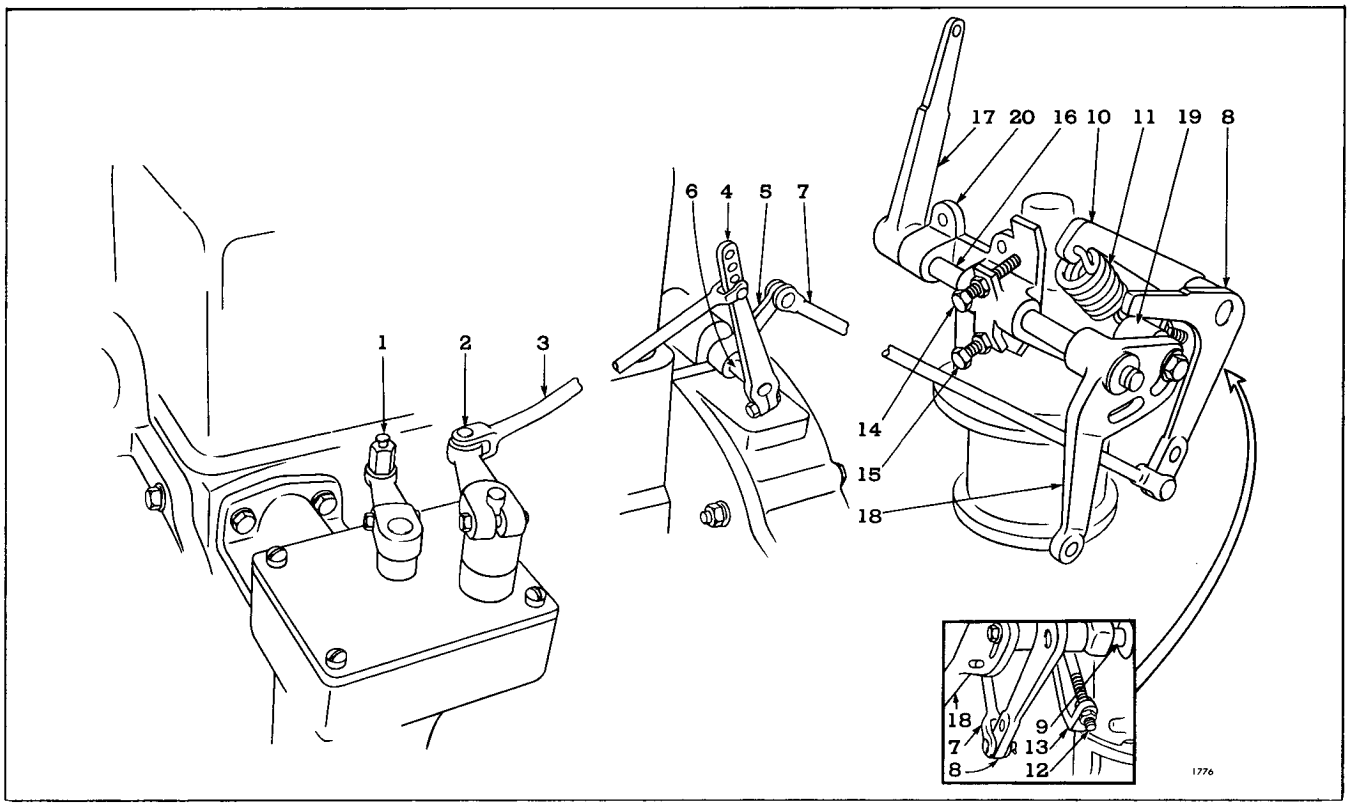


Fig. 1 - Mechanical Output Shaft Governor and Linkage

1. Lever-Shut Off
2. Lever-Throttle Shaft
3. Shaft-Throttle Control
4. Lever-Throttle Control Shaft
5. Lever-Throttle Control Cross Shaft
6. Cross Shaft-Throttle Control
7. Rod-Throttle Control
8. Lever-Linkage Operating
9. Shaft-Control
10. Arm-Spring Retaining
11. Spring-Governor
12. Eye Bolt
13. Lever-Speed Control Shaft Adjusting
14. Stop Screw-Maximum Speed
15. Stop Screw-Minimum Speed
16. Shaft-Speed Control
17. Lever-Speed Control Shaft
18. Lever-Over Rule
19. Roller-Ball Bearing
20. Bracket-Speed Control Shaft

14.10 MECHANICAL OUTPUT SHAFT GOVERNOR ADJUSTMENT

Adjustments

Refer to Fig. 1 and adjust the governor and linkage as follows:

1. Adjust valve clearance as outlined in section 14.1.
2. Time fuel injectors as outlined in section 14.2.
3. Adjust the engine governor as outlined under "Tune-Up Procedure for Units with Limiting Speed Single-Weight Mechanical Governors". The linkage from the output shaft governor must be disconnected when adjusting the engine governor, then reconnected after the engine governor adjustments are made.

   NOTE: The governor cover throttle shaft lever on the mechanical governor of the engine moves approximately 32 1/2 degrees from IDLE to FULL FUEL position. The throttle shaft lever should be adjusted so that when it is in the center of its travel, it is on an imaginary line through the center of the governor operating shaft perpendicular to the cylinder head. This will allow the throttle shaft lever on the engine governor and the speed control lever of the output shaft governor to move approximately the same distance. This adjustment can be made by loosening the bolt on the throttle shaft lever, and the bolt on the throttle control shaft (short) lever (5), Fig. 1, and moving the governor cover throttle shaft lever to the desired position then retightening the bolt.

   NOTE: The throttle control shaft (3) should be attached to the bottom hole in the throttle control cross shaft (4 hole) lever (4).

4. Lubricate all joints of the throttle control linkage and make sure that the linkage is free of any binds.
5. Loosen lock nut and turn in the output shaft governor minimum speed stop screw (15), until sufficient spring force is applied to hold the linkage operating lever (8) in the FULL FUEL position.
6. Hold the throttle control cross shaft (4 hole) lever (4) in the FULL FUEL position and tighten the clamping bolt in the throttle control cross shaft (short) lever (5). This will put both the linkage operating lever (8) and the governor cover throttle shaft lever (2) in the FULL FUEL position.
7. Back out the minimum speed stop screw (15) until it is flush with the rear face of the minimum speed screw retaining boss of the speed control shaft adjusting lever (13). Place the linkage operating lever (8) in the FULL FUEL position. Move the speed control shaft lever (17) towards the minimum speed position until the extension on the speed control shaft adjusting lever (13) contacts the lug on the spring retaining arm (10) forcing the throttle shaft lever on the engine governor into the IDLE position.

   If there is no lug on the side of the spring retaining arm (10), the minimum speed stop screw may be backed off until the clearance between the eye bolt (12) and the bottom of the spring retaining arm (10) is 1/8".

   NOTE: The above adjustments permit the engine to be returned to the idle position through the movement of the speed control shaft lever (17) towards the reduced fuel position. On some applications the low-speed stop screw (15) may be used to maintain an engine speed above the idle setting. On these installations it is necessary to use the overrule lever (18) to return the engine to the idle speed position before being shut-down.

8. Hold the speed control shaft lever (17) in the minimum speed position, established in step 7 above, and screw the minimum speed stop screw in until it contacts the speed control shaft bracket (20). Retighten lock nut.
9. Holding the speed control shaft lever in the minimum speed position, back off the inner nut on the eye bolt (12). Turn in the outer nut (clockwise) on the eye bolt (12) until the spring is just barely tight. Retighten the inner lock nut.

   CAUTION: Do not preload spring to the extent that it would prevent the throttle shaft lever on the engine governor from moving into the IDLE position.

10. Start engine and move the speed control shaft lever (17) in a direction to provide the maximum desired no-load output shaft speed. The no-load speed of the output shaft should be approximately 200 r.p.m. higher than the required full-load speed.

NOTE: Any remote throttle control linkage attached to the speed control shaft lever (17) must be very rigid and hold the speed control shaft firmly without permitting it to move in response to engine speed changes.

11. Turn in the maximum speed stop screw (14), until the screw contacts the speed control shaft bracket (20), to maintain the NO LOAD speed setting.

12. Move the speed control shaft lever (17) to the IDLE position, and then return to the FULL FUEL position thereby bottoming the maximum speed stop screw (14) against the speed control shaft bracket (20). There should be no change in the high speed setting of the engine.

HYDRAULIC WOODWARD OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

The following tune-up procedure applies to the Series 71 engine units incorporating a mechanical limiting speed governor and a hydraulic output shaft governor working as a single unit, through connecting linkage, to provide the proper output shaft speed, see Fig. 1.

The following linkage and governor adjustments should be made with the engine stopped, and after the limiting speed governor on the engine has been adjusted according to the procedure for units with single weight limiting speed governor assemblies.

Since the release of this application, various improvements have been made to the throttle linkage and governors necessitating revisions in the tune-up procedure. The following procedure applies to the current units incorporating keyed levers and a non-adjustable output shaft governor throttle rod, and with the revisions set forth under the paragraph entitled "Early Installations", may be used to adjust former units having the torque converter output shaft governor.

The following linkage and governor adjustments

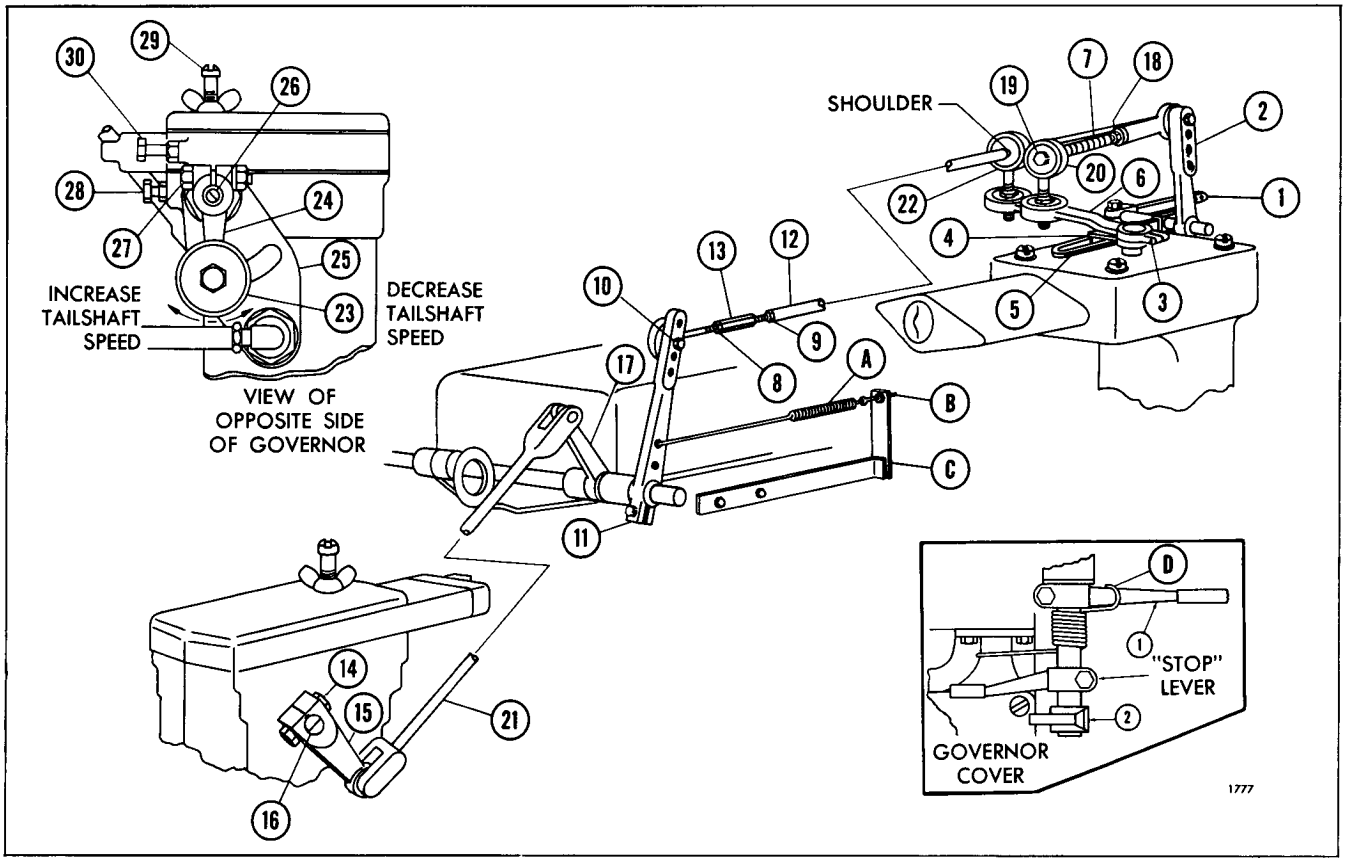


Fig. 1 - Hydraulic Output Shaft Governor and Linkage (With Keyed Levers)

1. Lever-Throttle Control
2. Lever-Governor Throttle Control
3. Screw-Clamp
4. Lever-Governor Throttle Accelerator
5. Cam-Governor
6. Lever-Governor Control
7. Spring-Repulsing
8. Lock Nut
9. Lock Nut
10. Bolt-End Bearing
11. Lever-Throttle Control Rear Cross Shaft
12. Rod-Throttle
13. Turnbuckle
14. Bolt and Nut-Clamp
15. Lever-Output Shaft Governor Control
16. Shaft-Governor Terminal
17. Lever-Throttle Control Rear Cross Shaft
18. Lock Nut
19. Bolt-Spring
20. Rod-End Bearing
21. Rod-Throttle
22. End Bearing-Rod
23. Knob-Speed Control
24. Lever-Speed Control
25. Quadrant
26. Shaft-Speed Adjusting
27. Bolt-Clamping
28. Screw-Maximum Speed Limit Adjusting
29. Screw-Minimum Speed Limit Adjusting
30. Screw-Maximum Fuel Adjusting
- A. Spring-Pull Back
- B. Screw-Pull Back Spring Adjusting
- C. Bracket-Pull Back Spring
- D. Spring-Throttle Control Return

should be made with the engine stopped, and after the limiting speed governor on the engine has been adjusted according to the procedure outlined in a previous section of this manual.

Adjustments

1. Place the remote throttle hand lever (1), Fig. 1, in the "FULL SPEED" position.

2. Force the control lever (6) and throttle accelerator lever (4) into the IDLE notch of the governor cam (5). The repulsing spring (7) should be fully compressed at the time the throttle accelerator lever reaches the idle notch of the governor cam (5). If this spring is not fully compressed, loosen clamp screw (3) in the end of the governor control lever (6) and move control lever until spring is compressed. Should repulsing spring become fully compressed prior to the throttle accelerator lever reaching the IDLE notch of the governor cam, loosen lock bolt (3) in the governor control lever (6) and manually move the throttle accelerator lever (4) into the IDLE notch.

3. Hold the throttle accelerator lever (4) halfway between the IDLE and FULL FUEL position, and loosening lock nuts (8) and (9), adjust the turnbuckle (13) on the throttle rod (12) so that the rear cross shaft lever (11) is vertical.

4. Loosen the lock bolt (14) in the output shaft governor control lever (15) and remove lever from terminal shaft (16). With the cross shaft lever (11), force the throttle accelerator lever (4) into the IDLE position and reinstall and lock the output shaft governor control lever (15) onto the terminal shaft (16).

   NOTE: Move the rear cross shaft lever (11) into the FULL FUEL position and check to see that there is no bind between the throttle rod clevis on the end of throttle rod (21), and the output shaft governor control lever (15).

5. Move the throttle accelerator lever (4) into the FULL FUEL position of the governor cam (5) and check to see that there is from 1/32" to 1/16" clearance between the rod end bearing (20) and the head of the spring bolt (19). If the clearance is not correct, loosen lock nut (18) and adjust spring bolt (19) until this clearance is obtained.

6. Manually hold the throttle accelerator lever (4) in the IDLE position. Loosen lock nuts (8 and 9) and adjust turnbuckle (13) until shoulder of throttle rod (12) just contacts its rod end bearing (22) holding accelerator lever (4) in IDLE position.

Early Installations

In a few isolated cases, when the load was removed from the output shaft, the force exerted by the repulsing spring prevented the tailshaft hydraulic governor from moving the mechanical governor accelerator lever fully into the IDLE position; therefore, to eliminate the possibility of the recurrence of this difficulty, the force exerted by this spring was reduced. If the governor accelerator lever does not return to the IDLE position, loosen the clamp screw of governor control lever (6) and move the lever away from the governor a sufficient amount to very slightly relieve the tension on the repulsing spring (7). This reduction in spring force will permit the governor control lever (6) to return to the IDLE position; however, repeat step 5 of this procedure to obtain clearance between the head of spring bolt (19) and rod end bearing (20).

Early installations included a pull-back spring (A), one end of which was connected to an eye-bolt (B) in a bracket (C) attached to the cylinder head. The other end of the spring was hooked into the upper small hole drilled in the throttle control rear cross shaft lever (11). This spring is adjusted by means of the eye-bolt, to counteract the tension of the repulsing spring (7) which tends to move the governor control lever (6) into the FULL FUEL position. Spring (A) should be adjusted so its force solidly compresses the repulsing spring when the governor control lever is in the IDLE position. The function performed by the retracting spring (A) in the early installations is accomplished in current installations by a spring incorporated in the tailshaft governor assembly.

In these early installations, the terminal shaft (16) must be rotated in a counterclockwise direction to the NO FUEL position when installing the tailshaft governor control lever onto the terminal shaft. This can be accomplished with a screwdriver inserted into the slot provided in the end of the terminal shaft.

The remote control linkage installed in various engine torque converter and tailshaft governor linkage installations may include a variety of bellcranks, levers, rods, and flexible control cable. Due to the probability of moving the throttle control lever into various operating positions between "stop", "idle", and "run" many times during the working day, any "play" in the linkage may gradually delay the instantaneous response of the linkage when moving the throttle control lever from

one position to another. In view of this, a throttle control lever return spring has been added to the linkage arrangement to "take-up" any "play" (which may be caused by worn clevises or pins) by keeping the linkage "loaded" against the operator's control.

The new spring is installed on the front cross shaft--the long curved end of the spring bears against that portion of the engine governor housing which is connected to the cylinder head--the opposite end hooks over the throttle control lever, as shown in the inset of the accompanying illustration and marked "D".

The throttle control lever return springs for use on "A" and "C" type engines may be incorporated in the torque converter tailshaft governor linkage of former installations which do not include this feature. All that need be done is to remove the stop and governor throttle control levers from the front cross shaft, install the spring onto the shaft so that the long end bears against the governor housing, and the short end is hooked over the throttle control lever.

The tailshaft governor control rods and cross shafts used in the torque converter tailshaft governor linkage have been revised from time to time in order to provide a more secure linkage, locate the levers in a fixed position, and thus simplify the procedure for adjusting the linkage.

Shortly after the advent of the keyed cross shafts, several minor revisions were incorporated in order to further improve the geometrical relationship between the rods and levers.

The revisions to the front cross shaft are as follows:

a. The addition of another key-slot for the governor throttle control lever to permit its use on "C" type engines.

b. The relocation of the key-slot for the throttle control lever 180^{o} from its former position, thus positioning the key-way on the shaft facing the key-way in the lever; whereas, formerly the key-way in the shaft faced the "split" in the lever.

c. The addition of a key-slot for the stop lever.

The revisions in the rear cross shafts and one of the governor control rods are as follows:

a. The rear cross shaft with key-ways spaced $37\text{-}1/2^{o}$ apart was revised by spacing the keyways 44^{o} apart. This shaft is used only on engine units incorporating TCA type torque converters.

b. The tailshaft governor control rod was shortened approximately 3/8" to conform with the relocated key slots in the above described rear cross shaft. This rod is used only on engine units incorporating TCA type torque converters.

c. A new rear cross shaft with key-ways spaced 32^{o} apart has superseded the former rear cross shaft with the key-ways spaced $37\text{-}1/2^{o}$ apart. This shaft is used only on engine units incorporating TCDA type torque converters.

d. The tailshaft governor control rod remains unchanged and is used only on engine units incorporating TCDA type torque converters.

Since the tailshaft governor control lever may be removed from the terminal shaft and moved slightly in either direction; and, the turn-buckle on the throttle rod, or the spring bolt on the governor control shaft adjusted to compensate for any small variations in length caused by relocating the key slots, the foregoing revisions will in no way alter the procedure for adjusting the torque converter tailshaft governor linkage (with keyed levers).

Final Adjustments

Place the remote throttle control in "mid-position", then start the engine. After the engine reaches normal operating temperature under no-load, place the remote throttle control in the FULL FUEL position and check the torqmatic converter output shaft speed. This speed will vary depending upon engine application requirements. If it is necessary to adjust the output shaft speed, loosen the speed-control knob and move the speed-control lever toward the engine to increase speed, or away from the engine to decrease speed. The high droop of the torqmatic converter output shaft hydraulic governor is due to it being driven through the torque converter, therefore, the "no-load" setting should be at least 150 r.p.m. higher than the desired "full-load" setting. Tighten the speed control knob when the required "no-load" is obtained.

> **CAUTION:** Do not set the torqmatic converter output shaft speed in excess of that speed specified by the equipment manufacturer, otherwise, damage may result to the driven machinery.

During operating of the engine, it will be noted that minimum droop will vary between 150 to 175 r.p.m. However, if the droop requires adjustment, move the droop bracket (inside the output shaft hydraulic

governor) toward the engine to decrease, and away from the engine to increase, the amount of droop.

NOTE: To compensate for the output shaft speed droop, the no-load engine speed must be set approximately 175 r.p.m. above the required full load engine speed.

In this application of a hydraulic governor, the maximum fuel adjusting screw and the maximum speed adjusting screw are not employed and therefore, should be backed "out-of-play".

Linkage should be lubricated periodically.

THROTTLE LINKAGE ADJUSTMENTS FOR LOAD EQUALIZATION— TWIN AND QUAD UNITS

Each twin unit consists of two engines and each quad unit of four engines connected by clutches to a common gear box. The throttle adjustment is made so that each engine of a twin or quad unit will carry its share of the load. Throttle adjustments are divided into two groups, depending on the type of governor used.

The two groups are:

1. Throttle adjustments on twin or quad units with limiting or variable speed mechanical governors.
2. Throttle adjustments on tandem twin marine units with variable speed mechanical governors.

THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON TWIN OR QUAD UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

The individual engine tune-up is very important in the adjustment of twin and quad units as the engines must be closely synchronized to enable each to carry its full share of the load.

Therefore, disconnect the control rods (157), Fig. 2, from control levers (12) and perform the tune-up procedures for single engines before adjusting the throttle control linkage. Then, with engines stopped and valve covers removed:

1. Check the two levers on top of each governor for vertical alignment (i.e. one exactly over the other). If the levers are not in alignment, adjust the top lever (12), Fig. 2, on its shaft until the alignment is correct.

2. Make sure that the individual throttle control levers (195) are latched to their quadrant (218) by positioning pin (197), Fig. 1.

3. Move the master throttle control lever (161) to the FULL FUEL position.

4. Make sure each control lever (12), Fig. 2, is in the FULL FUEL position. The pin of the lever (12) must be just touching the end of the slot in cam (17).

5. If the governor control levers are not in the FULL FUEL position, loosen the two turnbuckle nuts (141) and adjust turnbuckles (115) until all levers are in their FULL FUEL position, see Figs. 2 and 3.

6. Tighten the turnbuckle lock nuts (141) and check the position of lever (12). When tightening the lock nuts, be careful not to "cock" the end bearing (136), Figs. 2 and 3.

7. Move the master control lever (161) to the IDLE position and start the engines.

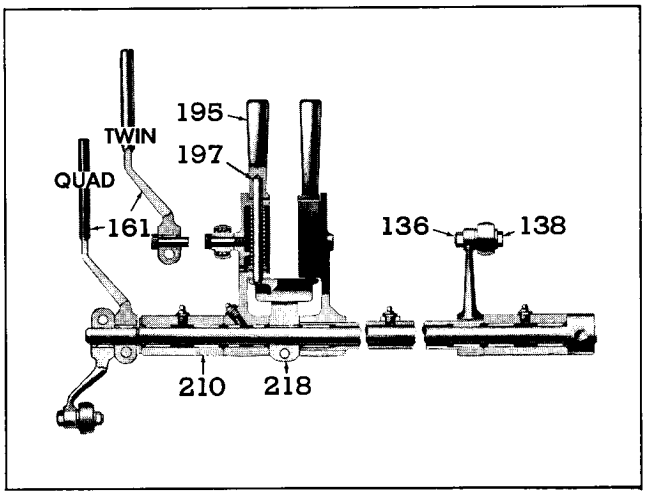


Fig. 1 - Throttle Control Shaft Assembly - Twin and Quad Units

136. Bearing-Control Rod End
138. Bolt-Control Rod
161. Lever-Master Throttle Control
195. Lever-Throttle Control
197. Pin-Throttle Control Lever
210. Bracket-Control Shaft
218. Quadrant-Throttle Control

CAUTION: Be sure the clutches are disengaged before starting engines.

8. Run the engines until they are at normal operating temperature.

9. Move the master control lever (161) to the IDLE position and check idle speed of each engine.

10. Move the master control lever (161) to the FULL FUEL position and check no-load speed of each engine.

11. Move the master control lever (161) to a position approximately 200 r.p.m. below the no-load

14.12 THROTTLE LINKAGE ADJUSTMENTS

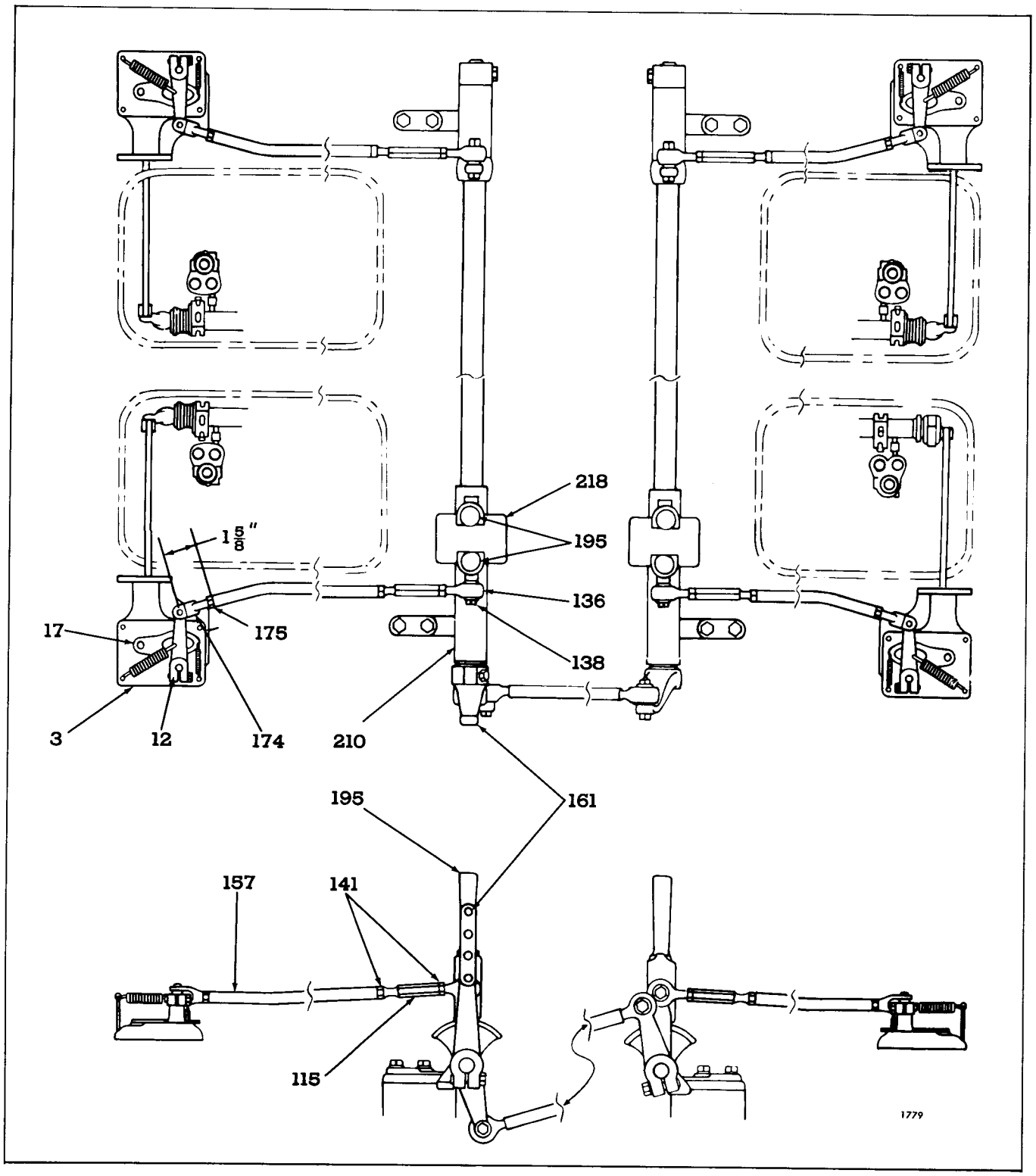
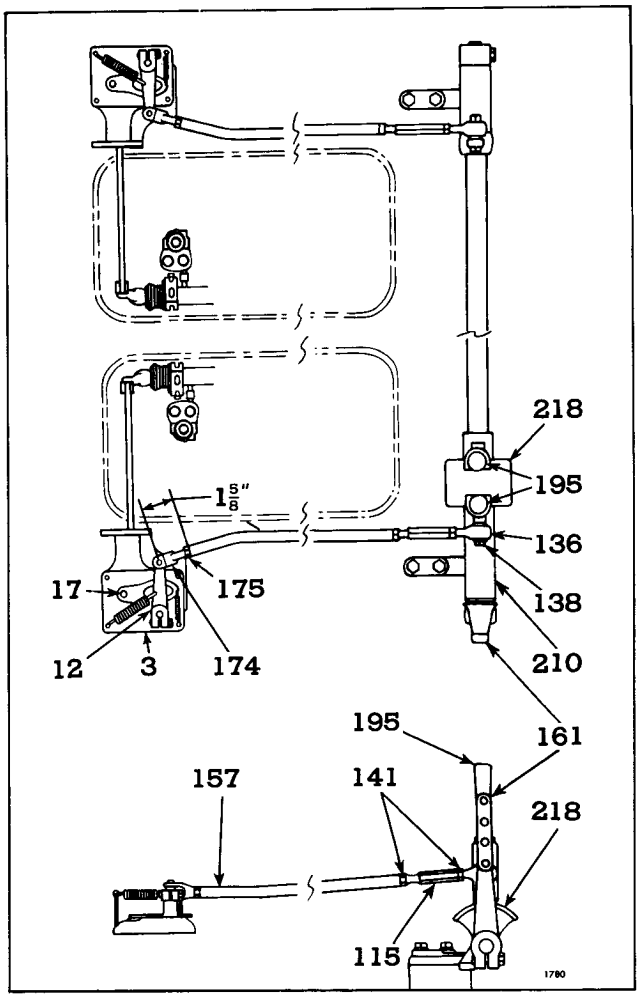


Fig. 2 - Diagram of Throttle Control Linkage for Quad Units with Limiting Speed Mechanical Governors

3. Cover-Governor
12. Lever-Governor Control
17. Cam-Cover
115. Turnbuckle
136. Bearing-Control Rod End.
138. Bolt-Control Rod
141. Lock Nut-Turnbuckle
157. Rod-Control
161. Lever-Master Throttle Control
174. Clevis-Control Rod
175. Lock Nut-Clevis
195. Lever-Throttle Control
210. Bracket-Control Shaft
218. Quadrant-Throttle Control

Fig. 3 - Diagram of Throttle Control Linkage for Twin Units with Limiting Speed Mechanical Governors

3. Cover-Governor
12. Lever-Governor Control
17. Cam-Cover
115. Turnbuckle
136. Bearing-Control Rod End
138. Bolt-Control Rod
141. Lock Nut-Turnbuckle
157. Rod-Control
161. Lever-Master Throttle Control
174. Clevis-Control Rod
175. Lock Nut-Clevis
195. Lever-Throttle Control
210. Bracket-Control Shaft
218. Quadrant-Throttle Control



speed. Check the engine r.p.m.s. Engines should be running within 50 r.p.m. of each other.

a. Move the master control lever (161) to a position approximately 200 r.p.m. below step 11. Check the engine r.p.m.s again. Engines should be running within 50 r.p.m. of each other.

b. Move the master control lever (161) to a position approximately 200 r.p.m. below step a. Check the engine r.p.m.s again. They should be within 50 r.p.m. of each other.

If this procedure does not bring the engines within close synchronization, recheck each engine for poor compression, faulty injectors, low fuel oil pressure, or other conditions which may cause unsatisfactory engine operation. See Trouble Shooting in section 15.

12. Install valve covers.

THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON SIDE-BY-SIDE TWIN OR QUAD UNITS USING VARIABLE SPEED GOVERNORS

The individual engine tune-up is very important in the adjustment of twin and quad engine units as the engines must be closely synchronized to enable each to carry its full share of the load. Therefore, disconnect the control rods (157) from control levers (21) and cross link equalizer spring (239) from cross link (114), see Fig. 4. On quad units, loosen screw (147), Fig. 5, and remove the master control equalizer spring (103). Then with engines stopped and valve covers removed:

1. Check the link (234), Figs. 4 and 5, on each engine. Be sure the bolt (111) is just touching the end of link in idle position.

2. Make sure that the individual throttle control levers (195) are latched to their quadrant (218) by positioning pins, Fig. 1.

3. Move the master throttle control lever (161), Figs. 4 and 5, to the FULL FUEL position.

4. Make sure each control lever (21) is in the FULL FUEL position (all the way back).

5. If the governor control levers are not in the FULL FUEL position, loosen the two turnbuckle nuts (141) and adjust turnbuckles (115) until all levers are in their FULL FUEL position.

6. Tighten the turnbuckle lock nuts (141), and check the position of each governor lever. Levers must be all the way back. Be careful not to "cock" the end bearing (136).

The following steps should be performed to adjust the booster spring (144) if necessary.

14.12 THROTTLE LINKAGE ADJUSTMENTS

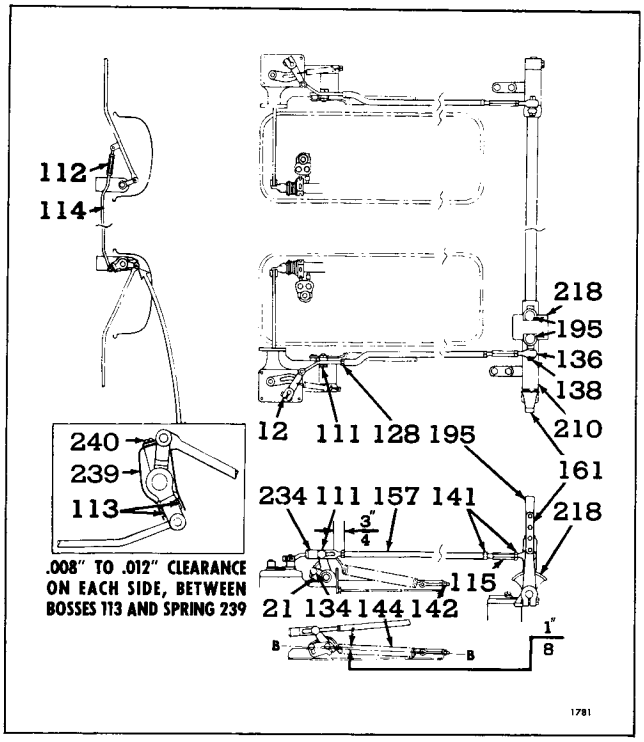


Fig. 4 - Diagram of Throttle Control Linkage for Twin Units with Variable Speed Mechanical Governors

12. Lever-Governor Control
21. Lever-Speed Control
111. Bolt-Lever to Link
112. Turnbuckle-Cross Link Equalizer
113. Boss
114. Link-Equalizer
115. Turnbuckle
128. Lock Nut
134. Pin-Booster Spring
136. Bearing-Control Rod End
138. Bolt-Control Rod
141. Lock Nut-Turnbuckle
142. Lock Nut-Booster Spring Adjusting
144. Spring-Booster
157. Rod-Control
161. Lever-Master Throttle Control
195. Lever-Throttle Control
210. Bracket-Control Shaft
218. Quadrant-Throttle Control
234. Link-Control Rod End
239. Spring-Link Equalizer
240. Screw-Equalizer Spring

With idle speed set, the booster spring may be adjusted as follows:

a. Set the governor booster spring pin (134) 1/8" below over-center line B-B, as shown in Figs. 4 and 5.

b. Make sure the clutches are disengaged and start each engine.

c. Release each speed lever individually from the FULL FUEL position, and note its return to the idle position. The lever should return quickly.

d. Refer to Fig. 4 and loosen booster spring retaining nut on speed control lever (21). Loosen nut and lock nut on eyebolt at opposite side of spring (144).

e. Move bolt up or down in slot of lever (21) to a position that will allow speed control lever to move from the FULL FUEL position to the IDLE position. Hold bolt and tighten spring retaining nut.

f. Turn nut on eyebolt to a position that will allow the speed control lever to be moved to the FULL FUEL position with the least amount of effort.

7. Connect each of the governor control rods (157) to lever (21).

8. Set the gap between the end of link (234) and governor control lever (21) at 1/16" to 1/8" by adjusting the lever (21) on its shaft. While setting the gap, the governor lever must be in the IDLE position, and the forward end of the slot in link (234) must be contacting the lever-to-link bolt (111).

9. Secure the master throttle control lever (161) in the FULL FUEL position, then replace equalizer spring (239) and secure with screw (240).

10. Loosen the lock nut (141) at turnbuckle (112). Adjust the turnbuckle until there is equal clearance between each leg of the equalizer spring (239) and lower boss (113), approximately .010" clearance on each side.

11. Tighten turnbuckle lock nut (141) and recheck clearance. Readjust if necessary.

12. Lubricate the link joints of the equalizer linkage with a few drops of engine oil. Move the master throttle control lever (161) back and forth to check for binding in the equalizer. Note if the equalizer link (114) rubs inside the tube. Correct any binding that may exist.

13. Disengage clutches. Move master throttle control lever (161) to IDLE position and start engine.

14. Run engines until they are operating at normal temperature.

15. Move master throttle control lever (161) to IDLE position and check idling speed.

    The idling speed of the engine, not incorporating the equalizer spring (239), will probably be less than that of the engine which has the spring due to the expansion of the cross link (114). In such cases, remove the valve cover and proceed as follows:

16. Loosen the equalizer turnbuckle lock nut (141),

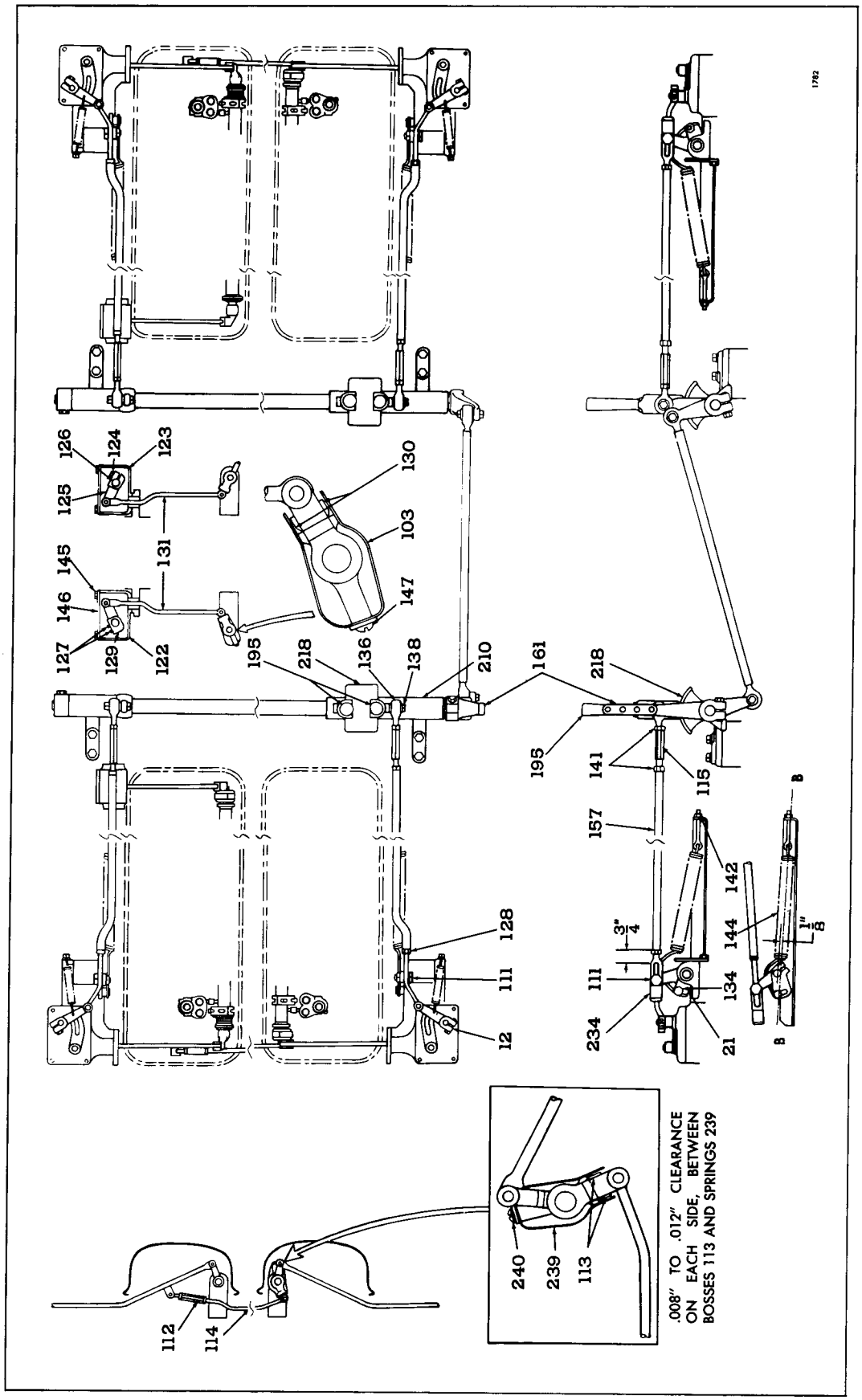


Fig. 5 - Diagram of Throttle Control Linkage for Quad Units with Variable Speed Governors

12. Lever-Governor Control
21. Lever-Speed Control
103. Spring-Equalizer
111. Bolt-Lever to Link
112. Turnbuckle-Cross Link Equalizer
113. Boss
114. Link-Equalizer
115. Turnbuckle
122. Housing-Master Control Equalizer
123. Housing-Master Equalizer
124. Bolt
125. Lever-Master Equalizer
126. Shaft-Equalizer
127. Screw-Adjusting
128. Lock Nut
129. Lever-Master Control Equalizer
130. Boss-Master Control Equalizer
131. Link-Master Control Equalizer
134. Pin-Booster Spring
136. Bearing-Control Rod End
138. Bolt-Control Rod
141. Lock Nut-Turnbuckle
142. Lock Nut-Booster Spring Adjusting
144. Spring-Booster
145. Bolt-Equalizer Housing
146. Cover-Equalizer Housing
147. Screw-Master Control Equalizer Spring
157. Rod-Control
161. Lever-Master Throttle Control
195. Lever-Throttle Control
210. Bracket-Control Shaft
218. Quadrant-Throttle Control
234. Link-Control Rod End
239. Spring-Link Equalizer
240. Screw-Equalizer Spring

and adjust the turnbuckle (112) until both engines are idling at the same speed. Clearance between each leg of the equalizer spring (239) and lower bosses (113) should be equal.

17. Install valve covers.

18. Start engines and move throttle control lever (161) to the FULL FUEL position and check the maximum no-load speed of each engine.

    The speed should now be the same as previously set. If not, check for binding in the equalizer.

19. With the clutches still disengaged, move the master throttle control lever until the engines are running approximately 200 r.p.m. lower than the maximum no-load speed.

20. Using a hand tachometer, check the speed of the engines. They should be running within 25 r.p.m. of each other.

21. If a variation of more than 25 r.p.m. exists, check the tune-up of each individual engine as outlined in this manual.

    Then adjust the master control equalizer between the front and rear engine pairs comprising the quad unit, see Fig. 5.

22. Remove valve covers, if not previously removed.

23. Remove bolts (145), covers (146) and gaskets from equalizer housing (122) and (123).

24. Loosen bolt (124) until lever (125) swings freely on equalizer shaft (126).

25. Adjust screws (127) until they are threaded equally into the adjusting lever (129) and are contacting the flats in the equalizer shaft. Bolts should be fairly tight.

26. With the individual control levers (195) latched to their quadrants (218), move the master control lever (161) to the FULL FUEL position and secure master lever.

27. Move the equalizer link (131) connected to equalizer adjusting each leg of the equalizer spring (103) and each boss (130).

    The clearance should be approximately .010'' on each side.

28. Hold the equalizer link in this position and tighten clamping bolt (124) on equalizer lever (125).

29. Recheck the clearance between each leg of the equalizer spring (103) and lower bosses (130). Readjust if necessary.

30. Install valve covers.

31. Move the master throttle control lever (161) to the IDLE position and start engines.

32. Move master throttle control lever (161) to accelerate engines until they reach normal operating temperatures.

33. Move the master throttle control lever to the FULL FUEL position and check the maximum no-load speed on each engine.

34. Move the master throttle control lever (161) to the IDLE position and check the idle speed of each engine.

    The maximum no-load speed and idle speed of each engine should be the same as previously set.

35. If speeds in steps (33) and (34) are not as previously set, it will be necessary to readjust the master equalizer adjusting lever (129) by means of adjusting screws (127).

36. After these adjustments have been satisfactorily completed, install equalizer housing gaskets and covers.

    If this procedure does not bring the engines within close synchronization, it is suggested that each engine be checked for possible causes of low power, such as poor compression, faulty injectors, low fuel pressure, etc. All engines must be in good operating condition to secure close synchronization, especially under load, as any of the mentioned conditions will prevent an engine from developing full power.

THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON TANDEM TWIN UNITS USING VARIABLE SPEED MECHANICAL GOVERNORS

Figures 6 and 8 illustrate the arrangement of the throttle and reverse gear controls on Tandem Twin Units, while Figs. 7 and 9 illustrate the master control and individual throttle lever assemblies.

Master throttle levers and master reverse gear control levers are provided in both the engine room and pilot house, thus permitting operation of the propulsion unit at either location through this dual control arrangement.

The individual engine tune-up is very important in the adjustment of these twin units as the engines must be closely synchronized to enable each to carry its full share of the load.

Therefore, refer to Fig. 8 and disconnect the control rods (157) from control levers (21) and perform the tune-up procedures for single engines given in this manual before adjusting the throttle control linkage. Then, with engines stopped and valve covers removed:

1. Remove any bind or excess play from clevis pins.

2. Refer to Figs. 7 and 9 and move master throttle lever (129) toward FULL OPEN position until the two clevis pins in the upper and lower arms of the throttle lever shank are in a vertical straight line, as observed through the two holes

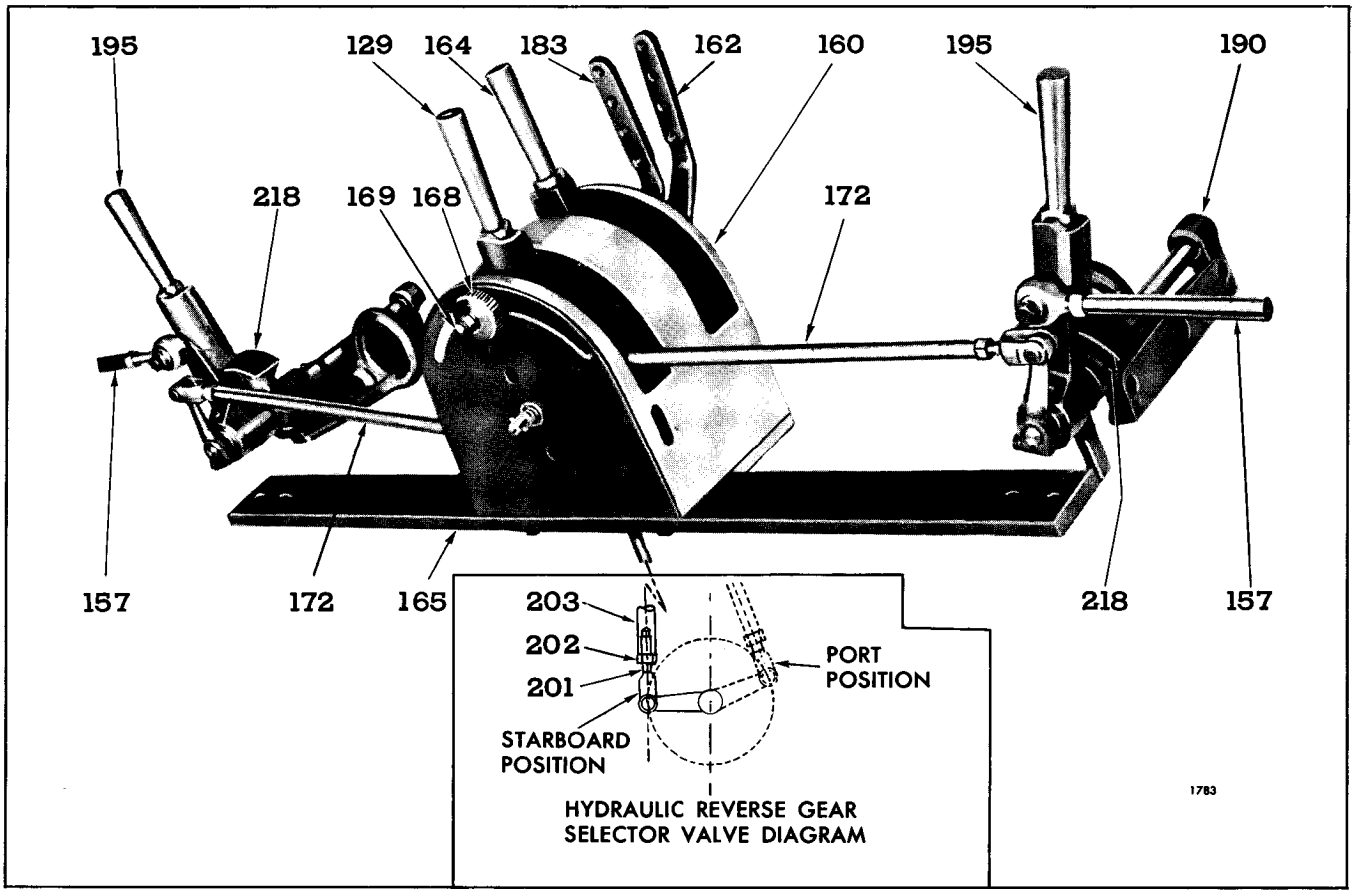


Fig. 6 - Arrangement of Throttle Levers on a Tandem Twin Marine Unit

129. Lever-Master Control Equalizer
157. Rod-Control
160. Housing-Master Throttle and Control Valve Lever
162. Lever-Master Throttle Remote Control
164. Lever-Master Remote Control Valve
165. Support-Throttle Control and Valve Housing
168. Nut-Master Hand Throttle Locking
169. Nut Retaining
172. Rod-Master Throttle Control
183. Lever-Reverse Gear Control Valve (Remote Control)
190. Bracket-Engine Lifting
195. Lever-Throttle Control
201. Clevis-Valve Control Rod
202. Nut-Valve Control Rod
203. Rod-Valve Control
218. Quadrant-Throttle Control

14.12 THROTTLE LINKAGE ADJUSTMENTS

at the side of the lever housing (160). Secure the throttle lever in this position by means of the knurled lock nut (168).

3. Disconnect both master throttle control rods (172) from the cross shaft operating levers (199) of the individual throttle levers (195) at the "A" and "C" engines, Fig. 8.

4. Lock both throttle levers (195) to their quadrants (218) and fix them in a vertical position.

5. Loosen clamp bolt on quadrant (218), if necessary, and set both cross shaft operating levers (199) vertically with holes for clevis pins on an imaginary line extending through the centers of cross shafts and rod end bearings, and between these centers. Tighten clamp bolts on quadrants.

6. While maintaining levers (195) in a vertical position, adjust the master throttle control

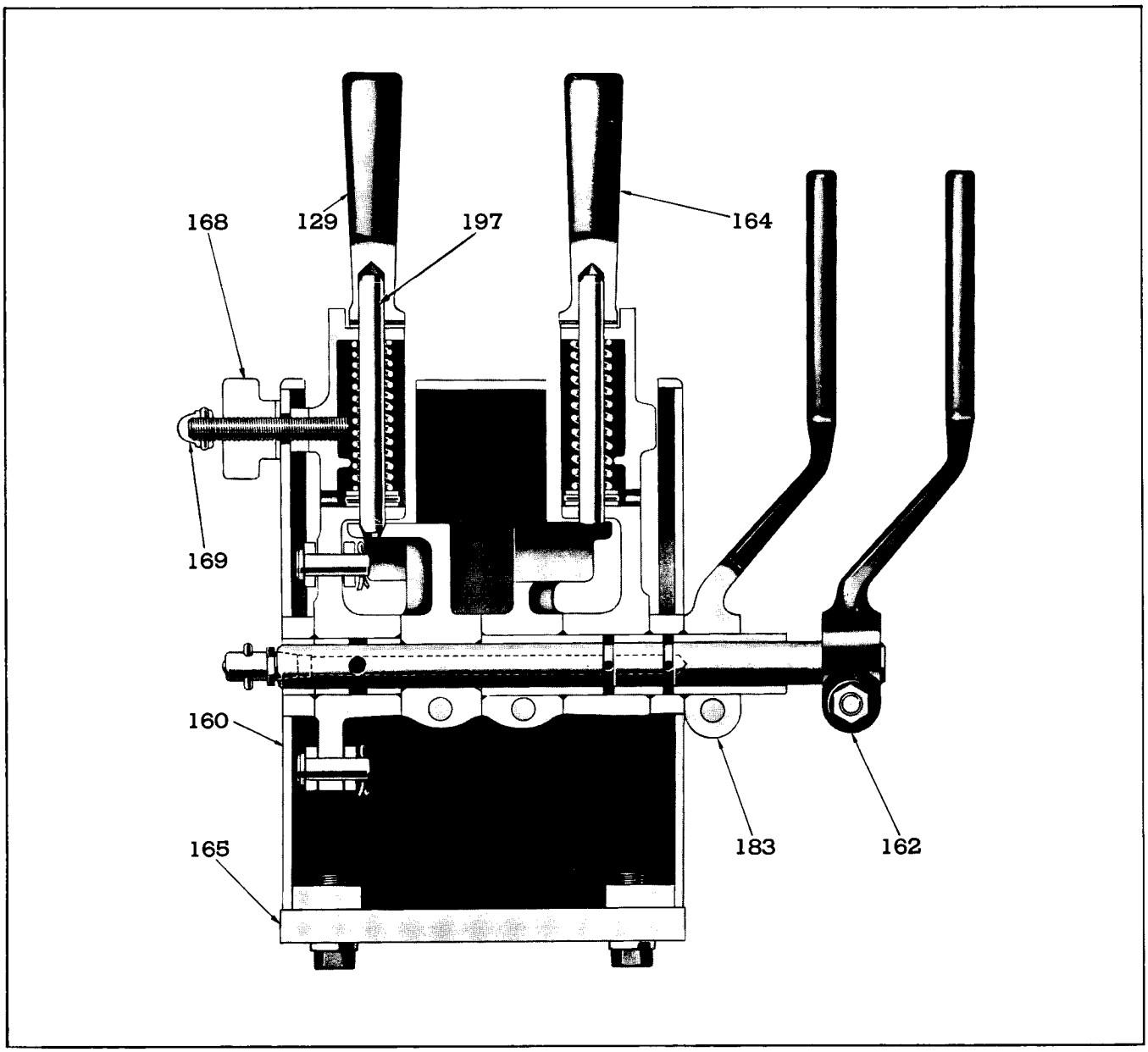


Fig. 7 - Master Throttle Assembly on a Tandem Twin Unit

129. Lever-Master Control Equalizer
160. Housing-Master Throttle and Control Valve Lever
162. Lever-Master Throttle Remote Control
164. Lever-Master Remote Control Valve
165. Support-Throttle Control and Valve Housing
168. Nut-Master Hand Throttle Locking
169. Nut-Retaining
183. Lever-Reverse Gear Control Valve (Remote Control)
197. Pin-Throttle Control Lever

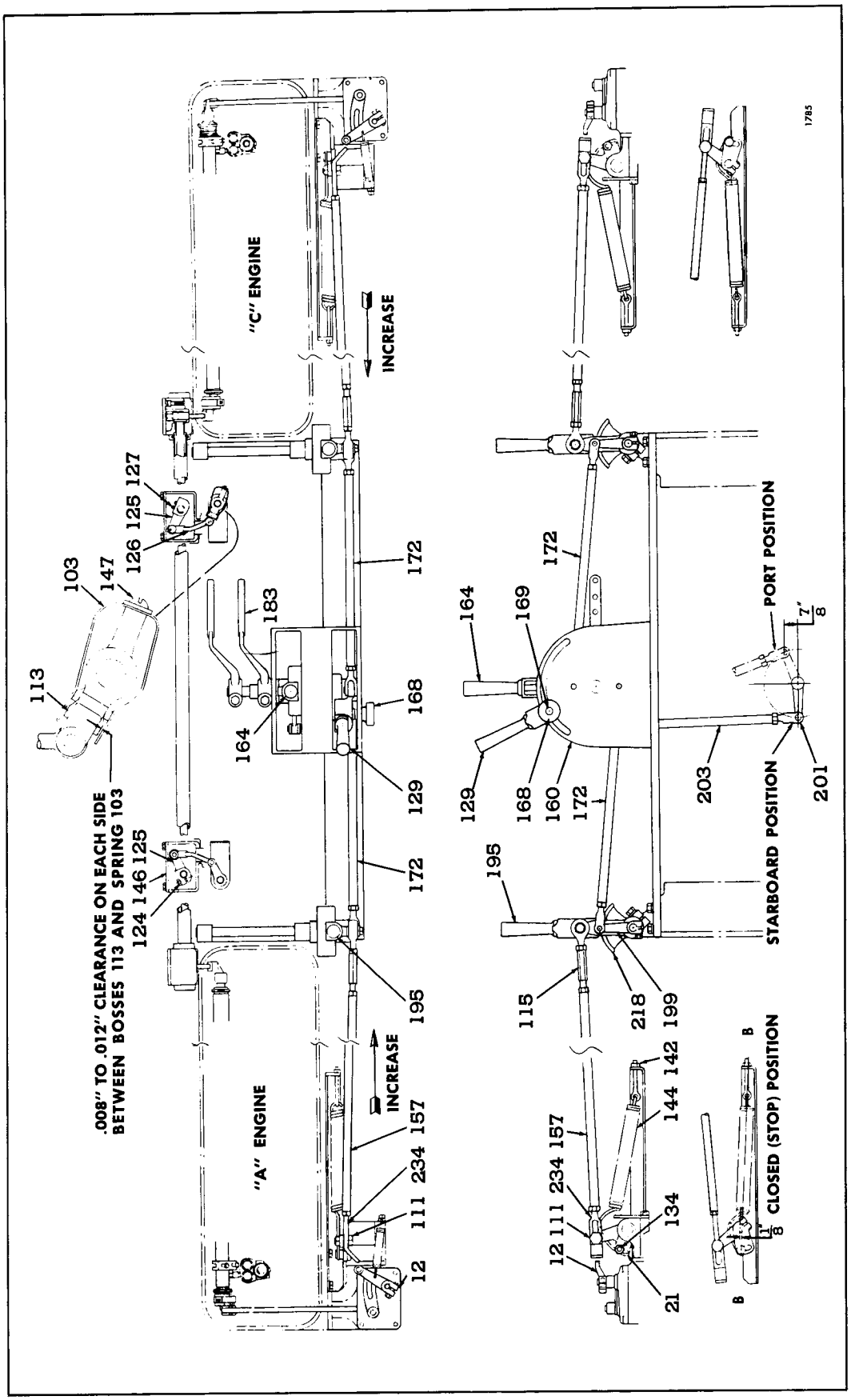


Fig. 8 - Diagram of Throttle Control Linkage for Tandem Twin Marine Unit with Variable Speed Governors

12. Lever-Governor Control
21. Lever-Speed Control
103. Spring-Equalizer
111. Bolt-Link
113. Boss-Master Equalizer
115. Turnbuckle
124. Bolt
125. Lever-Master Equalizer
126. Shaft-Equalizer
127. Screw-Adjusting
129. Lever-Master Control Equalizer
134. Pin-Booster Spring
142. Lock Nut-Booster Spring Adjusting
144. Spring-Booster
146. Cover-Equalizer Housing
147. Screw-Master Control Equalizer Spring
157. Rod-Control
160. Housing-Master Throttle and Control Valve Lever
164. Lever-Master Remote Control Valve
168. Nut-Master Hand Throttle Locking
169. Nut-Retaining
172. Rod-Master Throttle Control
183. Lever-Reverse Gear Control Valve (Remote Control)
195. Lever-Throttle Control
199. Lever-Throttle Control Cross Shaft
201. Clevis-Valve Control Rod
203. Rod-Valve Control
218. Quadrant-Throttle Control
234. Link-Control Rod End

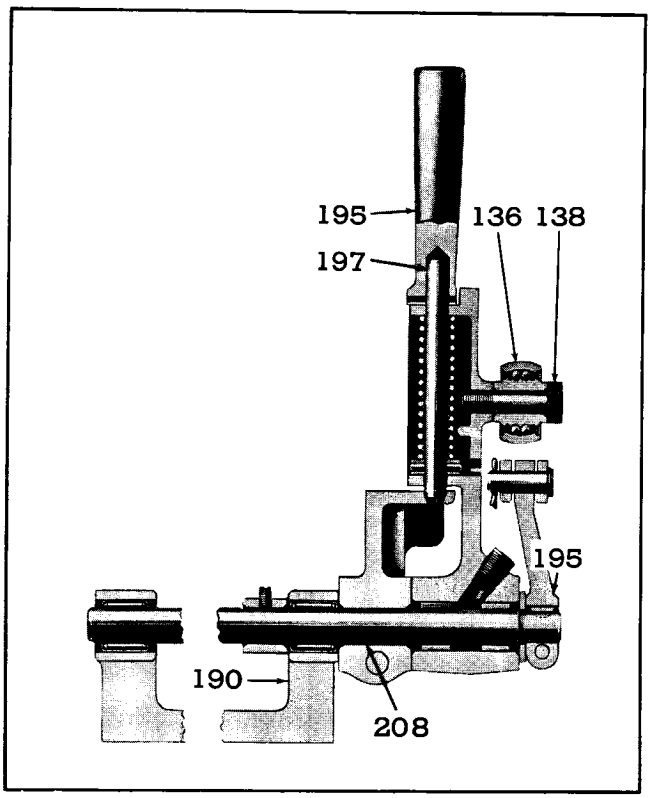


Fig. 9 - Individual Throttle Assembly on a Tandem Twin Unit

136. Bearing-Control Rod End
138. Bolt-Control Rod
190. Bracket-Engine Lifting
195. Lever-Throttle Control
197. Pin-Throttle Control Lever
208. Shaft-Throttle Lever

rods (172), by means of the clevises, to such length that the clevis pins will just slide into position through the holes in the clevises and levers (199). Install cotter pins.

7. Loosen knurled lock nut (168) and move master throttle lever (129) toward FULL OPEN position until the locking stud (169) is within 3/8" to 1/2" from end of slot in housing (160). Tighten lock nut (168).

8. Adjust length of throttle control rods (157), by means of turnbuckles (115), until the speed control levers (21), at the governor, are fully open. Tighten turnbuckle lock nuts.

   When tightening lock nuts on turnbuckles, be careful to keep rod end bearings perpendicular to the bearing support bolt to avoid damage to the bearing seal.

9. If all of the above adjustments have been carefully made, the speed of each engine should be the same as when checked individually for top speed. To check top speed of the individual engines:

   a. Disconnect equalizer link at lever on the "A" engine.

   b. Warm engines up to operating temperature, then run each engine at top speed and compare the speeds with original top speed to check proper length of control rod (157).

   c. If engine speeds are O.K., connect equalizer link and install cotter pin; if speeds are unsatisfactory, adjust length of rod or rods (157) as necessary.

10. With the reverse gear control valve lever (164) set in a vertical position, check the position of the selector valve lever on the reverse gear. On a port propulsion unit, the center of the clevis pin hole in selector valve lever will lie on a horizontal center line drawn through the center of selector valve shaft, as shown in Fig. 8, and point forward. On a starboard propulsion unit, the clevis pin hole in the selector valve lever will point aft and lie 7/8" above the horizontal center line drawn through the center line of the selector valve shaft.

11. Adjust equalizer levers so each engine will carry its share of the load as follows:

    a. With engines stopped, and master throttle lever (129) in the FULL OPEN position and equalizer links connected at the "A" and "C" engines, loosen clamp bolt (124) in equalizer shaft lever (125) at the "A" engine so that the lever can turn on the equalizer shaft.

    b. Set the two adjusting screws (127) in adjustable equalizer lever (125) at the "C" engine the same height in the lever so that lever can be adjusted later if necessary.

    c. Rotate lever (125) on shaft until the free ends of the equalizer spring (103) are resting—without strain—against the two bosses on the injector control tube lever and are an equal distance from the bosses (113) at each side of the equalizer link lever. While maintaining the clearance between lever bosses and spring, tighten clamp bolt in lever (125).

    d. Again check clearance between bosses and spring; and if clearance was changed while tightening clamp bolt in lever, adjust screws (127) and change position of lever (125) until clearance between bosses (113) and spring (103) is the same on both sides of equalizer link lever.

e. With clutches disengaged, move throttle to IDLE position and start engines.

f. With engines up to operating temperature, clutches still disengaged and the individual throttle levers (195) locked to their quadrants (218), move master throttle lever (129) to FULL OPEN position and check the speed of each engine with a tachometer and record the speed.

The speed of each engine should now be the same as the no load top speed previously set on the individual engines.

g. Now move the master throttle to IDLE position and check the speed of the individual engines.

If either the idle or top speed is not the same as that previously established on the individual engines, readjust the clearance between the bosses (113), on equalizer link lever and the spring (103) if necessary, as outlined in item "4" above.

12. Install valve covers.

EARLY DESIGN THROTTLE LINKAGE USED ON INDUSTRIAL TWIN AND QUAD UNITS

The early design throttle linkage differs from the currently used linkage due to the use of bellcranks, small ball and socket joints, small quadrants, and thinner linkage rods used in the early linkages. The following linkage adjustment procedures cover the throttle adjustments for load equalization on twin and quad units having these early linkage arrangements.

Each twin unit consists of two engines and each quad unit of four engines connected by clutches to a common gear box. The object of the throttle adjustment is to cause each engine of either the twin or quad unit to carry its share of the load. The throttle adjustments on the twin and quad units have been divided into three groups, depending upon the type of governor used to control engine speed.

1. Throttle adjustments on twin or quad units with limiting speed mechanical governors.
2. Throttle adjustments on twin or quad units with variable speed mechanical governors.
3. Throttle adjustments on twin or quad units with constant speed hydraulic governors.

Each group is treated separately in the following pages.

Two types of throttle arrangements will be found on quad industrial units using limiting speed mechanical governors to control the engine speeds; the initial type, Fig. 10, and the later type, Fig. 11. The initial type in this adjustment procedure will be known as type "A" and the later type used will be called type "B".

TYPE "A" THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON QUAD INDUSTRIAL UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

The throttle control linkage should be adjusted after adjusting the engines exhaust valves, timing the fuel injectors, and performing the tune-up covering the appropriate governors used on the unit as follows:

1. With engines stopped, refer to Fig. 10, remove any bind or excess play from clevises and pins and ball joints. If ball joints need adjusting, remove cotter pins from the various joints and turn the ball joint nut down until it bottoms. Then, back off on nut to the nearest position where slot in nut aligns with holes in end of ball joint. Replace and spread cotter pin. Throttle adjustments cannot be made satisfactorily with loose joints or bind in the mechanism.

2. Engage the throttle lever pins (7) of each individual throttle lever (5) with the quadrants (3).

3. Move the quadrant control lever (37) to such position that throttle control levers (5) set vertically; then check the geometry of the linkage as follows: Set the outer arms of the four bellcranks (13) on brackets (2) and (2a) parallel with and the inner arms crosswise of the engine center line. A straight edge or line (18) from brackets (2) and (2a), as shown in diagram, Fig. 10, will aid in making this check.

4. With bellcranks positioned, as outlined in item "3", the pins in all governor throttle control levers (19) should rest in the IDLE notch of the governor control cams (29). If pins do not rest in notches of all four cams, adjust length of throttle rods (21) at turnbuckle (12) until this condition is brought about.

   Length of rods (21) is adjusted by loosening lock nuts and turning turnbuckle (12).

5. Now move the quadrant control lever (37) so that throttle levers are in FULL OPEN position. Observe if the pins in the throttle control levers (19) all strike the extreme end of the slot in the governor control cams (29). If not, adjust rods (21) slightly so that the pins in all levers just strike the extreme end of the slot in the cams simultaneously. Do not put any strain in the throttle linkage when making this adjustment.

6. Disengage clutches, move throttle levers to IDLE position, and start all engines of the unit.

   NOTE: When all engines of the unit are not equipped with starting motors, it will be necessary to first start the engine or engines so equipped; then engage the clutch on the running engine and the other clutches in turn to crank the engines.

14.12 THROTTLE LINKAGE ADJUSTMENTS

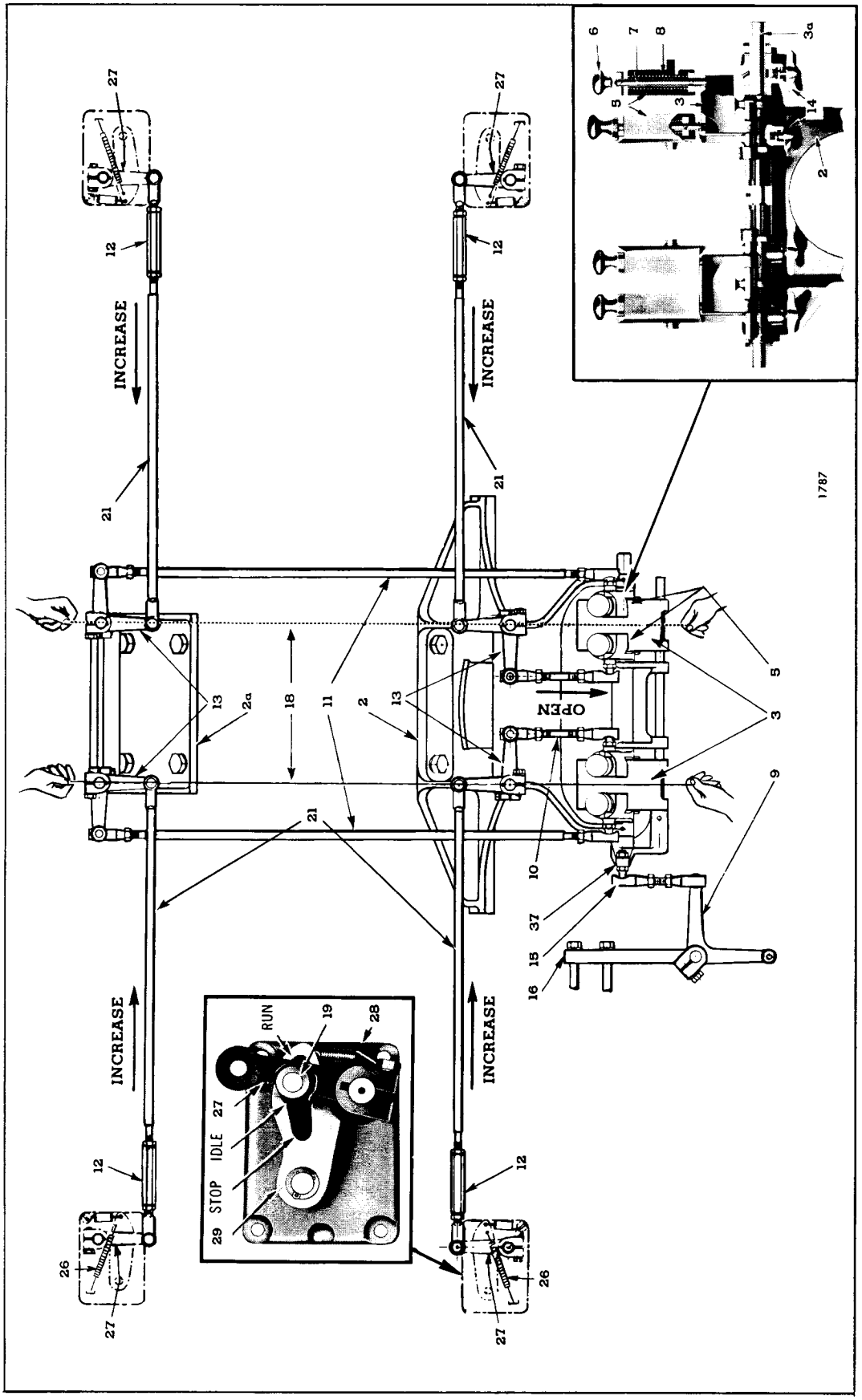


Fig. 10 - Type "A" Throttle Control Adjustment Diagram for Quad Industrial Units Using Limiting Speed Mechanical Governors

2. Bracket-Control Support
2a. Bracket-Bell Crank (Rear)
3. Quadrant-Throttle Lever
3a. Shaft-Quadrant
5. Lever-Throttle Control
6. Knob-Throttle Control Lever
7. Pin-Throttle Control Lever
8. Spring-Throttle Lever
9. Bell Crank-Quadrant Control Lever Link
10. Rod-Throttle Lever to Bell Crank Control (Short)
11. Rod-Throttle Lever to Bell Crank Control (Long)
12. Turnbuckle-Throttle Control Rod
13. Bell Crank-Throttle Lever and Throttle Control Rods
14. Wing Screw
15. Link-Quadrant Control to Bell Crank
16. Bracket-Governor Control Link Bell Crank
18. Taut Line
19. Lever-Governor Throttle Control
21. Rod-Throttle Control to Governor
26. Spring-Governor Control Lever Retracting
27. Lever-Governor Control
28. Governor
29. Control Cam-Governor
37. Lever-Master

7. Having started all engines, disengage the clutches and bring engines up to operating temperature.

   NOTE: If conditions permit, the engines can be warmed up to operating temperature in less time by applying part load. If warmed up at part load, disengage the clutches afterward for the following steps.

8. With individual throttle levers (5) locked to their quadrants (3), move quadrant control lever (37) to FULL OPEN throttle position and check the speed of each engine with a tachometer and record the speed. The speed of each engine should now be the same as the no load top speed previously set on the individual engines.

   NOTE: With the limiting speed mechanical governor, the no load speed will be 125 r.p.m. greater than the full load speed unless otherwise stated on the unit name plate. As for example: For a unit with a desired top full load speed of 1600 r.p.m., the no load speed would be approximately 1725 r.p.m.

9. With all clutches still disengaged, check the speed of the individual engines at approximately three-fourths (3/4) full load speed. This check should show all engines running at the same speed, within 100 r.p.m., which is allowable.

   If any engine varies more than the allowable 100 r.p.m., then more than likely the governor spring plunger gap was not properly set on that engine. In this event, reset the governor spring plunger gap and then reposition the injector racks on that engine.

10. With clutches disengaged, again check the speed of the individual engines at approximately three-fourths (3/4) full load speed.

TYPE "B" THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON TWIN OR QUAD INDUSTRIAL UNIT USING LIMITING SPEED MECHANICAL GOVERNORS

The throttle control linkage should be adjusted after adjusting the engines exhaust valves, timing the fuel injectors, and performing the tune-up covering the appropriate governors used on the unit as follows:

1. With engines stopped, refer to Fig. 11 and remove any bind or excess play from clevises and pins and ball joints. If ball joints need adjusting, remove cotter pins (20) from the various joints (51) and turn nut down until it bottoms. Then back off on nut to the nearest position where slot in nut aligns with holes in end of ball joint. Replace and spread cotter pin. Throttle adjustments cannot be made satisfactorily with loose joints or bind in the mechanism.

2. Lock throttle levers (5) to quadrants (3) on all engines by means of pins (7).

3. If adjustments are being made on Quad units, and the throttle levers for the forward engines do not align with those for the rear engines (lengthwise of the engines), loosen clamp bolt (4) on one of the quadrants (3) and move quadrant on shaft until all four levers are in alignment lengthwise of the engine. Tighten clamp bolt (4).

4. By means of the master lever (37) push all throttle levers toward FULL OPEN position until the stop bosses (3b) on the back side of quadrants (3) contact the brackets (2).

   Loosen lock nuts (3d) and turn stop screw (3c) into bosses (3b) of quadrants (3) until each screw projects 1/32", or slightly more, through its boss, but with screws contacting the throttle brackets (2). Tighten lock nuts (3d) temporarily.

5. While maintaining the throttle levers in the FULL OPEN position as in "4" above, adjust the throttle to bell crank rods (10) and (11) to such length that the ball joint of the bell crank arms (13), that lie crosswise of the engines, are 1 1/4" off center--away from the front end of the engine--of a line drawn through the center of the bell crank fulcrums, as shown in Fig. 11.

   To adjust the length of the short rod (10), remove the ball of the ball joint (51) from the bell crank (13); then loosen lock nut and turn the rod as desired. The long rod (11) may be adjusted without removing the ball joint by loosening the lock nuts and turning the turnbuckle (12).

6. While maintaining the throttle levers in FULL OPEN position, adjust all governor to bell crank throttle rods (21) to such length that the pins in all governor throttle control levers (19) just strike the extreme end of the slot in the governor control cams (29) simultaneously. When the pins in all governor throttle control levers (19) just strike the extreme end of the slot in the governor control cams (29), both stop screws (3c) (two screws for Quad or one stop screw of Twin) will be resting against the throttle brackets (2).

7. Now loosen lock nuts (3d) on both stop screws (3c) (of Quad or one on Twin) and turn bolts in 1/6 turn. Tighten lock nuts permanently.

8. With throttle levers (5) locked to quadrants (3), move master lever (37) to IDLE position. If adjustments of throttle rods (21) as outlined in item "6" above were carefully made, the pins in all governor throttle control levers (19) should rest in the IDLE notches of governor control cams (29).

9. Disengage clutches and start all engines of the unit.

   NOTE: When all engines of the unit are not equipped with starting motors, it will be necessary to first start the engine or engines so equipped; then engage the clutch on the running engine and the other clutches in turn to crank the engines.

10. Bring engines up to operating temperature.

    NOTE: If conditions permit, the engines can be warmed up to operating temperature in less time by applying part load. If warmed up at part load, disengage the clutches afterward for the following steps.

11. With individual throttle levers (5) locked to their quadrants (3), move master lever (37) to FULL OPEN throttle position and check the speed of each engine with a tachometer and record the speed. The speed of each engine should now be the same as the no load top speed previously set on the individual engines.

    NOTE: With the limiting speed mechanical governor, the no load speed will be 125 r.p.m. greater than the full load speed unless otherwise stated on

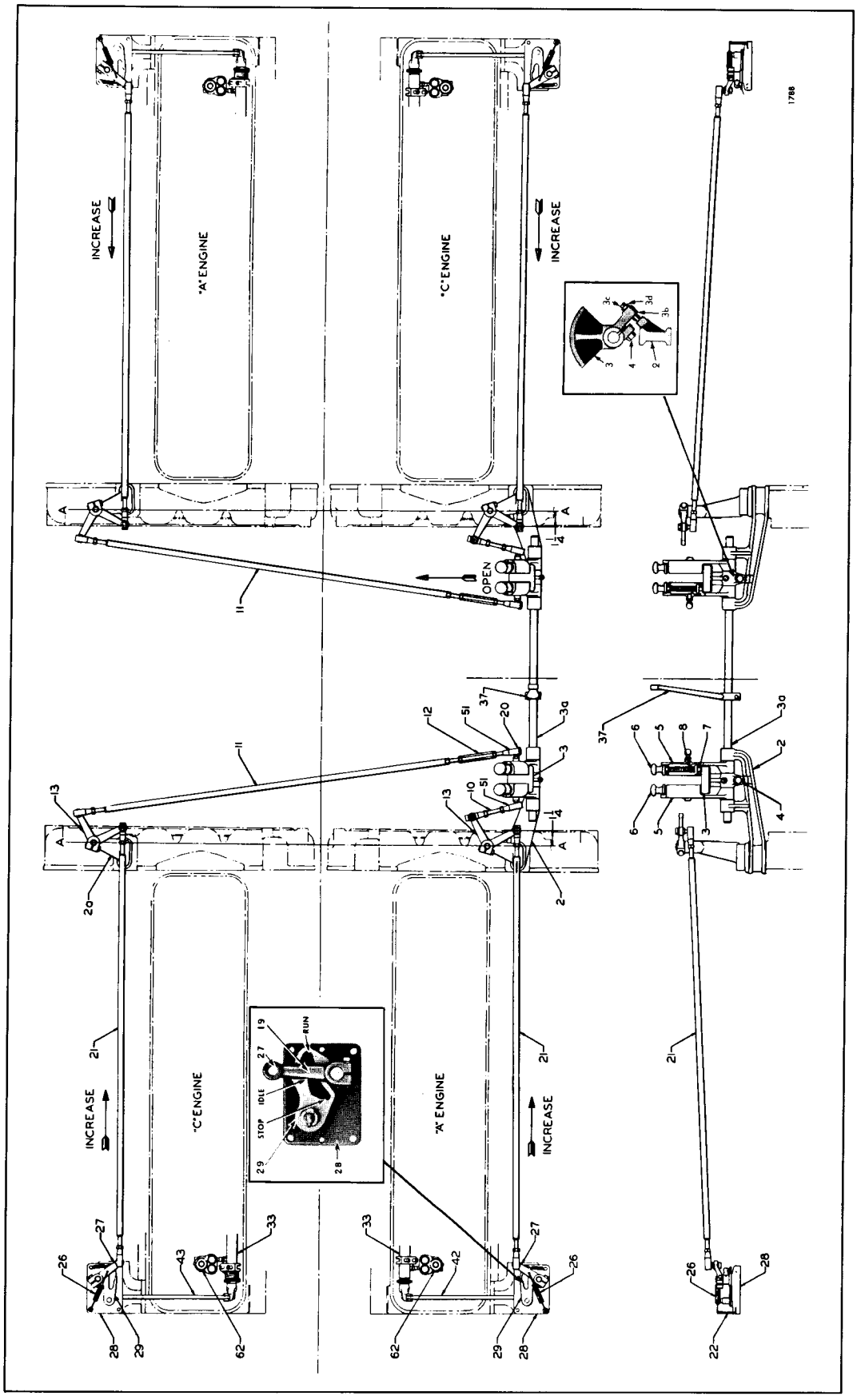


Fig. 11 - Type "B" Throttle Control Adjustment Diagram for Twin or Quad Industrial Units Using Limiting Speed Mechanical Governors

2. Bracket-Support Control
2a. Bracket-Bell Crank (Rear)
3. Quadrant-Throttle Lever
3a. Shaft-Quadrant
3b. Stop Boss-Quadrant
3c. Screw-Quadrant Stop
3d. Lock Nut-Quadrant Stop Screw
4. Bolt-Quadrant Clamp
5. Lever-Throttle Control
6. Knob-Throttle Control Lever
7. Pin-Throttle Control Lever Locking
8. Spring-Throttle Lever
10. Rod-Throttle Lever to Bell Crank Control (Short)
11. Rod-Throttle Lever to Bell Crank Control (Long)
12. Turnbuckle-Throttle Control Rod
13. Bell Crank-Throttle Lever and Throttle Control Rods
19. Lever-Governor Throttle Control
20. Cotter Pin-Ball Joint
21. Rod-Throttle Control
22. Clip-Governor Control Lever Retracting Spring
26. Spring-Governor Control Lever Retracting
27. Lever-Governor Control
28. Governor
29. Control Cam-Governor
33. Tube-Injector Rack Control
37. Lever-Master
42. Link-Governor Control (For "A" Engine)
43. Link-Governor Control (For "C" Engine)
51. Ball Joint
62. Injector

the unit name plate. As for example: For a unit with a desired top full load speed of 1600 r.p.m., the no load speed would be approximately 1725 r.p.m.

12. With all clutches still disengaged, check the speed of the individual engines at approximately three-fourths (3/4) full load speed. This check should show all engines running at the same speed within 100 r.p.m., which is allowable.

If any engine varies more than the allowable 100 r.p.m., then more than likely the governor spring plunger gap was not properly set on that engine. In this event, reset the governor spring plunger gap and then reposition the injector racks on that engine.

13. With clutches disengaged, again check the speed of the individual engines at approximately three-fourths (3/4) full load speed and at full open throttle.

THROTTLE ADJUSTMENTS FOR LOAD EQUALIZATION—MULTIPLE ENGINE UNITS—VARIABLE SPEED GOVERNOR

Since multiple engine units using variable speed governors are provided with a booster spring at each engine to assist in opening the throttle; also with an equalizer (cross) link between each pair of engines to allow for the mechanical differences in the governors and open the injector racks exactly the same distance on each engine, these devices must be suitably adjusted along with setting the throttle linkage. The booster spring is adjusted before adjusting the throttle linkage and the cross link is adjusted after adjusting the throttle linkage.

Fig. 12 illustrates the throttle control adjustment diagram applicable to either Twin or Quad units equipped with variable speed mechanical governors. The complete adjustment procedure for the booster spring, the throttle linkage and the cross link for load equalization is outlined below:

SET GOVERNOR SPEED CONTROL LEVER BOOSTER SPRING—MULTIPLE ENGINE UNITS—VARIABLE SPEED GOVERNOR—EQUALIZER CROSS LINK DISCONNECTED—ENGINES RUNNING

1. With engine running, set the governor speed control lever (23), Fig. 12, in the IDLE position.
2. Adjust spring fulcrum pin (56) 1/8" below a line "BB" drawn through the center of the eye bolt hole (53) and the center of the speed lever control shaft (57) as shown in Fig. 12.
3. Remove nut from the link to speed lever control bolt (25) and separate link (24) from bolt (25).
4. Tighten eye bolt nut (52) until the speed control lever (23) will return from FULL SPEED to IDLE position when the lever is jerked back and released. Back off nuts until lever returns quickly. Lock nuts in position.
5. Check force required to operate speed control lever--a uniform force over the range of lever travel is desired. If the force is greatest at the beginning of lever travel, adjust booster spring fulcrum pin (56) upward in the slot of the speed control lever (23). If the force seems too light at beginning of lever travel, adjust booster spring fulcrum pin downward in the slot at the speed control lever.
6. Reconnect link (24) to lever (23) with bolt (25).

THROTTLE ADJUSTMENTS FOR LOAD EQUALIZATION AND ADJUSTMENT OF EQUALIZER (CROSS) LINK—MULTIPLE ENGINE UNITS—VARIABLE SPEED GOVERNORS—EQUALIZER LINK DISCONNECTED—ENGINES STOPPED

1. With engines stopped, remove any bind or excess play from clevises and pins and ball joints. If ball joints need adjusting, remove cotter pins (20) from the various joints (51) and turn nut down until it bottoms. Then back off on nut to the nearest position where slot in nut aligns with holes in end of ball joint. Replace and spread cotter pin. Throttle adjustments cannot be made satisfactorily with loose joints or bind in the mechanism.
2. Lock throttle levers (5) to quadrants (3) on all engines by means of pins (7).
3. If adjustments are being made on Quad units, and the throttle levers for the forward engines do not align with those for the rear engines (lengthwise of the engines), loosen clamp bolt (4) on one of the quadrants (3) and move quadrant on shaft until all four levers are in alignment lengthwise of the engine. Tighten clamp bolt (4).
4. By means of the master lever (37), push all throttle levers toward FULL OPEN position until the stop bosses (3b) on the back side of quadrants (3) contact the brackets (2).

14.12 THROTTLE LINKAGE ADJUSTMENTS

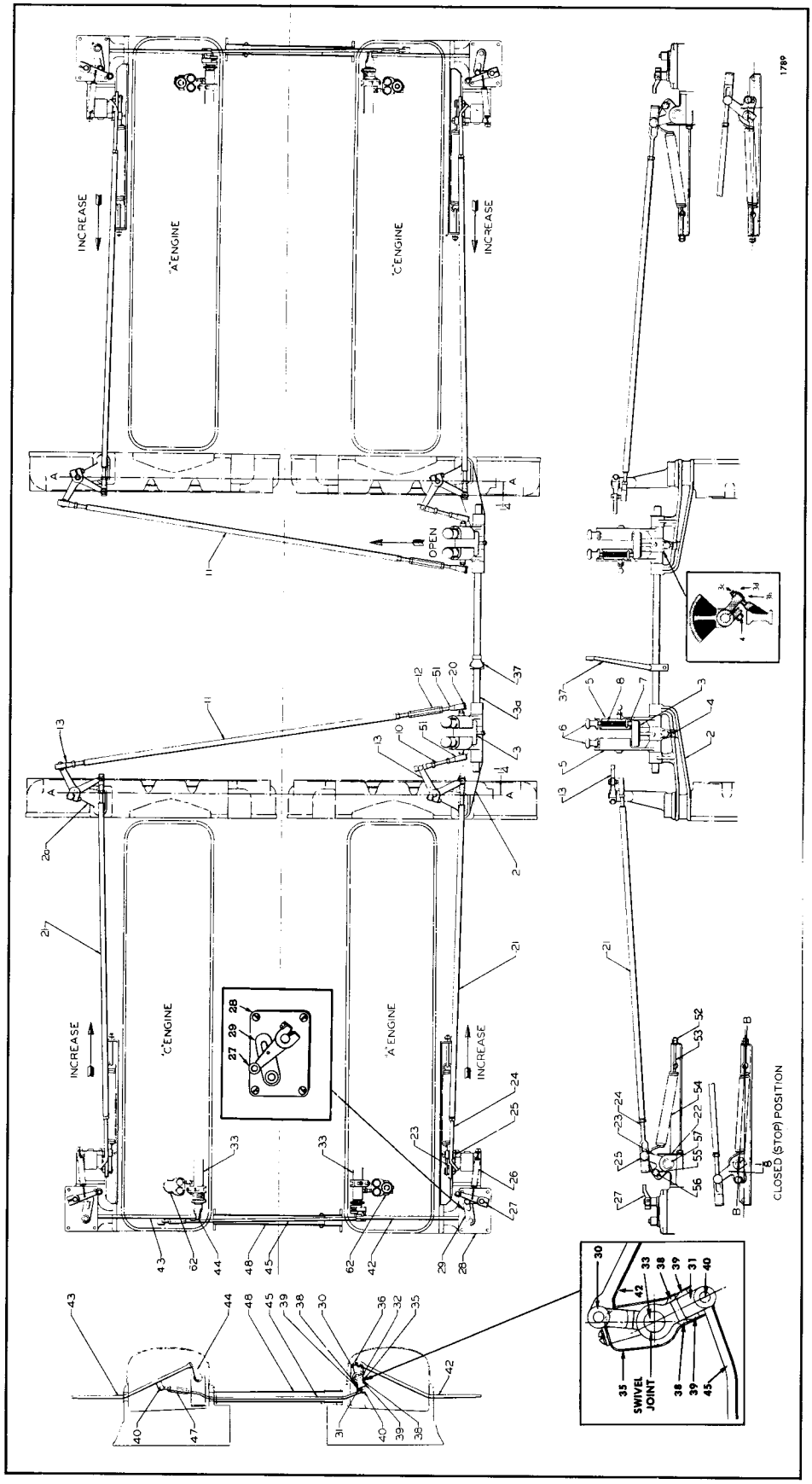


Fig. 12 - Throttle Control Adjustment Diagram for Twin or Quad Industrial Units Using Variable Speed Mechanical Governors

2. Bracket-Control Support
2a. Bracket-Bell Crank (Rear)
3. Quadrant-Throttle Lever
3a. Shaft-Quadrant
3b. Stop Boss-Quadrant
3c. Screw-Quadrant Stop
3d. Lock Nut-Quadrant Stop Screw
4. Bolt-Latch Quadrant Clamp
5. Lever-Throttle Control
6. Knob-Throttle Control Lever
7. Pin-Throttle Control Lever Locking
8. Spring-Throttle Lever
10. Rod-Throttle Lever to Bell Crank Control (Short)
11. Rod-Throttle Lever to Bell Crank Control (Long)
12. Turnbuckle-Throttle Control Rod
13. Bell Crank-Throttle Lever and Throttle Control Rods
20. Cotter Pin-Ball Joint
21. Rod-Throttle Control
22. Clip-Stop Lever Retracting Spring
23. Lever-Speed Control
24. Link-Throttle Control to Governor
25. Bolt-Link to Speed Control Lever
26. Spring-Stop Lever Retracting
27. Lever-Governor Control (Shut-down)
28. Governor
29. Control Cam-Governor
30. Lever-Injector Control Tube
31. Lever-Equalizer Link
32. Pin-Injector Control Tube Lever to Control Tube
33. Tube-Injector Rack Control
35. Spring-Equalizer
36. Screw-Equalizer Spring to Lever
37. Lever-Master
38. Boss-Control Tube Lever
39. Boss-Equalizer Link Lever
40. Pin-Equalizer Link to Lever
42. Link-Governor Control (For "A" Engine)
43. Link-Governor Control (For "C" Engine)
44. Lever-Equalizer Link and Control Tube (For "C" Engine)
45. Link-Equalizer
47. Turnbuckle-Equalizer Link
48. Cover Tube-Equalizer Link
51. Ball Joint
52. Nut-Booster Spring Eye Bolt
53. Eye Bolt
54. Spring-Booster
55. Nut-Booster Spring Fulcrum Pin
56. Pin-Booster Spring Fulcrum
57. Shaft-Speed Lever Control
62. Injector

Loosen lock nuts (3d) and turn stop screw (3c) into bosses (3b) of quadrants (3) until each screw projects 1/32", or slightly more, through its boss, but with screws contacting the throttle brackets (2). Tighten lock nuts (3d) temporarily.

5. While maintaining the throttle levers in the FULL OPEN position, as in "4" above, adjust the throttle to bell crank rods (10) and (11) to such length that the ball joint of the bell crank arms (13), which lie crosswise of the engines, are 1 1/4" off center--away from the front end of the engine--of a line drawn through the center of the bell crank fulcrums, as shown in Fig. 12.

   To adjust the length of the short rod (10), remove the ball of the ball joint (51) from the bell crank (13); then loosen lock nut and turn the rod as desired. The long rod (11) may be adjusted without removing the ball joint by loosening the lock nuts and turning the turnbuckle (12).

6. While holding all throttles (5) in FULL throttle position, adjust the four bell cranks to governor throttle control rods (21) so that all governor speed control levers (23) reach FULL throttle simultaneously. All governor speed control LEVERS (23) will be at the wide open, or the extreme rear position, when both stop screws (3c) are resting against the throttle brackets (2).

7. Now loosen lock nuts (3d) on stop screws (3c) and turn bolts in 1/6 turn. Tighten lock nuts permanently.

8. Refer to Figs. 16 and 17 and with throttle linkage properly adjusted, as outlined above, there should be 1/16" to 1/8" clearance between each link (24) and the shut-down lever (27) when the throttles are set in the RUN position--pin in throttle control lever (19) at rear end of slot in cam (29) and speed control lever (23) in IDLE position. If adjustment is necessary, loosen clamp bolt in lever (27), hold pin of lever (57) at extreme rear end of slot in cam, move lever (27) for proper clearance, and tighten clamp bolt.

9. Adjust Equalizer Cross Link (Engines Stopped).

   a. With engines stopped, equalizer cross link (45) disconnected, and all individual throttle levers (5) locked to their quadrants (3), push all throttle levers to the FULL OPEN position and lock them in that position.

   b. Connect the equalizer link (45) to the equalizer lever (44) at the "C" engine with pin (40); then install and spread cotter pin.

   c. Loosen lock nuts, and by means of the turnbuckle (47), adjust the length of the equalizer link (45) so that clevis pin (40) will just slip through clevis pin holes in lever (31) and through hole in link (45) at the "A" engine, when the free ends of the equalizer spring (35) are resting--without strain--against bosses (38) and (39) at each side of the injector control tube lever (30) and the equalizer link lever (31), respectively. Tighten turnbuckle lock nuts and install cotter pin into clevis pin (40).

      NOTE: If the equalizer link (45) is cold when installed and adjusted, undoubtedly the link will increase in length sufficiently, after the engines are warmed up, so that the "C" engine will stop when the throttle levers are moved to the IDLE position. Check this condition as follows:

   d. With clutches disengaged, move throttles to IDLE position and start engines.

      NOTE: When all engines of the unit are not equipped with starting motors, it will be necessary to first start the engine or engines so equipped; then engage the clutch on the running engine and the other clutches in turn to crank the engines.

   e. With engines up to operating temperature, move throttles to IDLE position and if the "C" engine does not stop, check its idling speed against that of the "A" engine. Idling speed of the "C" engine will probably be less than that of the "A" engine. To bring idling speed the same on both engines:

      With equalizer link (45) disconnected at the "C" engine, and with both engines running at the same idle speed, adjust length of equalizer link (45) so that clevis pin (40) just slips in place through link and holes in clevis. Install cotter pin.

10. With individual throttle levers (5) locked to their quadrants (3), move master lever (37) to FULL OPEN throttle position and check the speed of each engine with a tachometer and record the speed. The speed of each engine should now be the same as the no load top speed previously set on the individual engines.

    NOTE: With the variable speed mechanical governor, the no load speed will be 150 r.p.m. greater than the full

load speed unless otherwise stated on the unit name plate. As for example: For a unit with a desired top full load speed of 1600 r.p.m., the no load speed would be 1750 r.p.m.

11. With all clutches still disengaged, check the speed of the individual engines at approximately three-fourths (3/4) full load speed. This check should show all engines running at the same speed, within 100 r.p.m., which is allowable.

    If any engine varies more than the allowable 100 r.p.m., then more than likely the tune-up procedure for the individual engines, such as setting the spring plunger gap, positioning the injector racks, etc., was not properly performed or perhaps the governor linkage or control rack mechanism may be binding. In this event, the individual engine should be thoroughly checked and tuned up, as previously outlined.

12. After rechecking any engine that was performing improperly and again adjusting the throttle linkage, check individual engine speeds at full open throttle and three-fourths (3/4) full load speeds, as outlined in items "10" and "11" above.

THROTTLE ADJUSTMENTS FOR LOAD EQUALIZATION—MULTIPLE ENGINE UNITS—HYDRAULIC GOVERNOR—ENGINES STOPPED

Illustrated in Fig. 14 is the throttle control adjustment diagram applicable to Twin industrial units equipped with hydraulic governor.

Since the throttle control rods (21)--leading to the governors--increase or decrease the fuel by a rotary motion, no bell cranks are needed for motion transfer between the throttle levers and the throttle rods, as with the mechanical governors.

Having checked the individual engines according to the tune-up procedure for engines equipped with hydraulic governors, as previously outlined, refer to Fig. 14 and carry out the throttle adjustments for load equalization as follows:

1. With engines stopped, remove any lost motion from clevises and pins and ball joints, or bind from the throttle linkage. Throttle adjustments cannot be made satisfactorily with loose joints or bind in the mechanism.

2. Refer to Fig. 14 and set the unit throttle lever (61) in the IDLE position in its quadrant (3) and lock the individual throttle levers (5) in their quadrant (3). Loosen clamp bolt in quadrant (3) and move levers (5) to a vertical position, then tighten clamp bolt.

3. With the throttle levers set as in item "2" above, the throttle control rod levers (60) at back end of rods (21) should be at right angles to the rods (10) and (11) leading from the throttles (5) to levers (60), as shown in Fig. 14, when the bends in throttle rods (21) are straight up. If levers do not set at right angles to rods, loosen clamp bolts in levers (60) at both engines and adjust the length of rod (10) on the "A" engine and rod (11) on the "C" engine to bring levers at right angles to the rods.

   To adjust length of rod (10), remove the ball joint from lever (60); then adjust rod length as required. The length of rod (11) may be adjusted by the turnbuckle (12) without disconnecting ball joint from lever.

4. With throttle levers still set as in item "2" above, refer to Fig. 13 and loosen clamp bolt in throttle control rod levers (58), on both engines, and move outer end of levers up as far as possible to remove all lost motion between rods (21) and levers (58).

5. With unit throttle lever (61), Fig. 14, still in IDLE position and the individual throttle levers (5) in IDLE position, start engines. If engines will not start, loosen clamp bolt in governor control lever (27) and turn the speed adjusting shaft (37a) slightly with an offset screwdriver as shown in Fig. 13. Turning the shaft counterclockwise on the "A" engine governor increases the engine speed, and turning the shaft clockwise on the "C" engine governor increases the engine speed.

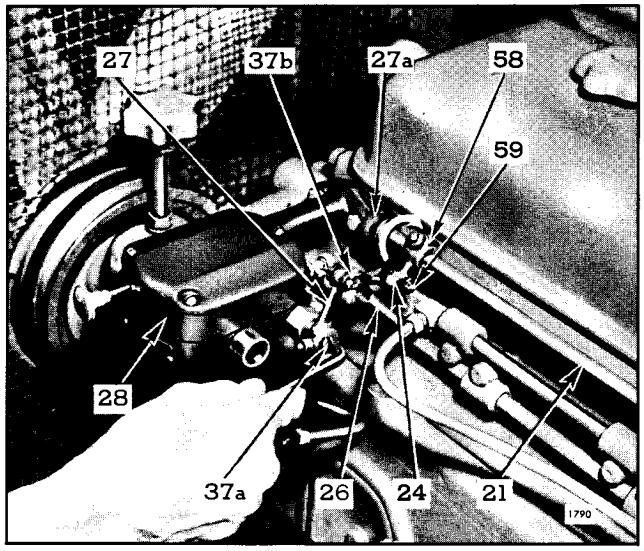


Fig. 13 - Setting Hydraulic Governor Speed Adjusting Shaft and Position of Throttle Control Rod Lever on Throttle Control Rod

21. Rod-Throttle Control
24. Link-Throttle Control
26. Spring-Governor Control Lever Retracting
27. Lever-Governor Control
27a. Bracket-Throttle Control Rod
28. Governor
58. Lever-Throttle Control Rod
59. Clevis Pin
37a. Shaft-Governor Speed Adjusting
37b. Clevis Pin

6. With engines warmed up to operating temperature, move unit throttle lever (61), Fig. 14, to the RUN position and lock it in its quadrant (3).

7. Again using an offset screwdriver, as illustrated in Fig. 13, turn the governor speed adjusting shaft (37a) to such position that each engine is running 80 r.p.m. higher than the full load speed as recorded by a tachometer. Tighten clamp bolt in speed adjusting shaft (37a).

   NOTE: With the constant speed hydraulic governor, the no load speed will be 80 r.p.m. greater than the full load speed unless otherwise stated on

14.12 THROTTLE LINKAGE ADJUSTMENTS

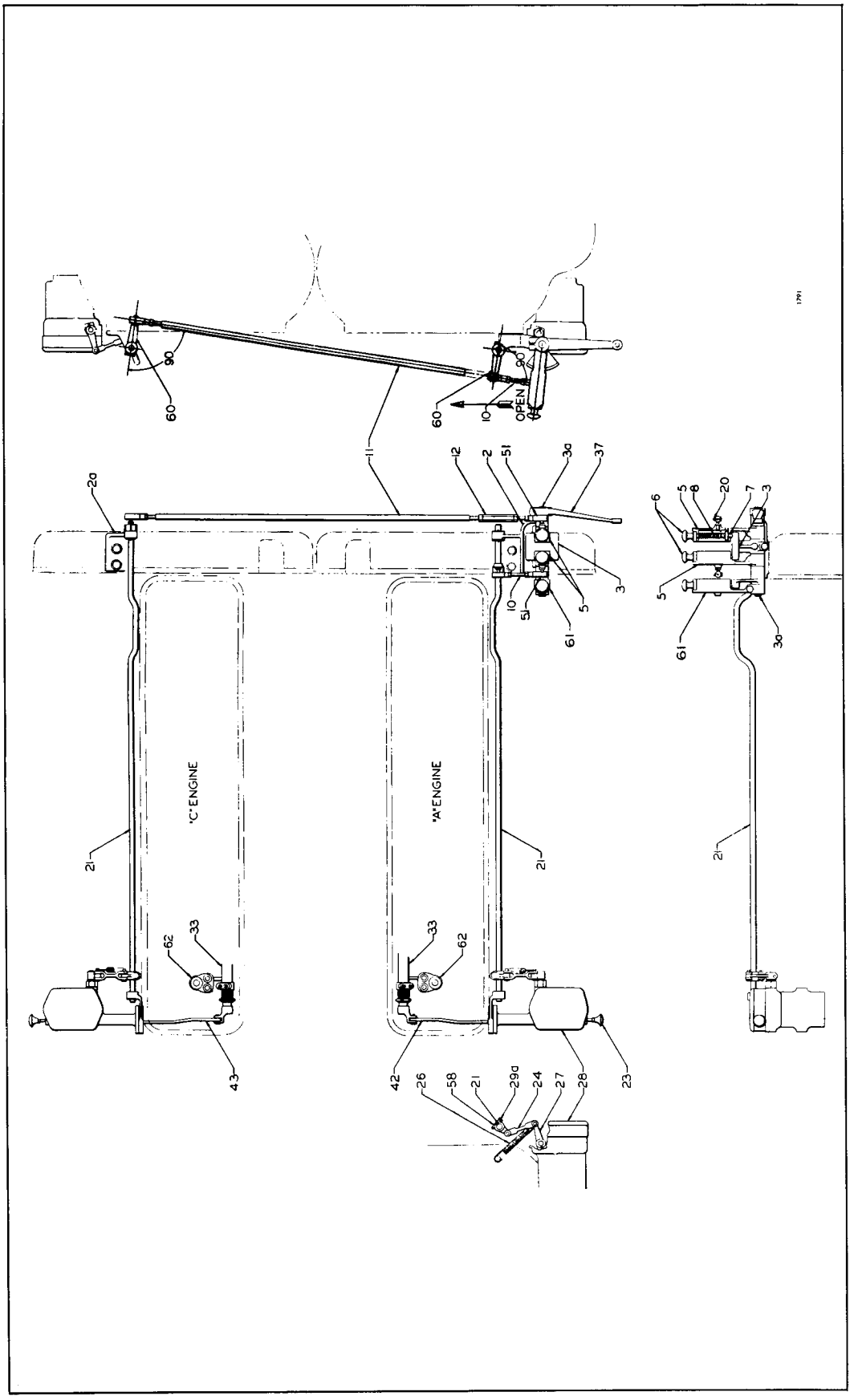


Fig. 14 - Throttle Control Adjustment Diagram for Twin Industrial Units Using Constant Speed Hydraulic Governors

2. Bracket-Control Support
2a. Bracket-Bell Crank (Rear)
3. Quadrant-Throttle Lever
3a. Shaft-Quadrant
5. Lever-Throttle Control (Engine)
6. Knob-Throttle Control Lever
7. Pin-Throttle Control Lever Locking
8. Spring-Throttle Lever
10. Rod-Throttle Lever to Throttle Control Rod (Short)
11. Rod-Throttle Lever to Throttle Control Rod (Long)
12. Turnbuckle-Throttle Control Rod
20. Cotter Pin-Ball Joint
21. Rod-Throttle Control
23. Shut-down Knob-Governor
24. Link-Throttle Control
26. Spring-Governor Control Lever Retracting
27. Lever-Governor Control
28. Governor
29a. Clamp Bolt-Throttle Control Rod Lever
33. Tube-Injector Rack Control
37. Lever-Master
42. Fuel Rod (For "A" Engine)
43. Fuel Rod (For "C" Engine)
51. Ball Joint
58. Lever-Throttle Control Rod (at Governor)
60. Lever-Throttle Control Rod (at Flywheel Housing)
61. Lever-Throttle Control (Unit)
62. Injector

the unit name plate. As for example: For a unit with a desired top full load speed of 1600 r.p.m., the no load speed will be approximately 1680 r.p.m. This difference represents the governor droop which was previously established when setting the governor droop on the individual engines.

8. With unit throttle lever (61) set in the RUN position, release one of the individual throttles (5) and push throttle open until engine speed is 1925 r.p.m. While holding throttle for this speed, set the governor maximum speed adjusting screw to allow this speed. Check and adjust governor on the other engine in the same manner.

9. With clutches disengaged and the individual throttle levers (5) locked to their quadrant, recheck engine speeds by moving the unit throttle to the RUN position and checking the speed of the individual engines with a tachometer. The speed of each engine should be approximately 1680 r.p.m.

10. With clutches still disengaged and the individual throttle levers (5) still locked to their quadrant, move the unit throttle to approximately 3/4 full load speed and check the speed of each engine with a tachometer.

    If engine speeds differ more than the allowable 100 r.p.m., then more than likely the individual engines were not carefully checked or the throttle linkage was not properly set, in which case, a re-check of these items should be made.

EARLY DESIGN THROTTLE LINKAGE USED ON TWIN MARINE UNITS

The throttle linkage used on the early marine units differed from the early linkage on industrial units. The marine units did not use bellcranks, but had throttle rods similar to the current arrangement, see Figs. 2 and 5, except for the equalizer spring used with variable speed governors and the lack of quardrants as shown in Figs. 15 and 17.

THROTTLE LINKAGE USED ON TWIN MARINE UNITS WITH VARIABLE SPEED GOVERNORS

Description

Figure 15 illustrates the throttle control arrangement used on the six-cylinder, twin marine units using variable speed governors.

A variable speed governor is one which maintains uniform speed of the engine with varying load conditions, yet the desired speed may be varied at will by the operator.

Idling speed (500 r.p.m.) may be varied by an adjusting screw. Maximum speed (2000 r.p.m.) is controlled by the governor spring. The governor may be set at any speed between idle and maximum speed and held within the limits of the governor droop.

The entire speed range of the engine is controlled by the speed control lever (23), which varies the tension on the governor spring. A stop lever (27), on the governor cover, moves the injector links (42) and (43) to the OFF or RUN position as the case may be.

Two conditions must be met when two engines are coupled to and drive a common load where either engine may be declutched while the other engine is loaded, or partly loaded, as is the case in this discussion:

1. The two engines must divide the load equally under all conditions of load and speed.
2. Each governor must control its own engine independently should different loads be demanded from the two engines.

Condition 1 is met by using an equalizer (cross) link (45) between the injector control tube levers (30) and (44) on the two engines--hereinafter known as "B" and "D" engines (port and starboard) respectively. This link is adjusted so that the injector racks of the two engines reach full load position simultaneously. It follows then, that in any intermediate position between FULL and OFF position, the same quantity of fuel oil will be injected into each engine.

Condition 2 is met by incorporating a swivel joint between the injector control tube lever (30) and the equalizer link lever (31) at the "B" engine. Lever (30) is pinned to the injector rack control tube (33), lever (31) swivels on the control tube (33).

An equalizer spring (35) is fastened to the injector control tube lever (30) and an adjusting screw (60) in the equalizer link lever (31) bears against the free end of the equalizer spring. A link (42) from the governor on the "B" engine attaches to the lever (30) on the injector control tube, while a similar link (43) attaches to the injector control tube lever (44) on the "D" engine.

Throttle control rods (21) to each engine governor (28) are connected to a common throttle control shaft (1), which in turn is manipulated by a lever (37). A slotted link (24), at the governor end of each control rod (21), moves the governor stop lever (27) to the STOP position when the master throttle is moved to OFF position; when the master throttle is moved to IDLE position, link (24) allows the stop lever to move--by the retracting spring (26)--to RUN position before engaging the governor spring with the speed control lever (23). Farther opening of the master throttle allows link (24) to pick up the speed control lever (23), increase the tension on the governor spring and increase the engine speed. IDLE position of the master throttle is likewise idling speed on the governor. Any opening of the throttle past idling speed engages the governor spring and increases the engine speed accordingly.

Opening the master throttle past IDLE brings two boosters (81) into play to assist in moving the throttle against the tension on the two governor springs. As will be seen from the illustration, the boosters are fulcrumed on studs (77) to the brackets (2) at the lever ends and attached to the throttle cross shaft (1) by the levers (70) at the upper end. The throttle control lever (5) is arrested in the IDLE position by a ball (50) and spring (49). The increase in effort to open the throttle against the

14.12 THROTTLE LINKAGE ADJUSTMENTS

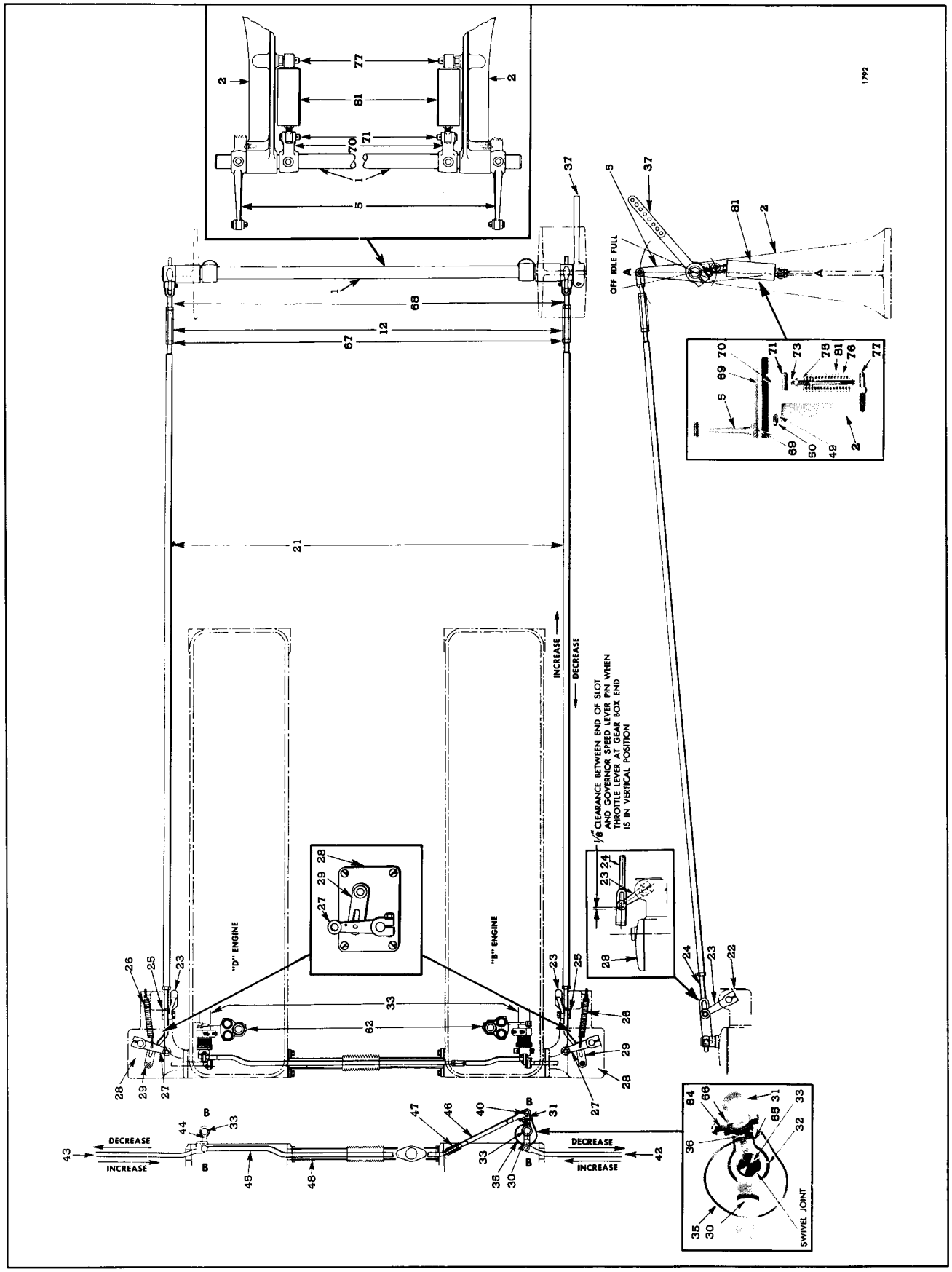


Fig. 15 - Throttle Control Adjustment Diagram for Twin Marine Engines with Variable Speed Governors

Fig. 15 - Throttle Control Adjustment Diagram for Twin Marine Engines with Variable Speed Governors

1. Cross Shaft-Throttle Control
2. Bracket-Throttle Control Support
5. Lever-Throttle Control
12. Turnbuckle-Throttle Control Rod
21. Rod-Throttle Control
22. Clip-Speed Control Lever Retaining Spring
23. Lever-Speed Control
24. Link-Throttle Control to Governor
25. Bolt-Link to Speed Control Lever
26. Spring-Stop Lever Retracting
27. Lever-Governor Control
28. Governor
29. Control Cam
30. Lever-Injector Control Tube
31. Lever-Equalizer Link
32. Pin-Injector Control Tube Lever to Control Tube
33. Tube-Injector Rack Control
35. Spring-Equalizer
36. Screw-Equalizer Spring to Lever
37. Lever-Master Throttle Control
40. Pin-Equalizer Link to Lever
42. Link-Governor Control (for "B" Engine)
43. Link-Governor Control (for "D" Engine)
44. Lever-Equalizer Link and Control Tube (for "D" Engine)
45. Link-Equalizer (Long)
46. Link-Equalizer (Short)
47. Turnbuckle-Equalizer Link
48. Cover Tube-Equalizer Link
49. Spring-Throttle Control Lever Stop
50. Ball-Throttle Control Lever Stop Spring
62. Injector
64. Screw-Equalizer Spring Adjusting
65. Stop-Equalizer Spring
66. Lock Nut-Equalizer Spring Adjusting Screw
67. Lock Nut-Throttle Control Rod
68. Clevis-Throttle Control Rod
69. Pin-Throttle Booster Lever to Shaft
70. Lever-Throttle Booster
71. Pin-Booster to Throttle Booster Lever
73. Rod-Booster-Adjuster
75. Nut-Booster Spring Adjusting
76. Spring-Booster Compression
77. Stud-Booster Support
81. Booster

governor springs past the IDLE position is counterbalanced by the boosters, which are also more effective the farther the throttle is opened.

Operation

The function of the link (45) between the two injector control racks, the swivel joint at the injector control tube on the "B" engine, and the equalizer spring (35) is best explained by reference to conditions (a), (b), and (c) in Fig. 16.

Condition (a) depicts the normal operating position when both engines are clutched to the common drive so that both governors allow the engines to run at exactly the same speed. The equalizer spring adjusting screw (64) is pressing against the free end of the equalizer spring (35), but the force is not sufficient to lift the spring from the spring stop (65). This force is obtained by setting the governors so that the "D" engine wants a little more fuel than the "B" engine, i.e., the "D" engine governor is set a little high with respect to the "B" engine governor. It is impractical to build two governors exactly alike as to spring rates, governor weight masses, linkage ratios and clearances so that when they are run at exactly the same speed they position the injector racks in the same location. Therefore, at various loads and speeds, the force on the equalizer spring (35) at the swivel joint on the "B" engine, will vary according to the differences in the two governors.

Condition (b) illustrates the position of the linkage when the "B" engine is loaded more than "D" engine. In this case, the clutch of the "D" engine has been disengaged and the governor on the "D" engine will withdraw the equalizer spring adjusting screw (64) away from the spring (35) in order to decrease fuel to the "D" engine.

Condition (c) shows the position of the linkage when the "D" engine is loaded more than "B" engine. If the clutch on the "B" engine is disengaged for any reason, this engine will tend to run away. This condition is prevented by the governor on the "B" engine which overpowers the preload on the equalizer spring (35) through the swivel joint between the injector control tube lever (30) and the equalizer link lever (31) to reduce the quantity of fuel to the free ("B") engine.

> **NOTE:** The "B" engine will have a higher no load speed at wide open throttle than the "D" engine, because the governor of the "B" engine has the equalizer spring (35) at the swivel joint to overcome in addition to its own spring.

Adjustments

Throttle control adjustments are divided into three groups:

1. Adjustments of individual governors before installing the equalizer (cross) link.
2. Adjustments of governor speed lever control linkage.
3. Adjustment of equalizer link between the two engines.

1. Individual Governor Adjustments

Adjust engines individually as outlined in "Variable Speed Mechanical Governor and Injector

Rack Adjustment'' before connecting equalizer linkage and throttle control linkage.

2. Adjustments of Speed Lever Control Linkage--With Engines Stopped. (See Fig. 15).

   After adjusting the individual governors and connecting both speed lever links (24), adjust speed lever control linkage as follows:

   a. Set the throttle control cross shaft (1) so that throttle control levers (5) are in a vertical position as shown in Fig. 1. In this position, the detent ball (50) will drop into position in lever (5).

   b. Adjust turnbuckles (12) on the throttle control rods (21) so there is 1/8'' between the forward end of the slot in throttle control link (24) and the bolt (25) in the speed control lever (23). This insures that when the master throttle is returned to IDLE (detent position) each governor is free from the throttle linkage.

   c. Move the master throttle (37) until the ''B'' engine link (24) just barely starts to pick up the governor speed lever (23). Lock the master throttle in this position.

   d. Adjust the turnbuckle (12) on the throttle control rod (21) for the ''D'' engine until its link (24) starts to pick up its speed lever, then take not less than 1/4 nor more than 1/2 additional shortening turns on the turnbuckle (12) for the ''D'' engine only. Tighten lock nuts (67) at turnbuckles on both throttle control tubes.

3. Adjustment of Equalizer (Cross Link)

   With the equalizer link cover (48) and the equalizer link (45) in place, adjust link as follows with engine stopped; see Fig. 15.

   a. Back out equalizer spring adjusting screw (64) so there is a definite clearance between the screw and the free end of the equalizer spring (35).

   b. Loosen lock nut at turnbuckle (47) on equalizer link for ''B'' engine and remove pin (40) that connects link (46) to lever (31).

   c. Set equalizer link lever (31) at ''B'' engine so that its clevis pin (40) center is directly over the center of the injector rack control tube (33). Set equalizer link lever (44) at ''D'' engine so that its clevis pin center is directly beneath the center of its injector rack control tube.

   d. Adjust the length of link (46) so that pin (40) at the ''B'' engine can just be slipped in place with levers (31) and (44) held in the positions given in item ''c'' above. Tighten turnbuckle lock nut and install cotter pin.

   e. Check as follows: Rotate the injector rack control tube (33) of the ''D'' engine until the cross link clevis pin is directly under the center of the injector control tube, i.e., on an imaginary vertical line passing through the center of the two pieces. Holding this position, check to see that the clevis pin on the other end of the cross link is directly over the center of the injector rack control tube of the ''B'' engine. Careful adjustment of the cross link length, as closely as can be judged by the eye, is essential to proper operation.

   f. Set the master throttle so that the governor speed control levers (23) are approximately vertical, in which position the governor springs will push the injector rack into FULL FUEL position.

   g. Carefully screw in the equalizer spring adjusting screw (64) in the equalizing link lever (31) at the ''B'' engine until the screw just touches the free end of the spring (35). Tighten lock nut (66) and check the adjustment. If the mechanism is correctly adjusted, spring (35) will touch the stop (65) and the adjusting screw (64) simultaneously, with all slack taken out of the cross link pin joints.

Starting

When starting, open the master throttle to any position greater than IDLE and press the starter button.

> **NOTE:** If master throttle is set in IDLE position and the ''B'' engine is started first, difficulty may be encountered in attempting to start the ''D'' engine. This is because of the fast idle on the ''B'' engine after starting.

If the ''B'' engine only is to be used, hold the ''D'' engine stop lever (27) in the OFF position by unhooking the retracting spring (26) and fastening it toward the front of the engine.

Stopping

Stop the engines by moving the master throttle to the OFF position. This moves the stop lever to the OFF position by means of the link (24) on the throttle control rod (21).

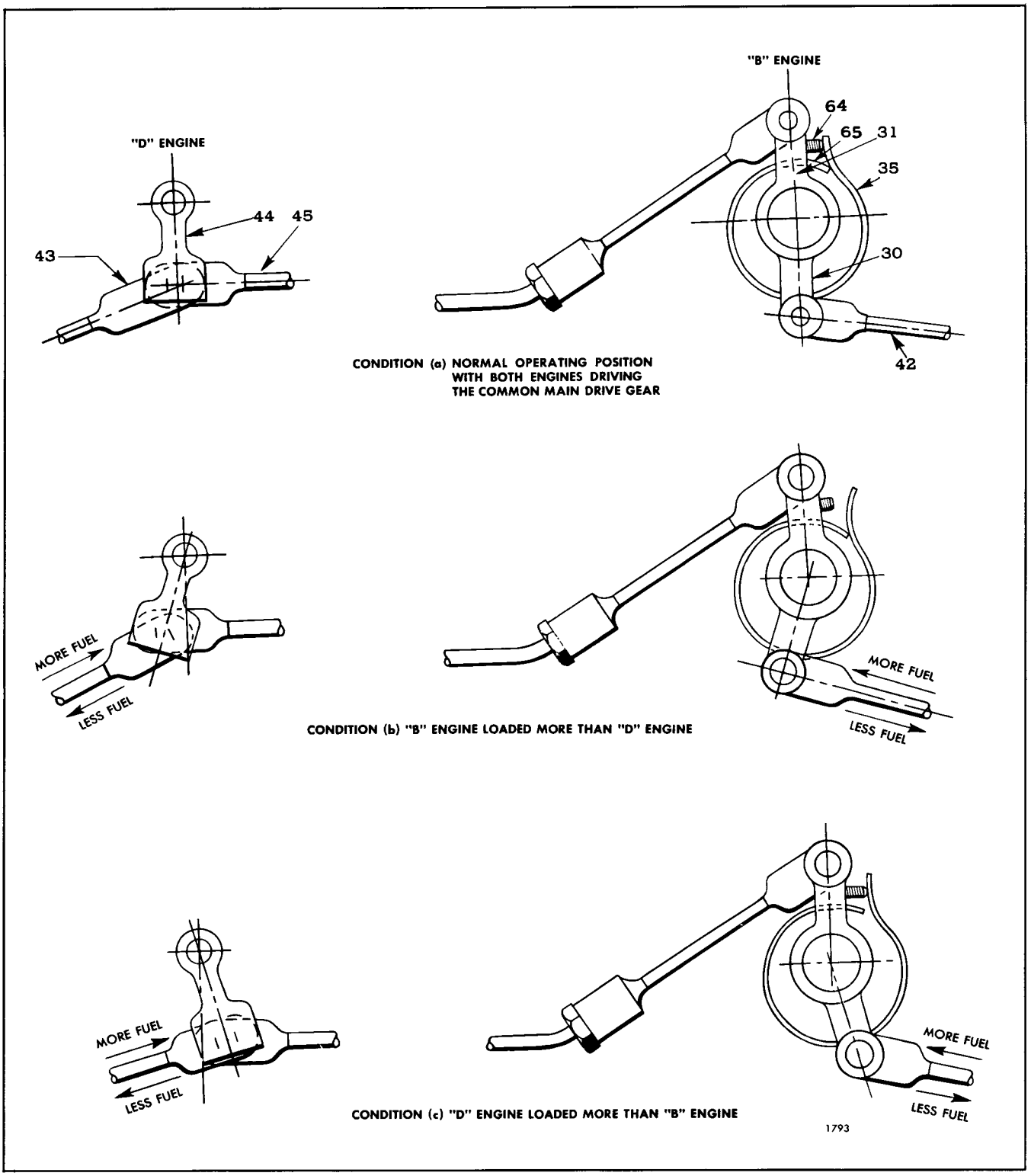


Fig. 16 - Positions of Throttle Linkage Between Twin Engine Units With Equal Load on Engines, Also When Unequally Loaded.

30. Lever-Injector Control Tube
31. Lever-Equalizer Link
35. Spring-Equalizer
42. Link-Governor Control (for "B" Engine)
43. Link-Governor Control (for "D" Engine)
44. Lever-Equalizer Link and Control Tube (for "D" Engine)
45. Link-Equalizer (Long)
64. Screw-Equalizer Spring Adjusting
65. Stop Equalizer Spring

THROTTLE LINKAGE USED ON TWIN MARINE UNITS WITH LIMITING SPEED GOVERNOR

The throttle linkage may be adjusted after setting the valves, timing the injectors and adjusting the governor and the injector operating linkage as follows:

1. With engines stopped, set the throttle control cross shaft (1) so that throttle control levers (5) are in a vertical position as shown at "A-A", Fig. 17.

2. With engines stopped, adjust turnbuckles (12) on the two throttle control rods (21) so that pins in throttle control levers (19) at governor cover rest against the shoulders of the control cams (29) in the "IDLE" position at the two governors.

3. Now move master throttle (37) to "FULL" open position, at which setting the pin in throttle lever (19) at both governors should just strike the extreme end of the slot in the cam (29) at the "RUN" position. If either or both pins do not reach end of slot in cams, adjust turnbuckles (12) to bring about this condition. The linkage must be so adjusted that the pins in the throttle levers at governor covers reach "RUN" position in the control cam at exactly the same time. Do not put any strain in the throttle linkage when making this adjustment.

4. Start and warm up both engines to operating temperature. Move master throttle to "IDLE" position. Declutch both engines and set idling speed of each engine to 500 r.p.m.

   NOTE: Engine may be brought up to operating temperature by declutching engines and setting throttle to approximately 1200 engine r.p.m.

   If quick warm-up is attempted by turning the propeller, the ship must be securely tied to the dock with no loose lines or floating obstructions to foul the propeller.

5. Set governor no-load top speed

   Usually the top no-load speed is set the same on both governors of twin units before the engines leave the factory. If check as outlined below shows top no-load speeds to be different on the two governors, correct as follows:

   a. With both engines warmed up, stop engines and disconnect throttle control rod (21) for "B" engine by removing pin at clevis (68).

   b. Start "D" engine, declutch and move master throttle to "FULL" open position.

   c. Note and record maximum no-load speed as indicated by tachometer.

   d. Stop engine and connect throttle control tube for "B" engine and disconnect "D" engine.

   e. Start "B" engine, declutch, and with master throttle in "FULL" open position, note and record speed.

   f. If no load speeds of the two engines are not the same, increase the speed of low engine by adding shims (63) between the high speed spring (82) and the spring plunger (83) as shown in Fig. 17.

      To add shims, remove low-speed adjusting screw cover (84), back out nut (85) and place shims between inner end of spring and shoulder on plunger.

      Add one shim at a time and check speed after each shim is added.

6. Synchronize engine speeds at no-load. Speeds of the two engines must be synchronized to obtain, as nearly as possible, the same no-load speeds in the range just below the rated load speed by adjusting the linkage to each governor. Thus, a unit rated at 1850 r.p.m. should have the engines synchronized at 1700-1800 r.p.m. Synchronize as follows:

   a. With engines warmed up, declutch both engines and move master throttle to such position that speed of "B" engine is 1750 r.p.m. as recorded by the tachometer. Lock the master throttle in this position.

   b. Note speed of the "D" engine. If the speeds of the two engines are not the same, loosen the two lock nuts at turnbuckle (12) on the "D" engine, and by adjusting turnbuckle, shorten throttle rod (21) to increase or lengthen to decrease engine speed.

   c. Unlock and move master throttle to "FULL" open position. In the "FULL" open position, without strain on the throttle linkage, the pins in throttle control levers (19) at the governor covers of both engines should be within 1/16" of the same distance from the end of the slot in cam (29). If the levers are

14.12 THROTTLE LINKAGE ADJUSTMENTS

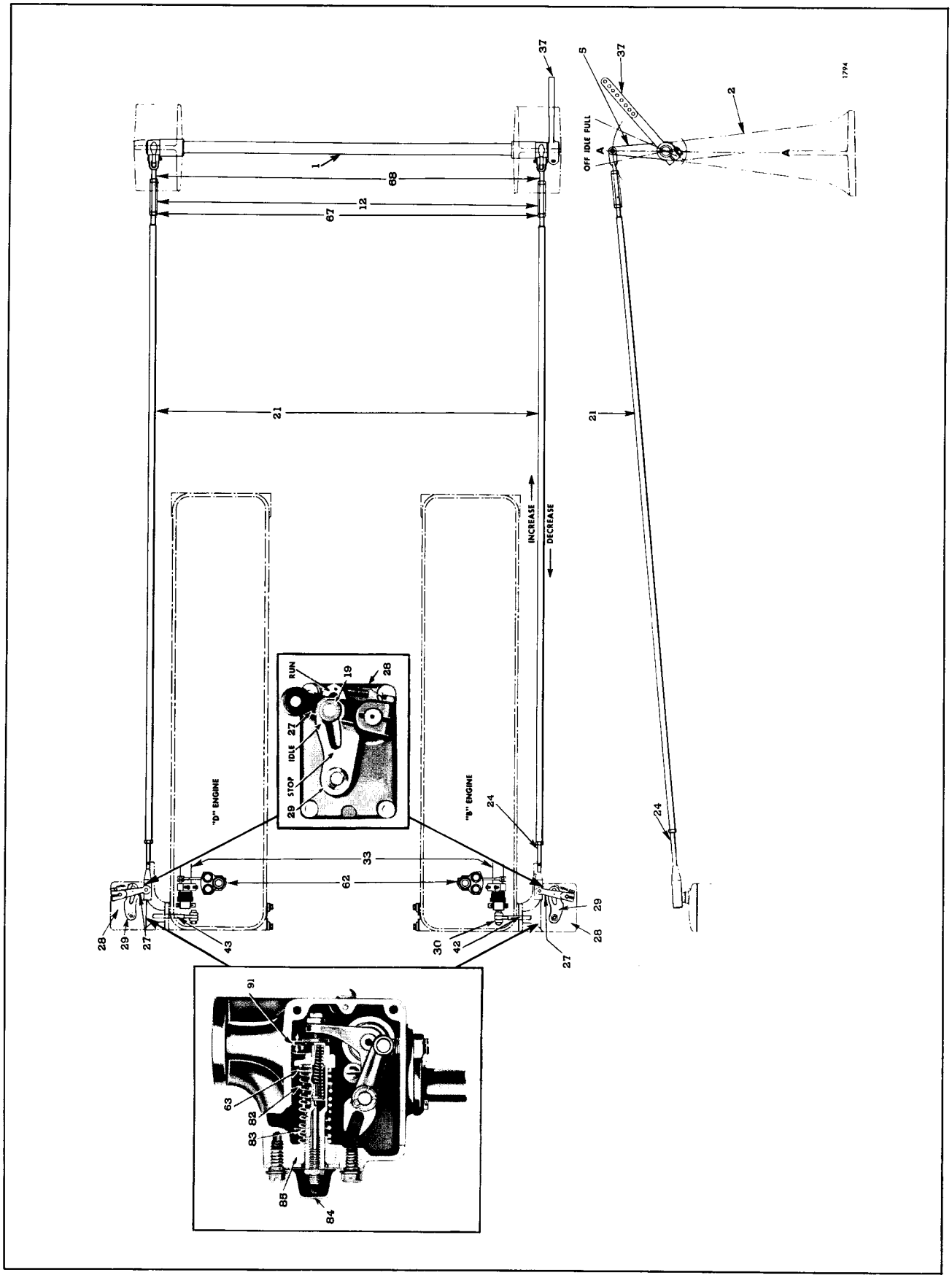


Fig. 17 - Throttle Control Adjustment Diagram for Twin Engines Using Limiting Speed Governors

Fig. 17 - Throttle Control Adjustment Diagram for Twin Engines Using Limiting Speed Governors

1. Cross Shaft-Throttle Control
2. Bracket-Throttle Control Support
5. Lever-Throttle Control
12. Turnbuckle-Throttle Control Rod
19. Lever-Governor Throttle Control
21. Rod-Throttle Control
24. Link-Throttle Control to Governor
27. Lever-Governor Control
28. Governor
29. Control Cam
30. Lever-Injector Control Tube
33. Tube-Injector Rack Control
37. Lever-Master
42. Link-Governor Control (for "B" Engine)
43. Link-Governor Control (for "D" Engine)
62. Injector
63. Shims
67. Lock Nut-Throttle Control Rod
68. Clevis-Throttle Control Rod
82. Spring-High Speed
83. Spring Plunger
84. Cover-Low Speed Adjusting Screw
85. Nut-High-Speed Spring Retaining
91. Low Speed Spring Gaps

not within this limit, the chances are that the governor gaps or the injector rack adjustments are not identical on the two engines and should be rechecked.

The governor with the pin closest to the end of the cam slot may have a "close" gap or the governor with the pin farthest from the end of the cam slot may have the injector racks too "tight". If adjustments are necessary, recheck engine speeds after making adjustments.

HYDRAULIC WOODWARD UG8 GOVERNOR AND THROTTLE LINKAGE ADJUSTMENTS

The hydraulic UG8 dial type governor is used to regulate the output shaft speed of units that require precise speed control and at times zero speed droop operation. Speed adjustment (synchronizer), speed droop, and load limit controls are mounted on the dial of the governor.

The synchronizer or speed adjusting control is used to change the engine speed when running alone or to change the engine load when the engine has been paralleled with other units. The synchronizer indicator, located directly below the synchronizer, indicates the number of revolutions of the synchronizer knob.

A synchronizing motor may be mounted on the top of the UG8 governor to provide remote speed control. Its use enables the switchboard operator to match the frequency of an engine driven alternator with that of other units, or a system, before paralleling and to change load distribution after paralleling.

A slip coupling is provided between the motor shaft and the synchronizer adjusting gear to allow the engine operator to adjust speed by turning the synchronizer control knob on the governor. This coupling is of the friction type.

The speed droop control can be set to permit automatic division and balance of load between units driving the same shaft, or paralleled in an electrical system.

Droop is incorporated in the governor through a linkage which varies the compression of the speeder (speed adjusting) spring as the terminal shaft rotates. As the terminal shaft rotates toward the increased fuel position, the speeder spring tension is reduced, thus reducing the output shaft governor speed setting accordingly. The unit will gradually reduce its speed as load is applied. This relationship between load and speed permits the unit to operate in parallel with other units and properly share the load with these units.

As droop is reduced to zero, the unit is able to change load without changing speed. As a general rule, units running alone should be set on zero droop, interconnected units should be run at the lowest droop setting that will give satisfactory load division.

A.C. generating units tied in with other units should have droop set sufficiently high (30 to 50 on the dial) to prevent interchange of load between units.

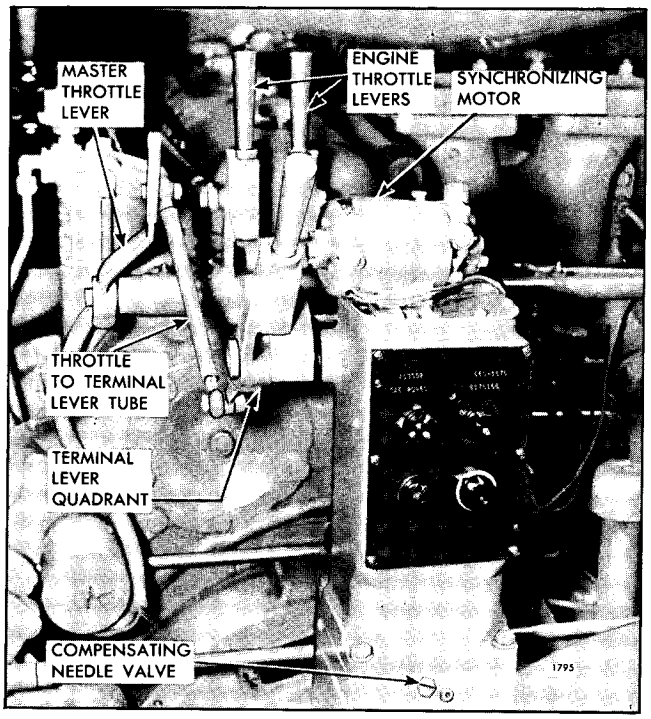


Fig. 1 - UG8 Governor and Throttle Linkage

The load limit control hydraulically limits the load that can be put on the engine by restricting the angular terminal shaft rotation of the governor, and consequently, the quantity of fuel supplied to the engine.

> **CAUTION:** Do not manually force engine linkage to increase fuel without first turning load limit knob to 10.

When the governor is installed on the engine, particular care should be exercised to see that it is mounted squarely and that the drive connection to the engine is aligned properly. A gasket is placed between the base of the governor and the mounting pad on the engine.

> **CAUTION:** Do not drop or rest the governor on its drive shaft.

The gear placed on the keyed type governor drive shaft should be checked to ensure that it is meshing properly. There should be neither excessive backlash nor binding. Irregularities caused by uneven gear teeth, shaft runout, etc., will be picked up by the governor, transmitted to the fuel control system, and will result in erratic governing.

Since the load limit device operates hydraulically rather than mechanically, the load indicating pointer

position cannot be changed by turning the load limit control unless the governor is running (or has oil pressure in its accumulators). When installing the governor, the terminal shaft must be rotated by a lever in order to obtain the zero load position.

> **CAUTION:** Do not manually force engine linkage to increase fuel without first turning load limit knob to 10.

The linkage from the UG8 governor terminal shaft to the fuel control lever on the engine governor should be free from lost motion or excessive friction.

Use SAE 20 or SAE 30 oil in the UG8 governor for ordinary temperature conditions. If governor operating conditions are extremely hot, use SAE 40 or SAE 50, if extremely cold, use SAE 10.

The oil must not contain additives which are used to free up engine piston rings, remove carbon, etc., unless a non-foaming additive is also present. The oil should not foam or sludge excessively when agitated, or form gummy deposits when heated.

DIRTY OIL CAUSES MOST GOVERNOR TROUBLES. Use clean, new oil or filtered oil. All containers must be clean and should be rinsed with light grade fuel oil before using.

Keep governor oil at correct level in oil gauge.

Adjust Throttle Linkage on Twin Units with UG8 Governor Assemblies

1. Remove throttle lever to terminal lever tube, Fig. 1.

2. Remove governor control rod from governor control lever on top of each engine's limiting speed governor.

3. Adjust each engine according to the procedure in section 14.3 for engine with limiting speed governor assemblies or 14.4 for constant speed governor assemblies.

   The individual engine tune-up is very important when adjusting a twin unit since the engines must be closely synchronized to enable each to carry its full share of the load.

4. Adjust the throttle linkage between the engines as outlined in section 14.12 for twin engine units.

5. Set engine governors in the IDLE position, if limiting speed governors are used, or in the OFF position if constant speed governors are used. The handles of the engine throttle levers should be in a vertical position when pin is in quadrant. If the throttle linkage to the engine governors requires alteration to move the handles in a vertical position, adjust the turnbuckle of each governor control lever an equal amount and then retighten. The engine speeds must be rechecked and the linkage adjusted if necessary as outlined in section 14.12.

6. Rotate governor terminal lever toward a decrease fuel position until the pointers on the load limit indicator point to zero, at the end of its travel. Then turn load limit knob to zero to lock terminal lever in this position.

7. Adjust the throttle to terminal lever tube until it is 15" in length between end bearing centers on units with standard twin transfer gear housings. If unit has a "O" housing for mounting of a generator or torque converter, the tube should be adjusted to a length of 10 7/8". Tighten nuts retaining the adjustment.

8. Loosen clamping bolt retaining quadrant to governor terminal lever. Place pin of handle in governor quadrant.

9. Attach the throttle to terminal lever tube to the master throttle lever, in the third hole from top, and to the terminal lever quadrant. Tighten retaining bolts securely.

10. Tighten clamping bolt retaining quadrant to governor terminal lever.

    > **NOTE:** Do not manually force engine linkage to an increased fuel position without first turning load limit knob to 10.

Starting Engine

When starting the engine, set the load limit (fuel limit) at 10 on the dial. By means of the synchronizer, adjust engine to its normal operating no-load speed.

Compensating Adjustments

Although the governor may appear to be operating satisfactorily because the engine runs at constant speed (without load), the governor still may not be adjusted correctly. High overspeeds and underspeeds after load changes and slow return to normal speed are results of incorrect compensation adjustments.

Make the following adjustments to be certain that the governor will give optimum control.

After the temperature of the engine and the oil in

the governor have reached their normal operating values, the compensation should be adjusted without load on the engine as follows:

1. Loosen the nut holding the compensation adjusting pointer and set the pointer at its extreme downward position, see Fig. 1.

2. Remove the plug, open compensating needle valve two or three turns with a screwdriver, and allow the engine to hunt or surge for about one half minute to bleed trapped air from governor oil passages.

3. Gradually close needle valve until hunting just stops. Do not go beyond this position. Then check the amount of needle valve opening by closing the valve completely, noting the amount of a full turn required to close. Open the valve to the previously determined opening at which hunting stopped. Test action by manually disturbing engine speed. If the needle valve is now less than 1/2 turn open and more than 1/8 turn open, the adjustment is satisfactory and steps 4, 5, 6 and 7 should be ignored.

4. If hunting did not stop with the needle valve at least 1/8 turn open, raise the compensation pointer two divisions of the scale and continue with the following instructions.

5. Open needle valve approximately one turn to allow engine to hunt.

6. Proceed with instruction 3.

7. If necessary repeat 4, 5 and 3 until adjustment is satisfactory. Desirable needle valve opening is from 1/8 to 1/4 turn open.

8. It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change.

   Excessive dashpot plunger travel caused by adjustment of the compensation adjusting pointer too far toward maximum position will cause excessive speed change upon load change.

Speed Droop Setting

The governor speed droop is adjustable and may be changed by turning the knob on the face of the dial. When the pointer on the knob is on zero, the governor is set for isochronous operation. When the pointer is on 100 the governor is set for maximum governor speed droop.

It is recommended that units operating in parallel should have the speed droop set sufficiently high (30 to 50 on the dial) to permit interchange of load between units.

ENGINE LOAD LIMITING DEVICE ADJUSTMENT

Engines may be equipped with a load limiting device to reduce the maximum horsepower of an engine by reducing the fuel input. This device, illustrated in Fig. 1, mechanically limits the travel of the injector racks and thereby the fuel output of the injectors.

When adjusting the load limiting device on an engine, it is necessary to know how much movement of the load limit screw is required to reduce the fuel input the desired amount. This is shown in the graph, Fig. 2.

The computations involved in the curves of the graph, Fig. 2, are based on a percentage of engine rated brake horsepower of engines using 60 or 70 cu/mm injector assemblies. The rated brake horsepower of an engine may be obtained from the engine's option equipment plate.

The graph, Fig. 2, may be used to determine the correct dimension to use for the "setting". For example, assume the rated brake horsepower of an engine is 195 at 2000 r.p.m. and the desired horsepower is 160. Divide the desired horsepower by the rated horsepower, then multiply this result by 100 to obtain the percentage of rated brake horsepower required, which in this case will be 82.1 percent. Read the percentage of rated brake horsepower at the left side of the graph and follow the horizontal line until it intersects the proper speed curve of 2000 r.p.m. Bring this point of intersection vertically downward and read .176", which is the correct dimension required for setting the load limiting screw.

Procedure for Adjustment

After the engine tune-up is completed, it should be ascertained that the parts comprising the load limiting device are properly installed on the engine as shown in Fig. 2. The load limiting device may then be adjusted in accordance with the following procedure.

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 that the bottom of the lock nut is 1 3/4" from the bottom of the load limit screw.
4. Loosen the load limit lever clamp bolts so that 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, 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 derived from use of the graph, or to the markings on the adjusting screw plate.
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.

Although the "settings", shown on the attached graph, have been very carefully determined, they may not be "right on the nose" in some cases. Occasionally, it may be necessary to vary the "setting" very slightly in accordance with the actual performance required of the engine unit.

14.14 ENGINE LOAD LIMITING DEVICE ADJUSTMENT

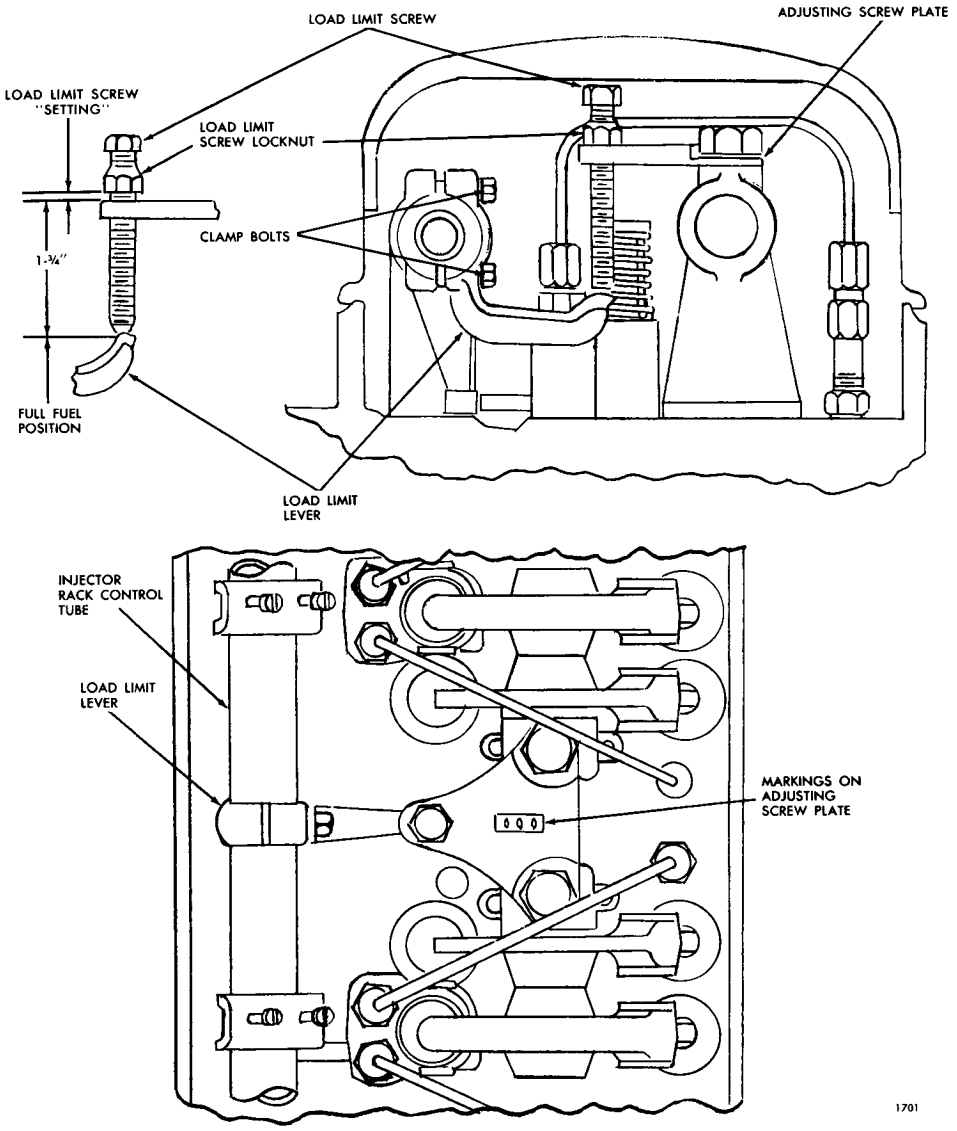


Fig. 1 - Load Limiting Device Mounted on Series 71 Engine

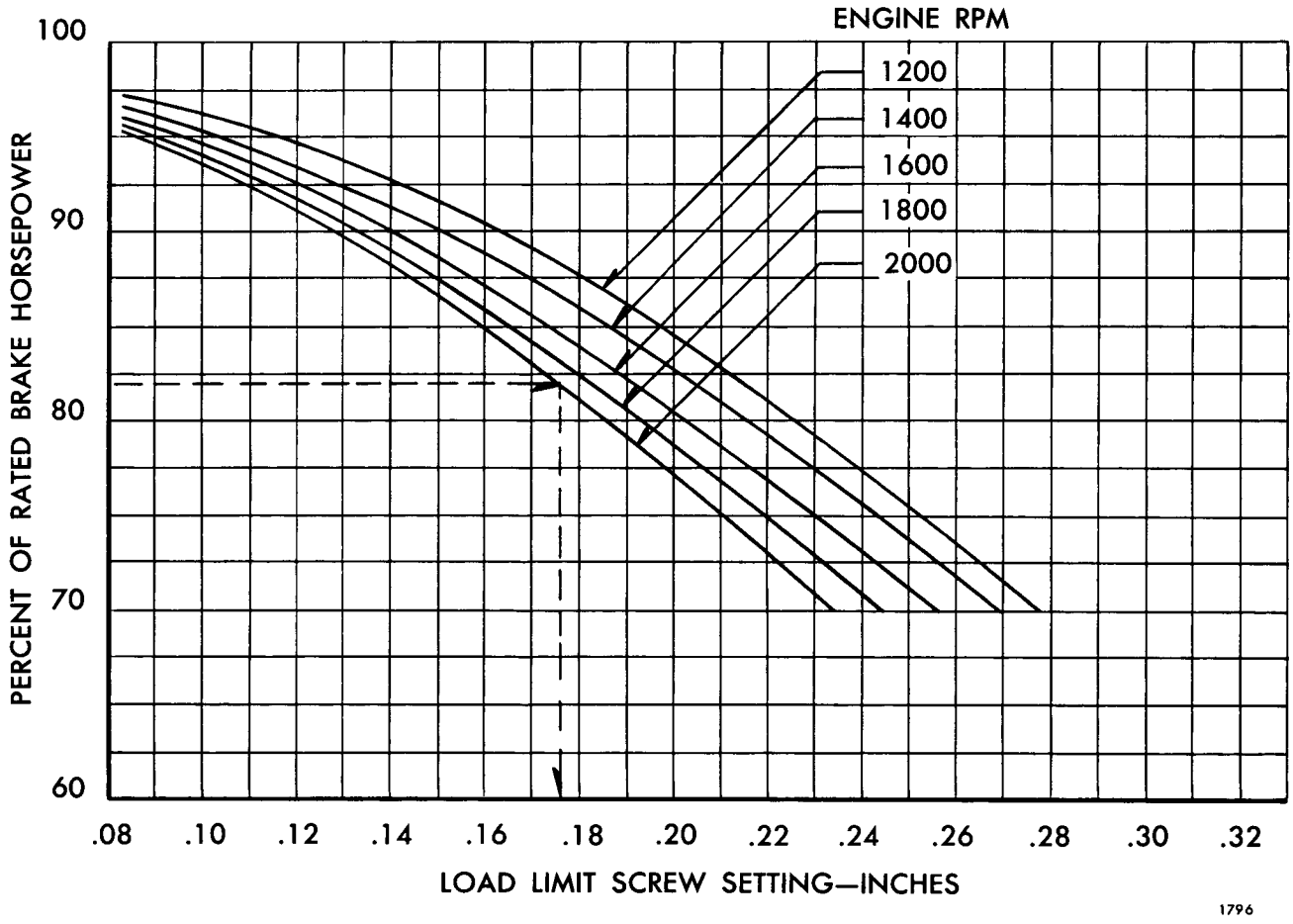


Fig. 2 - Chart-Load Limit Screw Setting for Series 71 Engines - 60 & 70 CU/MM Injectors

Instructions

Read desired % of rated BHP at left and follow horizontal line to intersection with proper speed curve. Bring point of intersection vertically down and read load limit screw setting.

Example

Model 6030C with "70" injectors, rated BHP = 195 @ 2000 rpm, desired BHP = 160

$$\frac{160}{195} \times 100 = 82.1\%$$

Then, from graph, load limit screw setting = .176"

ENGINE MOUNTED PIERCE MECHANICAL OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A near constant output shaft speed may be obtained on Series 71 engines having a torque converter with the use of a Pierce mechanical output shaft governor. The output shaft governor when mounted at the front of the engine is driven by a flexible shaft from the converter output shaft.

The output shaft governor contains a set of flyweights that bear through a riser, thrust bearing, operating fork and rocker shaft against an external speed adjusting spring. The speed of the torque converter output shaft is governed by the tension of the speed adjusting spring. The tension of the speed adjusting spring is established by the operator when he moves the output shaft governor speed adjusting lever to the desired speed setting.

An output shaft governor rod is connected between the rocker shaft lever and the output shaft governor lever located on the engine's governor cover as shown in Figs. 1 and 2.

The engine governor operating lever is positioned by the operator to limit the maximum fuel input to the engine. For most purposes, such as drag line and shovel operation, the lever is advanced to its maximum position to permit the output shaft governor to obtain full power from the engine. The lever may be used as an overrule lever when performing such jobs as laying of structural steel. An engine governor operating lever return spring is attached to the governor operating lever to return it, after it has been moved, to the idle position. The travel of the governor operating lever is limited by a stop pin (bolt).

The engine governor throttle control lever is pinned to the shaft on which the output shaft governor lever rides. The engine governor operating lever rides on the hub attached to the governor cover that surrounds the shaft. The throttle control lever is connected to these two levers by a stop pin. The stop pin transmits the action of the output shaft governor lever and/or the engine governor operating lever through the throttle control lever to the injector racks. A torsion spring is used to retain the throttle control lever pin against the output shaft governor lever. This torsion spring yields to permit the governor operating lever to move the throttle control lever toward the idle position regardless of the position of the output shaft governor lever as determined by the output shaft governor. A slot in the underside of the hub, located under the engine governor cover, limits the travel of the throttle control lever in both its maximum and minimum speed positions.

The movement of the output shaft governor speed adjusting lever is limited by the maximum and minimum speed adjusting bolts.

The engine is stopped by an engine shut-down lever. This lever is connected through a shaft to another lever, under the governor cover, that will bear against the pin in the differential lever and move the differential lever to the NO FUEL position when it is desired to stop the engine.

Lubrication

The output shaft governor is lubricated by engine oil that is contained within the governor housing. The movement of the governor weights throws the oil to all parts in the governor requiring lubrication. The governor sump should be filled, with the unit's output shaft stopped, through the hinged cap oiler until it begins to drip out of the oil level hole shown in Fig. 2. When the sump is full, the oil will drip from the oil level hole. The plug should be installed and tightened sufficiently to prevent oil leakage.

> **NOTE:** Care should be taken to remove all dirt on foreign material from the governor openings before filling or checking oil level.

The bearing surfaces of the speed adjusting shaft should be lubricated by a hand oiler with engine oil. Rod end ball joints are sealed assemblies and do not require lubrication. The throttle control lever and the levers surrounding its shaft should be lubricated with all purpose grease through the grease fitting.

Operation

Advancing the output shaft speed adjusting lever increases the governor spring tension. This increased spring tension results in movement of the output shaft governor rocker shaft and through linkage results in advancement of the injector fuel racks. Speed increases as a result of the increased fuel until the output shaft governor weight force is sufficient to balance the increased spring tension. The weights then move against the spring and reduces the injector rack fuel setting to an amount sufficient to maintain the new higher speed setting.

Should the operator move the speed adjusting shaft lever to a decreased speed position, the tension on the speed adjusting spring is decreased and the governor weights will overcome the spring tension

14.15 ENGINE MOUNTED OUTPUT SHAFT GOVERNOR

and move the rocker shaft lever and connecting linkage to the engine's throttle control lever to a decreased speed position. This moves the injector racks to a reduced fuel position decreasing the fuel input and reduces the engine speed. The engine speed reduces until the force of the output shaft governor weights equals the tension of the speed adjusting spring. The engine now operates at the desired reduced speed setting.

When the load is applied to the unit, the output shaft slows down and the force exerted by the flyweights is reduced allowing the spring to move the governor rocker shaft lever to an increased fuel position. As the engine speed increases the output shaft speed increases toward its former speed, the force exerted by the weights will again equal the tension of the speed adjusting spring and the unit will operate at a speed that is equal to its former no load speed minus the speed droop of the governor.

When the load on the unit is removed the output shaft speed will increase. This speed increase will increase the force exerted by the governor weights, overcoming the tension of the speed adjusting spring moving the rocker shaft lever and connecting linkage to the engine's throttle control lever to a decreased fuel position. The engine speed will decrease until the output shaft is again stabilized at the former no load speed.

Tune-Up

The function of the torque converter output shaft governor is to automatically control the speed setting of the engine's limiting speed mechanical governor maintaining a near constant output shaft speed. The exhaust valves, fuel injectors and the engine and output shaft governors should be adjusted as follows:

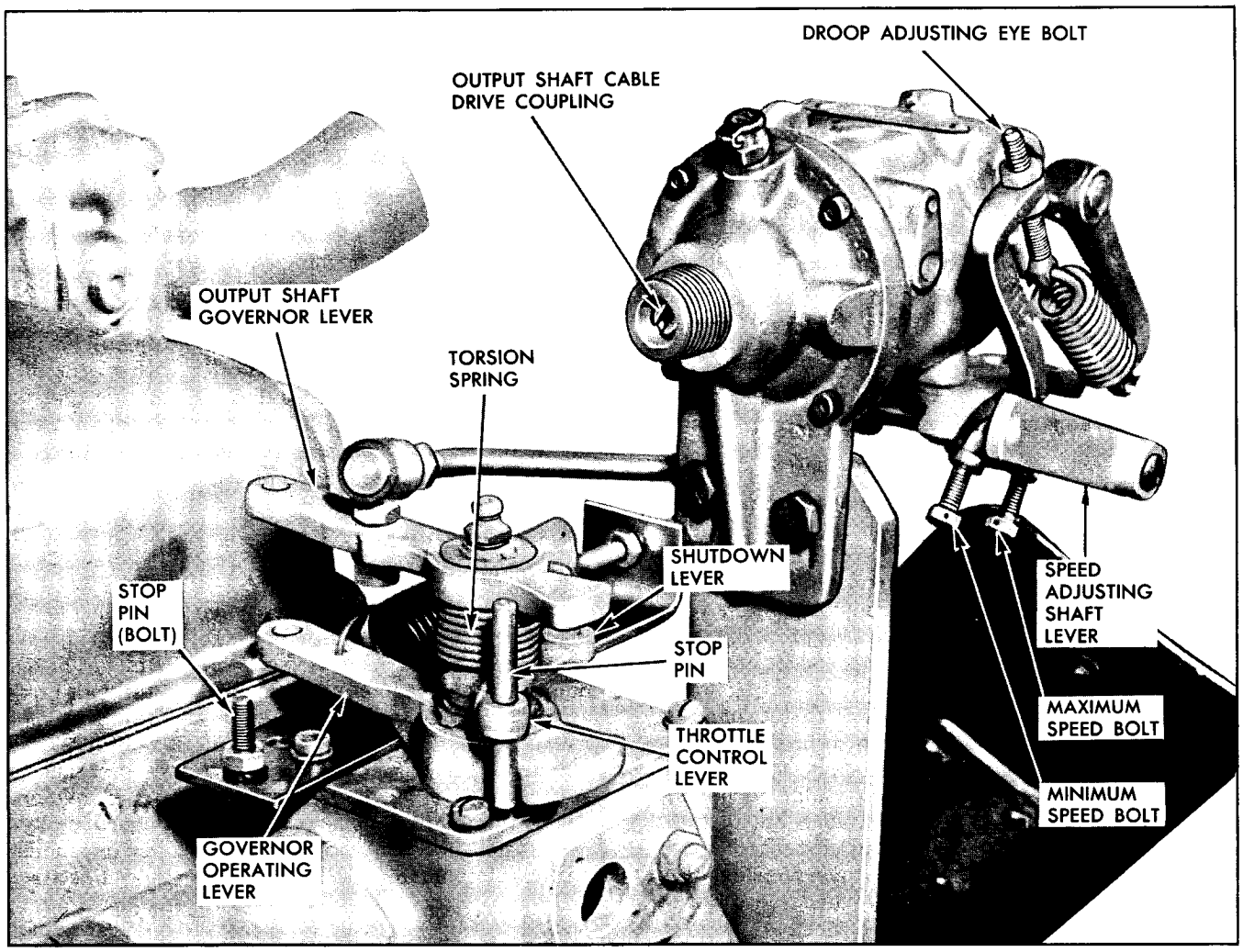


Fig. 1 - Mounting of Output Shaft Governor and Linkage to Engine Governor - Viewed from Rear of Engine

1. Adjust the engine exhaust valve clearance as outlined in section 14.1.

2. Time the engine's fuel injectors as outlined in section 14.2.

3. Remove the output shaft governor rod and the linkage to the engine governor operating lever at this time.

4. Adjust engine limiting speed mechanical governor as outlined in section 14.3.

   NOTE: Set the No Load engine speed to that specified on the engine option plate. The engine's No Load speed will vary between applications depending upon the converter used and the maximum output shaft speed setting.

5. Reconnect linkage to the governor operating lever and check total travel of operating lever. The lever should move to the stop pin (bolt) in one direction and the governor lever return spring should move the lever, in the other direction, until the throttle control lever reaches the end of its travel.

6. Move governor operating lever to maximum speed position against stop pin (bolt).

7. Move rocker shaft lever, of output shaft governor, to maximum fuel position and retain by moving speed adjusting lever to full speed position.

8. Move output shaft governor lever to the maximum speed position and retain (throttle lever will contact pin in governor and stop moving).

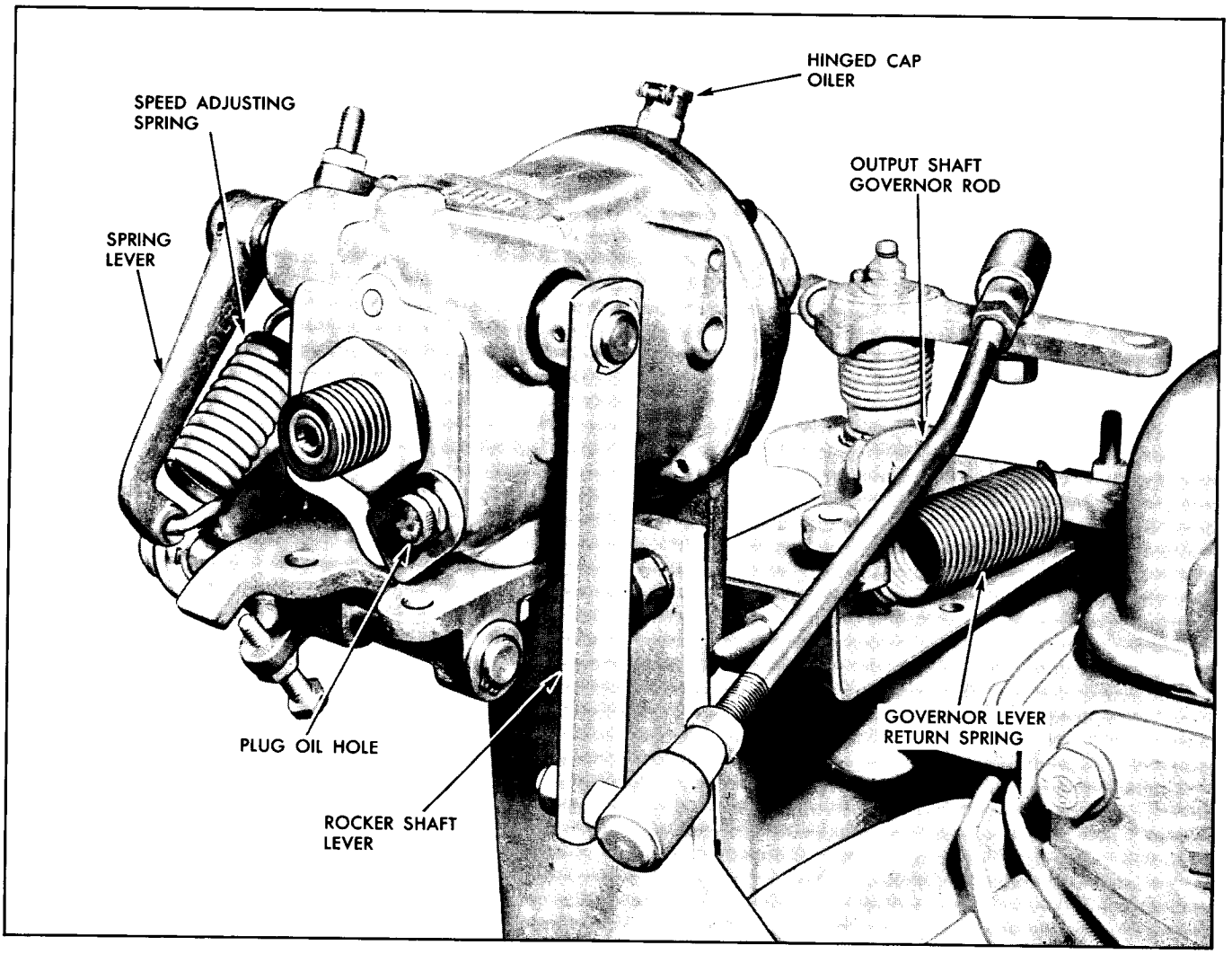


Fig. 2 - Mounting of Output Shaft Governor and Linkage to Engine Governor - Viewed from Front of Engine

9. Adjust output shaft governor rod length until it will just slide into the inner radius hole of output shaft governor lever. Then increase length of output shaft governor rod until there is approximately .020'' between the stop pin and the output shaft governor lever and bend in rod is positioned as shown in Fig. 2. Tighten adjustment securely.

10. Adjust the governor operating lever return spring by retaining the rocker shaft lever in the full speed position and increasing the tension on the spring, by use of the adjusting eye bolt and nuts, until the tension of the torsion spring is overcome and the throttle control lever is moved against its stop in the idle position.

11. Move output shaft governor speed adjusting shaft lever to minimum speed position and start engine.

12. Advance output shaft governor speed adjusting shaft lever to the desired maximum output shaft speed and adjust maximum speed adjusting bolt to retain lever.

13. Move output shaft governor speed adjusting shaft lever to the desired minimum speed position and adjust minimum speed adjusting bolt to retain the lever.

14. Recheck output shaft maximum and minimum speeds and readjust position of speed adjusting bolts, if necessary.

15. Check unit speed droop by moving speed adjusting shaft lever, with engine operating at no load, to the maximum speed position. Then move output shaft governor rod to cause a speed decrease of several hundred r.p.m. Release rod and observe hunting when governor returns engine to the maximum speed setting. If engine stabilizes in less than three surges, droop may be too high. If engine does not stabilize in five surges, the droop may be set too low. The speed droop may be set as follows:

a. Speed droop too high, engine hunts less than 3 surges, back off inner speed adjusting spring eye bolt nut one full turn and tighten outer nut one turn, retaining the adjustment.

   Speed droop too low, engine hunts more than 5 surges, back off outer speed adjusting spring eye bolt nut one full turn and tighten inner nut one turn, retaining the adjustment.

   NOTE: Make sure eye of eye bolt is in a horizontal position to avoid twisting spring.

b. Reset maximum engine no-load speed, if necessary, as outlined in steps 12 and 13.

c. Recheck speed droop. The engine speed should be stable when the governor droop is 7-1/2% to 10% of the full-load speed. Thus, for example, output shaft speed setting of 1800 r.p.m. full load the output shaft speed droop should be 150 to 200 r.p.m. Therefore, the no load output shaft speed should be set at 1950 to 2000 r.p.m.

VARIABLE SPEED GOVERNOR WITH HYDRAULIC THROTTLE KNOCKDOWN

A variable speed mechanical governor with a hydraulic throttle knockdown is used on some vehicle applications to permit the shifting of hydraulic type transmissions without the application of full engine torque to the clutches at the time of their engagement. This reduction in engine torque is accomplished by the use of a knockdown assembly and valving that operates automatically when the vehicle shift lever is moved.

Construction

The variable speed governor assembly with hydraulic knockdown consists of a standard variable speed governor assembly, but having a revised spring housing as shown in Fig. 1.

The speed adjusting shaft is mounted on roller bearings in the spring housing and has a variable speed spring lever keyed to it. One end of the speed adjusting shaft has a booster spring lever and at the other end a jaw is retained by a pin. A speed control lever is mounted on the speed adjusting shaft, riding on roller bearings, and connects to the shaft through a torsion spring. The variable speed spring lever bears against the variable speed spring plunger through a roller at its lower end. The upper end rides in the slot of the piston, bearing against the ends of the slot through a roller. The head of the piston rides in a cylinder and is sealed by a seal ring. The other end of the piston is retained in a plate and tube assembly. A spring presses against the plate and tube assembly retaining the piston in its forward position.

Operation

To start an engine equipped with this type of governor the governor control lever is placed in the run position and the engine is started. The engine will operate at idle speed until the speed control lever is moved to its maximum speed position.

As soon as the engine is started, oil pressure builds

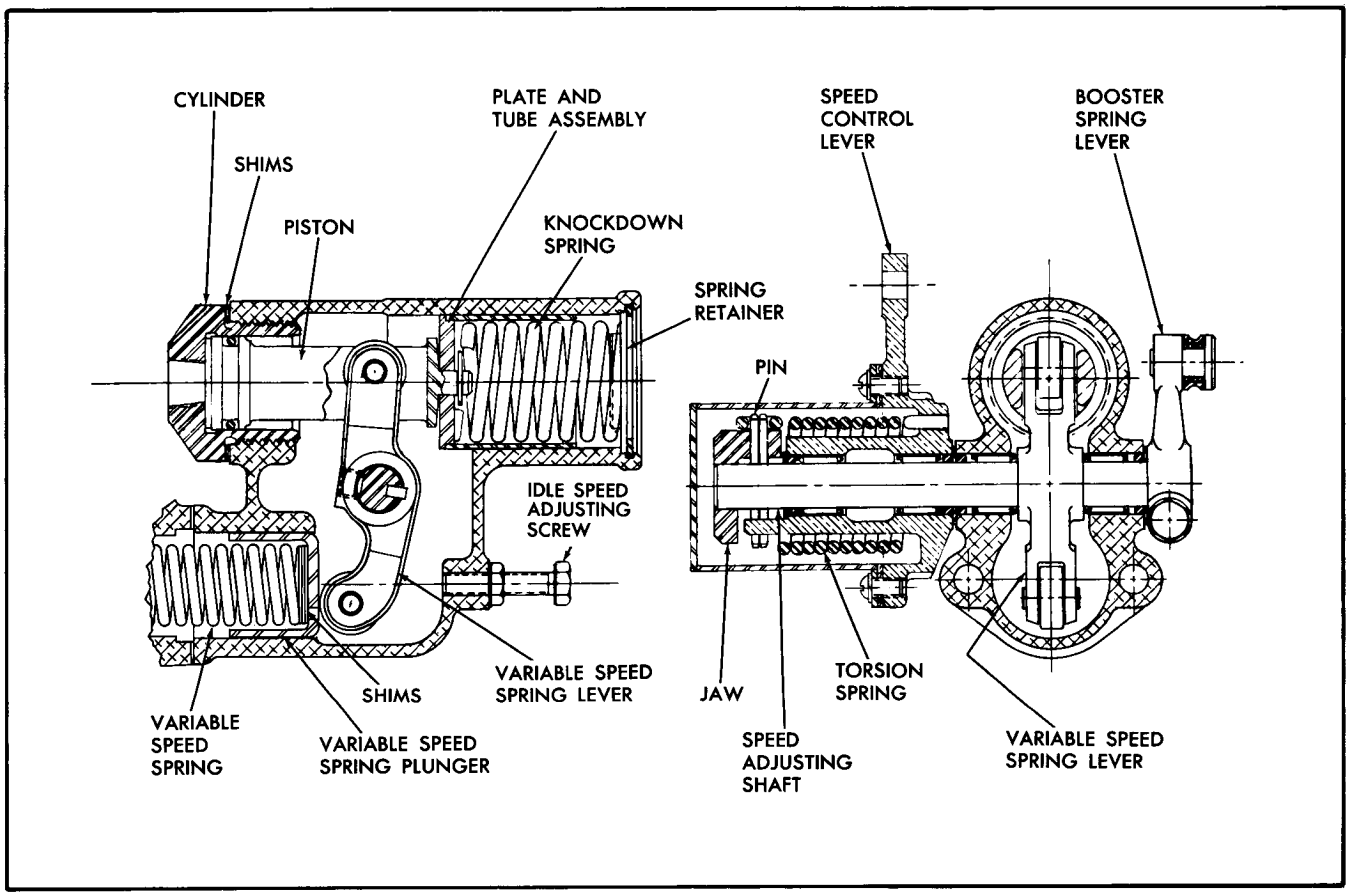


Fig. 1 - Cross Section of Variable Speed Governor with Throttle Knockdown

up in the transmission and is impressed on to the piston of the knockdown assembly. This oil pressure moves the piston to the end of its travel. Movement of the piston is stopped as the tube of the plate and tube assembly bottoms against the spring retainer. When the speed control lever is moved into the full speed position the engine will accelerate to the maximum speed setting.

When the vehicle operator shifts the transmission, a valve operated by the shift lever opens, dumping the oil pressure behind the piston, permitting the spring to move the piston to the end of its cylinder and the speed adjusting lever to the knockdown speed position. At the completion of the shift the oil pressure is again applied automatically to the piston and the engine again operates at its maximum speed setting.

VARIABLE SPEED MECHANICAL GOVERNOR— THROTTLE KNOCKDOWN TYPE ADJUSTMENT

Adjust engines with a variable speed mechanical governor and hydraulic knockdown assembly after adjusting the exhaust valves and timing the fuel injectors as follows.

ADJUST GOVERNOR GAP

With the engine stopped, the governor gap may be adjusted as follows:

1. Remove governor cover.
2. Disconnect and plug pressure line to governor knockdown assembly.

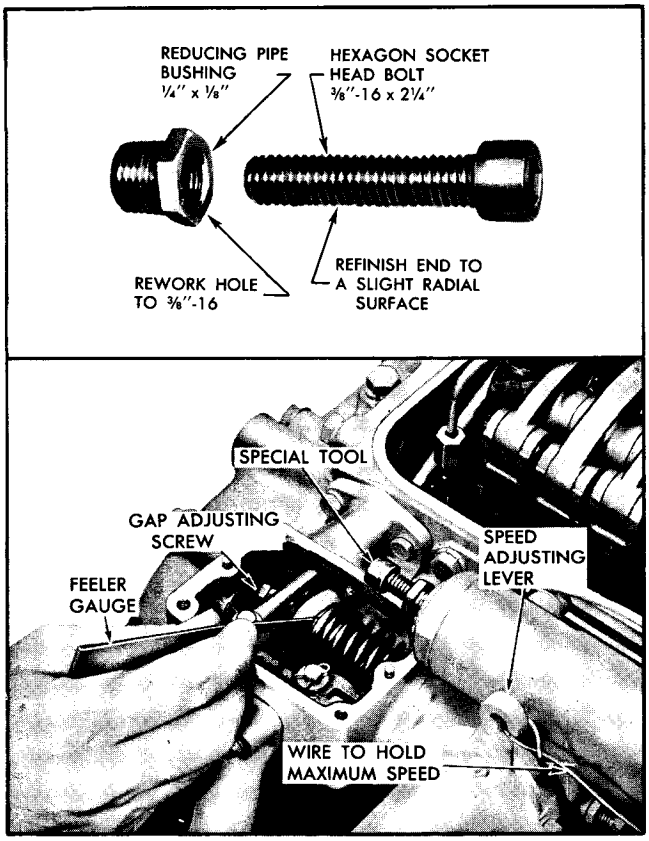


Fig. 2 - Adjusting Governor Gap Using Special Tool

NOTE: Shift transmission into neutral before removing pressure line to governor.

3. Install special tool, shown in Fig. 2, into knockdown assembly and force piston to the end of its travel.
4. Place speed control lever in the FULL SPEED position.

NOTE: To check if variable speed spring is fully compressed, place a wrench on upper end of the variable speed spring lever and force it toward the rear of the engine. If movement exists increase tension on booster spring until movement ceases.

5. Insert a .006" feeler gauge between the spring plunger and the plunger guide as shown in Fig. 2. If required, loosen lock nut and turn gap adjusting screw in or out until a slight drag is noted on the feeler gauge.
6. Hold adjusting screw and tighten lock nut. Recheck gap and readjust if necessary.
7. Install governor cover and proceed with "Position Injector Control Racks."

Position Injector Control Racks

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

The injector control racks may be adjusted after installing the special tool, outlined in step 3 of "Adjust Governor Gap", as follows:

1. Disconnect any linkage attached to governor control lever.

2. Loosen lock nut and back out buffer screw approximately 5/8".

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

4. Move speed control lever to the FULL speed position and retain.

5. Move governor control lever to the RUN position. Turn inner adjusting screw down until a step up in effort is noted. This will place No. 1 injector rack in the FULL FUEL position. Turn down outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight

6. With the governor control lever held in the RUN position, check for a slight movement of the injector control tube lever. This movement should not exceed .005".

7. If no movement is observed back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

   If the movement exceeds that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten 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 6.

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

   a. Speed control lever is at full speed position.

   b. Governor control lever is in the RUN position.

   c. High speed spring plunger is within .005" to .007" of its seat in governor control housing.

   d. Injector fuel control racks are within .005" of maximum fuel position (measured at clevis end of injector control tube lever).

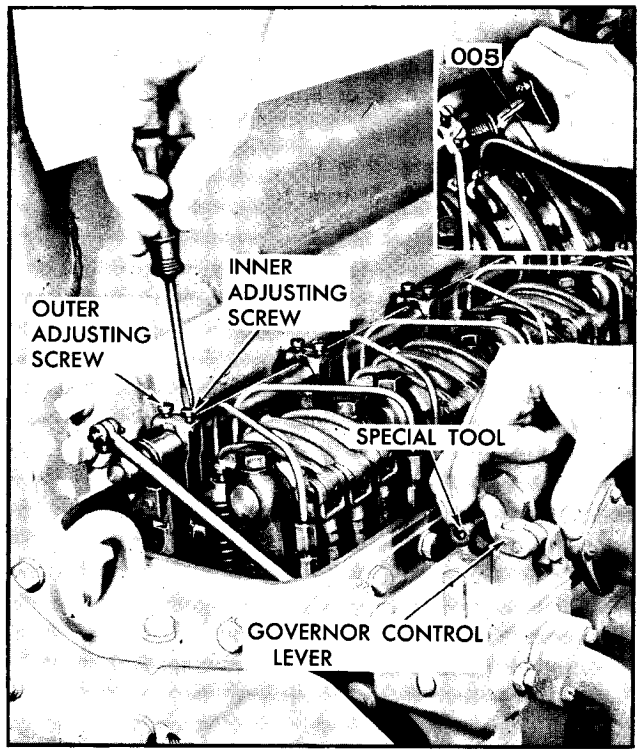


Fig. 3 - Positioning No. 1 Injector Control Rack

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

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

10. Recheck No. 1 injector rack to be sure that it has remained snug on the pin of the rack control lever while positioning No. 2 injector rack. If the rack of No. 1 injector has become loose, back off slightly the inner adjusting screw on No. 2 injector rack control lever. Tighten outer adjusting screw.

    While holding the injector control tube in the FULL FUEL position, press straight down on the rack with a screw driver. The rack should return to its original position.

11. Position the remaining injector control rack levers as outlined in steps 9 and 10.

When the settings are correct, the rack of all injectors must be snug on the pin of the control rack levers and still maintain that movement of the control tube lever specified in item 6.

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

13. Proceed with "Adjust Maximum No-Load Speed" or reconnect pressure line to governor.

Adjust Maximum No-Load Speed

The maximum no-load speed on units equipped with a variable speed governor must not be less than 125 r.p.m. or more than 150 r.p.m. above the full load speed desired. The maximum no-load speed may be set as follows:

1. Remove and plug the pressure line to governor assembly and then install the special tool as outlined in step 3 of "Adjust Governor Gap".

   NOTE: A check of the maximum no load speed can be made in the vehicle without disconnecting the oil pressure line. The oil pressure will retain the piston in the maximum speed position when the engine is operating.

2. Start engine and manually move booster spring lever to the end of its travel, to the maximum speed position, and note engine speed.

3. If maximum no-load speed requires adjustment, remove two bolts and withdraw variable speed spring housing and variable speed spring plunger inside spring housing.

4. Add shims between the governor spring and spring plunger to obtain the necessary maximum no-load speed. For each .001" shim added the operating speed will increase approximately 1 r.p.m.

   Governor shims are available in .010" and approximately .078".

5. Reassemble governor spring housing and spring plunger assembly to governor.

6. Start engine and recheck engine maximum no-load speed as outlined in steps 1 and 2. Readjust if necessary.

7. Stop engine and remove special tool from hydraulic throttle knockdown.

Adjust Knockdown Speed

After adjusting the maximum NO-LOAD engine speed the knockdown speed may be adjusted as follows:

1. Remove and plug the pressure line to the governor assembly.

2. Start engine and place engine speed control lever in the maximum speed position.

3. Note engine knockdown speed and if adjustment is necessary continue with step 4.

4. Adjust the engine knockdown speed as follows:

   a. Remove cylinder from piston.

   b. Reduce the number of shims between cylinder and housing to increase the knockdown speed or increase the number of shims to reduce the knockdown speed.

   c. Reassemble the cylinder over the piston and into the spring housing and secure.

5. Start engine and recheck knockdown speed as outlined in steps No. 1 and 2. Repeat adjustment if necessary until the desired knockdown speed is established.

6. Remove plug from governor pressure line and attach line to governor assembly.

Adjust Idle Speed

With the maximum no-load and knockdown speed properly adjusted, the idle speed may be adjusted as follows:

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

2. With engine operating, loosen idle speed adjusting screw lock nut. Turn idle adjusting screw until engine idles at the recommended idle speed.

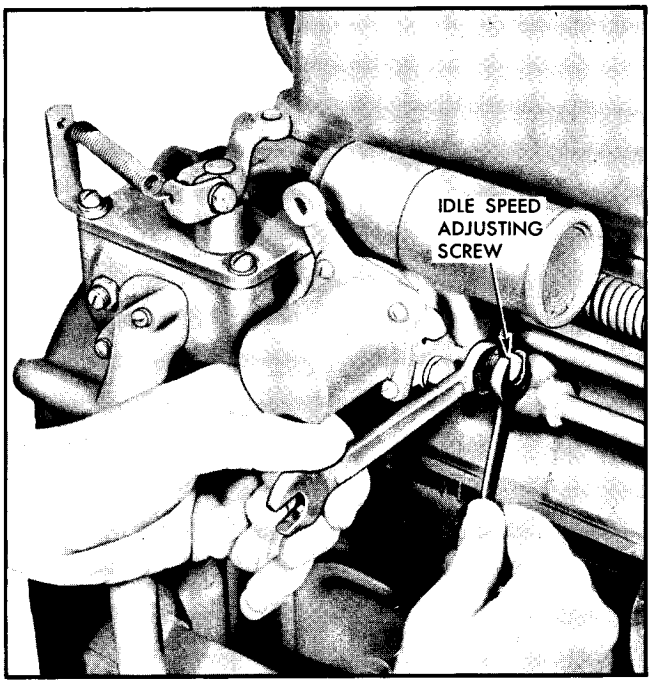


Fig. 4 - Adjusting Idle Speed

The recommended idle speed is 500 r.p.m., but may vary with special engine applications.

3. Hold idle screw and tighten lock nut.

Adjust Buffer Screw

With idle speed properly adjusted, the buffer screw may be adjusted as follows:

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

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

2. Hold buffer screw and tighten lock nut.

Adjust Booster Spring

With idle spring properly set, the booster spring is adjusted as follows:

1. If moved, position booster spring lever on speed control shaft in a horizontal position pointing toward front of engine.

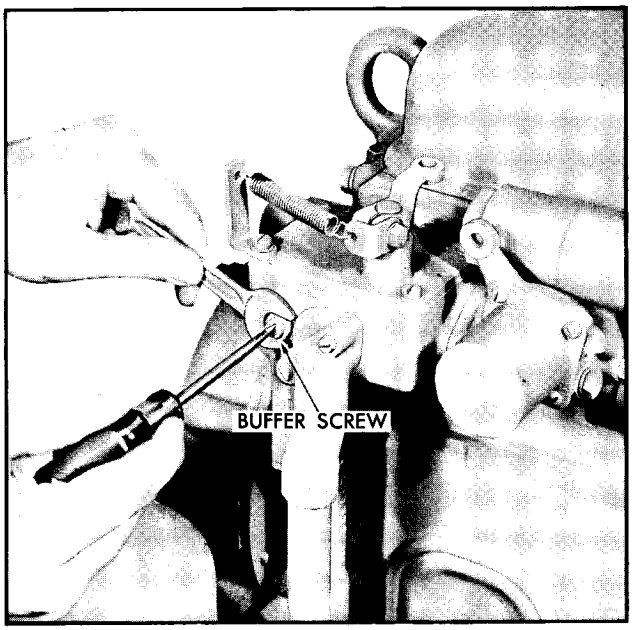


Fig. 5 - Adjusting Buffer Screw

2. Connect booster spring, with tension released, to booster spring lever.

3. Start engine and apply 125 p.s.i. pressure to governor knockdown assembly, then move speed control lever to the full speed position and release. The speed control lever should return to the idle position. If it does, continue to increase the spring tension until the point is reached that it will not return to idle position. Then, reduce the tension until it does return to idle position and tighten lock nut on eye bolt. This setting will result in the minimum force required to operate the speed control lever.

   If difficulty is encountered in setting the booster spring tension, change the position of the booster spring lever slightly on the speed control shaft.

   NOTE: If the speed returns from the maximum speed position satisfactorily but does not return from an intermediate speed position, moving the booster spring lever on the speed control shaft downward slightly may correct this condition.

   When the spring tension and the position of the booster spring lever are adjusted properly, the force required to move the speed control lever to the maximum speed position should be between 4 and 12 pounds, at the hole position of

14.16 VARIABLE SPEED—THROTTLE KNOCKDOWN TYPE GOVERNOR

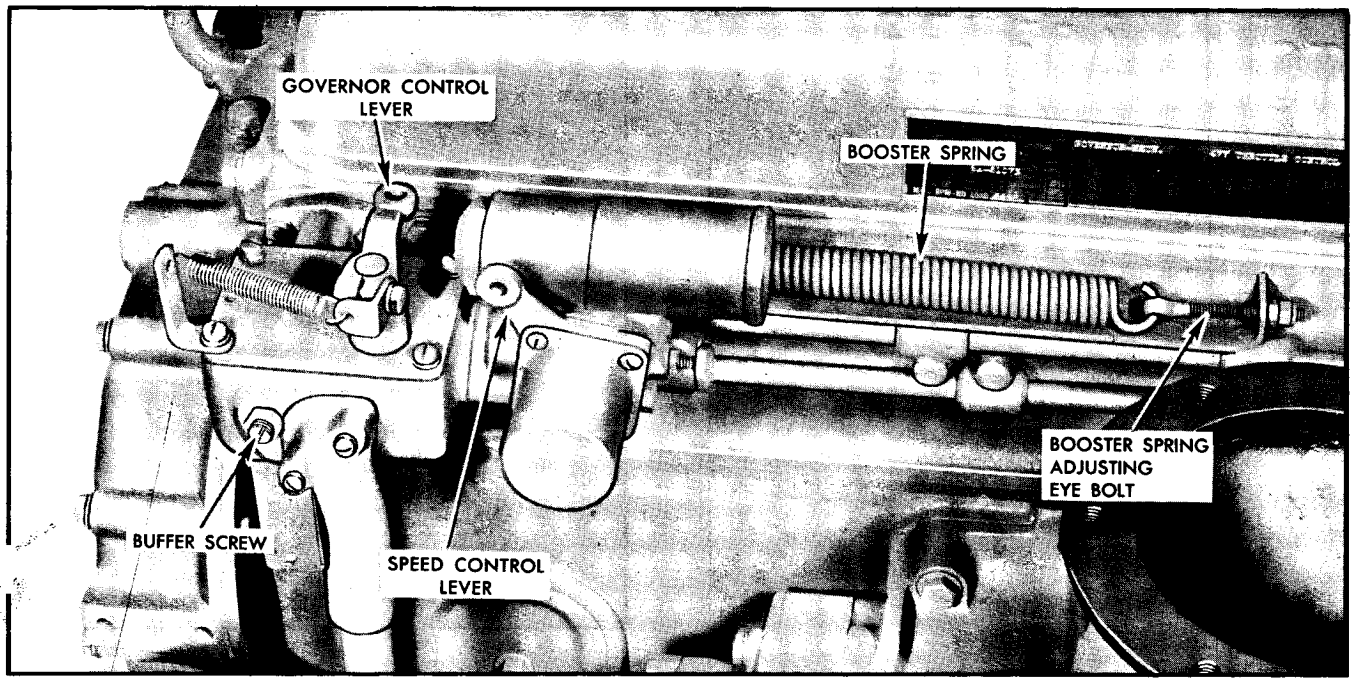


Fig. 6 - Governor Assy. Mounted on Engine

the speed control lever. The force required to move the speed control lever should be nearly constant. The correct setting should result in the speed control lever moving rapidly to the idle position when released at any position in its arc of travel.

4. Recheck to see if maximum no-load speed can be attained by movement of the speed control lever into the maximum speed position.

5. Release pressure to throttle knockdown assembly and stop engine.

ENGINE TUNE-UP PROCEDURES

Approximately 100 hours after the initial start, or after an engine overhaul, and thereafter at 1000 hour intervals, check the various engine adjustments and make the necessary corrections.

Three types of governors are used. Since each governor has different characteristics, the tune-up procedure varies accordingly. The three types are:

1. Limiting speed mechanical.
2. Variable speed mechanical.
3. Hydraulic.

The mechanical engine governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double weight limiting speed governor. A single weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor, or injectors have been replaced or overhauled, then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine (see Section 14.1).

To tune-up an engine completely, all of the adjustments, except the valve bridge adjustment, are made by following the applicable tune-up sequence given below, after the engine has reached the normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

NOTE: The exhaust valve bridge is adjusted at the time the cylinder head is installed on the engine and, until wear occurs, no further adjustment is required. When wear is evident, perform a complete valve bridge adjustment as outlined in Section 1.2.2.

Tune-Up Sequence for Mechanical Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rods and vertical link assembly.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Adjust the speed droop.
7. Adjust the maximum no-load speed.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders, and eventually burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will insure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

UNITS WITH TWO VALVE CYLINDER HEADS

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Place the governor stop lever in the NO-FUEL position.

2. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation as the bolt will be loosened.

3. Loosen the push rod lock nut.

4. Place a .013" feeler gage, tool J 9708, between the valve stem and the rocker arm (see Fig. 1). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

5. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.

6. Recheck the clearance. At this time, if the adjustment is correct, the .011" feeler gage will pass freely between the valve stem and the rocker arm, but the .013" feeler gage will not pass through.

7. Check and adjust the remaining valves in the same manner as outlined above.

Exhaust Valve Clearance Adjustment (Hot Engine)

Maintaining the normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become insufficient.

With the engine at normal operating temperature (160^{o}-185^{o}F.), recheck the exhaust valve clearance with the feeler gage. At this time, if the valve clearance is correct, the .008" feeler gage will pass freely between the valve stem and the rocker arm, but the .010" gage will not pass through. Readjust the push rod, if necessary.

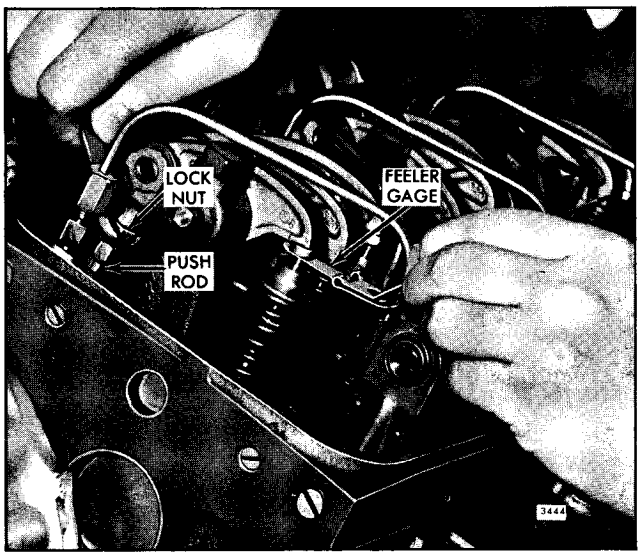


Fig. 1 - Adjusting Valve Clearance

14.1 EXHAUST VALVE ADJUSTMENT

UNITS WITH FOUR VALVE CYLINDER HEADS

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. Until wear occurs, no further adjustment is required on the exhaust valve bridges. When wear is evident, make the necessary adjustments as outlined in Section 1.2.2.

The exhaust valve clearance is always adjusted at the push rod. DO NOT DISTURB THE EXHAUST VALVE BRIDGE ADJUSTING SCREW.

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Place the governor stop lever in the NO-FUEL position.
2. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation as the bolt will be loosened.

3. Loosen the push rod lock nut.
4. Place a .017" feeler gage, tool J 9708, between the end of the valve stem and the valve bridge adjustment screw (spring-loaded bridge only) or between the valve bridge and the valve rocker arm pallet (unloaded bridge only) -- see Figs. 2 and 3. Adjust the push rod to obtain a smooth "pull" on the feeler gage.
5. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.
6. Recheck the clearance. At this time, if the adjustment is correct, the .015" feeler gage will pass freely between the valve stem and the adjustment screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .017" feeler gage will not pass through.
7. Check and adjust the remaining valves in the same manner as outlined above.

Exhaust Valve Clearance Adjustment (Hot Engine)

Maintaining the normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become insufficient.

With the engine at normal operating temperature (160^{o}-185^{o}F.), recheck the exhaust valve clearance with the feeler gage. At this time, if the valve clearance is correct, the .013" feeler gage must pass freely between the valve stem and the valve bridge adjusting screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .015" gage must not pass through. Readjust the push rod if necessary.

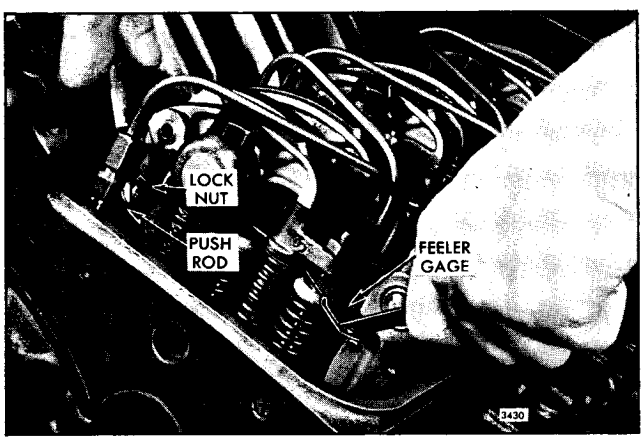


Fig. 2 - Adjusting Valve Clearance (Spring-Loaded Valve Bridge)

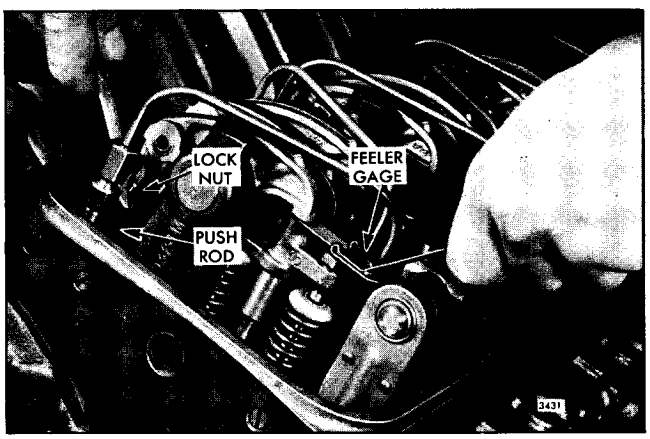


Fig. 3 - Adjusting Valve Clearance (Unloaded Valve Bridge)

TIMING FUEL INJECTOR

To properly time the injectors used in the V-71 engines, the injector follower must be adjusted to a height of 1.460" with timing gage J 1853.

The exception to this is bus engines. The injector followers in these engines must be adjusted to a height of 1.484" with timing gage J 1242.

All of the injectors can be timed in firing order sequence during one full revolution of the crankshaft. Refer to the general specifications at the front of the manual for the firing order.

Time Fuel Injector

1. Place the governor speed control lever in the no fuel position.

2. Rotate the crankshaft until the exhaust valves are fully depressed on the particular cylinder to be timed.

   CAUTION: When using a wrench on the crankshaft bolt or camshaft nut at the front of the engine, do not turn the engine in a left-hand direction of rotation as the bolt will be loosened.

3. Place the small end of the injector timing gage in the hole provided in the top of the injector body with the flat of the gage toward the injector follower (Fig. 1).

4. Loosen the push rod lock nut.

5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the lock nut. Check the adjustment and if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

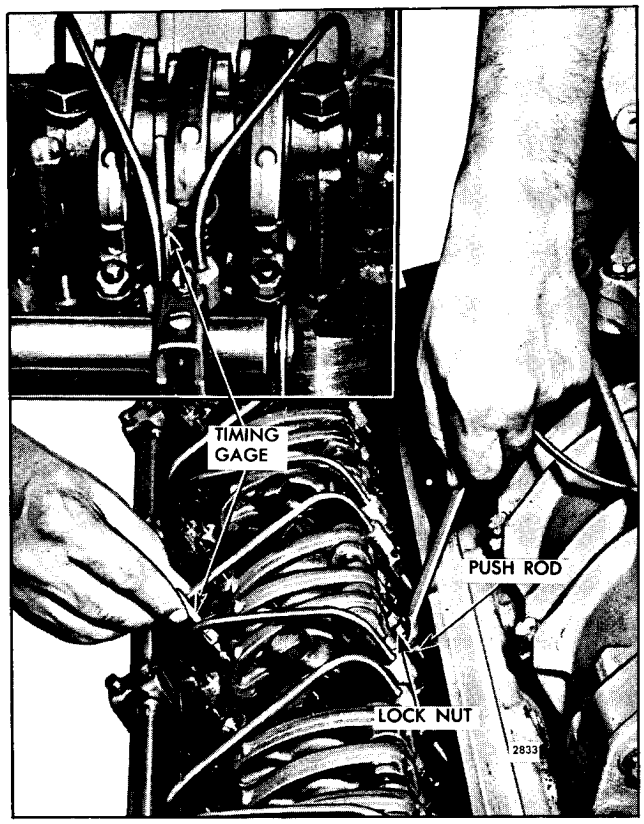


Fig. 1 - Timing Fuel Injector

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

The two types of limiting speed mechanical governors used on the V-71 engines are covered in this procedure. The difference between each type of governor is in the high speed spring retainer and spring housing assembly. Industrial engines use the standard limiting speed governor, while some vehicle applications may find it advantageous to use the dual range limiting speed governor.

The only variation in the tune-up procedure between each type of governor is in the setting of the maximum no-load speed. Therefore, the setting of the maximum no-load engine speed is given for each type of limiting speed governor.

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

Adjust the Governor Gap

With the engine at operating temperature, set the governor gap as follows:

1. With the engine stopped, remove two bolts and withdraw the governor high speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the lock nut.

3. Start the engine and loosen the idle speed adjusting screw lock nut and adjust the idle screw to obtain the desired idle speed.

4. Stop the engine and remove the governor cover and lever assembly.

5. Start and run the engine between 800 and 1000 r.p.m. by manual operation of the differential lever as shown in Fig. 1.

   CAUTION: Do not overspeed the engine.

6. With the engine operating between 800 to 1000 r.p.m., set the gap between the low speed spring cap and the high speed spring plunger at .0015" by adjusting the gap adjusting screw in the operating shaft lever.

7. Hold the gap adjusting screw and tighten the lock nut.

8. Recheck the governor gap, with the engine operating between 800 and 1000 r.p.m., by placing a screw driver between the gap adjusting screw and the governor housing and manually forcing the gap closed. If the setting is correct, the .0015" movement can be seen.

   NOTE: The gap closing can be easily seen if a drop of oil is placed into the gap just before it is closed.

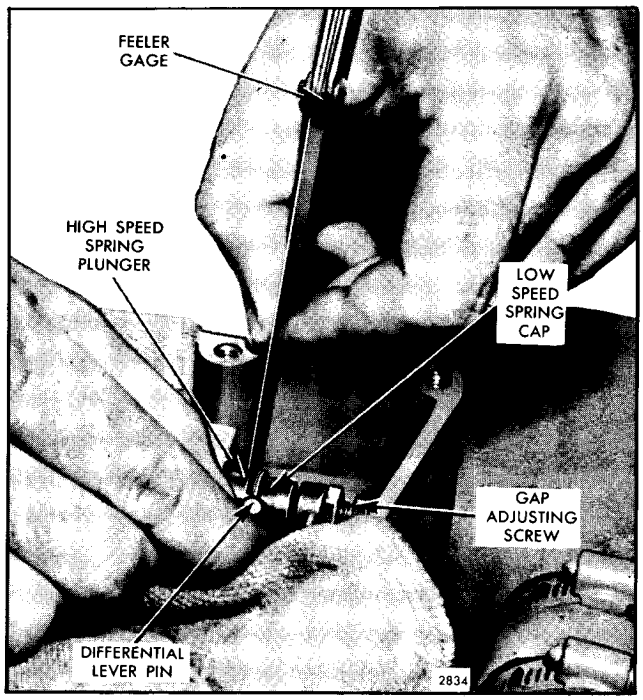


Fig. 1 - Adjusting Governor Gap

9. Stop the engine and re-install the governor cover and lever assembly.

Position Injector Rack Control Levers

Properly positioned injector rack control levers with the engine at FULL LOAD will result in the following:

Speed control lever at the maximum speed position.

Governor low speed gap closed.

High speed spring plunger on the seat in the governor control housing.

Injector fuel control racks in the FULL FUEL position.

14.3 LIMITING SPEED GOVERNOR ADJUSTMENT

The letters R and L indicate the injector location in the right or left cylinder bank, 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 left bank injector rack control levers.

1. Disconnect any linkage attached to the governor speed control lever.

2. Adjust the idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the lock nut when the nut is against the high speed plunger.

3. Loosen the buffer screw lock nut and back out the buffer screw approximately 5/8", if not previously set.

4. Remove the valve rocker covers.

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

6. Check for any bind in the governor to control tube linkage by moving the linkage through its full range of travel with one hand on the governor speed control lever and the other hand on one of the control tube levers.

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

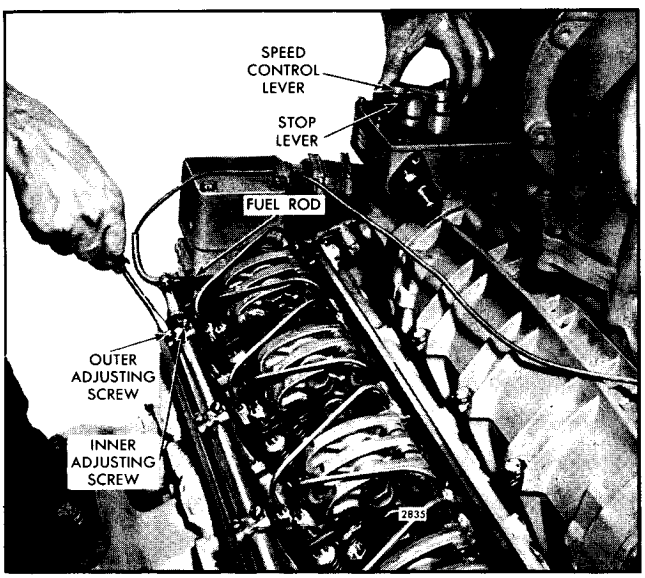


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

8. Move the governor speed control lever to the maximum speed position; hold in that position with light finger pressure. Turn the inner adjusting screw of the No. 1L injector rack control lever down until a step up in effort is noted (Fig. 2). This will place the No. 1L 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: The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load as previously described.

   CAUTION: Care should be used to avoid setting the injector rack too tight causing the fuel rod to bend.

9. To be sure the control lever is properly adjusted, the following check should be performed.

   Hold the speed control lever in the maximum speed 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 injector rack returns to its original position.

   If the rack does not return to its original position, it is too loose. To correct, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

   The setting is too tight if, when moving the speed control lever from the idle to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover).

   This will result in a step up in effort required to move the speed control lever to the end of its travel and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). To correct this condition, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

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

11. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the 1R injector rack control lever as previously outlined in Step 8.

12. 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 lever as outlined in Step 9.

    Carefully observe and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

13. To adjust the remaining injector rack control levers, hold the No. 1L injector rack in the FULL FUEL position by means of the lever on the end of the control tube assembly and turn down the inner adjusting screw of No. 2L injector rack control lever 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 until tight.

    Recheck the No. 1L injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while positioning the No. 2L injector rack. If the rack of No. 1L injector has become loose, back off slightly the inner adjusting screw on the No. 2L injector rack control lever. Tighten the outer adjusting screw.

    When the settings are correct, both injector racks must respond in the same manner on the ball end of their respective rack control levers as previously outlined in Step 9.

14. Position the remaining injector rack control levers as outlined in Step 13 on the left bank.

15. Position the right cylinder bank injector rack control levers as outlined above for the left cylinder bank in Step 13.

16. Turn the idle speed adjusting screw in until it projects 3/16" from the lock nut, to permit starting the engine.

Adjust Idle Speed

The idle speed may be adjusted as follows:

1. With the engine running, at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine idles at the recommended idle speed. See Fig. 3.

    NOTE: It may be necessary to use the buffer screw to eliminate the engine roll. Back out the buffer screw after the idle speed is established to the previous setting (5/8").

    The recommended idle speed is 400-450 r.p.m. but may vary with special engine applications.

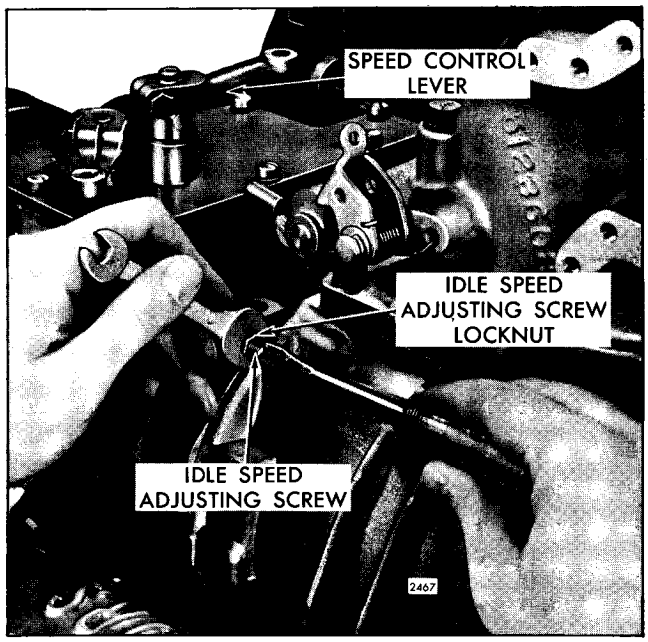


Fig. 3 - Adjusting Engine Idle Speed

2. Hold the idle screw and tighten the lock nut

3. Install the high speed spring retainer cover.

Adjust Maximum No-Load Engine 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 unit name plate, the maximum no-load speed may be set as follows:

Engines with Early Dual Range Limiting Speed Mechanical Governor

After positioning the injector rack control levers and setting the idle speed, set the maximum engine speeds.

NOTE: 1: Be sure the buffer screw projects 5/8" from the lock nut to prevent its interference while adjusting the maximum no-load speeds.

NOTE: 2: To prevent air leakage between the piston and sleeve assembly, coat the mating threads with sealant.

14.3 LIMITING SPEED GOVERNOR ADJUSTMENT

With the spring housing assembly mounted on the governor, the piston and sleeve assembly assembled as illustrated in Fig. 4, and the low maximum speed adjusting screw extended from the spring housing approximately 3/4" beyond the lock nut, proceed as follows:

CAUTION: Do not apply air pressure to the governor until performing Step 1h.

1. Set the high maximum no-load speed.

   a. Start the engine and place the engine speed control lever in the maximum speed position.

   b. Loosen the lock nut and turn the low maximum speed adjusting screw in until the desired no-load high maximum speed is obtained.

   c. Stop the engine and remove the spring housing assembly. Note the distance the sleeve extends beyond the spring housing.

   CAUTION: Do not permit the seal ring on the piston to slide past the air inlet port, since the seal ring will be damaged.

   d. Remove the piston and sleeve from the bottom of the spring housing.

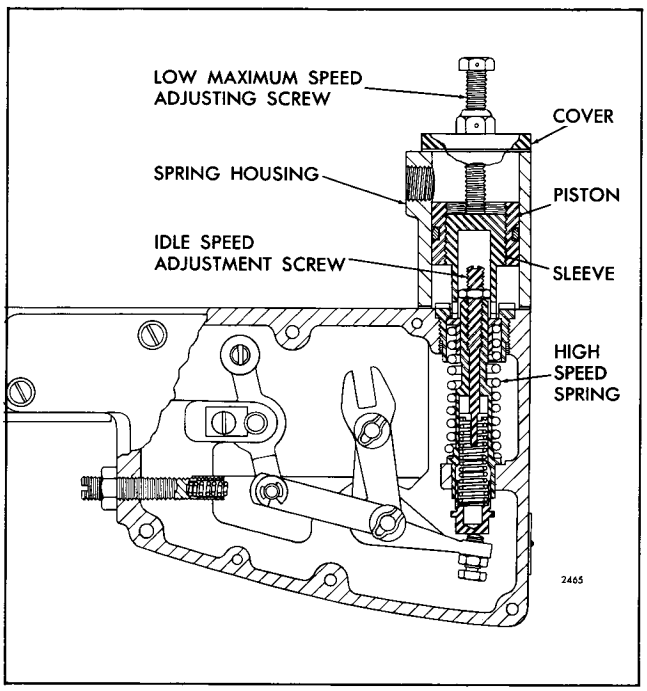


Fig. 4 - Early Dual Range Governor (Top View)

   e. Turn the piston until the sleeve extends from the bottom of the piston the same distance the sleeve extends beyond the spring housing, Step c.

   f. Check the adjustment by installing the piston and sleeve in the spring housing. The piston should be flush to 1/64" below the bottom of the spring housing when it is tight against the adjustment screw.

   NOTE: The cover, cover gasket and spring housing must be held as an assembly when checking the piston position.

   g. Replace the piston and sleeve in the governor spring housing and assemble to the governor.

   h. Start the engine and place the engine speed control lever in the maximum speed position and apply air pressure to the governor.

   NOTE: To overcome the tension of the governor high speed spring, 50 p.s.i. air pressure will be required in the governor spring housing.

   i. Back out the low maximum speed adjustment screw 1/4". If the piston is adjusted correctly, the engine will operate at the recommended high maximum no-load speed.

   j. Remove the air pressure from the governor.

   k. Make minor adjustment on the piston and sleeve if necessary to establish the exact speed desired.

2. Set the low maximum no-load engine speed.

   a. Adjust the low maximum speed adjusting screw, with the engine speed control lever in the maximum speed position, until the desired low maximum speed is obtained. Turn the screw in to increase or out to decrease engine speed.

3. Check both high maximum and low maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 and 2.

Engines with Current Dual Range Limiting Speed Mechanical Governor

After positioning the injector rack control levers, set the maximum engine speeds.

NOTE: Be sure the buffer screw projects 5/8" from the lock nut to

prevent interference while adjusting the maximum no-load speeds.

With the spring housing assembly mounted on the governor, the piston and sleeve assembled with four .100" shims and ten .010" shims as illustrated in Fig. 5, and the low maximum speed screw extending from the spring housing approximately 1-1/4", proceed as follows:

CAUTION: Do not apply air pressure to governor until performing Step 1f.

1. Set the high maximum no-load speed.

   a. Start the engine and position the engine speed control lever in the maximum speed position.

   b. Turn the low maximum speed adjustment screw in until the high maximum speed desired is obtained.

   c. Stop the engine and remove the spring housing assembly.

   CAUTION: Do not permit the seal ring on the piston to slide past the air inlet port, since the seal ring will be damaged.

   d. Note the distance the piston is within the spring housing when it is against the low maximum speed screw, and then remove the sleeve from the piston.

   NOTE: When checking this distance, the piston should be held tight against the adjustment screw of the cover that is held in position, with its gasket, against the end of the spring housing.

   e. Remove a quantity of shims, from the shims within the piston, equal to the distance noted in Step d.

   f. Start the engine and position the engine speed control lever in the maximum speed position and apply air pressure to the governor and note the engine speed.

   g. Remove the air pressure from the governor and stop the engine, then install or remove shims as required to obtain the correct high maximum no-load speed. Removing shims will decrease the engine speed and adding shims will increase the engine speed.

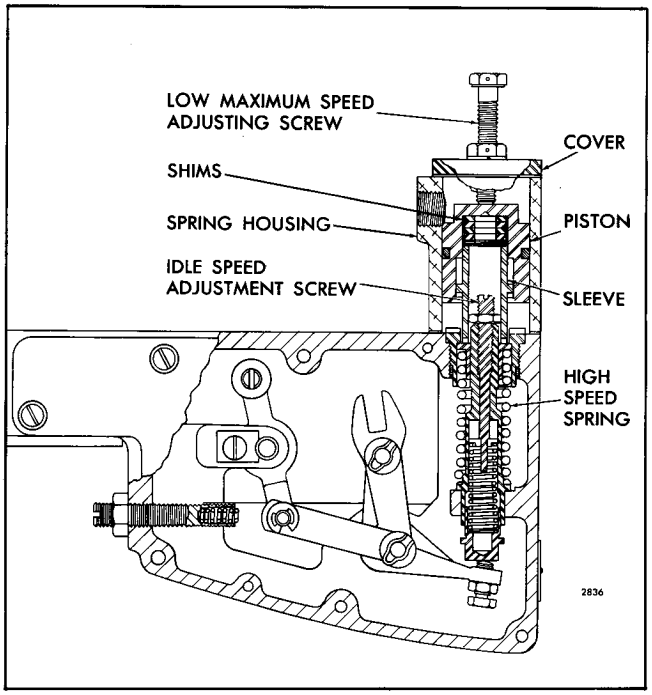


Fig. 5 - Current Dual Range Governor (Top View)

NOTE: Each .010" shim removed or added will decrease or increase the engine speed approximately 10 r.p.m.'s.

2. Set the low maximum no-load engine speed.

   a. Adjust the low maximum speed adjusting screw, with the engine speed control lever held in the maximum speed position, until the desired low maximum is obtained. Turn the screw in to increase or out to decrease the engine speed.

   b. Recheck the engine speed and readjust if necessary.

3. Check both the high maximum and low maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 and 2.

Engines with Limiting Speed Mechanical Governor

After positioning the injector rack control levers and setting the idle speed, set the maximum engine speed as follows:

NOTE: Be sure the buffer screw projects 5/8" from the lock nut to prevent interference while adjusting the maximum no-load speed.

14.3 LIMITING SPEED GOVERNOR ADJUSTMENT

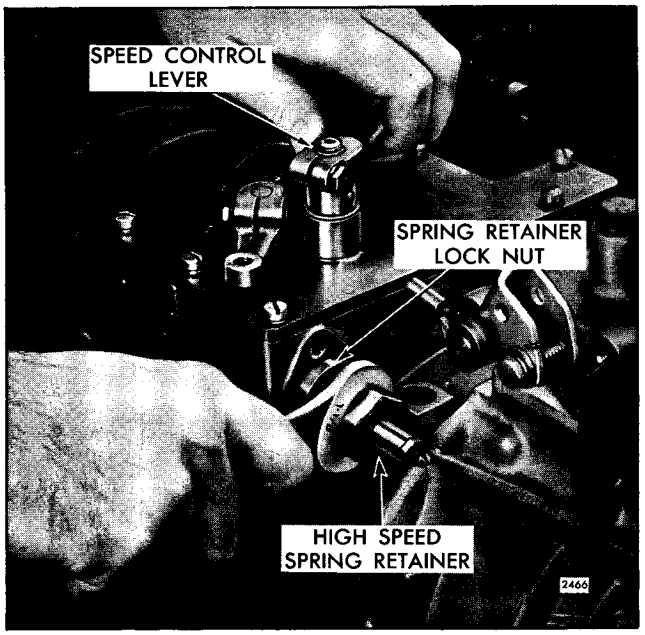


Fig. 6 - Adjusting Maximum No-Load Speed

1. Loosen the spring retainer lock nut, Fig. 6, and back off the high speed spring retainer approximately five turns.

2. With the engine running at operating temperature and no-load on the engine, place the speed control lever in the maximum speed position. Turn the high speed spring retainer until the engine is operating at the recommended no-load speed.

3. Hold the high speed spring retainer and tighten the lock nut.

Adjust Buffer Screw

With the idle speed set, the buffer screw may be adjusted as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in so that it contacts the differential lever as lightly as possible and still eliminates the engine roll. See Fig. 7.

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

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

3. Recheck the maximum no-load speed. If it has increased more than 25 r.p.m., back off the buffer screw until the increase is less than 25 r.p.m.

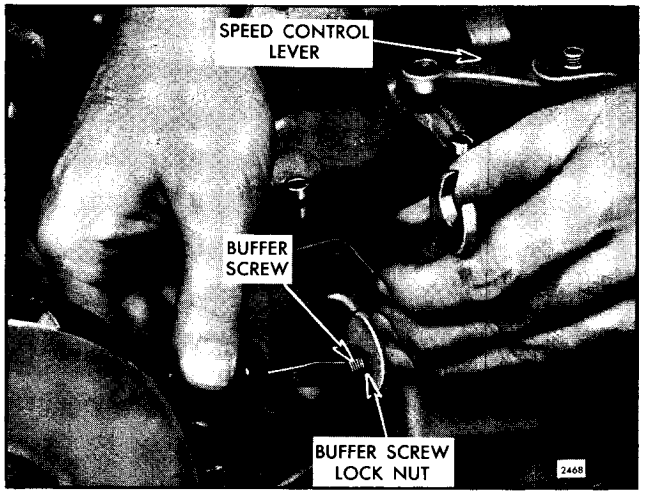


Fig. 7 - Adjusting Buffer Screw

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

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

Adjust Governor Gap

With engine stopped, the governor gap may be set as follows:

1. Remove the governor cover.
2. Place the speed control lever in the maximum speed position.
3. 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 adjusting screw until a slight drag is noted on the feeler gage.
4. Hold the adjusting screw and tighten the lock nut. Check the gap. If necessary readjust.
5. Install the governor cover.

Position Injector Rack Control Levers

Properly positioned injector rack control levers with the engine at FULL LOAD will result in the following:

Speed control lever at the maximum speed position.

Stop lever in the run position.

High speed spring plunger is within .005" to .007" of its seat in the governor control housing.

Injector fuel control racks in the full fuel position.

The letters R and L indicate the injector location in the right or left cylinder bank, 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 left bank control levers.

1. Disconnect any linkage attached to the stop lever.
2. Loosen the buffer screw lock nut and back out the buffer screw approximately 5/8".
3. Remove the valve rocker covers.

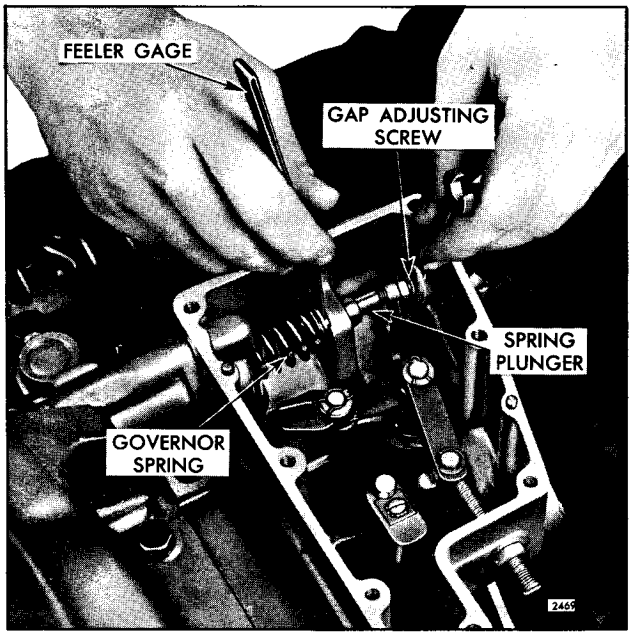


Fig. 1 - Adjusting Governor Gap

4. Loosen all the inner and outer injector rack control lever adjusting screws on both cylinder heads. Be sure all the injector rack control levers are free on the injector control tubes.
5. Check for any bind in the governor to control tube linkage by moving the linkage through its full range of travel with one hand on the stop lever and the other hand on one of the control tube levers.
6. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.
7. Move the speed control lever to the maximum speed position.
8. Move the stop lever to the run position; hold in that position with light finger pressure. Turn the inner adjusting screw of the No. 1L injector rack control lever down until a step up in effort is noted. This will place the No. 1L 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.

   CAUTION: Care should be used to avoid setting the rack too tight causing the fuel rod to bend.

14.4 VARIABLE SPEED GOVERNOR ADJUSTMENT

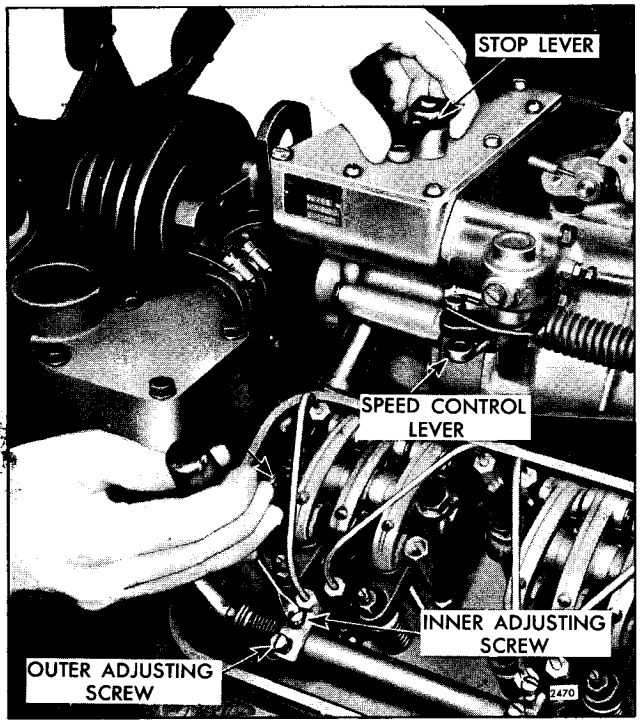


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

NOTE: The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load as previously described.

9. To be sure the control lever is properly adjusted, the following check should be performed.

   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 injector rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly. 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 (as determined by the stop under the governor cover). This will result in a step up in effort required to move the stop lever to the end of its travel and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). To correct, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

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

11. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the 1R injector rack control lever as previously outlined in Step 8.

12. 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 lever as outlined in Step 9.

    Carefully observe and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

13. To adjust the remaining injector rack control levers, hold the No. 1L injector rack in the FULL FUEL position by means of the lever on the end of the control tube assembly and turn down the inner adjusting screw of No. 2L injector rack control lever 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 until tight.

    Recheck the No. 1L injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while positioning the No. 2L injector rack. If the rack of No. 1L injector has become loose, back off slightly the inner adjusting screw on the No. 2L injector rack control lever. Tighten the outer adjusting screw.

    When the settings are correct, both injector racks must respond in the same manner on the ball end of their respective rack control levers as previously outlined in Step 9.

14. Position the remaining injector rack control levers as outlined in Step 13 on the left bank.

15. Position the right cylinder bank injector rack control levers as outlined above for the left cylinder bank in Step 13.

Adjust Maximum No-Load Speed

The maximum no-load speed on units equipped with variable speed governors must not be less than 100 r.p.m. or more than 140 r.p.m. above the recommended full load speed.

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

1. Disconnect the booster spring and the retracting spring.

2. Remove the two bolts and withdraw the variable speed spring housing and the variable speed spring plunger inside the spring housing.

3. Refer to the chart below and determine the stops or shims required for the desired no-load speed.

V-71 Variable Speed Governor Adjustment

Full Load Speed*	Stops	Shims
1200 - 1750	2	Up to .325"
1750 - 2100	1	in Shims
2100 - 2300	0	Maximum

*No Load Speed is 100-140 r.p.m. above Full Load Speed.

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

5. If required, add or remove the shims to obtain the necessary operating speed. For each .001" shim added the operating speed will increase approximately 1 r.p.m.

Governor shims are available in .010" and approximately .078".

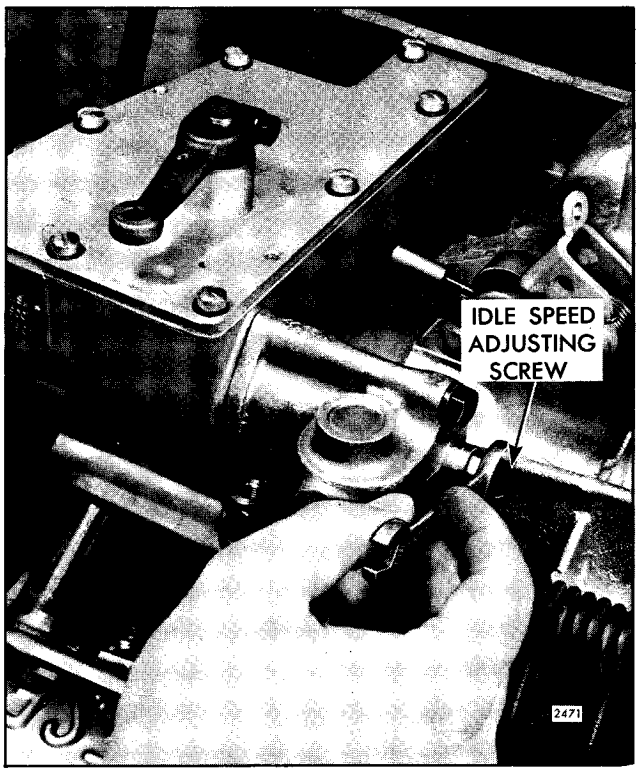


Fig. 3 - Adjusting Idle Speed

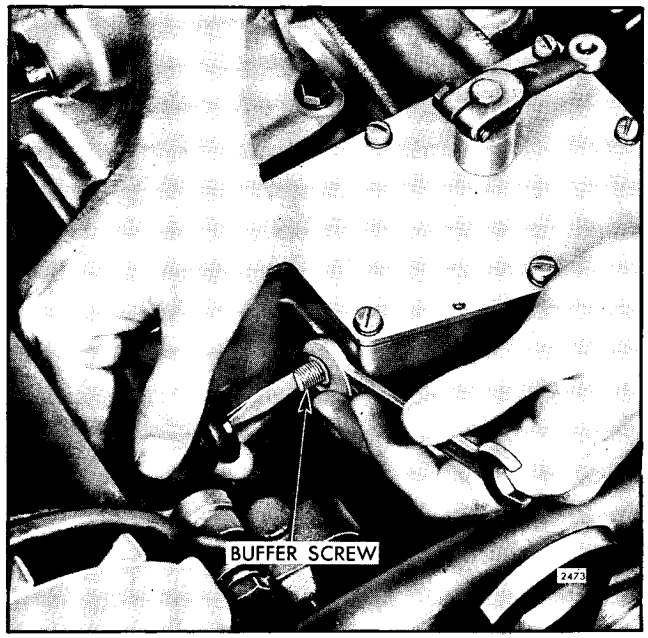


Fig. 4 - Adjusting Buffer Screw

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

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted 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. Turn the idle speed adjusting screw, Fig. 3, until the engine idles at the recommended idle speed.

   The recommended idle speed is 550 r.p.m., but may vary with special engine applications.

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

Adjust Buffer Screw

With the idle speed properly adjusted, the buffer screw may be adjusted as follows:

14.4 VARIABLE SPEED GOVERNOR ADJUSTMENT

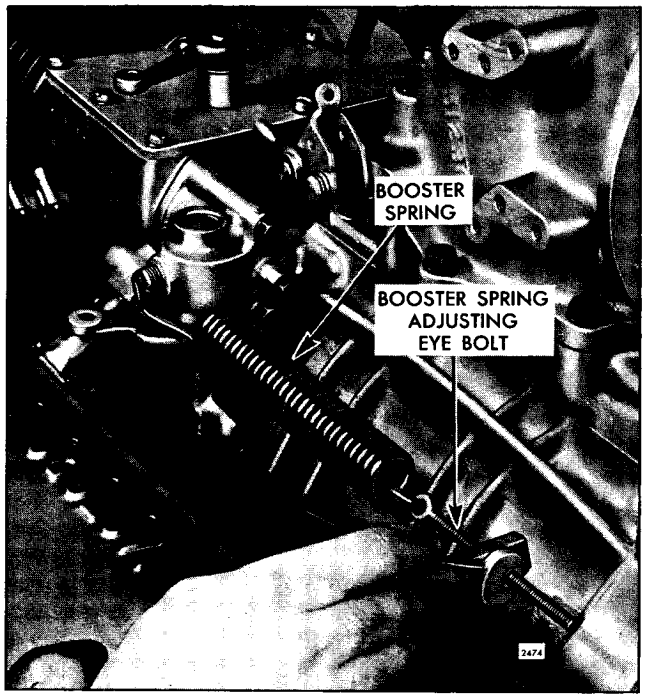


Fig. 5 - Adjusting Booster Spring

1. With the engine at idle speed, screw IN the buffer screw, Fig. 4, so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

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

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

Adjust Booster Spring

With the idle speed set, the booster spring is adjusted as follows:

1. Refer to Fig. 5 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.
2. Move the bolt up or down in the slot of speed control lever until the center of the bolt is on or slightly below 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 speed control lever to the maximum speed position and release. The speed control lever should return to the idle position. If it does not, reduce the booster spring tension. If it does, 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.

HYDRAULIC GOVERNOR (EXTERNAL LINKAGE) AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, perform the following adjustments on the 6, 8 and 12 cylinder V-71 engines that incorporate a hydraulic governor and an external linkage (see Fig. 1).

Adjust Governor Linkage and Position Injector Rack Control Levers

Adjust the governor-to-injector control tube linkage and position the injector fuel racks as follows:

1. Remove the exhaust valve rocker cover from each cylinder head.
2. Loosen all of the inner and outer injector rack control lever adjusting screws. Be sure that all of the control levers are free on the injector control tubes.
3. Back out the governor load limit adjusting screw, after removing the governor cover, until the end of the screw is flush with the boss in the housing. Leave the lock nut loose.
4. Remove the upper end of the vertical link assembly from the governor operating lever.
5. Turn down the inner and outer injector rack control lever adjusting screws (see Fig. 2) for the No. 1L and No. 1R injectors until they bottom on the injector control tubes. Then, adjust the screws of the No. 1 cylinders until they all project the same height from the control levers and tighten them securely.

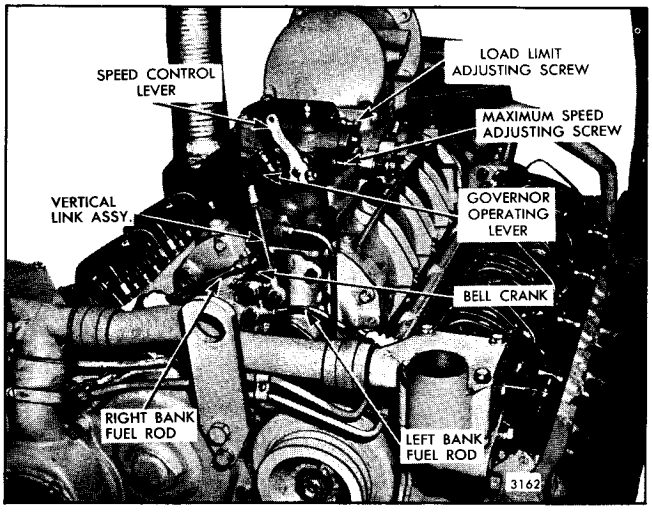


Fig. 1 - Typical Mounting of Hydraulic Governor Assembly with External Linkage Type Drive

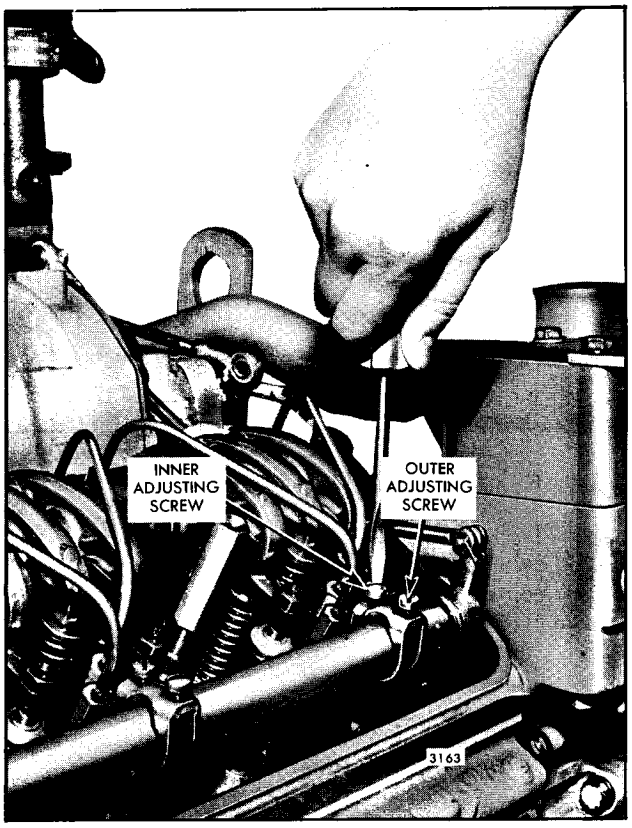


Fig. 2 - Adjusting Injector Rack Control Lever Adjusting Screws

6. Disconnect the right cylinder bank fuel rod at the bell crank. Then, adjust the length of the left fuel rod until the bell crank arms are in a vertical position, at one-half of the arc of travel. The grease fitting on the end of the fuel rod must be in an upright position (see Fig. 3). Tighten the fuel rod end lock nut securely to retain the adjustment.
7. Place the left fuel rod in the FULL-FUEL position and maintain this position by holding the horizontal arm of the bell crank. Then, place the right cylinder bank fuel injector rack in the FULL-FUEL position. Next, adjust the length of the right fuel rod, as shown in Fig. 4, so that the hole in the rod end bearing and the mating hole in the bell crank are aligned as nearly as possible, while maintaining the grease fitting in an upright position. Assemble the fuel rod end bearing to the bell crank and tighten the attaching bolt securely.

NOTE: It may be necessary to adjust the inner and outer adjusting

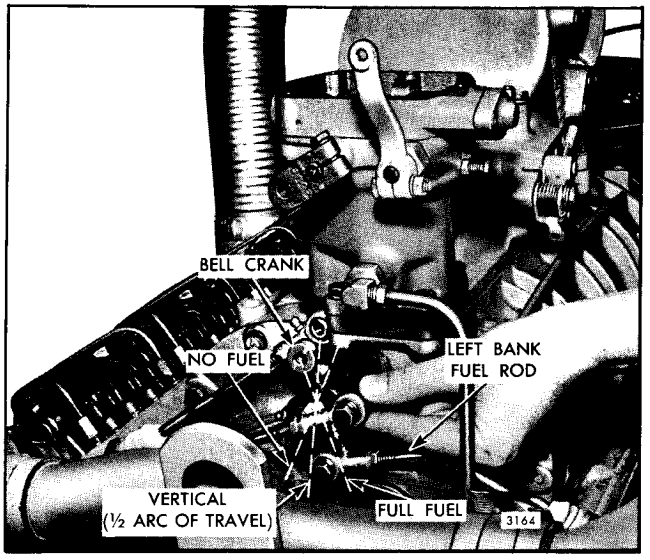


Fig. 3 - Adjusting Length of Left Cylinder Bank Fuel Rod

screws on the No. 1R injector rack control lever to place the injector rack in the FULL-FUEL position.

8. Adjust the length of the governor vertical link assembly to 6-1/8" (SGX governor) or 6-9/16" (PSG governor) between the centers of the rod end bearings and tighten the rod end lock nuts securely.

9. Hold the bell crank in the NO-FUEL position and check the alignment between the rod end bolt hole in the vertical link assembly and the tapped hole in the governor operating lever as shown in Fig. 5.

   If misalignment is less than one-half of the hole diameter, adjust the length of the vertical link assembly until the holes are in alignment.

   If misalignment is greater than one-half of the hole diameter, remove the governor operating lever and reposition it. Then, adjust the length of the vertical link assembly until the holes in the link and lever are in alignment.

10. Shorten the vertical link assembly one-quarter turn, so that the injector racks will not bottom in the NO-FUEL position, and tighten the rod end lock nuts securely.

11. Disconnect the fuel rods from the injector control tube levers.

12. While holding onto the clevis at the end of the right cylinder bank injector control tube, position the No. 1R injector in the FULL-FUEL position. Then, turn down the inner adjusting screw of the No. 2R injector until the rack control lever for that injector moves the fuel rack into the FULL-FUEL position. This may be felt at the clevis end by a slight movement as contact is made. Tighten the outer adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten the inner and outer adjusting screws until the control lever is secure.

13. Make sure the injector rack remains snug on the ball end of the control lever of the No. 1R injector.

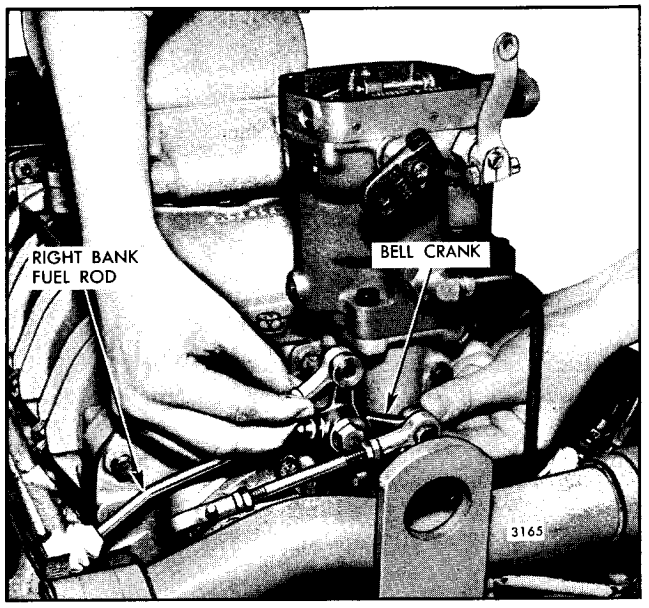


Fig. 4 - Adjusting Length of Right Cylinder Bank Fuel Rod

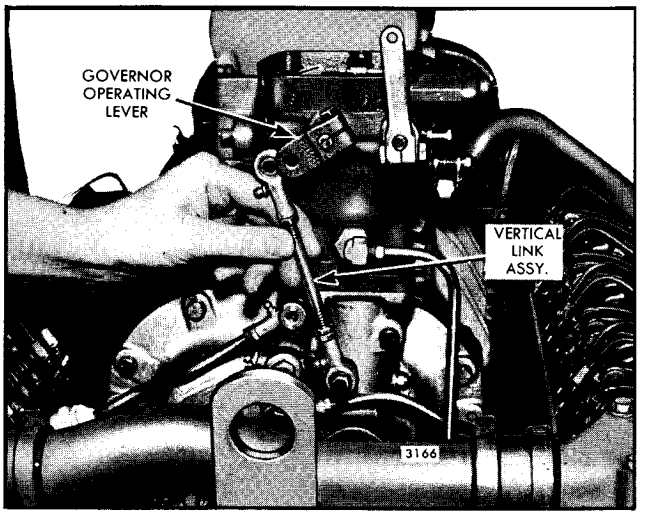


Fig. 5 - Checking Alignment Between Vertical Link Assembly and Governor Operating Lever

14. If the No. 1R injector rack becomes loose, back off slightly on the inner adjusting screw of the No. 2R injector rack control lever. Then, 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.

15. Position the remaining injector rack control levers on the right cylinder bank as outlined in Steps 12, 13 and 14. When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the FULL-FUEL position.

16. Adjust the injector rack control levers of the left cylinder bank in a similar manner as outlined in Steps 12, 13, 14 and 15.

17. Connect the fuel rods to the injector control tube levers.

Adjust Load Limit

With the injector rack control levers properly adjusted, set the load limit as follows:

1. With the governor cover off and the load limit screw lock nut loosened, place and retain the governor operating lever in the FULL-FUEL position as shown in Fig. 6.

   CAUTION: Do not overstress the linkage.

2. Turn the load limit adjusting screw inward until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the lock nut. Then, install the governor cover.

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the temperature of the engine and the oil supplied to the governor reach normal operating values, adjust the governor compensation needle valve, without load on the engine, as follows:

1. Open the valve (see Fig. 10) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

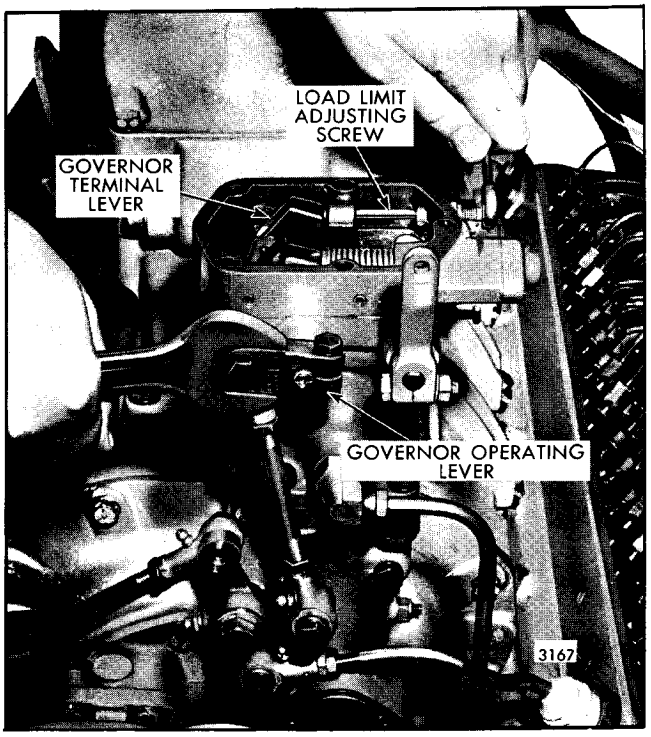


Fig. 6 - Adjusting Load Limit Screw

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

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 speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

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

14.7.1 HYDRAULIC GOVERNOR ADJUSTMENT (EXTERNAL LINKAGE)

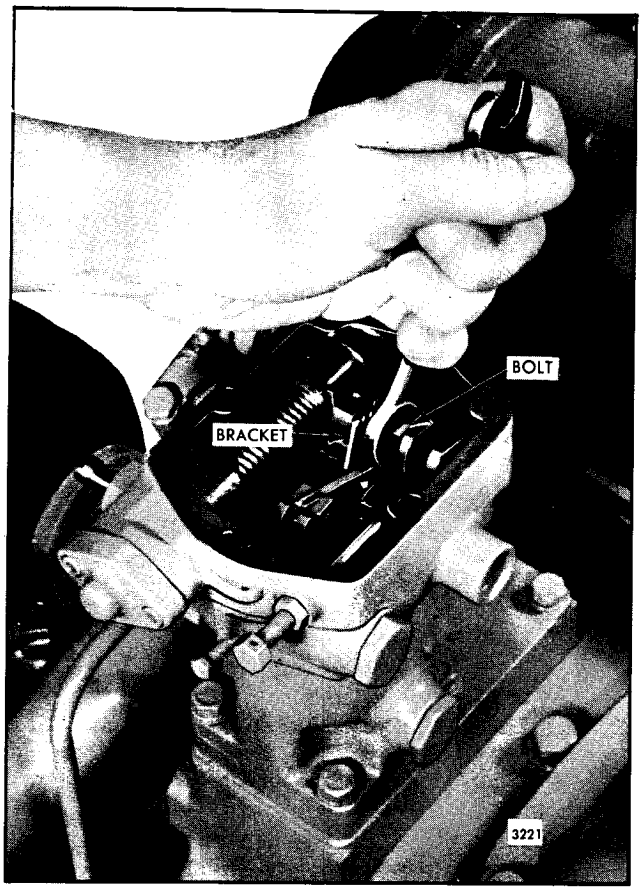


Fig. 7 - Adjusting Speed Droop

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

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. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

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

4. Loosen the droop adjusting bolt (see Fig. 7). Move the droop bracket so that the bolt is midway between the ends of the slot in the bracket. Tighten the bolt. Be sure that the bracket remains on the shoulder of the terminal lever.

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, loosen the droop adjusting bolt and move the adjusting bracket IN toward the center of the governor. Tighten the bolt. To increase the speed droop, move the bracket OUT, away from the center of the governor.

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 governor to obtain the desired variation between engine no load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 r.p.m. (2-1/2 cycles) for units operating at 1,000 and 1,200 r.p.m., and 75 r.p.m. (2-1/2 cycles) for units operating at 1,500 and 1,800 r.p.m. (see table). However, this speed droop recommendation may be varied to suit the individual application.

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

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (see Fig. 8). This enables the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then, adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming

unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop with the external droop control as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob (see Fig. 8) and move the slider all the way in toward the center of the governor. Then, tighten the knob.

6. Loosen the lock nut on the maximum speed adjusting screw (see Fig. 9) and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to full-load speed.

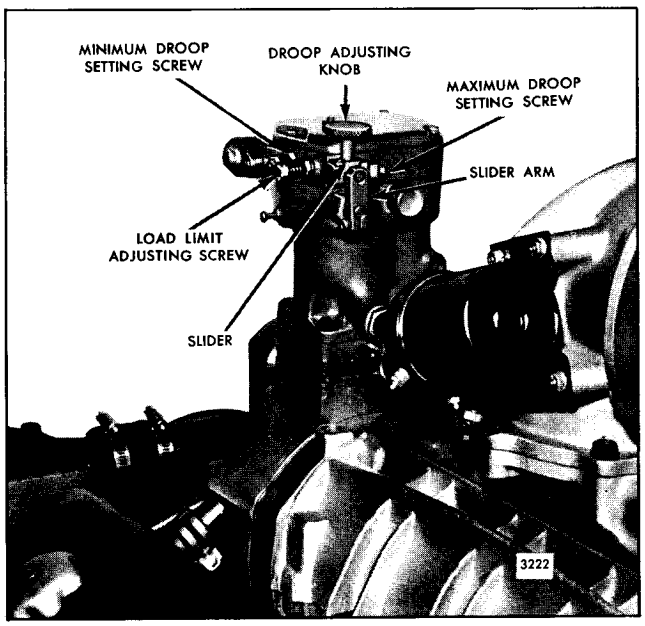


Fig. 8 - External Droop Control on PSG Isochronous Governor

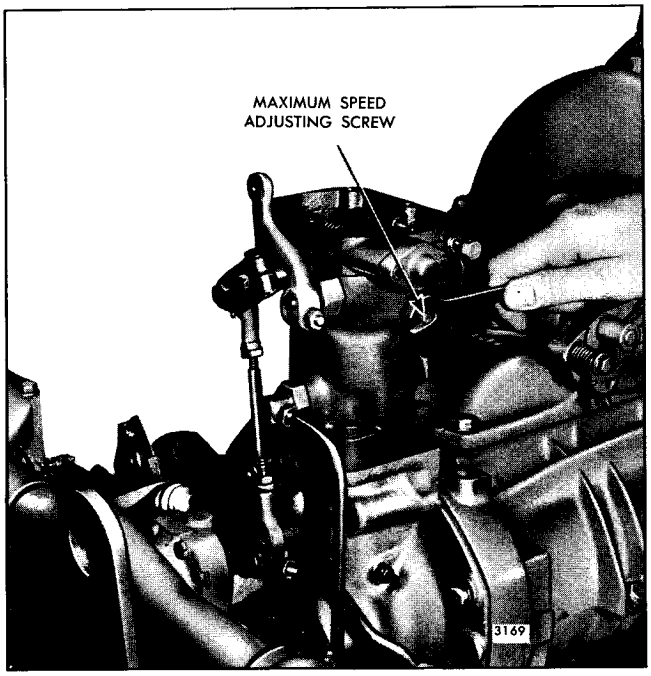


Fig. 9 - Adjusting Maximum No-Load Engine Speed

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the lock nut and turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the lock nut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are attained.

13. Adjust the maximum no-load speed.

14.7.1 HYDRAULIC GOVERNOR ADJUSTMENT (EXTERNAL LINKAGE)

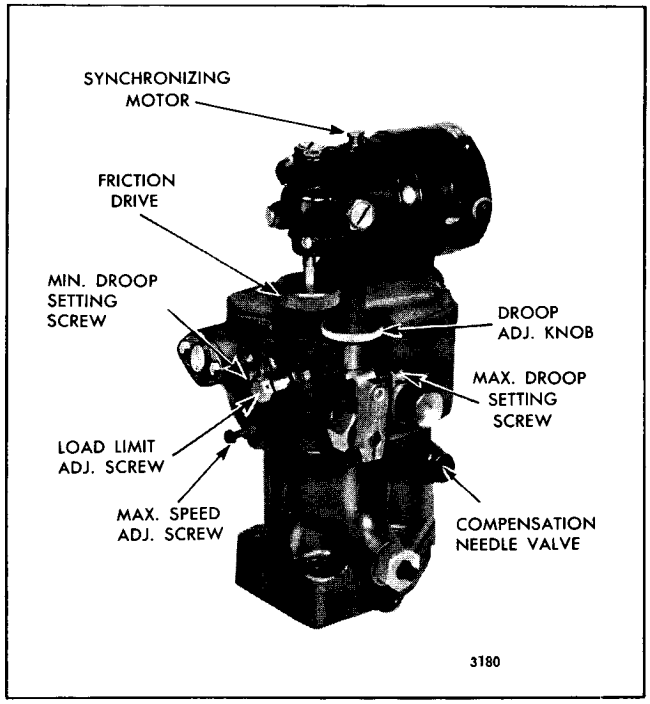


Fig. 10 - Typical Synchronizing Motor Mounting

Adjust Maximum No-Load Speed

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

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

2. Turn the maximum speed adjusting screw (see Fig. 9) in until it contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the lock nut.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor (see Fig. 10) mounted on the governor cover.

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

VARIABLE SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (6, 8 AND 12V)

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor linkage and position the injector rack control levers (Fig. 1).

Adjust Governor Linkage and Position Injector Rack Control Levers

1. Remove the valve rocker cover from each cylinder head.

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

3. Remove the vertical link assembly from the governor operating lever and from the bell crank lever below.

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the linkage gage J 21304 over the operating lever shaft and through the bolt hole in the bell crank lever, (Fig. 2). The tang on the side of the gage should just touch the top of the governor drive housing cover when the gage is properly positioned.

6. Adjust the 1R injector rack by turning the inner adjusting screw down until it bottoms on the control tube (Fig. 3). Turn down the outer adjusting screw until it also bottoms on the control tube. Then tighten both the inner and outer adjusting screws alternately until they are tight.

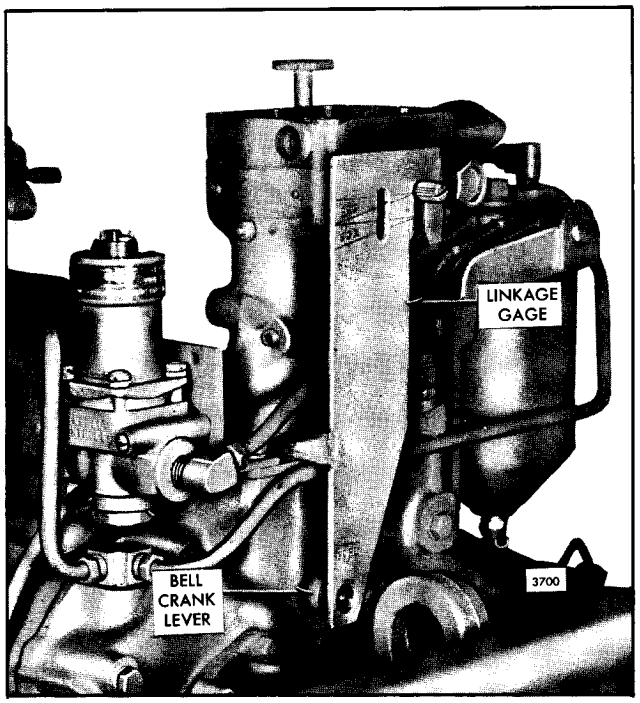


Fig. 2 - Linkage Gage Placed on Governor

CAUTION: Care should be taken to avoid setting the racks to tight causing the fuel rod to bend.

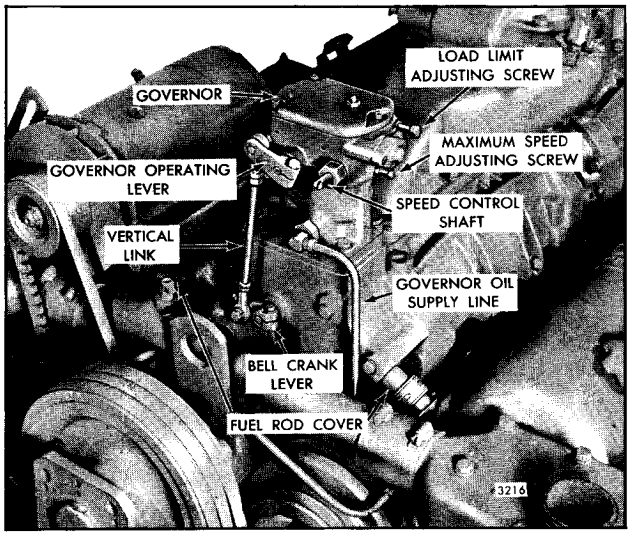


Fig. 1 - Hydraulic Governor Mounted on Engine

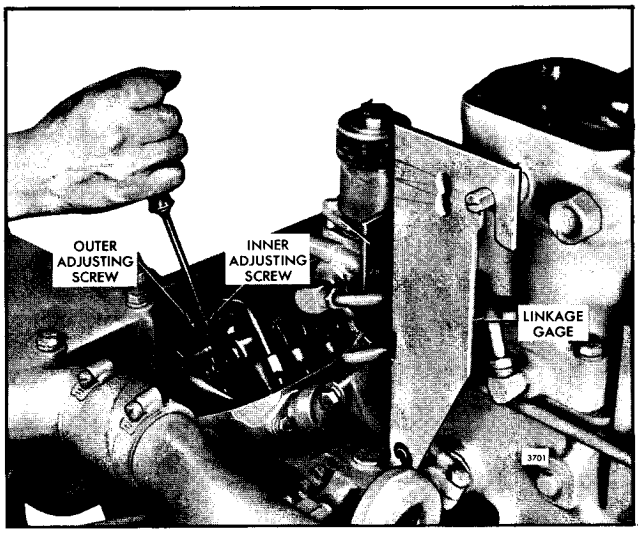


Fig. 3 - Positioning No. 1R Injector Rack Control Lever

14.7.2 VARIABLE SPEED HYDRAULIC GOVERNOR (6, 8 AND 12V)

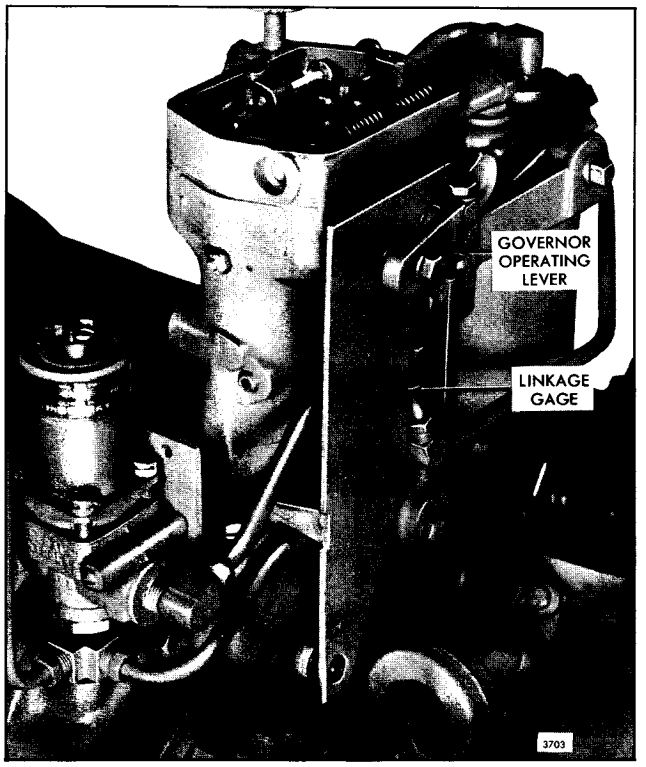


Fig. 4 - Positioning Governor Operating Lever

7. To be sure the rack control lever is properly adjusted, the following check should be performed:

   Press down on the injector rack with a screw driver or finger tip. A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

8. Adjust the 1L injector rack control lever as outlined in Steps 6 and 7.

9. Check the adjustment on the 1R and 1L injector rack control lever. If the setting is correct, the injector racks will be in the FULL-FUEL position and snug on the ball end of the control levers.

10. To adjust the remaining injector rack control levers, hold the No. 1L injector rack in the full fuel position by means of the lever on the end of the control tube assembly. Turn down the inner adjusting screw of the No. 2L injector rack control lever until the injector rack 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 until tight.

    Recheck the No. 1L injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while positioning the No. 2L injector rack. If the rack of No. 1L injector has become loose, back off slightly the inner adjusting screw on the No. 2L injector rack control lever. Tighten the outer adjusting screw.

    When the settings are correct, both injector racks must respond in the same manner on the ball end of their respective rack control levers as previously outlined in Step 7.

11. Position the remaining injector rack control levers on the left and right cylinder heads as outlined in Step 10.

    When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full fuel position.

12. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the gage (Fig. 4). The type of governor (SGX or PSG) will determine the proper position of the lever.

13. Remove the gage.

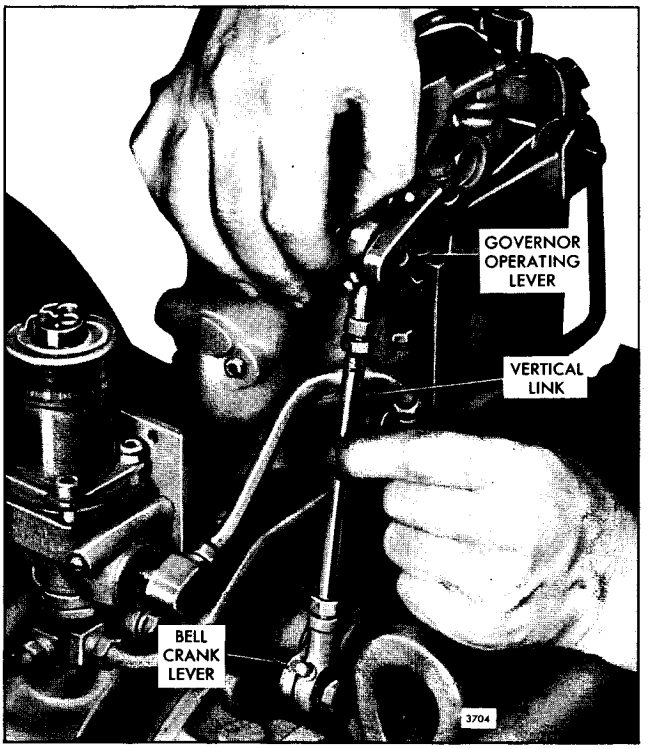


Fig. 5 - Adjusting Vertical Link

14. Move the bell crank lever to the NO-FUEL position.

15. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 5).

16. Replace the two bolts in the levers and tighten the bolts.

17. Remove the governor cover.

18. With the load limit screw backed all the way out, retain the governor operating lever in the full fuel position. The governor terminal lever should touch the boss in the governor housing (Fig. 6). Adjust the vertical link so that all the injector racks are in the full fuel position, and then tighten the rod end lock nuts securely.

Adjust Load Limit

With the injector rack control levers properly adjusted, set the load limit as follows:

1. With the governor cover off and the load limit screw lock nut loosened, place and retain the governor operating lever in the FULL-FUEL position as shown in Fig. 7.

   CAUTION: Do not overstress the linkage.

2. Turn the load limit adjusting screw inward until the injector racks just loosen on the ball end of the control levers.

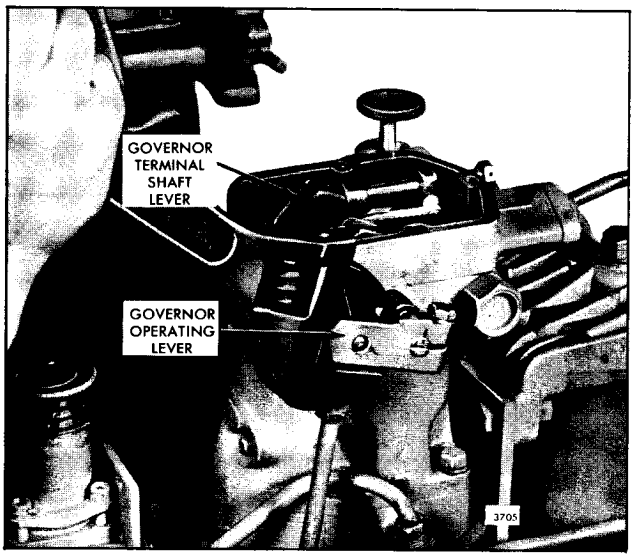


Fig. 6 - Final Adjustment on Vertical Link

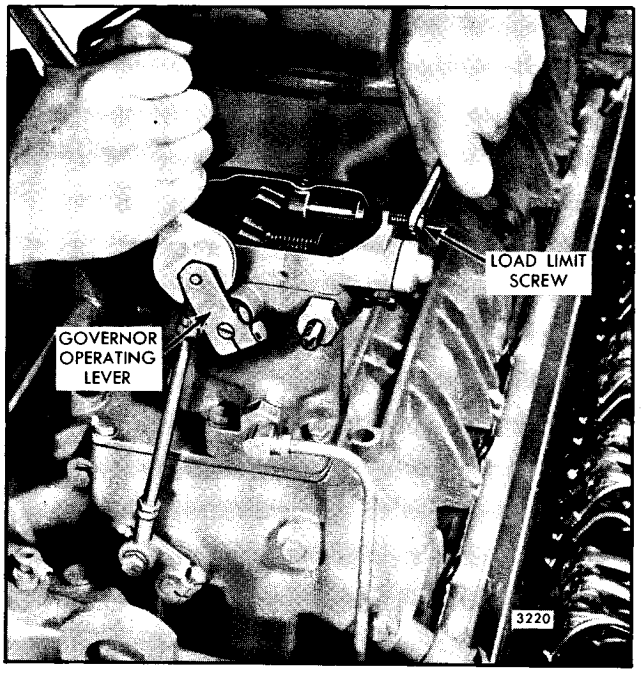


Fig. 7 - Adjusting Load Limit Screw

3. Release the governor operating lever and hold the adjusting screw while tightening the lock nut. Then, install the governor cover.

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve, without load on the engine, as follows:

1. Open the valve (see Fig. 11) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

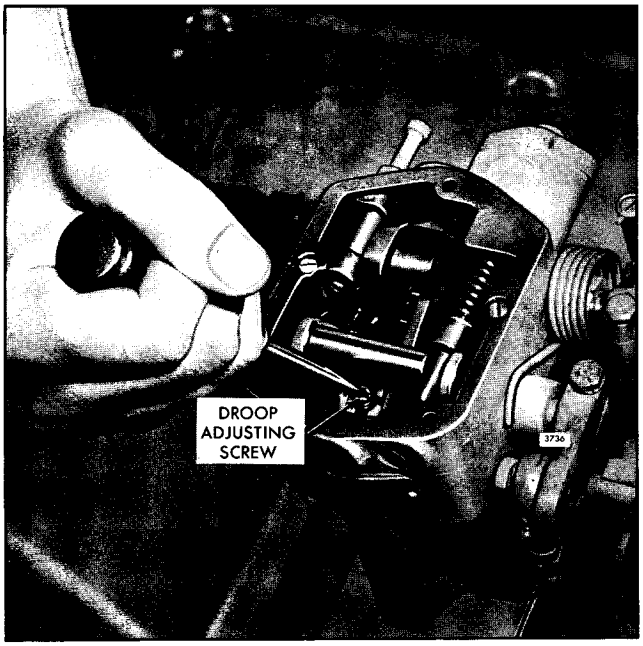


Fig. 8 - Adjusting Speed Droop

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

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 speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

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

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

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. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

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

4. Loosen the droop adjusting bolt on former units or the screw on current units. Move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw (Fig. 8).

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, loosen the droop adjusting screw and move the adjusting bracket IN toward the center of the governor. Tighten the screw. To increase the speed droop, move the bracket OUT, away from the center of the governor.

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 governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2-1/2 cycles) for units operating at 1,500 and 1,800 rpm (see table). However, this speed droop recommendation may be varied to suit the individual application.

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

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (Fig. 9). This permits the speed droop to be adjusted without removing the governor cover. With this feature, a

unit can be parallel with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then, adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob and move the slider all the way in toward the center of the governor. Then, tighten the knob.

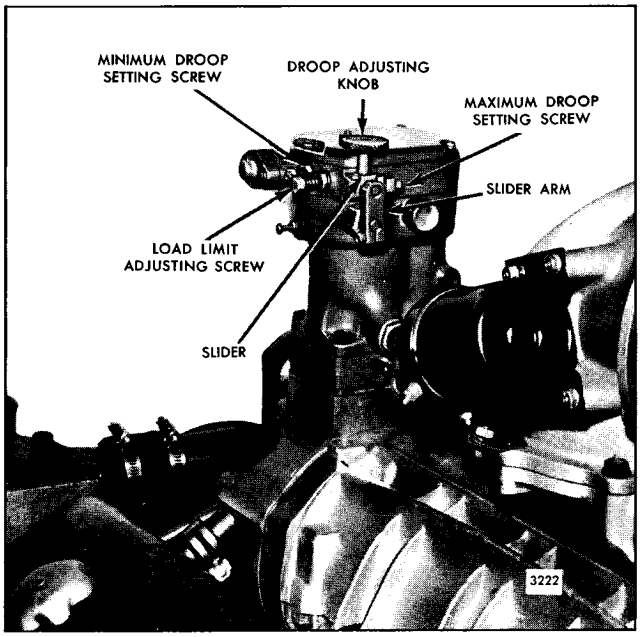


Fig. 9 - External Droop Control on PSG Isochronous Governor

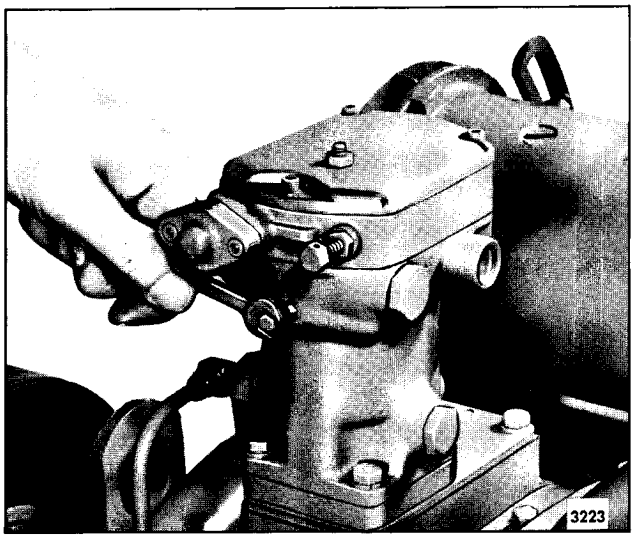


Fig. 10 - Adjusting Maximum No-Load Engine Speed

6. Loosen the lock nut on the maximum speed adjusting screw (see Fig. 10) and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to full-load speed.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the lock nut and turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the lock nut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

13. Adjust the maximum no-load speed.

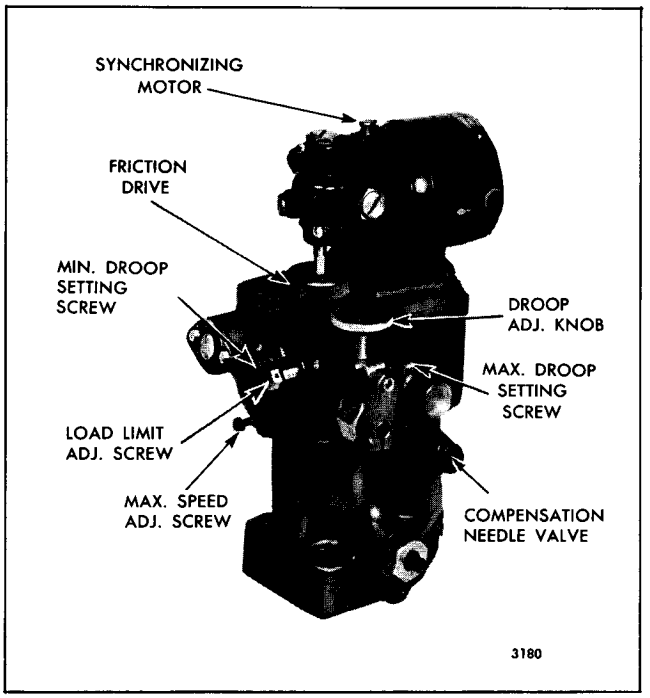


Fig. 11 - Typical Synchronizing Motor Mounting

Adjust Maximum No-Load Speed

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

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

2. Turn the maximum speed adjusting screw (see Fig. 10) in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the lock nut.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor (see Fig. 11) mounted on the governor cover.

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

VARIABLE SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (16V)

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 1). The governor-to-injector control tube linkage is shown in Fig. 2.

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

Adjust Governor Linkage and Position Injector Rack Control Levers

1. Remove the valve rocker cover from each cylinder head.

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

3. Remove the vertical link assembly from the governor operating lever and from the bell crank lever below.

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the linkage gage J 21304 over the operating lever shaft and through the bolt hole in the bell crank lever. The tang on the side of the gage should just touch the top of the governor drive housing cover when the gage is properly positioned (Fig. 3).

6. Adjust the 4R injector rack by turning the inner adjusting screw down until it bottoms on the control tube (Fig. 4). Turn down the outer adjusting screw until it also bottoms on the control tube. Then tighten both the inner and

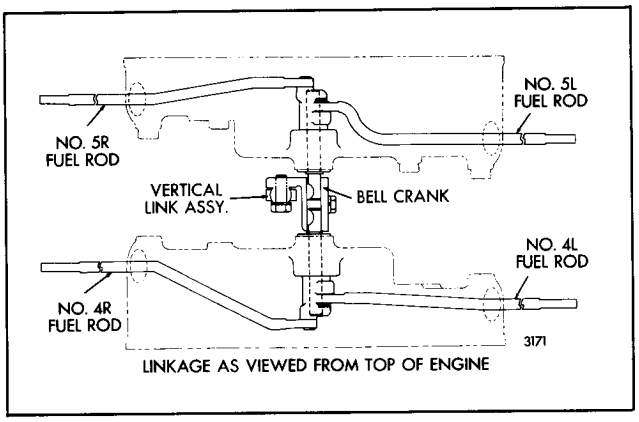


Fig. 2 - Governor to Injector Rack Control Linkage

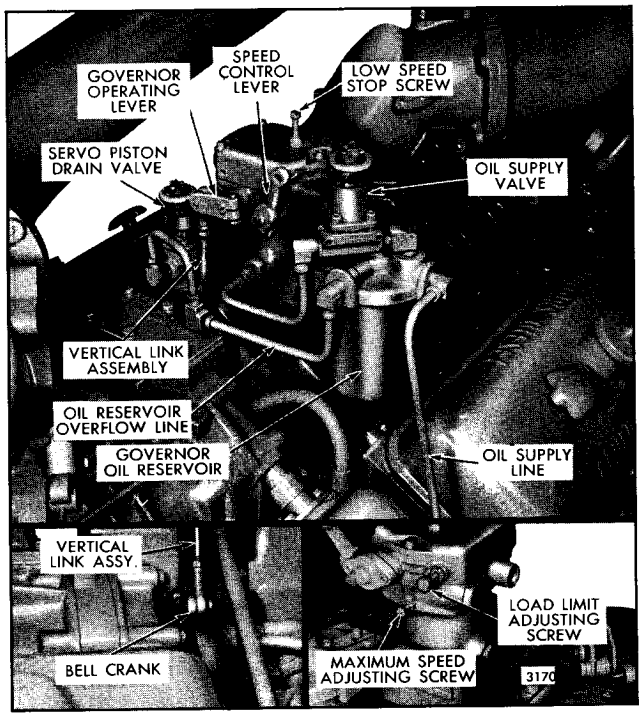


Fig. 1 - Hydraulic Governor Mounting

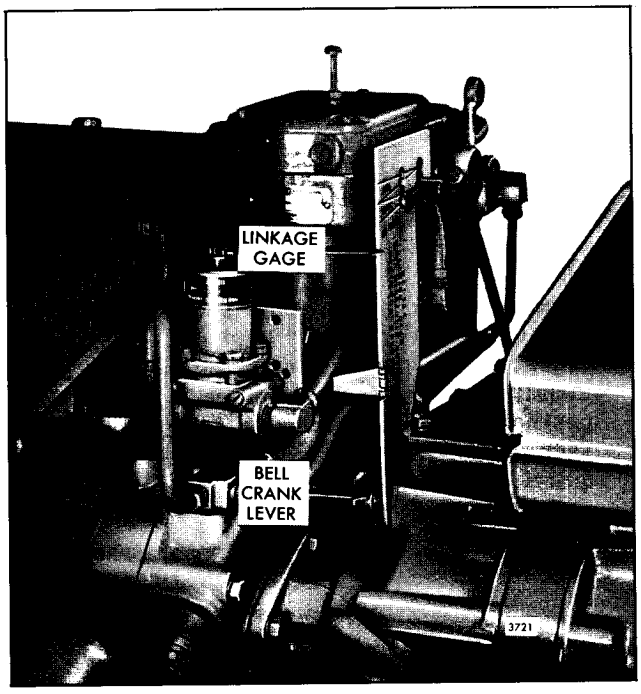


Fig. 3 - Linkage Gage Placed on Governor

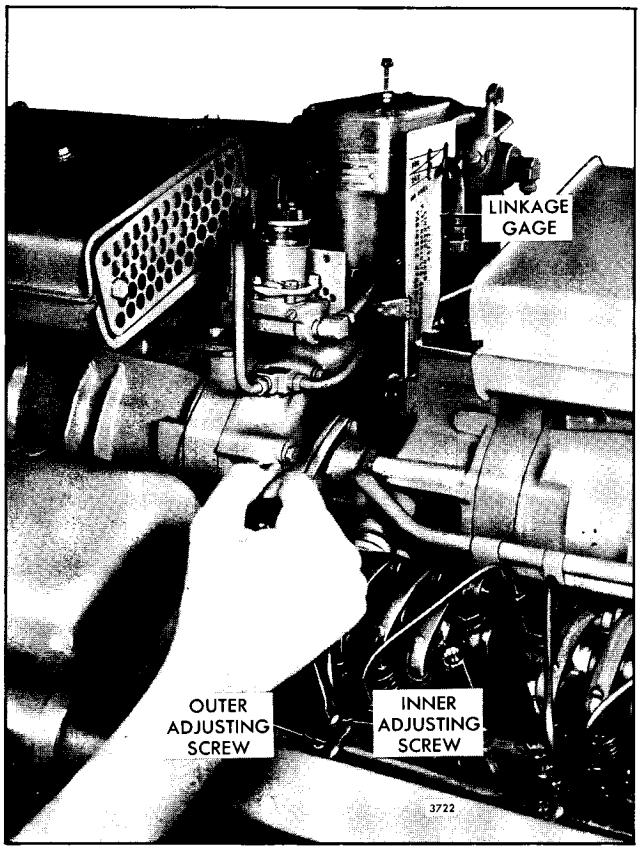


Fig. 4 - Positioning No. 4R Injector Rack Control Lever

outer adjusting screws alternately until they are tight.

CAUTION: Care should be taken to avoid setting the racks too tight causing the fuel rod to bend.

7. To be sure the rack control lever is properly adjusted, the following check should be performed:

   Press down on the injector rack with a screw driver or finger tip. A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

8. Adjust the 5R, 4L and 5L injector rack control levers as outlined in Steps 6 and 7.

   When the settings are correct, all four of the injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

9. To adjust the remaining injector rack control levers on the right front bank, hold the 4R injector rack in the full-fuel position by means of the lever on the control tube assembly and turn down the inner adjusting screw of the 3R injector rack control lever until the injector rack 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 until tight.

   Recheck the No. 4R injector rack to be sure that it has remained snug on the ball end of the injector rack control lever. If the rack of No. 4R injector has become loose back off the inner adjusting screw slightly on the 3R injector rack control lever. Tighten the outer adjusting screw.

   When the settings are correct, both injector racks must respond in the same manner on the ball ends of their respective rack control levers, as previously outlined in Step 7.

10. Position the remaining injector rack control levers on the right front cylinder head as outlined in Step 9.

    When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full-fuel position.

11. Adjust the remaining injector rack control levers on the right rear, left front, and left

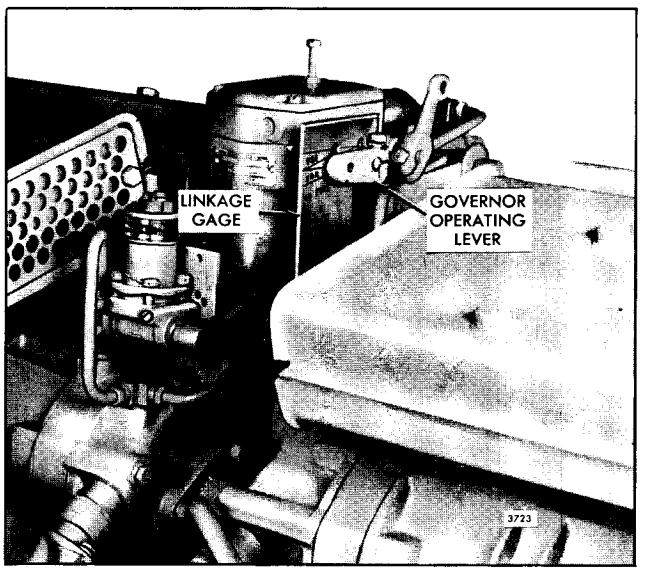


Fig. 5 - Positioning Governor Operating Lever

rear cylinder heads in the same manner as outlined in Steps 9 and 10.

12. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the gage. The type of governor (SGX or PSG) will determine the proper position of the lever (Fig. 5).

13. Remove the gage.

14. Move the bell crank lever to the no-fuel position.

15. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 6).

16. Replace the two bolts in the levers and tighten the bolts.

17. Remove the governor cover.

18. With the load limit screw backed all the way out, retain the governor operating lever in the full-fuel position. The governor terminal lever should touch the boss on the governor housing. Adjust the vertical link so that all the injector racks are in the full-fuel position, and then tighten the rod end lock nuts securely.

Adjust Load Limit

With the injector rack control levers properly adjusted, set the load limit as follows:

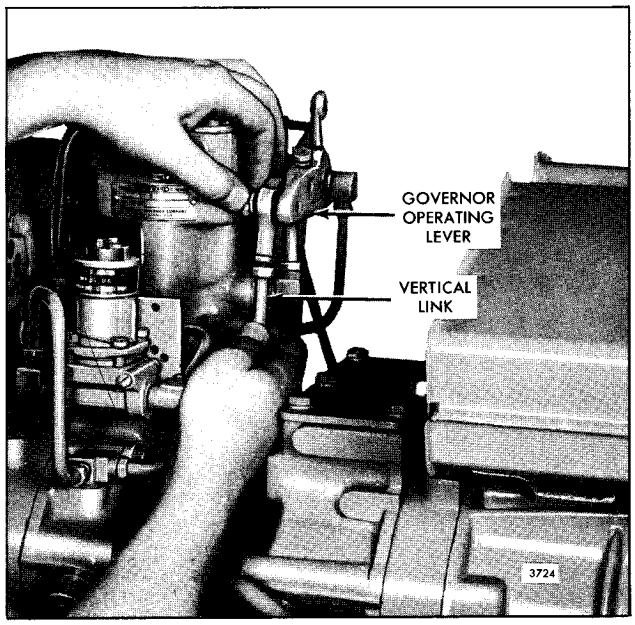


Fig. 6 - Adjusting Vertical Link

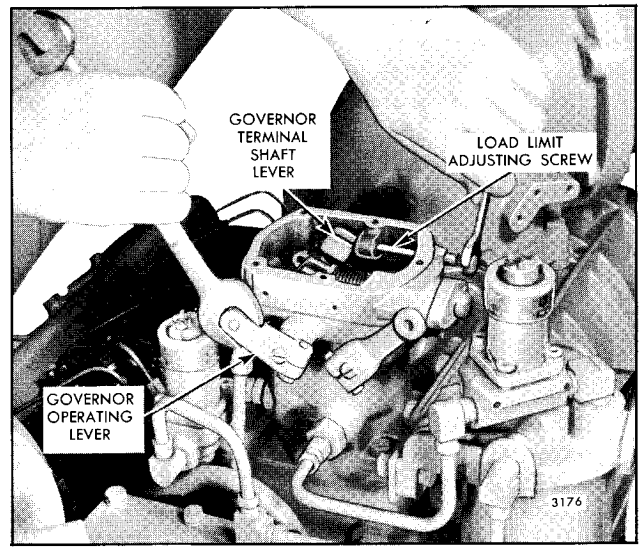


Fig. 7 - Adjusting Load Limit Screw

1. With the governor cover off and the load limit screw lock nut loosened, place and retain the governor operating lever in the full-fuel position as shown in Fig. 7.

   CAUTION: Do not overstress the linkage.

2. Turn the load limit adjusting screw in until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the lock nut. Then, install the governor cover.

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve, without load on the engine, as follows:

1. Open the valve (see Fig. 9) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small

overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

The purpose of adjusting the speed droop is to establish a definite speed at NO LOAD with a given speed at rated FULL LOAD.

The governor speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

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

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

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. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

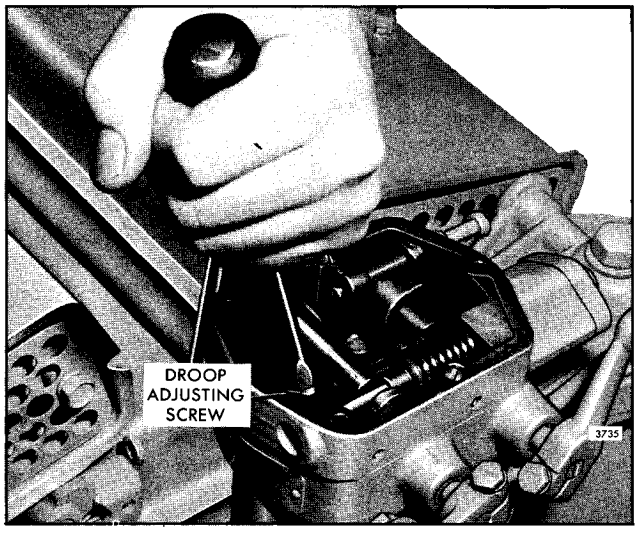


Fig. 8 - Adjusting Speed Droop

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

4. Loosen the droop adjusting bolt on former units or the screw on current units, Fig. 8. Move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw.

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, loosen the droop adjusting screw and move the adjusting bracket IN toward the center of the governor. Tighten the screw. To increase the speed droop, move the bracket OUT, away from the center of the governor.

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 governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2-1/2 cycles) for units operating at 1,500 and 1,800 rpm (see table). However, this speed droop recommendation may be varied to suit the individual application.

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

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (see Fig. 9). This

permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be parallel with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then, adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob (see Fig. 9) and move the slider all the way in toward the center of the governor. Then, tighten the knob.

6. Loosen the lock nut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to full-load speed.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the lock nut and turn the minimum droop setting screw in until it contacts the droop linkage within the governor. This will be felt by a step up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

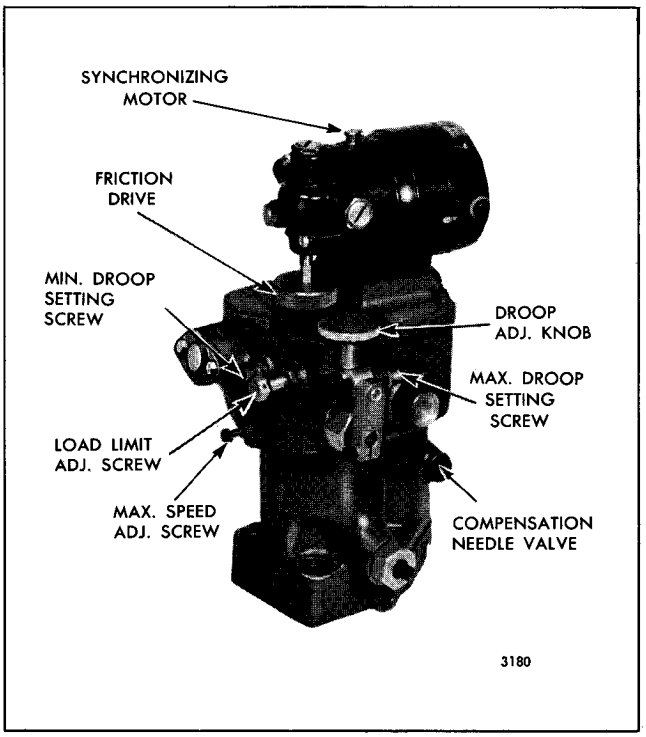


Fig. 9 - Typical Synchronizing Motor Mounting

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the lock nut and turn the maximum droop setting screw in until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

13. Adjust the maximum no-load speed.

Adjust Maximum No-Load Speed

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

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

2. Turn the maximum speed adjusting screw (Fig. 10) in until the screw contacts the throttle linkage internally, limiting the maximum speed

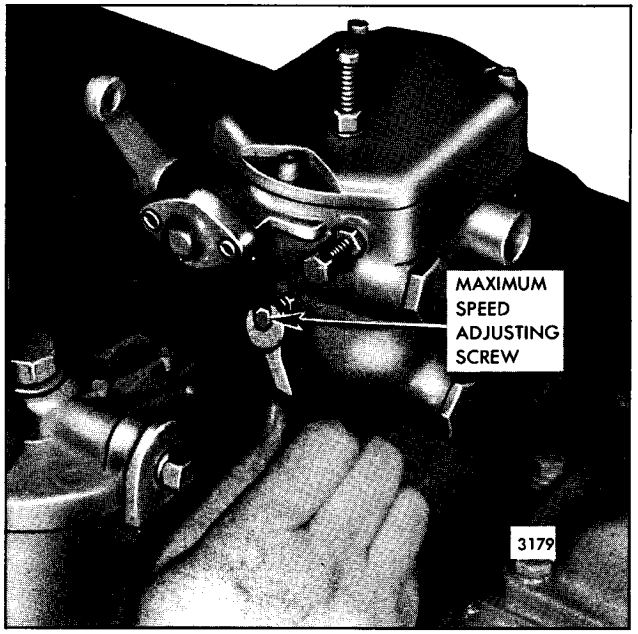


Fig. 10 - Adjusting Maximum No-Load Engine Speed

of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the lock nut.

Adjust Low-Speed Stop Screw (Marine Engine)

The low-speed stop screw (see Fig. 11) projects from the top of the governor cover. This screw is used to establish an idle speed setting when the throttle is moved to the IDLE/NEUTRAL position, thus preventing false engine shutdowns. To establish the desired engine idle speed, proceed as follows:

1. Loosen the lock nut and back out the low-speed stop screw.

2. Start the engine and carefully reduce the speed with the throttle until the desired idle speed is established.

3. Turn the low-speed stop screw down until the engine speed just begins to increase.

4. Tighten the lock nut to secure the stop screw in place.

NOTE: The marine engine is stopped when the solenoid in the oil dump line from the governor servo-piston is energized.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor (see Fig. 9) mounted on the governor cover.

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with the external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

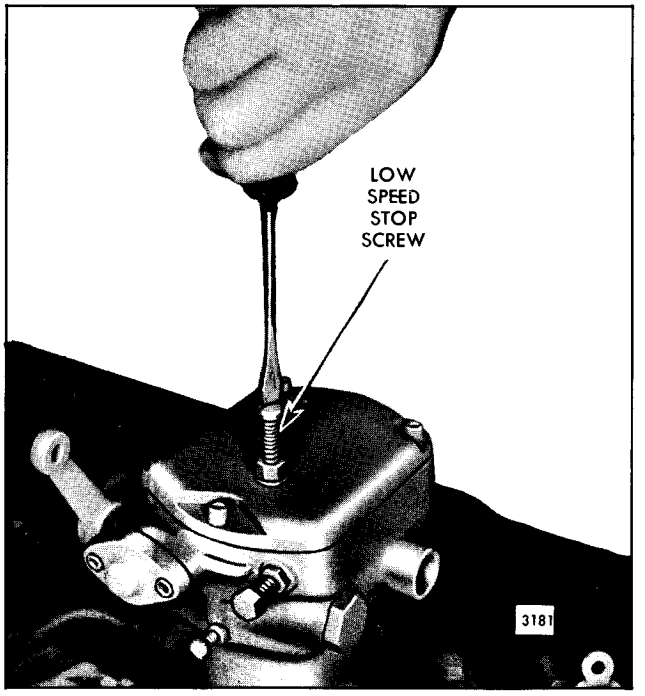


Fig. 11 - Adjusting Low-Speed Stop Screw

LIMITING SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (16V)

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 1). The governor to injector rack control linkage is shown in Fig. 2.

The objectives of the tune-up are (1) to adjust the linkage so the injector racks will be at the full-fuel position when the terminal lever shaft pointer indicates exactly 18°, (2) to set the band-level so the governor will place the pointer at exactly 18° just below full-load speed, and (3) to adjust the speed droop, idle speed, and maximum no-load speed.

Prior to starting the tune-up, remove the governor control housing cover and turn the buffer screw out until it clears the differential lever approximately 1/4 inch, when the speed control lever is in the idle position. Then, hold the speed control lever in the maximum speed position and move the governor operating lever to check the travel of the terminal shaft lever as indicated by the pointer. The pointer should move from 0° to 36° (on some governors, the pointer may not quite reach 36°). Next, check to be sure that the pointer is exactly at zero when the linkage is in the no-fuel position. If not, adjust the pointer or the terminal lever shaft position indicator plate (scale).

On current engines, the pointer is attached to a metal ring which is secured to the terminal shaft by a set screw (Fig. 3). To make the zero adjustment, loosen the set screw and, with the linkage in the no-fuel position, set the pointer at exactly zero. Then, tighten the set screw. On former engines, the pointer is pressed into the terminal lever shaft (Fig. 3). To make the zero adjustment, loosen the two screws which secure the pointer scale and, with the linkage in the no-fuel position, move the scale so the zero mark is aligned with the pointer. Then, tighten the two attaching screws.

On some early governors, it was possible to assemble the terminal lever shaft off one serration, which could result in difficulty in obtaining the proper adjustments. After the zero adjustment is completed, to make sure the shaft is assembled correctly, reach in behind the differential lever in the governor control housing and force the governor operating lever upward until the pointer is aligned exactly with the 18° mark (Fig. 6). The pointer should be vertical; if it is approximately 1/16" off vertical, the shaft is probably out one serration. To make the necessary correction, remove the sub-cap (refer to "Adjust Maximum No-Load Speed"), then remove the cotter pin from the

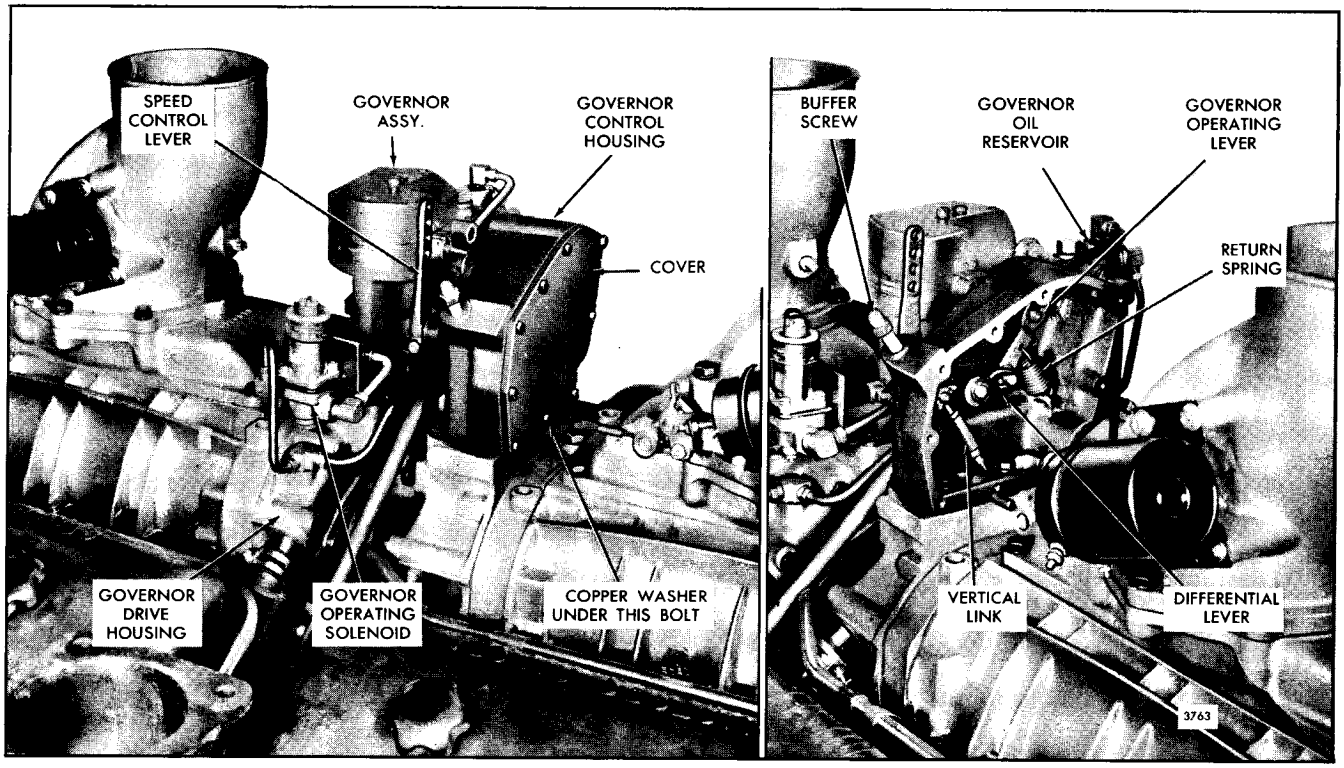


Fig. 1 - Governor Mounting and the Linkage in the Control Housing

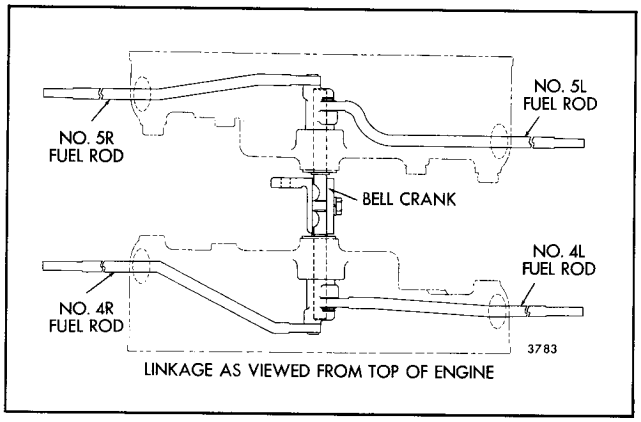


Fig. 2 - Governor-to-Injector Rack Control Linkage

shaft and make a careful visual check of the alignment of the holes in the terminal lever and the shaft. If they are not in alignment, remove the shaft and reinstall it so the holes are in perfect alignment. Then, install the cotter pin and the sub-cap.

Then, after adjusting the exhaust valves and timing the injectors, position the injector rack control levers, adjust the governor linkage, and adjust the governor.

Position Injector Rack Control Levers and Adjust Governor Linkage

1. Remove the valve rocker cover from each cylinder head.

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

3. Disconnect the upper end of the adjustable vertical link (Fig. 1) from the differential lever pin.

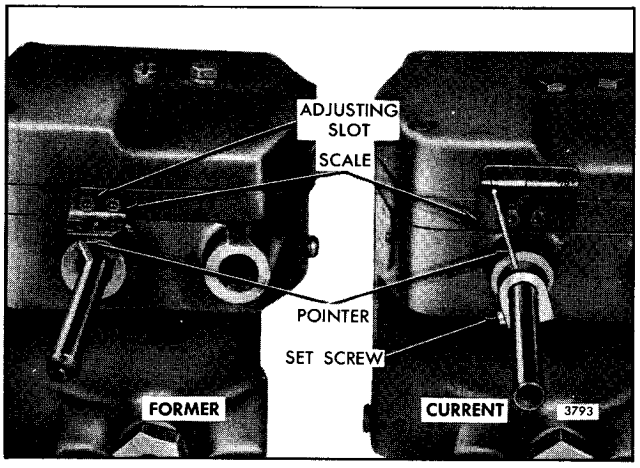


Fig. 3 - Governor Pointer and Scale

CAUTION: Stuff a clean rag in the opening to prevent the clip or washer from dropping into the engine.

4. Place linkage gage J 21351 in position so the pin in the gage enters the hole in the bell crank lever and the tangs on each side of the gage rest on top of the governor drive housing cover (Fig. 4). The gage holds the linkage in the full-fuel position while the injector racks are being adjusted.

5. Adjust the 4R injector rack by turning the inner adjusting screw down until a slight movement of the control tube is observed or a step-up in effort is noted (Fig. 5). This will place the rack in the full-fuel position. Turn the outer adjusting screw until it bottoms lightly on the control tube. Then, alternately tighten both the inner and outer adjusting screws.

   CAUTION: If the injector rack is set too tight, it will cause the fuel rod to bend.

6. To be sure the rack control lever is properly adjusted, press down on the injector rack with a screw driver or finger tip. A light pressure should cause the rack to rotate. The rack is sufficiently tight if it returns to its original position when the pressure is removed. The rack is too tight if heavy pressure is required to rotate it.

7. Adjust the 5R, 4L and 5L injector rack control levers as outlined in Steps 5 and 6. When the

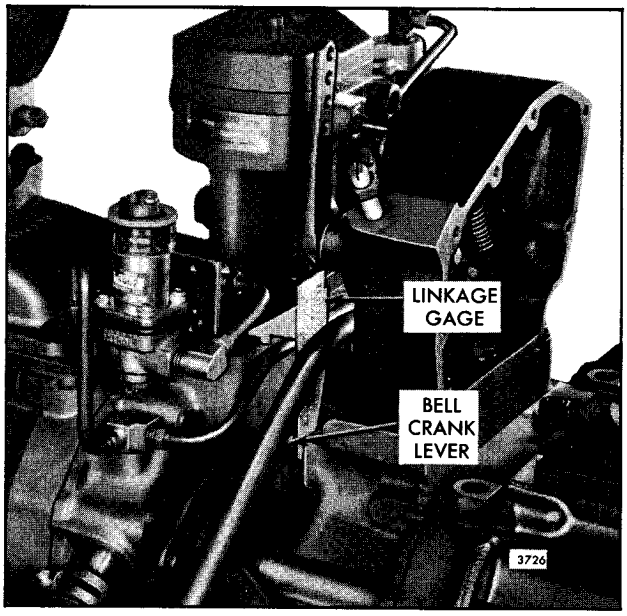


Fig. 4 - Linkage Gage Placed on Governor

settings are correct, all four of the injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position. The linkage gage may be removed at this time.

8. To adjust the remaining injector rack control levers on the right front bank, hold the 4R injector rack in the full-fuel position, by means of the control tube lever, and turn down the inner adjusting screw of the 3R injector rack control lever until the injector rack 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.

9. Recheck the 4R injector rack to be sure it has remained snug on the ball end of the injector rack control lever. If the 4R injector rack has become loose, back off the inner adjusting screw slightly on the 3R injector rack control lever and tighten the outer adjusting screw. When the settings are correct, both injector racks must respond in the same manner on the ball ends of their respective rack control levers as in Step 6.

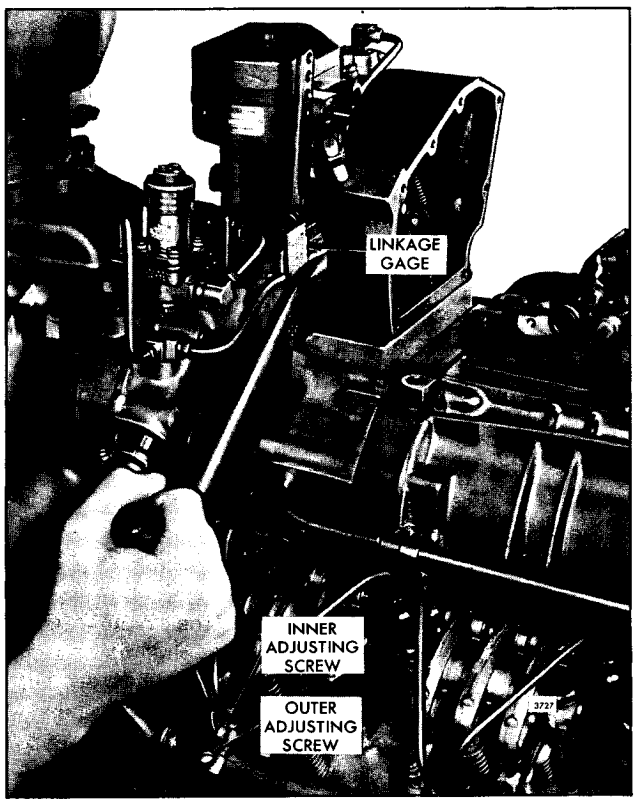


Fig. 5 - Positioning No. 4R Injector Rack Control Lever

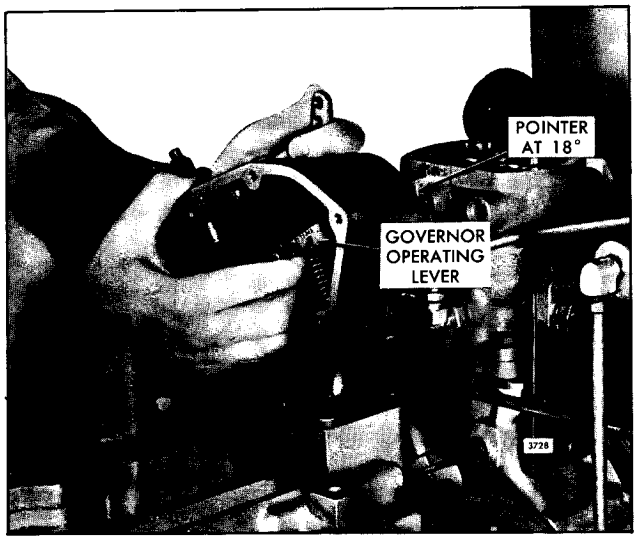


Fig. 6 - Moving Operating Lever

10. Position the remaining injector rack control levers on the right front cylinder head in the same manner. When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube is in the full-fuel position.

11. Adjust the remaining injector rack control levers on the right rear, left front, and left rear cylinder heads in the same manner as in Steps 8, 9 and 10.

12. Reconnect the upper end of the adjustable vertical link on the differential lever pin and secure it in place with the washer and clip.

13. To be sure that the governor flyweights will be in the vertical position throughout the intermediate speed range (between idle speed and full-load speed) adjust the vertical link as follows.

    a. Loosen and back off the two turnbuckle lock nuts two or three turns.

    b. Secure the speed control lever in the maximum speed position.

    c. Reach in behind the differential lever in the governor control housing and force the governor operating lever upward until the governor pointer is aligned exactly with the 18° mark (Fig. 6). Hold the lever in this position.

    NOTE: It is very important that the force to move the pointer to 18° be applied to the governor operating lever rather than to the differential lever. This is necessary to ensure

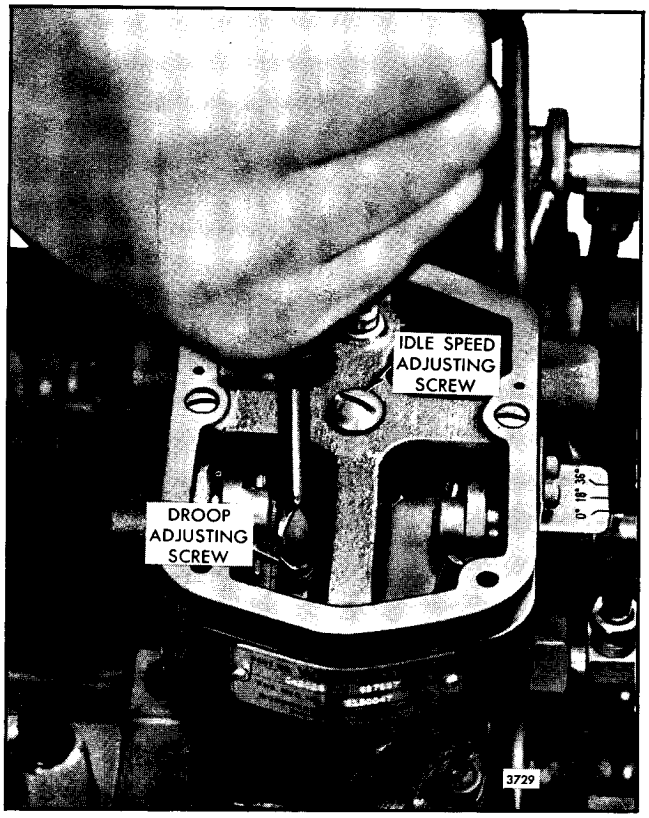


Fig. 7 - Adjusting Speed Droop

that the terminal lever pin is tight against the upper side of the slot in the differential lever just as it is when the engine is running under governor control.

d. Adjust the length of the vertical link, by means of the turnbuckle, so the injector racks are in the full-fuel position. Then, tighten the lock nuts.

e. Recheck to determine if the pointer still points to exactly 18° when the injector racks are at the full-fuel position. Readjust the vertical link, if necessary.

f. Release the speed control lever. With the lever in the idle speed position, the pointer should be at zero.

Adjust Governor Speed Droop

1. Remove the governor cover.

2. Set the governor speed droop bracket at its mid position (Fig. 7). After the other adjustments are made, the speed droop may be increased if the engine speed is unstable.

Preliminary Band—Level Adjustment

The band-level adjustment corresponds to the gap adjustment on a mechanical limiting speed governor. In the low idle speed range, the governor pointer will be between the 18° and 36° marks. As the speed is increased, by moving the speed control lever, the pointer will gradually approach 18° and should be exactly at 18° just below the full-load speed of the engine. After full load is reached, the pointer will move rather rapidly until at the no-load speed it will indicate a position approximately half way between the 18° and 0° marks.

If the pointer is above 18° just below the full-load speed of the engine, the band-level is too low, if the pointer is below 18°, the band-level is too high. Perform a preliminary band-level adjustment as follows:

1. Hold the linkage so the pointer indicates 18°.

2. With a long thin screw driver, pry one of the flyweights outward with a light force (Figs. 8 and 9). It should reach a vertical position. If not, proceed with Step 3.

   NOTE: The position of the flyweights determines the position of the pilot valve plunger, which controls the flow of oil to the servo piston. If the flyweights are too far in, the plunger will not close off the ports and oil will flow to the servo piston. This will cause the terminal lever to move the pointer beyond 18° and result in excessive speed when the engine is started. When the flyweights are too far out, the plunger moves up and dumps the oil from the servo piston. This causes the terminal lever to drop below the 18° position and will result in difficulty in starting the engine or in attaining speed.

3. Loosen the band-level pivot arm lock screw and turn the band-level adjusting nut (Figs. 8 and 10) clockwise to raise the band-level or counterclockwise to lower the band-level. Tighten the lock screw to draw the pivot arm assembly in place. Then, check the adjustment as described in Step 2. Readjust the band-level, if necessary.

   CAUTION: Turning the band-level adjusting nut does not in itself complete the adjustment. The lock screw

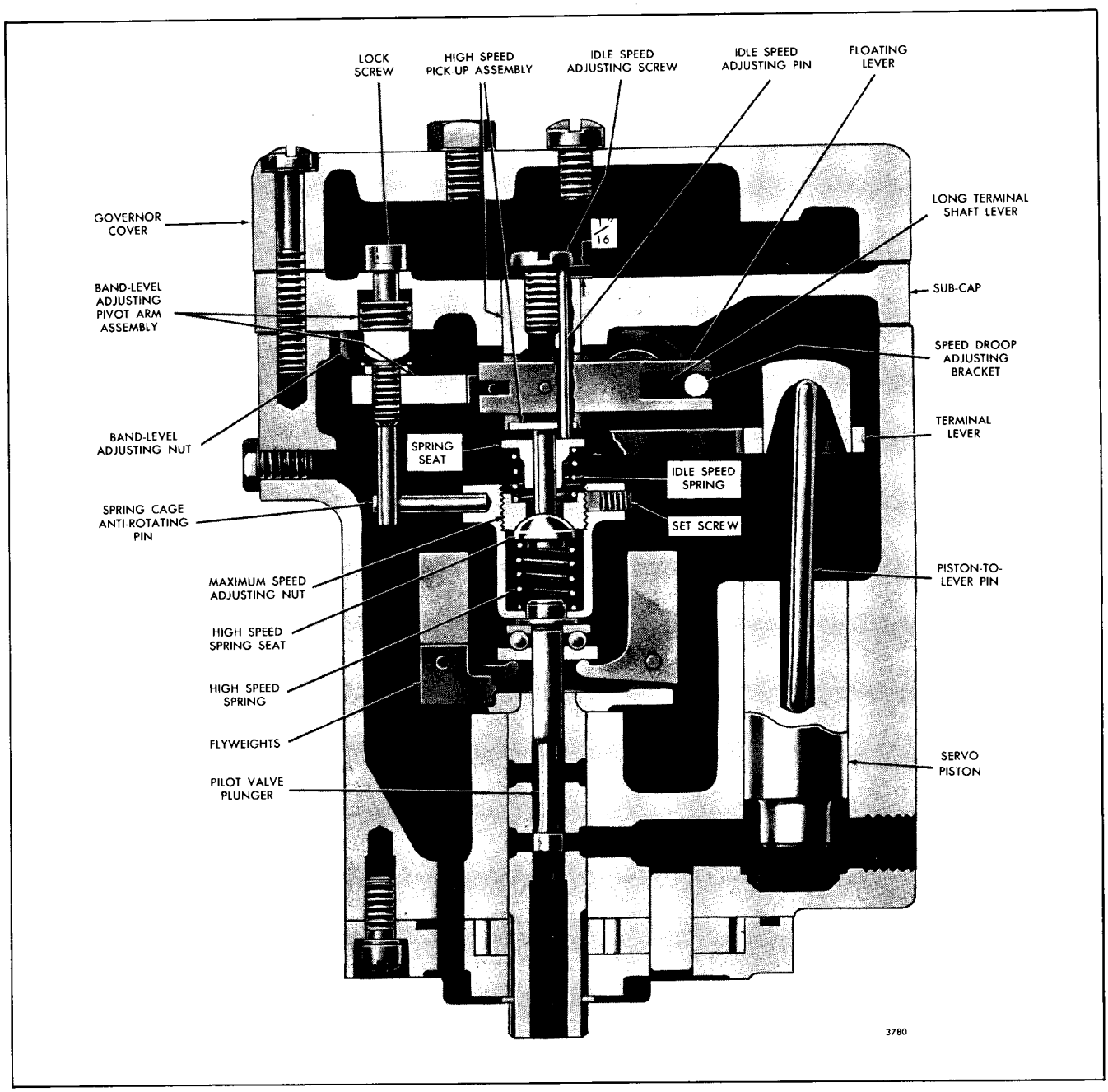


Fig. 8 - Cross-Section of Limiting Speed Hydraulic Governor for 16V Engine

must be tightened to draw the pivot arm assembly into the new position, especially if the nut was turned down.

Adjust Idle Speed

There should be approximately 1/16" clearance between the bottom of the idle speed adjusting screw head and the plunger directly under the screw head (Fig. 8).

1. Close the governor operating solenoid valve switch, if a normally open type valve is used.
2. Start the engine.

CAUTION: Stop the engine if the speed starts to increase above idle speed while the speed control lever is in the idle position. Raise the band-level again until the speed remains at idle.

14.7.4 LIMITING SPEED HYDRAULIC GOVERNOR (16V)

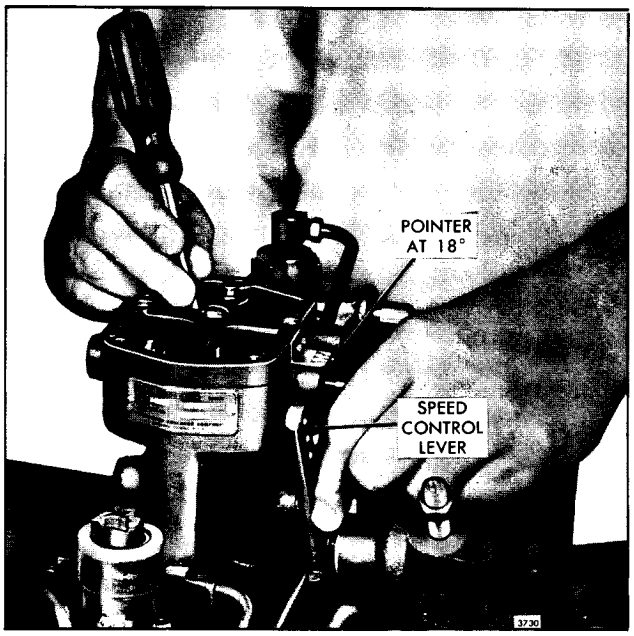


Fig. 9 - Moving Flyweight with Screw Driver

Fig. 10 - Adjusting Band-Level

3. If the engine stalls with the speed control lever in the idle position, turn the idle screw down (clockwise) 1/4 turn or until the engine will continue running.

4. Hold the speed control lever in the idle position. Then, turn the idle speed adjusting screw (Figs. 8 and 10) in or out until the desired idle speed is obtained.

Set Band-Level at 18°

1. Gradually move the speed control lever from the idle to maximum speed position and while doing this, observe the movement of the pointer

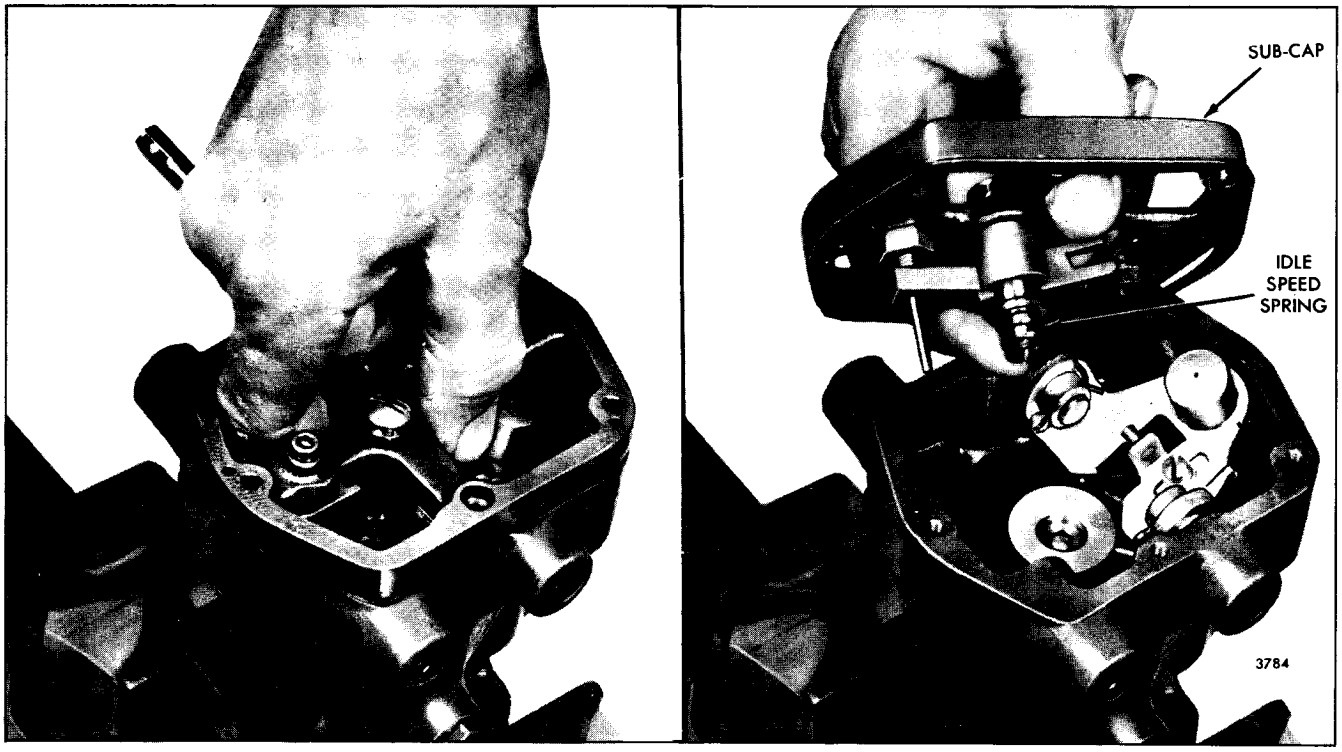


Fig. 11 - Removing or Installing Governor Sub-Cap Assembly

and also record the top no-load speed. The normal movement of the pointer in response to the speed control lever travel should be as follows:

a. During the first 100 or 200 rpm increase above idle speed, the pointer should move from approximately midway between 18° and 36° to slightly above 18°. Then, as the speed increases on up to approximately 300 rpm below the top no-load speed, the pointer should move slightly until it is exactly at 18°. From full-load speed up to no-load speed, the pointer should move from 18° to nearly midway between 18° and 0°.

b. If the pointer indicates more than 18° at approximately 300 rpm below the top no-load speed, the band-level is too low. The adjusting nut should be turned clockwise, in small increments, until the pointer indicates exactly 18° at the above speed.

c. If the pointer indicates less than 18° at approximately 300 rpm below the top no-load speed, the band-level is too high. The adjusting nut should be turned counterclockwise, in small increments, until the pointer indicates exactly 18° at the above speed. If the band-level is too high, the engine speed may fall several hundred rpm below the top no-load speed even though the speed control lever is in the maximum speed position.

d. Reset the idle speed, if the band-level has been changed.

Adjust Maximum No-Load Speed

1. Remove the sub-cap assembly, including the idle speed spring. Since the sub-cap is dowelled to the governor housing, removal will be made easier by moving the linkage so the pointer is near the 36° mark.

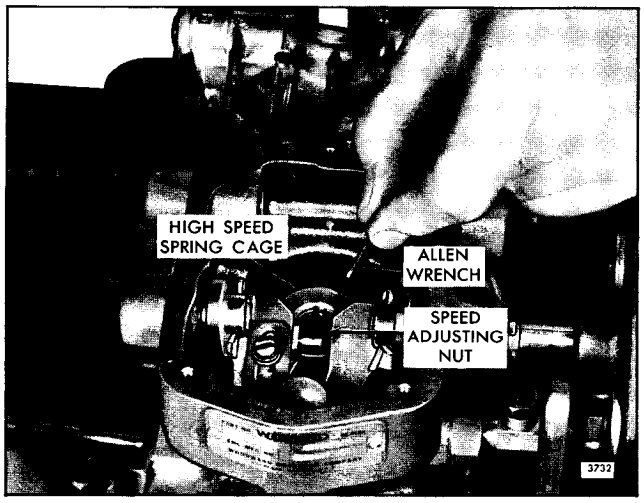


Fig. 12 - Loosening Allen Screw on Spring Cage

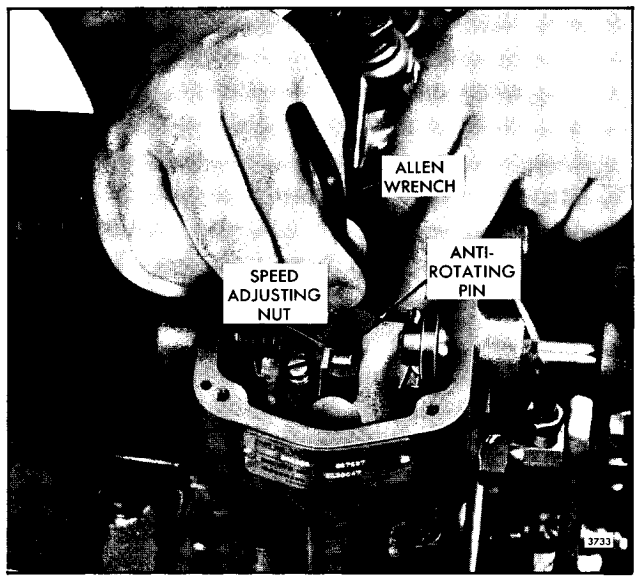


Fig. 13 - Turning High Speed Adjusting Nut

CAUTION: Hold the idle speed spring seat or spring with your finger, as shown in Fig. 11, to prevent it from falling into the governor housing.

2. Loosen the small set screw (on the side opposite the anti-rotating pin) in the high speed spring cage with a 5/64" Allen wrench (Figs. 8 and 12).

3. Turn the high speed adjusting nut up to decrease or down to increase the speed (Fig. 13).

NOTE: A 1/6th turn of the nut changes the speed 30-40 rpm. Use a 1/4" Allen wrench (the end of the wrench should be ground flat or slightly concave).

4. Tighten the small set screw to lock the adjusting nut in place.

5. Check to make sure the idle speed adjusting pin is in position and place the idle speed spring against the spring seat. Then, holding the spring in place with your finger (Fig. 11) and holding the linkage so the pointer is near the 36° mark, install the sub-cap assembly. Make sure the pin in the speed droop adjusting bracket enters the slot in the floating lever.

6. Reset the band-level adjustment.

7. Reset the idle speed.

8. Check the maximum speed.

9. Check the engine speed by suddenly moving the speed control lever from idle to maximum. If the engine speed does not stabilize after two to four surges, move the droop bracket outward. Recheck the idle and maximum speeds.

10 Install the governor cover.

Adjust Buffer Screw

The purpose of the buffer screw adjustment is to prevent the injector racks from going all the way to the no-fuel position and causing the engine to stall.

1. With the warm engine at idle, turn the buffer screw in until it just touches the lower left end of the differential lever. Then, back off three complete turns and tighten the lock nut.

2. Install the cover on the governor control housing.

ENGINE TUNE-UP PROCEDURES

Approximately 100 hours after the initial start or after overhaul and thereafter at 500 hour intervals, the various adjustments of the engine should be checked and the necessary corrections made.

Three types of governors are used on the Series 110 units. As each type governor has different characteristics, the tune-up procedure will vary accordingly.

The three types of governors are:

1. Limiting Speed Mechanical.
2. Variable Speed Mechanical.
3. Hydraulic.

A limiting speed or variable speed mechanical governor may be identified by the name plate attached to the governor. The letters S.W-L.S. stamped on the governor name plate denote a single weight limiting speed mechanical governor. A single weight variable speed mechanical governor name plate is stamped S.W.-V.S.

To completely tune-up an engine, all adjustments, except the bridge balancing adjustment (four valve cylinder head only), must be made by following the applicable tune-up sequence given below, after the engine has reached its normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to prevent it from cooling off excessively.

> **NOTE:** On engines with four valve cylinder heads, the exhaust valve bridge is adjusted and the adjustment screw securely locked at the time the cylinder head is installed on the engine. Until wear occurs with the operation of the engine, no further adjustment is required on the exhaust valve bridge. When wear is evident, make complete bridge balancing adjustment as outlined in Section 1.2.2.

Tune-Up Sequence for Engines with Limiting Speed Mechanical Governor

1. Adjust Exhaust Valve Clearance.
2. Time Fuel Injectors.
3. Adjust Governor Gap.
4. Position Injector Rack Control Levers.
5. Adjust Maximum No-Load Speed.
6. Adjust Idle Speed.
7. Adjust Buffer Screw.

Tune-Up Sequence for Engines with Variable Speed Mechanical Governor

1. Adjust Exhaust Valve Clearance.
2. Time Fuel Injectors.
3. Adjust Governor Gap.
4. Position Injector Rack Control Levers.
5. Adjust Maximum No-Load Speed.
6. Adjust Idle Speed.
7. Adjust Buffer Screw.
8. Adjust Throttle Booster Spring.

Tune-Up Sequence for Engines with Hydraulic Governor

1. Adjust Exhaust Valve Clearance.
2. Time Fuel Injectors.
3. Adjust Fuel Rod.
4. Position Injector Rack Control Levers.
5. Adjust Load Limit.
6. Adjust Speed Droop.
7. Adjust Maximum No-Load Speed.

Cold Engine Tune-Up

Normally, when performing a tune-up on an engine in service, it will only be necessary to check to ascertain that the various adjustments have not changed. However, if it becomes necessary to replace an injector, governor, or cylinder head, it will be necessary to tune-up the engine, so that it may be started and brought up to normal operating temperature.

The cold engine tune-up is performed by following the same tune-up sequence as outlined for the hot engine tune-up. However, the exhaust valve clearance on a cold engine is not the same as the valve clearance on a hot engine. Therefore, when adjusting valve clearance on a cold engine, refer to procedure covering "Exhaust Valve Clearance Adjustment" in Section 14.1.

EXHAUST VALVE CLEARANCE ADJUSTMENT

UNITS WITH TWO VALVE CYLINDER HEAD

The clearance between the valve rocker arm and the exhaust valve stem should be .009" with the engine at normal operating temperature (160°F.-185°F.).

Maintenance of normal operating temperature is particularly important when adjusting the valve clearance. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become too small.

Insufficient valve clearance will result in the loss of compression, misfiring cylinders and eventual burning of the valves and valve seat inserts. Excessive clearance will result in noisy operation, especially in the low speed range.

If the rocker arm bracket bolts, or cylinder head nuts are disturbed for any reason, the exhaust valve clearance should be adjusted to .015" before starting the engine. Then recheck valve clearance with gage J 8168 after the engine has reached its normal operating temperature.

All valve clearances can be adjusted in sequence of firing order during one full revolution of the crankshaft. For firing order, refer to the general specifications.

With the engine at normal operating temperature, adjust valve clearance as follows:

1. Place governor shut-off lever in the NO FUEL position.

2. Rotate crankshaft until the injector follower is fully depressed on the particular cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft bolt at the front of an engine, do not turn the engine in a left-hand direction of rotation as the crankshaft bolt will be loosened.

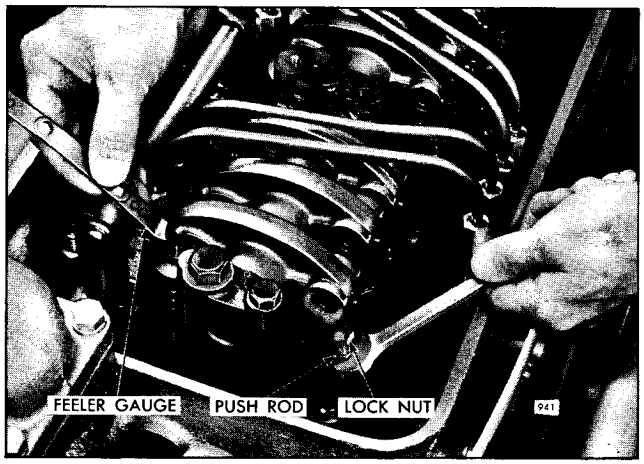


Fig. 1 - Adjusting Valve Clearance--Two Valve Cylinder Head

3. Loosen push rod lock nut, Fig. 1.

4. Place the .010" end of feeler gage J 8168 between the end of the valve stem and the rocker arm. Adjust push rod to obtain a smooth "pull" on the feeler gage.

5. Remove feeler gage. Hold push rod and tighten lock nut.

6. Recheck clearance with feeler gage. At this time, an .008" feeler gage should pass between the end of the valve stem and rocker arm and the .010" feeler should not. Readjust if necessary.

7. Check and adjust the remaining valves as outlined in Items 1 through 6.

UNITS WITH FOUR VALVE CYLINDER HEAD

The exhaust valve bridge is adjusted and the adjustment screw securely locked at the time the cylinder head is installed on the engine. Until wear occurs with the operation of the engine, no further adjustment is required on the exhaust valve bridge. When wear is evident, make complete bridge balancing adjustment as outlined in Section 1.2.2.

The clearance between the exhaust valve bridge pallet and the rocker arm should be .014" with the engine at normal operating temperature (160°F.-185°F.).

Maintenance of normal operating temperature is particularly important when adjusting the valve

14.1 EXHAUST VALVE CLEARANCE ADJUSTMENT

clearance. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become too small.

Insufficient valve clearance will result in the loss of compression, misfiring cylinders and eventual burning of the valves and valve seat inserts. Excessive clearance will result in noisy operation, especially in the low speed range.

If the rocker arm bracket bolts, or cylinder head nuts are disturbed for any reason, the exhaust valve clearance should be adjusted to .016'' before starting the engine. Then recheck valve clearance with gage J 6653 after the engine has reached its normal operating temperature.

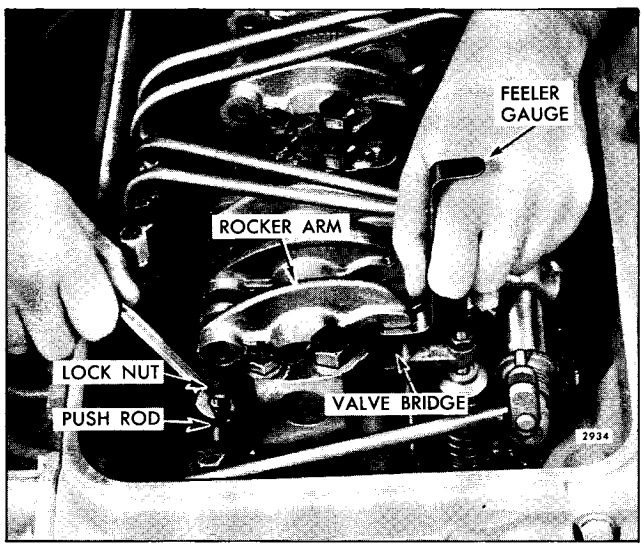


Fig. 2 - Adjusting Valve Clearance-- Four Valve Cylinder Head

All valve clearances can be adjusted in sequence of firing order during one full revolution of the crankshaft. For firing order, refer to the general specifications.

With the engine at normal operating temperature, adjust valve clearances as follows:

1. Place governor shut-off lever in the NO FUEL position.
2. Rotate crankshaft until the injector follower is fully depressed on the particular cylinder to be adjusted.

   CAUTION: When using a wrench on the crankshaft bolt at the front of an engine, do not bar the engine in a left-hand direction of rotation as the crankshaft bolt will be loosened.

3. Loosen push rod lock nut, Fig. 2.

   CAUTION: Valve clearance must always be adjusted at the push rod.

4. Place the .013'' end of feeler gage J 6653 between the valve bridge pallet and the rocker arm. Then adjust push rod to obtain a smooth ''pull'' on feeler gage.
5. Remove feeler gage. Hold push rod and tighten lock nut.
6. Recheck clearance with feeler gage. At this time, a .013'' feeler gage should pass between the valve bridge pallet and the rocker arm, and the .015'' feeler should not. Readjust if necessary.
7. Check and adjust the remaining valves as outlined in Items 1 through 6.

TIMING FUEL INJECTORS

To properly time an injector, the injector follower must be adjusted to a definite height in relation to the injector body.

All injectors can be timed in sequence of firing order during one full revolution of the crankshaft. For firing order, refer to the general specifications.

Refer to Fig. 1, and proceed as follows:

1. Place governor control lever in the NO FUEL position.
2. Rotate crankshaft, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

   NOTE: When using a wrench on the crankshaft bolt at the front of an engine, do not bar the engine in a left-hand direction of rotation as the crankshaft bolt will be loosened.

3. Place small end of injector timing gage, J 4184 (two valve cylinder head) or J 7186 (four valve cylinder head), in hole provided in top of injector body, with flat of gage toward the injector follower.
4. If required, loosen push rod lock nut and turn push rod until the extended part of the gage will just pass over the top of the injector follower.
5. Hold push rod and tighten lock nut. Check adjustment and readjust if necessary.
6. Time remaining fuel injectors as outlined above.

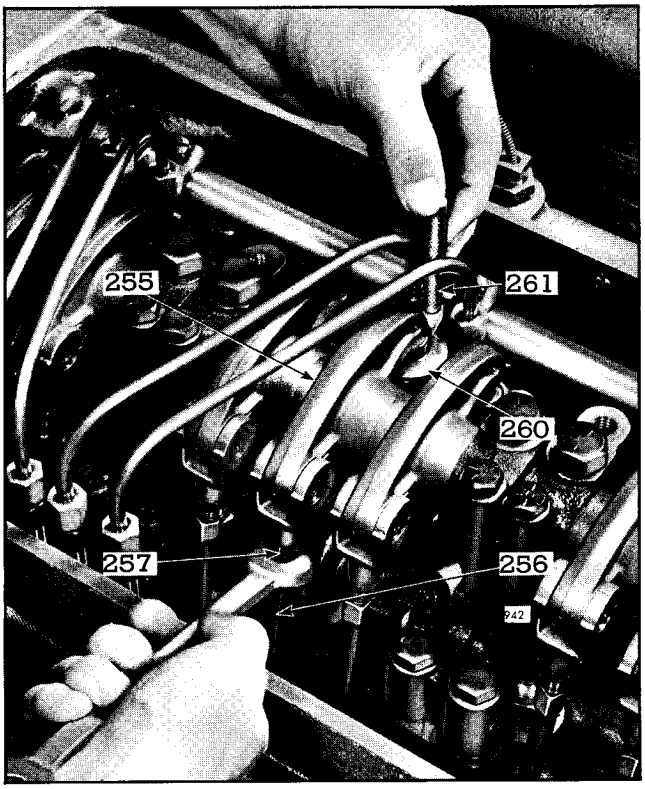


Fig. 1 - Timing Fuel Injectors

255. Arm--Injector Rocker
256. Rod--Injector Push
257. Lock Nut
260. Follower--Injector
261. Gage--Injector Timing

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, proceed with engine tune-up as follows:

Adjust Governor Gap

1. With engine running at normal operating temperature, check engine idle speed.

   The recommended idle speed is 550 r.p.m. for single weight governors, but may vary with special engine applications.

2. If required, loosen idle speed adjusting screw lock nut (56), Fig. 4, and turn idle speed adjusting screw (55) to obtain the recommended idle speed.

3. Hold idle screw and tighten lock nut.

4. Stop engine, and remove governor cover.

5. Remove fuel rod, between the governor and injector control tube lever.

6. Using governor gap gage (263) Fig. 1, check the gap between the low speed spring cap (47) and the high speed spring plunger (44).

7. If required, loosen lock nut (29) and turn gap adjusting screw (28) until a slight drag is felt on gage.

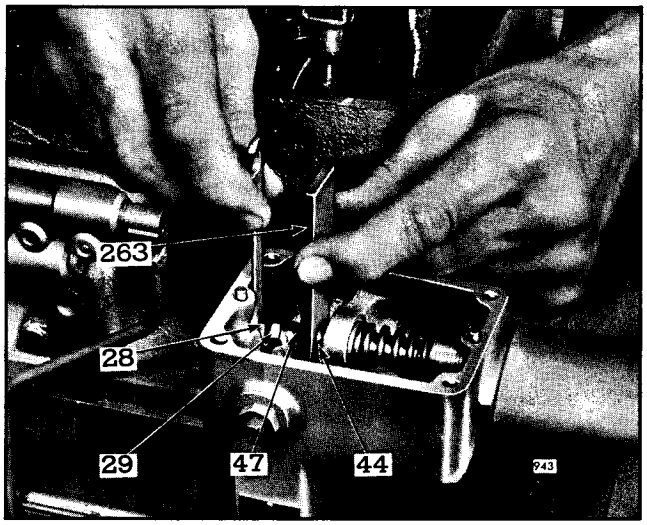


Fig. 1 - Adjusting Governor Gap-Tool J 5407

28. Screw--Gap Adjusting
29. Lock Nut
44. Plunger--High Speed Spring
47. Cap--Low Speed Spring
263. Gage--Governor Gap-Tool J 5407

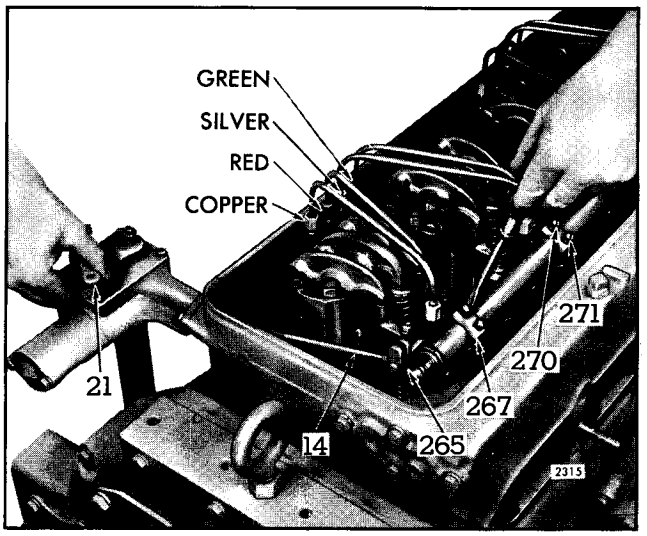


Fig. 2 - Positioning No. 6 Injector Rack Control Lever

14. Rod--Fuel
21. Lever--Speed Control
265. Lever--Injector Control Tube
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)

8. Hold adjusting screw and tighten lock nut.

9. Recheck gap and readjust if necessary.

10. Install the fuel rod between the governor and the injector control tube lever.

11. Install governor cover.

Position Injector Rack Control Levers

The position of the injector 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 No. 6 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Refer to Fig. 2 and disconnect any linkage attached to control lever (21).

2. Loosen lock nut (58), Fig. 3, and back out buffer screw (57) approximately 5/8'' to relieve the tension on the low speed spring.

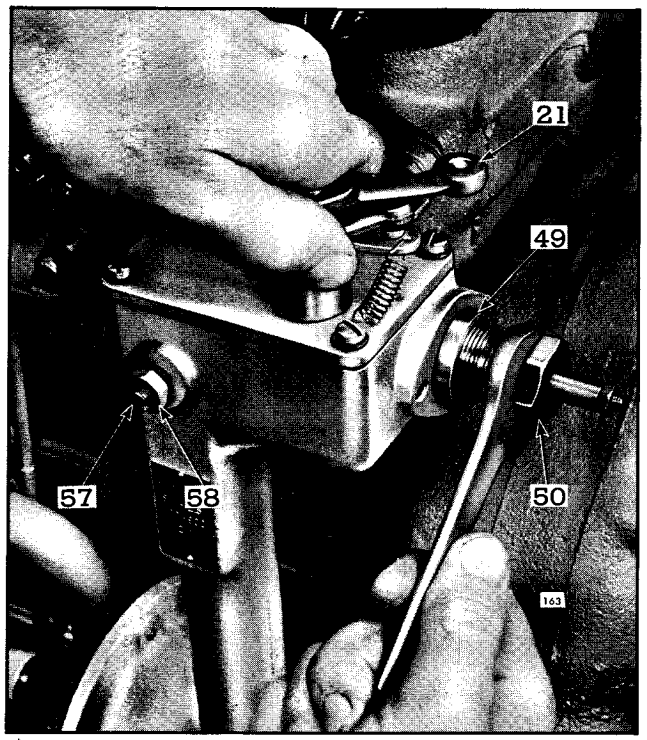


Fig. 3 - Adjusting Maximum No-Load Speed

21. Lever--Governor Control
49. Lock Nut--Spring Retainer
50. Retainer--High Speed Spring
57. Screw--Buffer
58. Lock Nut

3. Loosen inner and outer adjusting screws (270) and (271), Fig. 2, on each injector rack control lever (267). Be sure all injector rack control levers are free on the injector control tube.

4. While holding speed control lever (21) in the FULL FUEL position, turn inner adjusting screw (270) down until a slight movement of the injector control tube lever (265) is observed.

   Turn outer adjusting screw (271) down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

5. With the governor speed control lever held in the FULL FUEL position, check for a slight movement of the injector control tube lever. This movement should not exceed .005''.

6. If no movement is observed, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

   If the movement exceeds that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten inner adjusting screw.

On engines with a two valve cylinder head, when the setting is correct, the tang on the injector rack will contact the injector body and still maintain the movement specified in Item 5.

On engines with a four valve cylinder head, when the setting is correct, the injector rack will be snug on the ball end of the rack control lever and still maintain the movement specified in Item 5.

After No. 6 injector rack control lever has been correctly positioned, do not change its setting while positioning the remaining rack control levers.

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

a. Speed control lever is in the full fuel position.

b. Governor gap is closed.

c. High speed spring plunger is on its seat in governor control housing.

d. Injector racks are within .005'' of maximum fuel position (measured at clevis end of injector control tube lever.)

7. Disconnect fuel rod (14) from injector control tube lever (265).

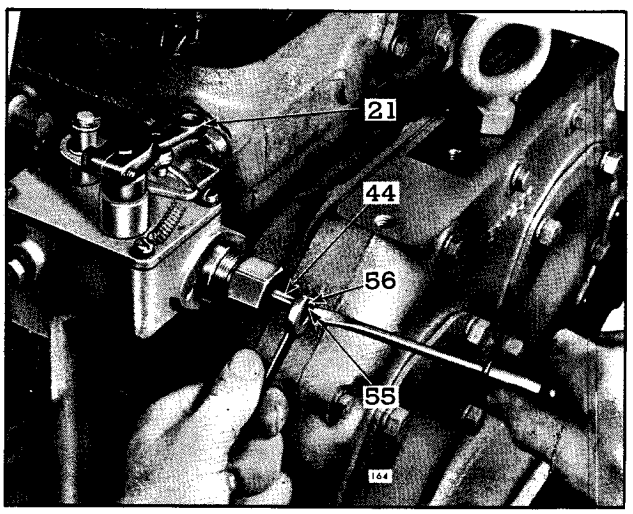


Fig. 4 - Adjusting Engine Idle Speed

21. Lever--Throttle Control
44. Plunger--High Speed Spring
55. Screw--Idle Speed Adjusting
56. Lock Nut

8. While manually holding No. 6 injector rack in the FULL FUEL position, position No. 5 injector rack control lever by turning inner adjusting screw (270) down until No. 5 injector rack control lever is in the FULL FUEL position. Tighten outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

   On a two valve cylinder head, when the settings are correct, the tang on both injector rack control levers must be contacting their respective injectors.

A method of determining whether both injector rack control levers are contacting the injectors is outlined below.

   a. Place a feeler gage between No. 6 injector rack control lever and the injector.

   b. Place another feeler gage of the same thickness between No. 5 injector rack control lever and the injector.

   c. Then while holding injector control tube lever (265) in the FULL FUEL position, move each feeler gage noting the drag on the feelers. The force required to move either feeler gage should be equal.

   NOTE: Should No. 5 injector, or any other, not have the same drag on the feeler gage as No. 6, readjust the inner and outer adjusting screws of the particular injector rack control lever being worked on. Never, under any circumstances alter the setting of No. 6 injector rack control lever.

   On a four valve cylinder head, when the settings are correct, the rack of both injectors must be snug on their respective rack control levers.

9. Position the remaining rack control levers as outlined above.

10. Connect fuel rod (14) to injector control tube lever (265).

11. Reconnect linkage to speed control lever (21).

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 which is usually given on the engine option plate, the maximum no-load speed may be set as follows:

1. Loosen lock nut (49), Fig. 3, and back off high speed spring retainer (50) approximately five turns.

2. If buffer screw was not previously backed out, loosen lock nut (58) and back out buffer screw (57) approximately 3/8''.

3. With engine at operating temperature and no-load on the engine, place speed control lever (21) in the FULL FUEL position. Turn high speed spring retainer (50) in until the engine is operating at the recommended no-load speed.

   The preferred method for checking the engine r.p.m. is by the use of an accurate hand tachometer.

4. Hold high speed spring retainer and tighten lock nut (49).

Adjust Idle Speed

The recommended idle speed is 550 r.p.m. on engines equipped with a single weight limiting speed mechanical governor, but may vary with special engine applications.

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. With engine at normal operating temperature, refer to Fig. 4 and loosen lock nut (56) on idle screw (55). Turn the idle screw until engine is operating at approximately 15 r.p.m. below the recommended idle speed.

2. Hold idle screw and tighten lock nut.

Adjust Buffer Screw

With the idle speed set at approximately 15 r.p.m. below the recommended idle speed, the buffer screw may be set as follows:

1. Turn buffer screw (57), Fig. 3, in until engine is operating at the recommended idle speed.

   Do not raise the engine speed more than 15 r.p.m. with the buffer screw.

2. Hold buffer screw and tighten lock nut (58).

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL AND THROTTLE CONTROL ADJUSTMENT (RDC ROOTS BLOWER ENGINES)

The limiting speed mechanical governor and injector rack control and throttle control adjustment procedure outlined below covers the governor and throttle control arrangements used on the current and former 62806 RD and 62808 RD model rail diesel car units.

The throttle control housing (300), Figs. 6 and 8, contains the throttle control lever (12) which is connected to and operated by the throttle operating solenoids (320) and (321) through the beam (324) and turnbuckle (343) or link (347).

The governor shut-down lever (310) is also contained in the throttle control housing. The shut-down lever is operated by the shut-down solenoid (305) which is attached to the outside of the throttle control housing and is actuated by the stop button on the control cabinet door.

Throttle control lever (12) is bolted to the governor throttle shaft and the two solenoids (320) and (321) are connected electrically to the remote throttle controller. Lever (12) is also connected, through the governor mechanism, to the injector racks in such a manner as to move the racks to a predetermined position when the lever (12) is moved between the IDLE and FULL FUEL positions, shown in Figs. 7 and 9.

The limiting speed governor controls the engine idle and maximum speeds. Intermediate speeds are dependent on the throttle control lever position and load on the engine. The remote throttle controller has five throttle positions -- OFF, 1, 2, 3 and 4. Number 1 is idle position and Number 4 is maximum speed position. Position Number 2 energizes throttle solenoid (321) and position Number 3 energizes throttle solenoid (320).

When the throttle controller is moved to the number 2 position, the solenoid (321) becomes energized, moving beam (324) away from the solenoids around point "A" as a fulcrum. Thus lever (12) moves away from the solenoids admitting more fuel.

When the throttle controller is moved to the number 3 position, solenoid (321) is de-energized and solenoid (320) is energized, moving beam (324) away from solenoid (320) around point "B" as a fulcrum. Arm "X" is longer than arm "Y" and, since solenoid plunger (346) moved for position 2, then lever (12) moves correspondingly farther admitting more fuel.

When throttle controller is moved to the number 4 position, both solenoids are energized, moving the throttle control lever to the maximum fuel position.

The throttle solenoids (320) and (321), when de-energized, move the throttle lever into the IDLE position only, not to the OFF position. The governor shut-down solenoid (305), when energized by pushing the STOP button on the control cabinet door, operates the shut-down lever (310) which moves the injector racks to the full OFF position. The stop button must be held IN until the engine stops.

Before proceeding with the governor and throttle linkage adjustments on the rail diesel car engine, perform the following steps:

1. Set car hand brake and air brake.
2. Remove the generator fuse located in regulator locker.
3. Pull air shut-down reset handle to open the air shut-down valve.

   NOTE: Since the air shut-down valve closes every time the engine stops, it must be reset and held until the engine oil pressure gauge shows a pressure in excess of 12 p.s.i.

Preliminary Throttle Linkage Adjustment (Current 62806 RD and 62808 RD Models)

The throttle control adjustment diagram, Fig. 7, shows the throttle linkage in the correct position before adjusting the engine intermediate speeds. The preliminary throttle adjustment should be made to establish a starting point by adjusting the geometry of the governor throttle linkage to a position where most of the linkage adjustment will be established before proceeding with the final engine governor and throttle adjustments.

Refer to Fig. 7 and perform the preliminary throttle linkage adjustment as follows:

1. Remove cotter pin and link pin that attach the throttle control lever link (347) to the throttle control operating beam (324).
2. Check arc of travel of the throttle control lever (12), then loosen throttle lever retaining bolt and set lever on throttle control shaft so that it will be in a vertical position at 1/2 of its travel. Tighten the throttle lever retaining bolt securely.

3. Loosen lock nuts on throttle control operating beam (324) and adjust beam until the throttle control lever to beam link (347) is parallel with operating solenoid plunger (345) and at right angles to the operating beam (324).

4. Loosen the operating solenoid plunger lock nut on both solenoids, and adjust the plungers (345) and (346) until their lengths are equal. With the throttle control lever (12) held in the IDLE position, adjust both solenoid plungers equally until the holes in control lever links (347) are in alignment with pin hole in operating beam (324). The adjustment is correct when the link pin can be inserted freely through the holes of links and operating beam, while the throttle lever is held in the idle position.

5. Install pin and cotter pin, then tighten the solenoid plunger lock nuts.

Preliminary Throttle Linkage Adjustment (Former 62806 RD Model)

The throttle control adjustment diagram (Fig. 9) shows the throttle control linkage in the correct position before adjusting the engine intermediate speeds. The preliminary throttle adjustment should be made to establish a starting point by adjusting the geometry of the governor throttle linkage to a position where most of the linkage adjustment will be established before proceeding with the final engine governor and throttle adjustments.

Refer to Fig. 9 and perform the preliminary throttle linkage adjustment as follows:

1. Remove the spherical rod end bearing bolt (341) from throttle control lever (12) then raise the turnbuckle and spherical rod end bearing up and rest it against the side of throttle control housing.

2. Check arc of travel of throttle lever (12), then loosen throttle lever retaining bolt and set throttle lever on throttle shaft so that it will be in a vertical position when the throttle shaft is at 1/2 of its total travel. Tighten throttle lever retaining shaft bolt securely.

3. Loosen lock nut and adjust turnbuckle (343) until it has at least three complete turns of travel to its shortest length.

4. Loosen lock nuts at each side of spherical rod end bearing (327) and adjust the spherical rod end bearing along the operating beam until the bearing and turnbuckle is parallel with turnbuckles (333) and (334) and at right angles to the operating beam (324).

5. Loosen lock nuts at both ends of operating solenoid to beam turnbuckles (333) and (334) and adjust them until their lengths are equal. Then adjust both turnbuckles (333) and (334) equally until the holes of the spherical rod end bearing (340) and throttle control lever (12), when the throttle control lever is held in the idle position, are in alignment. The adjustment is correct when the bolt can be inserted freely through the spherical rod end bearing and threaded into the throttle control lever with the throttle control lever still held in the idle position.

6. Install bolt (341) and tighten securely, then tighten the turnbuckle lock nuts.

Adjust Governor Gap

Start engine and warm engine up to operating temperature, then shut engine down and adjust the governor gap as follows:

1. Remove the governor high speed spring retainer cover.

2. Loosen the idle speed adjusting screw lock nut (56), see Fig. 5. Start engine, then adjust the idle speed screw (55), if necessary, to attain a speed of 750 r.p.m. as shown in Fig. 5. Then tighten the adjusting screw lock nut.

   NOTE: The normal engine idle speed is set at 750 r.p.m. (NO-LOAD), clutches disengaged.

3. Stop engine, then remove the throttle control housing and governor cover from the top of governor as outlined under "RDC Throttle Controls" in Section 2.9.2.

4. Remove fuel rod from the injector control tube lever.

5. Using a .170" gap gage, tool J 5407, as shown in Fig. 1, check the gap between the low speed spring cap (47) and the high speed spring plunger (44).

6. If required, loosen lock nut (29) and turn gap adjusting screw (28) until a slight drag is felt on gage.

7. Hold adjusting screw and tighten lock nut.

8. Recheck gap and readjust if necessary.

9. Install the fuel rod between the governor and the injector control tube lever.

10. Install the throttle control housing and governor cover on top of governor as outlined under "RDC Throttle Controls" in Section 2.9.2.

Position Injector Rack Control Levers (Two Valve and Four Valve Cylinder Heads)

The position of the injector 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 positioning of the injector rack control levers on the engine with a four valve head is essentially the same as the engine with the two valve head. Exception to the engine with the two valve head procedure will be indicated.

Adjust Number 6 injector rack control lever (267), Fig. 2, first to establish a guide for adjusting the remaining injector rack control levers.

Position injector rack control levers as follows:

1. Refer to Figs. 6 and 8 and disconnect the throttle linkage attached to the throttle control lever (12).

2. Refer to Figs. 6 and 8 and disconnect the engine shut-down control rod end (315) from the shut-down control lever (310).

3. Loosen buffer screw lock nut (58) and back buffer screw (57) out of governor housing approximately 5/8", see Fig. 4.

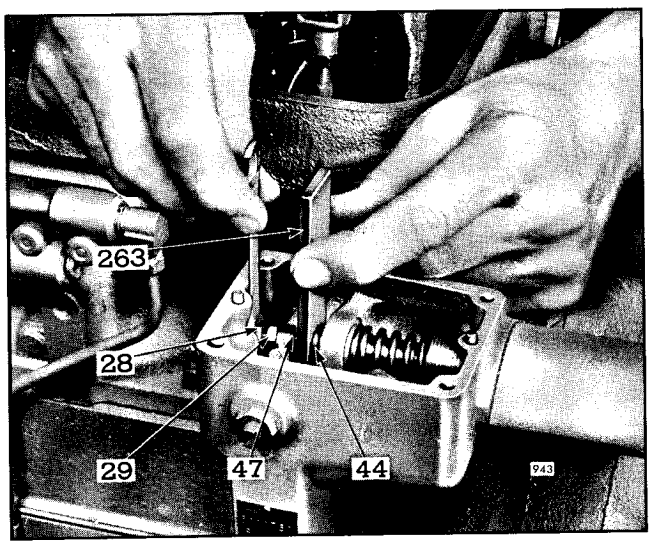


Fig. 1 - Adjusting Governor Gap - With Tool J 5407

28. Screw--Gap Adjusting
29. Lock Nut
44. Plunger--High Speed Spring
47. Cap--Low Speed Spring
263. Gage--Governor Gap Tool J 5407

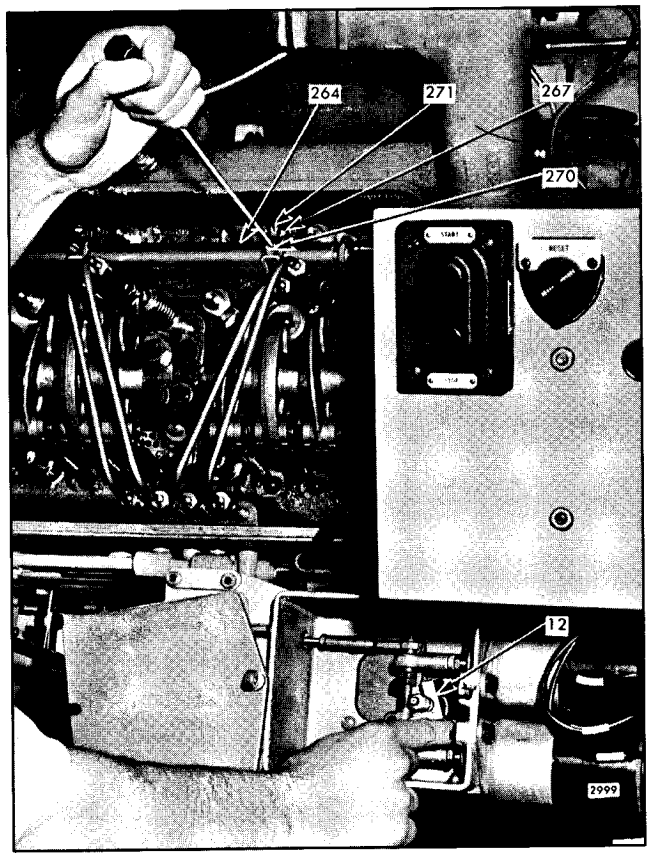


Fig. 2 - Positioning No. 6 Injector Rack Control Lever (Current 62806RD and 62808RD Models)

12. Lever--Throttle Control
264. Tube--Injector Control
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)

4. Loosen and back out the inner and outer adjusting screws (270) and (271), Fig. 2, on each injector rack control lever (267). Be sure all rack control levers are free on the injector control tube.

5. While holding the throttle control lever (12) in the FULL FUEL position, turn inner adjusting screw (270) down on Number 6 injector rack control lever until a slight movement of the injector control tube lever is observed.

6. Turn the outer adjusting screw (271) down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

7. With the throttle control lever (12) held in the FULL FUEL position, check for a slight movement of the injector control tube lever. This movement should not exceed .005".

14.3.3 GOVERNOR AND THROTTLE CONTROL ADJUSTMENT (RDC ROOTS)

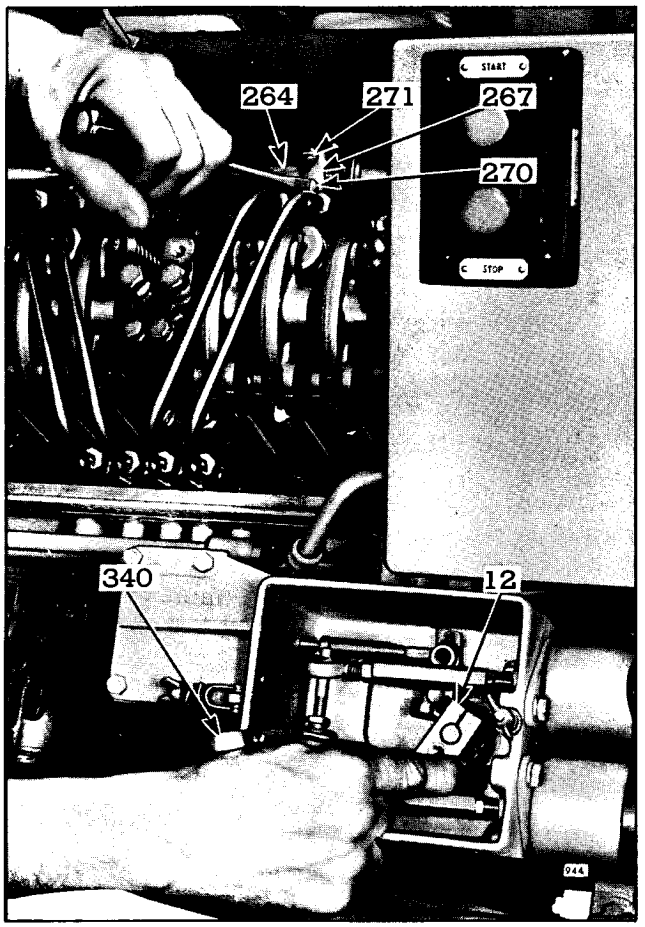


Fig. 3 - Positioning No. 6 Injector Rack Control Lever (Former 62806RD Model)

12. Lever--Throttle Control
264. Tube--Injector Control
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)
340. Bearing--Spherical Rod End

If no movement is observed, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

If the movement exceeds .005", back off outer adjusting screw approximately 1/8 of a turn and tighten the inner adjusting screw.

When the setting is correct, the tang on the injector rack control lever will contact the injector body and still maintain the movement as specified above.

On engines with a four valve cylinder head, the Number 6 injector rack control lever setting is correct when the injector rack will be snug on the ball end of rack control lever and still maintain the movement of .005" as specified above.

After No. 6 injector rack control lever has been correctly positioned, do not change its setting while positioning the remaining injector rack control levers.

NOTE: Performing Steps 5, 6 and 7 will result in placing the governor linkage and injector control tube assembly in the same positions that they will attain while the engine is running at full load. These positions are:

a. Throttle control lever in full fuel position.

b. Governor gap is closed.

c. High speed spring plunger is on its seat in governor control housing.

d. Injector racks are within .005" of maximum fuel position.

8. Disconnect fuel rod from injector control tube lever.

9. While manually holding the No. 6 injector rack in FULL FUEL position, position No. 5 injector rack control lever by turning inner adjusting screw (270) down until No. 5 injector rack control lever is in FULL FUEL position. Tighten outer adjusting screw (271) until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

When the setting is correct, the tang on both No. 5 and No. 6 injector rack control levers must be contacting their respective injectors.

A method of determining whether both injector rack control levers are contacting the injectors is outlined below.

a. Place a .002" feeler gage between the injector control lever and Number 5 injector body, then while holding the injector control tube lever in the FULL FUEL position, remove the feeler gage noting the drag on the feeler gage.

b. Place the same .002" feeler gage between the injector control lever and Number 6 injector body, then while holding the injector control tube lever in FULL FUEL position, remove the feeler gage noting the drag on the feeler gage.

The drag on the feeler gage, when removed, should be the same at both injectors.

NOTE: Should Number 5 injector rack control lever, or any other, not have the same drag on the feeler gage as Number 6, readjust the inner and outer adjusting screws of the particular injector rack control lever being worked on until it has the same feeler gage drag as Number 6 has. Never, under any circumstances, alter the Number 6 injector rack control lever setting.

On engines with a four valve cylinder head, make sure Number 6 injector rack remains snug on the rack control lever when tightening Number 5 injector rack control lever adjusting screws. If Number 6 injector rack becomes loose, back off slightly on Number 5 injector rack control lever inner adjusting screw and tighten outer adjusting screw.

When the settings are correct, the injector rack of both injectors will be snug on the ball end of their respective rack control levers and still maintain the movement of .005'' as specified in Step 7 above.

10. Position the remaining injector rack control levers as outlined in Step 9 above. Always return to Number 6 injector after each injector rack control lever has been adjusted and check adjustment with feeler gage as outlined above.

11. Connect fuel rod to the injector control tube lever.

Adjust Maximum No-Load Engine 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 which is usually given on the engine option plate, the maximum no-load speed may be set as follows:

1. Loosen lock nut (49), Fig. 4, and back off high speed spring retainer (50) approximately five turns.

2. Start engine and warm up to operating temperature. Then without any load on the engine, place the throttle control lever (12) in the FULL FUEL position and turn the high speed retainer (50) in, as shown in Fig. 4, until the engine is operating at 1920-1950 r.p.m. no-load speed on 62806 RD model, or 2120-2150 r.p.m. on 62808 RD model.

3. While holding the high speed spring retainer from turning, tighten lock nut.

Adjust Idle Speed

The recommended idle speed is 750 r.p.m. With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. With the engine running and warmed to normal operating temperature, refer to Fig. 5 and loosen lock nut (56) on the idle speed adjusting screw (55). Turn the idle adjusting screw IN or OUT until engine is operating at approximately 15 r.p.m. below the recommended idle speed.

2. While holding the idle screw from turning, tighten lock nut.

3. Install the governor high speed spring retainer gasket and cover.

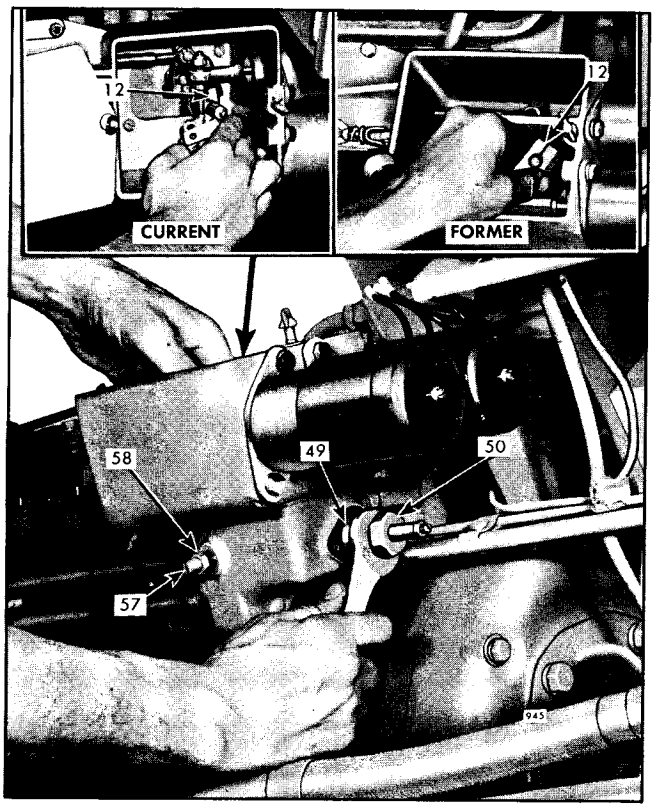


Fig. 4 - Adjusting Maximum No-Load Speed

12. Lever--Throttle Control
49. Lock Nut--Spring Retainer
50. Retainer--High Speed Spring
57. Screw--Buffer
58. Lock Nut

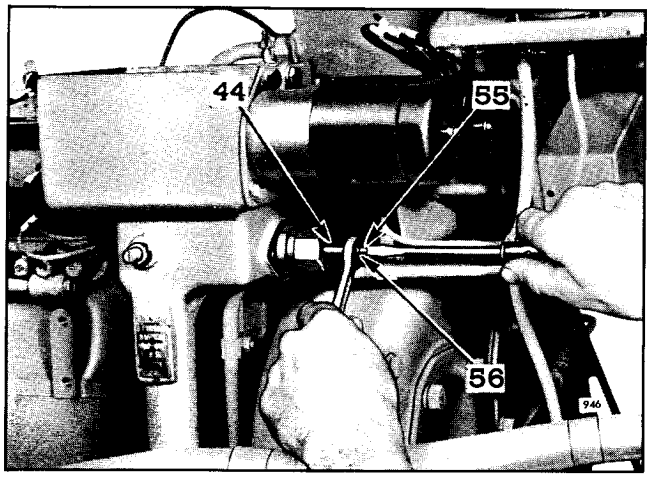


Fig. 5 - Adjusting Engine Idle Speed

44. Plunger--High Speed Spring
55. Screw--Idle Speed Adjusting
56. Lock Nut

Adjust Buffer Screw

With the engine idle speed set at approximately 15 r.p.m. below the recommended idle speed, the buffer screw may be adjusted as follows:

1. With the engine running at idle speed, turn the buffer screw (57), Fig. 4, IN so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

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

2. While still holding the buffer screw from turning, tighten lock nut (58).
3. Stop engine.
4. Refer to Figs. 6 and 8 and connect the throttle control linkage to the throttle control lever (12) that was previously removed.

Adjust Governor Shut-Down Solenoid

With the engine governor adjustments performed, the governor shut-down solenoid (305) and shut-down lever (310) shown in Figs. 6 and 8 may be adjusted as follows:

1. If previously removed, or moved from its original position, thread the shut-down control rod end on the solenoid plunger approximately four (4) complete turns.
2. On the current throttle control linkage arrangement shown in Fig. 6, place the shut-down control rod end (315) on pin in shut-down control lever; then, install and tighten the four bolts that secure the shut-down solenoid to the throttle control housing. Install washer and spring retainer on the shut-down control lever pin.

   On the former throttle control linkage arrangement shown in Fig. 8, place the shut-down control rod end (315) on shut-down control lever (310) and secure in place with bolt.

3. Loosen the shut-down control lever clamping bolt, then loosen lever on shaft.
4. With the injector racks in NO FUEL position, turn the shut-down control lever shaft counterclockwise with a pair of pliers until interference is encountered.
5. Move the injector racks to FULL FUEL position by energizing the throttle control operating solenoids (320) and (321), then tighten the shut-down control lever clamping bolt.
6. With the injector racks still in FULL FUEL position, loosen lock nut on the shut-down solenoid plunger and turn the solenoid plunger counterclockwise approximately one-and-one-half (1-1/2) turns, then check for movement of the shut-down control lever by pushing the lever back towards the solenoid. The lever and solenoid plunger should have approximately

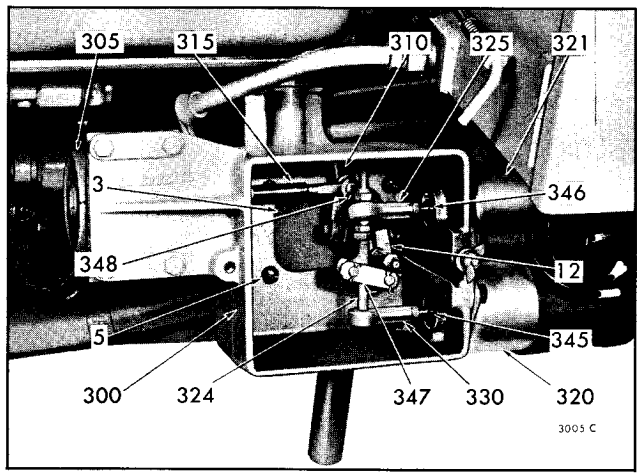


Fig. 6 - Throttle Control Linkage Arrangement (Current 62806RD and 62808RD Models)

3. Cover--Engine Governor
5. Screw--Throttle Control Housing and Governor Cover
12. Lever--Throttle Control
300. Housing--Throttle Control
305. Solenoid--Governor Shut-Down
310. Lever--Shut-Down Control
315. Rod End--Shut-Down Control
320. Solenoid--Throttle Operating
321. Solenoid--Throttle Operating
324. Beam--Throttle Control Operating
325. Bearing--Spherical Rod End (Beam)
330. Bearing--Spherical Rod End (Beam)
345. Plunger--Operating Solenoid
346. Plunger--Operating Solenoid
347. Link--Throttle Lever
348. Retainer--Spring

1/16" travel. When setting is correct, tighten lock nut.

7. De-energize the throttle control solenoids.
8. Start engine and check operation of shut-down solenoid.

NOTE: When shut-down solenoid is de-energized, the injector racks should be able to move to the FULL FUEL position. When shut-down solenoid is energized, the injector racks should be in the NO FUEL position.

Adjust Throttle Controls

The throttle controls may be checked and adjusted, if necessary, to insure proper idle and maximum no-load speeds as follows:

1. Set car hand brake and air brakes.
2. Remove generator fuse in regulator locker, if not previously removed.
3. Remove plug from receptacle on the transmission wiring harness.
4. Pull reset handle to open the air shut-down valve.
5. Start engine and warm up to operating temperature.

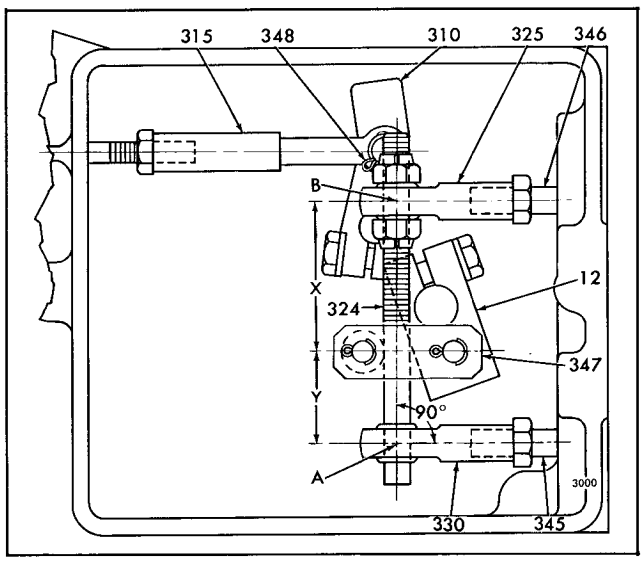


Fig. 7 - Throttle Control Linkage Adjustment Diagram (Current 62806RD and 62808RD Models)

12. Lever--Throttle Control
310. Lever--Shut-Down Control
315. Rod End--Shut-Down Control
324. Beam--Throttle Control Operating
325. Bearing--Spherical Rod End (Beam)
330. Bearing--Spherical Rod End (Beam)
345. Plunger--Operating Solenoid
346. Plunger--Operating Solenoid
347. Link--Throttle Lever to Beam
348. Retainer--Spring

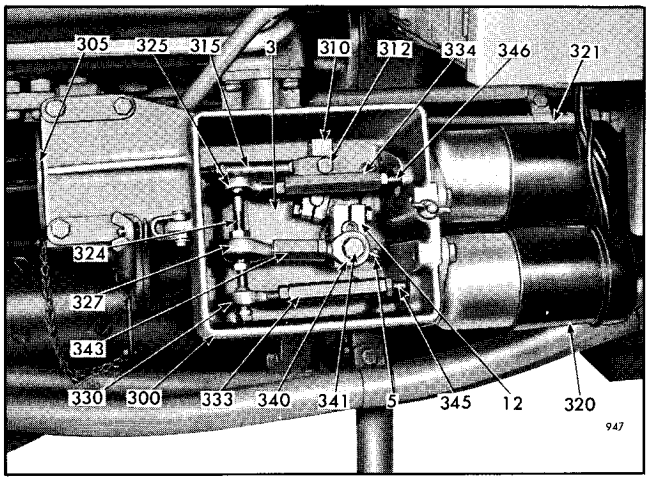


Fig. 8 - Throttle Control Linkage Arrangement (Former 62806RD Model)

3. Cover--Governor
5. Screw--Throttle Control Housing and Governor Cover
12. Lever--Throttle Control
300. Housing--Throttle Control
305. Solenoid--Governor Shut-Down
310. Lever--Shut-Down Control
312. Bolt--Shut-Down Control Rod End to Control Lever
315. Rod End--Shut-Down Control
320. Solenoid--Throttle Operating
321. Solenoid--Throttle Operating
324. Beam--Throttle Control Operating
325. Bearing--Spherical Rod End (Beam)
327. Bearing--Spherical Rod End (Beam)
330. Bearing--Spherical Rod End (Beam)
333. Turnbuckle--Operating Solenoid to Beam
334. Turnbuckle--Operating Solenoid to Beam
340. Bearing--Spherical Rod End
341. Bolt--Spherical Rod End Bearing to Throttle Lever
343. Turnbuckle--Throttle Lever to Beam
345. Plunger--Operating Solenoid
346. Plunger--Operating Solenoid

6. Check throttle controls as outlined under "Preliminary Throttle Linkage Adjustment".

NOTE: As a safety precaution while making the following tests, we recommend that a second man, familiar with the car controls, stay in the cab, or the wheels of the car be securely blocked to prevent car movement should the brakes fail.

7. Check free engine speeds with throttle linkage connected to the throttle control lever.
   a. Note engine idle speed -- if the idle speed is above 750 r.p.m., turn solenoid plungers (345) and (346) into rod end bearings (325) and (330) on the current throttle control linkage shown in Fig. 6. On the former throttle control linkage shown in Fig. 8, lengthen turnbuckle (343). If idle speed is below 750 r.p.m., re-adjust as outlined in "Adjust Idle Speed."

b. Move throttle controller to No. 3 position and check engine maximum speed -- if maximum speed is above or below the desired setting (1920-1950 r.p.m. on 62806RD model or 2120-2150 r.p.m. on 62808RD model), re-adjust as outlined under "Adjust Maximum No-Load Speed."

8. Move throttle controller to NEUTRAL position and stop engine.

9. Replace plug in receptacle on transmission wiring harness.

10. Pull reset handle to open air shut-down valve, then start engine.

11. Place throttle controller in No. 4 position. The engine stall speed should now be 1675 ± 75 r.p.m. on 62806RD model, or 1590 ± 75 r.p.m. on 62808RD model. If the engine stall speed falls short of this speed, recheck the maximum free engine speed. If the maximum free engine speed is correct, this may indicate that the engine does not produce full horsepower.

CAUTION: Do not operate the engine with controller in No. 4 position longer than 20 seconds with transmission stalled. Drive oil temperature should not exceed 250°F., any temperature in excess of this may be harmful to the torque converter of the transmission.

NOTE: All engine speeds except no-load idle (750 r.p.m.), idle stall (705 ± 5 r.p.m.), and maximum stall (1675 ± 75 r.p.m. on 62806RD model or 1590 ± 75 r.p.m. on 62808RD model) may be varied to suit the operating conditions. However, the maximum no-load engine speed should not exceed 1950 r.p.m. on 62806RD model or 2150 r.p.m. on 62808RD model.

12. Do not install the generator fuse in regulator locker until the engine intermediate speed adjustments are performed.

Adjust Engine Intermediate Speeds

The engine intermediate speeds may be adjusted so that the engine or engines will be synchronized in their operation as follows:

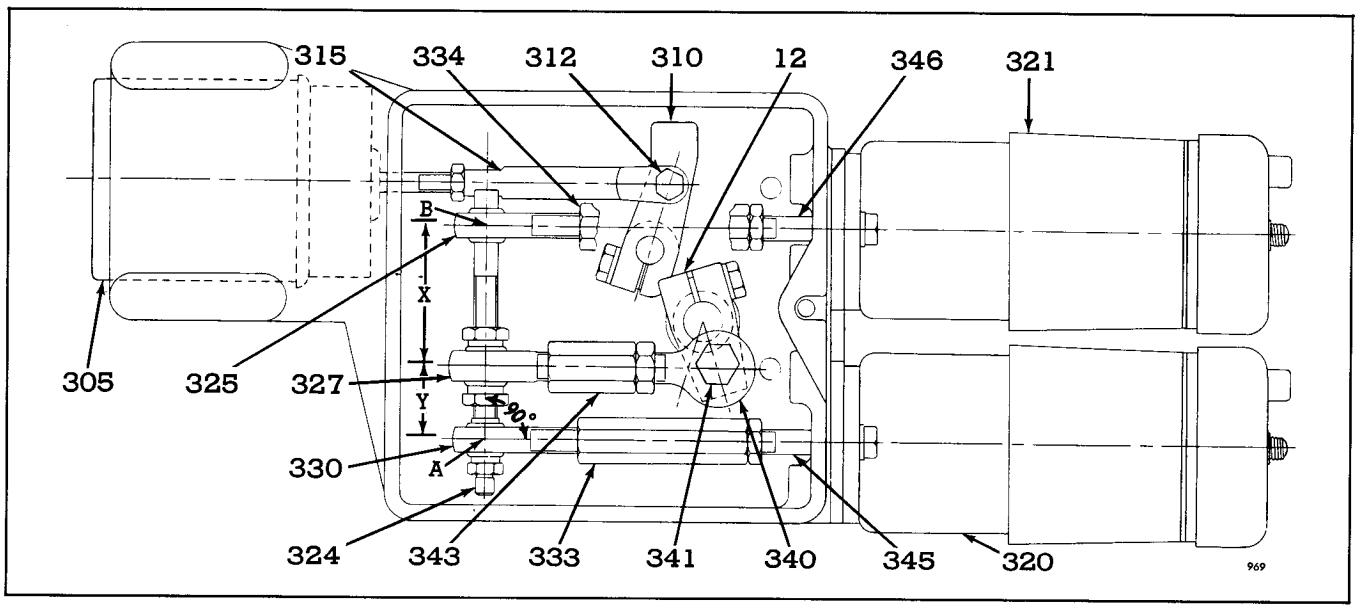


Fig. 9 - Throttle Control Linkage Adjustment Diagram (Former 62806RD Model)

12. Lever--Throttle Control
305. Solenoid--Governor Shut-Down
310. Lever--Shut-Down Control
312. Bolt--Shut-Down Control Rod End to Control Lever
315. Rod End--Shut-Down Control
320. Solenoid--Throttle Operating
321. Solenoid--Throttle Operating
324. Beam--Throttle Control Operating
325. Bearing--Spherical Rod End (Beam)
327. Bearing--Spherical Rod End (Beam)
330. Bearing--Spherical Rod End (Beam)
333. Turnbuckle--Operating Solenoid to Beam
334. Turnbuckle--Operating Solenoid to Beam
340. Bearing--Spherical Rod End
341. Bolt--Spherical Rod End Bearing to Throttle Lever
343. Turnbuckle--Throttle Lever to Beam
345. Plunger--Operating Solenoid
346. Plunger--Operating Solenoid

1. Set car hand brake and air brakes, if not previously set.

   NOTE: As a safety precaution while making the following tests, we recommend that a second man, familiar with the car controls, stay in the cab, or the wheels of the car be securely blocked to prevent car movement should the brakes fail.

2. Pull reset handle to open the air shut-down valve.

3. Start engine and warm up to operating temperature.

4. Place the direction control knob (in the engineers cab) in the forward position.

5. Check and adjust the engine stall speeds as follows:

   a. Controller in NEUTRAL position: check engine no-load idle speed (750 r.p.m.).

   b. Controller in No. 1 position: check engine idle stall speed (705 $\pm$ 5 r.p.m.).

   c. Controller in No. 2 position: check engine stall speed (1185 $\pm$ 5 r.p.m.).

   d. Controller in No. 3 position: check engine stall speed (1460 $\pm$ 40 r.p.m.).

   e. Controller in No. 4 position: check engine stall speed (1675 $\pm$ 75 r.p.m. on 62806RD model or 1590 $\pm$ 75 r.p.m. on 62808RD model).

   CAUTION: Do not operate the unit in excess of 20 seconds in the higher throttle positions to prevent the drive oil temperature from exceeding 250^{0}F., otherwise the transmission high oil temperature switch will shut the engine down. Temperatures in excess of 250^{0}F. may cause damage within the transmission.

   NOTE: If the engine maximum stall speed is low or excessively high, refer to "Trouble Shooting-Transmission" in Section 9.9.0 and "Trouble Shooting - Engine" in Section 15.2.

6. Place controller in No. 2 position and adjust engine speed, if necessary, by moving the operating beam (324) upward to increase the speed or downward to decrease the speed on the current throttle control linkage shown in Fig. 6, or moving rod end bearing (327) along the operating beam (324) on the former throttle control linkage shown in Fig. 8, by loosening one and tightening the other operating beam adjusting nut until a speed of 1185 $\pm$ 5 r.p.m. is obtained.

7. Place controller in NEUTRAL position and readjust idle speed to 750 r.p.m. if necessary.

8. Place controller in No. 2 position and recheck engine speed (1185 $\pm$ 5 r.p.m.).

   NOTE: Steps 6, 7 and 8 must be repeated until the desired speeds are obtained.

9. Place controller in No. 3 position and check engine speed (1460 $\pm$ 40 r.p.m.).

   NOTE: The engine stall speeds in No. 2 and No. 3 positions may be varied from the settings given above, if desired, to suit the existing operating conditions. It should be noted, due to the construction of the throttle linkage, if the No. 3 speed is increased, the No. 2 speed will be decreased and if No. 2 speed is increased, the No. 3 speed will be decreased.

10. Repeat all the above steps on the second engine. The engine speeds at the No. 2 controller position should be within 10 r.p.m. on each of the two engines.

11. Install generator fuse in regulator locker.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL AND THROTTLE CONTROL ADJUSTMENT (RDC CENTRIFUGAL BLOWER ENGINES)

The limiting speed mechanical governor and injector rack control and throttle control adjustment procedure outlined below covers the governor and throttle control arrangement used on the 62801RD and 62803RD model rail diesel car units.

The throttle control housing and cover assembly (223), Fig. 6, contains the throttle control lever (12) which is connected to and operated by the throttle operating solenoids (320) and (321) through the operating beam (324) and turnbuckle (343).

The governor shut-down lever (310) is also contained in the control housing and cover assembly. The shut-down lever is operated by the shut-down solenoid (305) which is attached to a support bracket outside the control housing and is actuated by the stop button on the control cabinet door.

Throttle control lever (12) is bolted to the governor throttle shaft and the two solenoids (320) and (321) are connected electrically to the remote throttle controller. Lever (12) is also connected, through the governor mechanism, to the injector racks in such a manner as to move the racks from the closed to open position when the lever (12) moves from position "H" to position "K", shown in Fig. 7.

The limiting speed governor controls the engine idle and maximum speeds. Intermediate speeds are dependent on the throttle control lever position and load on the engine. The remote throttle controller has five throttle positions -- OFF, 1, 2, 3 and 4. Number 1 is idle position and Number 4 is maximum speed position. Position Number 2 energizes throttle solenoid (321) and position Number 3 energizes throttle solenoid (320).

When the throttle controller is moved to the number 4 position, both solenoids are energized moving the throttle control lever to the maximum speed position.

The throttle solenoids (320) and (321), when de-energized, move the throttle lever into the IDLE position only, not to the OFF position. The governor shut-down solenoid (305), when energized by pushing the STOP button on the control cabinet door, operates the shut-down lever (310) which moves the injector racks to the full OFF position. The stop button must be held IN until the engine stops.

The throttle control linkage adjustment diagram, Fig. 7, shows the throttle linkage in the correct position for engine idle speed. Note that center lines "AA" and "BB" are parallel in relation to the side of the control housing.

When lever "AA" is parallel to the side of the control housing, the differential pin is against its idle stop. Also, center lines "CC", "DD", and "EE" are parallel. Center line "AA" is 90^{O} to "CC".

When the throttle controller is moved to the Number 2 position, the solenoid (321) becomes energized, moving beam (324) away from the solenoids around point "G" as a fulcrum. Thus lever (12) moves away from the solenoids, admitting more fuel.

When the throttle controller is moved to the Number 3 position, solenoid (321) is de-energized and solenoid (320) is energized, moving beam (324) away from solenoid (320) around point "F" as a fulcrum. Arm "X" is longer than arm "Y" and, since solenoid plunger (346) moves the same distance in position 3 as plunger (345) moved for position 2, then lever (12) moves correspondingly farther, admitting more fuel.

When the throttle controller is moved to the Number 4 position, both solenoids are energized, thus moving the throttle control lever to the maximum fuel position.

The engine speed is increased by moving lever (12) away from the solenoids. If bearing (327) is moved an appreciable distance along beam (324), turnbuckle (343) should be adjusted to hold the 90^{O} angle between center lines "AA" and "CC".

The throttle solenoids (320) and (321), when de-energized, move the throttle lever into the IDLE position only, not to the OFF position. The governor shut-down solenoid (305), when energized by pushing the STOP button on the control cabinet door, operates the shut-down lever (310) which moves the injector racks to the full OFF position. The stop button must be held IN until the engine stops.

Before proceeding with the governor and throttle linkage adjustments on the rail diesel car engine, perform the following steps:

1. Set car hand brake and air brake.
2. Remove the generator fuse located in regulator locker.
3. Pull air shut-down reset handle to open the air shut-down valve.

   NOTE: Since the air shut-down valve closes every time the engine stops, it must be reset and held until the engine oil pressure gauge shows a pressure in excess of 12 p.s.i.

14.3.4 GOVERNOR AND THROTTLE CONTROL ADJUSTMENT (RDC CENTRIFUGAL)

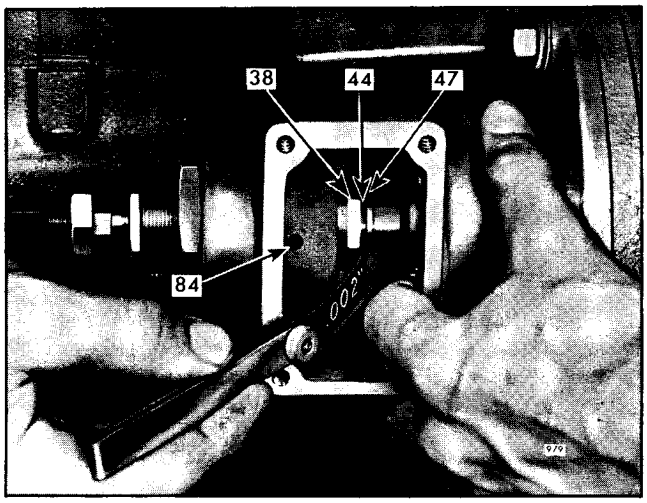


Fig. 1 - Setting Governor Gap

38. Nut--Gap Adjusting
44. Plunger--Spring
47. Seat--Low-Speed Spring
84. Set Screw

Adjust Governor Gap

1. Remove the governor high speed spring and weight housing covers.

2. To prevent the loss of lubricating oil when engine is started, install one of the governor high speed spring cover retaining bolts in the threaded hole directly below the high speed spring retainer.

3. Refer to Fig. 2 and loosen the inner and outer adjusting screws (270) and (271) on each injector rack control lever.

4. Loosen buffer screw lock nut (58) and back buffer screw (57) out of governor housing approximately 3/4'', see Fig. 5.

5. Refer to Fig. 4 and loosen idle speed adjusting screw lock nut (56), then back out adjusting screw (55) approximately 3/4''.

6. Move one of the low speed weights (large weights) inside the weight housing to its outward position.

7. If high speed plunger (44), Fig. 1, moves so gap will not close when the low speed weights are extended, adjust tension of springs by loosening idle speed adjusting screw (55), as shown in Fig. 4, or by tightening high speed spring retainer (50), as shown in Fig. 3, so high speed plunger will not move when low speed weight is extended.

8. While holding the low speed weight fully extended, measure the gap between the low speed spring seat (47) and the high speed plunger (44), as shown in Fig. 1. The gap should measure .0015'' to .002''.

9. If the gap varies from the specifications of .0015'' to .002'', loosen the set screw (84) inside of governor weight housing, see Fig. 1, and turn gap adjusting nut (38) to get the .0015'' to .002'' gap.

10. Crank the engine over until the other low-speed weight is in the position the first weight was when gap was checked. Force the second weight outward against the stop and recheck the gap.

11. If the gap is .0015'' to .002'' or slightly more when holding the second weight extended, no further check is necessary; however, if gap is less than .0015'' to .002'', turn the gap adjusting nut (38) as required to get the proper .0015'' to .002'' gap. Tighten set screw (84).

12. Install the gasket and cover to the side of governor weight housing.

Position Injector Rack Control Levers

The injector racks must be correctly positioned so that each cylinder will carry an equal share of the load and the injector racks are in correct relationship to the governor. The amount of fuel injected into each cylinder is controlled by the position of the injector rack. The maximum amount of fuel is injected into the cylinder when the racks are all the way IN, and no fuel is injected in the cylinders when the racks are all the way OUT.

Adjust Number 6 injector rack control lever (267), Fig. 2, first to establish a guide for adjusting the remaining injector rack control levers.

Position injector rack control levers as follows:

1. Refer to Fig. 6 and remove bolt that secures spherical rod end bearing (340) to throttle control lever (12), then raise the turnbuckle and spherical rod end bearing up and rest it against the side of throttle control housing, as shown in Fig. 2.

2. Loosen the throttle control lever retaining bolt and turn the lever to a perpendicular position, then tighten bolt.

3. While holding the throttle control lever (12) in the FULL FUEL position, turn inner adjusting screw (270) down on Number 6 injector rack control lever until the governor gap is just closed. A slight drag will be felt in the throttle control lever at this point.

4. Turn the outer adjusting screw (271) down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

   CAUTION: Care must be exercised to prevent the low speed spring seat from moving the high speed spring plunger off its seat.

   After No. 6 injector rack control lever has been correctly positioned, do not change its setting while positioning the remaining injector rack control levers.

5. Remove the pin which connects the fuel rod (14) to the injector control tube lever (265).

6. Place a .002'' feeler gage between the injector rack control lever stop button (43) and the body of No. 6 injector. Hold the injector control tube in FULL FUEL position.

7. Place a second .002'' feeler gage between the injector body and the injector rack control lever stop button of No. 5 injector. Turn the inner adjusting screw down until a slight drag can be felt on the feeler gage.

8. 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 until tight.

   When the setting is correct, the No. 5 and No. 6 injector rack control levers should have the same drag on the feeler gage when removed, with the control tube in FULL FUEL position.

   NOTE: Should Number 5 injector rack control lever, or any other, not have the same drag on the feeler gage as Number 6, readjust the inner and outer adjusting screws of the particular injector rack control lever being worked on until it has the same feeler gage drag as Number 6 has. Never, under any circumstances, alter the Number 6 injector rack control lever setting.

9. Position the remaining injector rack control levers as outlined in Steps 7 and 8 above. Always return to Number 6 injector after each injector rack control lever has been adjusted and check adjustment with feeler gage as outlined above.

10. Release the injector control tube from the FULL FUEL position and connect fuel rod (14) to the injector control tube lever (265) with pin.

Adjust Maximum No-Load Engine Speed

The no-load speed on units equipped with limiting speed governors must be not less than 125 r.p.m. or more than 150 r.p.m. above the rated full load speed. If required, the maximum no-load speed may be adjusted as follows:

1. Loosen the high-speed spring retainer lock nut (49) with tool J 4213. Then, using tool J 4211, back off the high speed retainer (50) approximately fifteen threads.

2. Turn the idle speed adjusting screw (55) in approximately 3/4''.

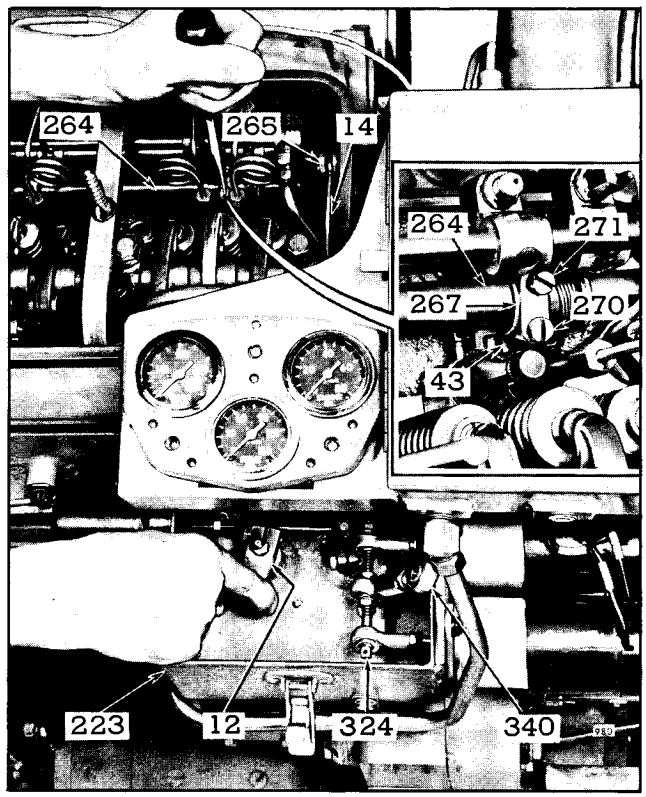


Fig. 2 - Positioning No. 6 Injector Rack Control Lever

12. Lever--Throttle Control
14. Rod--Fuel
43. Button--Rack Control Lever Stop
223. Governor Cover and Throttle Control Housing Assy.
264. Tube--Injector Control
265. Lever--Injector Control Tube
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)
324. Beam--Throttle Control Operating
340. Bearing--Spherical Rod End

14.3.4 GOVERNOR AND THROTTLE CONTROL ADJUSTMENT (RDC CENTRIFUGAL)

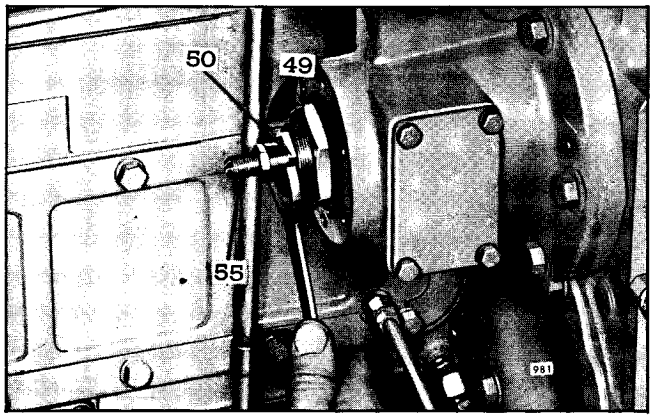


Fig. 3 - Adjusting Maximum No-Load Speed

49. Lock Nut--Spring Retainer
50. Retainer--High Speed Spring
55. Screw--Idle Speed Adjusting

3. Start engine and warm up to operating temperature. Then, without any load on the engine, place the throttle control lever (12) in FULL FUEL position and turn the high speed retainer (50) in as shown in Fig. 3 until the engine is operating at 1920-1950 r.p.m. no-load speed.

   The best method for checking the engine r.p.m. is by the use of an accurate hand tachometer.

4. While holding the high speed retainer from turning, tighten lock nut.

Adjust Idle Speed

The recommended idle speed is 750 r.p.m. With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

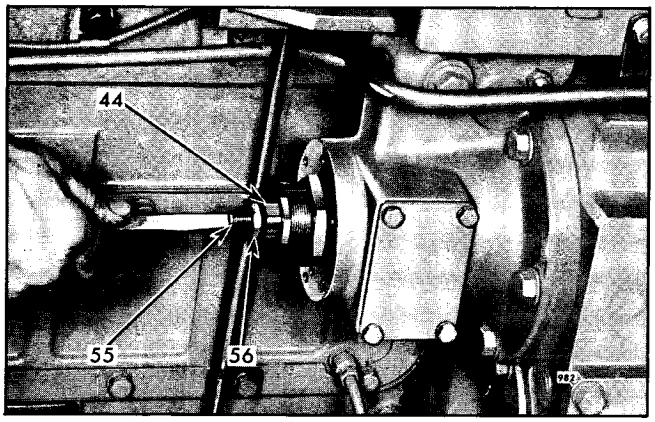


Fig. 4 - Adjusting Idle Speed

44. Plunger--High Speed Spring
55. Screw--Idle Speed Adjusting
56. Lock Nut

1. With the engine running and warmed to operating temperature, refer to Fig. 4 and turn the idle adjusting screw IN or OUT until engine is operating at approximately 15 r.p.m. below the recommended idle speed.

2. While holding the idle screw from turning, tighten lock nut.

3. Install the high speed spring retainer gasket and cover.

Adjust Buffer Screw

With the engine idle speed set at approximately 15 r.p.m. below the recommended idle speed, the buffer screw may be adjusted as follows:

1. With the engine running at idle speed, turn the buffer screw (57), Fig. 5, IN so that it contacts the differential lever as lightly as possible and still eliminate the engine roll.

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

2. While still holding the buffer screw from turning, tighten lock nut (58).

3. Stop engine.

4. Refer to Fig. 6 and connect the spherical rod end bearing (340) to the throttle control lever (12) that was previously removed.

Adjust Governor Shut-Down Solenoid

With the engine governor adjustments performed, the governor shut-down solenoid (305) and shut-down lever (310) shown in Fig. 6 may be adjusted as follows:

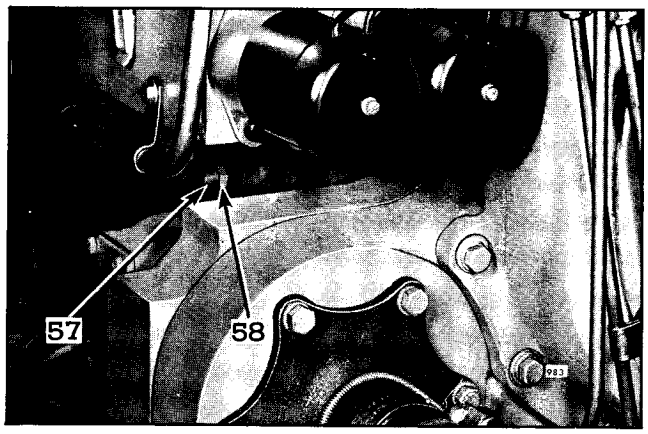


Fig. 5 - Buffer Screw Location

57. Screw--Buffer
58. Lock Nut

1. If previously removed, or moved from its original position, thread the turnbuckle (225) on the solenoid plunger and the shut-down link (229) into the turnbuckle approximately four (4) complete turns.

2. Place the shut-down link (229) on pin in shut-down control lever (310); then, attach the solenoid to the bracket at side of throttle control housing. Install washer and spring retainer on the shut-down control lever pin.

3. Loosen the shut-down control lever clamping bolt, then loosen lever on shaft.

4. With the injector racks in NO FUEL position, turn the shut-down control lever shaft counterclockwise with a pair of pliers until interference is encountered.

5. Move the injector racks to FULL FUEL position by energizing solenoid (320) and (321), then tighten the shut-down control lever clamping bolt.

6. With the injector racks still in FULL FUEL position, loosen lock nut and turn turnbuckle approximately one and-one-half (1-1/2) turns, then check for movement of the shut-down control lever by pushing the lever back towards the solenoid. The lever and solenoid plunger should have approximately 1/16" travel. When setting is correct, tighten lock nut.

7. De-energize the throttle control solenoids.

8. Start engine and check operation of shut-down solenoid.

   NOTE: When shut-down solenoid is de-energized, the injector racks should be able to move to the FULL FUEL position. When shut-down solenoid is energized, the injector racks should be in the NO FUEL position.

Adjust Throttle Controls

The throttle controls may be checked and adjusted, if necessary, to insure proper idle and maximum no-load speeds as follows:

1. Set car hand brake and air brakes.

2. Remove generator fuse in regulator locker, if not previously removed.

3. Refer to Fig. 6 and adjust turnbuckle (343) until the throttle control lever (12) is parallel to the throttle control operating beam (324) and tighten the lock nut. This is done merely to find a starting point.

4. Remove plug from the receptacle on the transmission wiring harness. A mechanical interlock in the remote controller prevents movement of the throttle with the reverse lever in NEUTRAL.

5. Disconnect shut-down solenoid by removing No. 11 lead wire at terminal on the left junction block, see Figs. 2 and 3 of Section 7.4.4.

6. Pull reset handle to open the shut-down valve.

7. Start engine and warm up to operating temperature.

8. Check free engine speeds with throttle control linkage connected to the throttle control lever.

   a. Note engine idle speed -- if the idle speed is above 750 r.p.m., lengthen turnbuckle (343), Fig. 7. If idle speed is below 750 r.p.m., re-adjust as outlined under "Adjust Idle Speed."

   b. Move throttle controller to No. 3 position and check engine maximum speed -- if maximum speed is above or below the desired setting (1920-1950 r.p.m.), re-adjust as outlined under "Adjust Maximum No-Load Speed."

9. Move throttle controller to NEUTRAL position and stop engine.

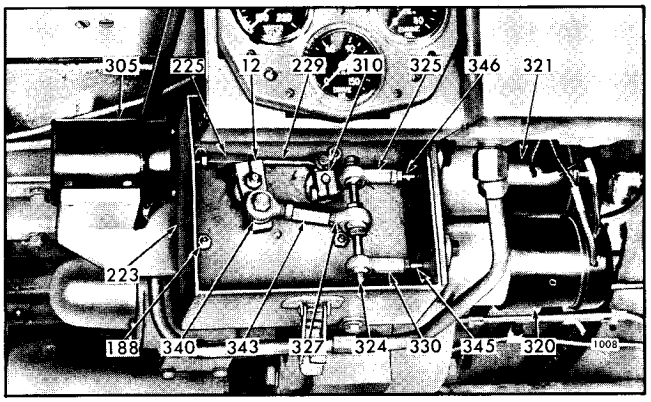


Fig. 6 - Throttle Control Linkage Arrangement

12. Lever--Throttle Control
188. Nut--Governor Cover
223. Governor Cover and Throttle Control Housing Assy.
225. Turnbuckle--Shut-Down Link to Solenoid
229. Link--Shut-Down
305. Solenoid--Governor Shut-Down
310. Lever--Shut-Down Control
320. Solenoid--Throttle Operating
321. Solenoid--Throttle Operating
324. Beam--Throttle Control Operating
325. Bearing--Spherical Rod End (Beam)
327. Bearing--Spherical Rod End (Beam)
330. Bearing--Spherical Rod End (Beam)
340. Bearing--Spherical Rod End (Control Lever)
343. Turnbuckle--Control Lever to Beam
345. Plunger--Operating Solenoid
346. Plunger--Operating Solenoid

14.3.4 GOVERNOR AND THROTTLE CONTROL ADJUSTMENT (RDC CENTRIFUGAL)

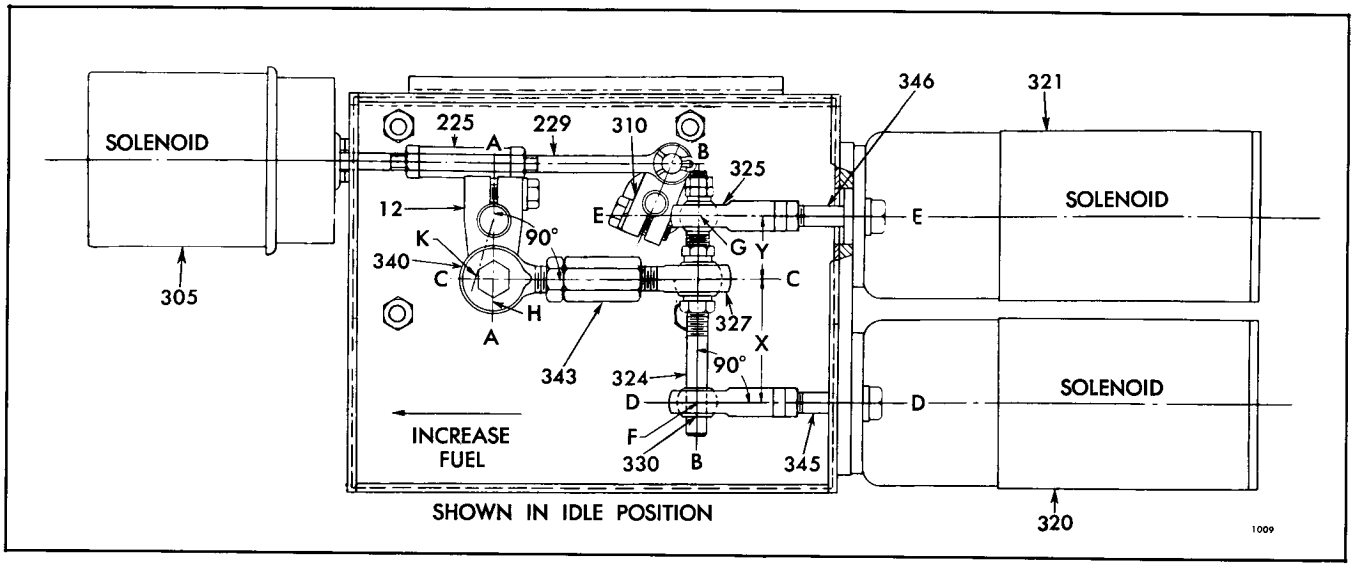


Fig. 7 - Throttle Control Linkage Adjustment Diagram

12. Lever--Throttle Control
225. Turnbuckle--Shut-Down Link to Solenoid
229. Link--Shut-Down
305. Solenoid--Governor Shut-Down
310. Lever--Shut-Down Control
320. Solenoid--Throttle Operating
321. Solenoid--Throttle Operating
324. Beam--Throttle Control Operating
325. Bearing--Spherical Rod End (Beam)
327. Bearing--Spherical Rod End (Beam)
330. Bearing--Spherical Rod End (Beam)
340. Bearing--Spherical Rod End (Control Lever)
343. Turnbuckle--Control Lever to Beam
345. Plunger--Operating Solenoid
346. Plunger--Operating Solenoid

10. Replace plug in receptacle on transmission wiring harness.

11. Reconnect the shut-down solenoid lead wire to No. 11 terminal on the left junction block, see Figs. 2 and 3 of Section 7.4.4.

12. Pull reset handle to open air shut-down valve, then start engine.

13. Place throttle controller in No. 4 position. The engine stall speed should now be 1650 $\pm$ 50 r.p.m. If the engine stall speed falls short of this speed, recheck the maximum free engine speed. If the maximum free engine speed is correct, this may indicate that the engine does not produce full horsepower.

    CAUTION: Do not operate the engine with controller in No. 4 position longer than 20 seconds with the transmission stalled. Drive oil temperature should not exceed 250°F., any temperature in excess of this may be harmful to the torque converter of the transmission.

14. Do not install the generator fuse in regulator locker until the engine intermediate speed adjustment is performed.

Adjust Engine Intermediate Speeds

The engine intermediate speeds may be adjusted so that the engine or engines will be synchronized in their operation as follows:

1. Set car hand brake and air brakes, if not previously set.

   NOTE: As a safety precaution while making the following tests, we recommend that a second man, familiar with the car controls, stay in the cab, or the wheels of the car be securely blocked to prevent car movement should the brakes fail.

2. Pull reset handle to open the air shut-down valve.

3. Start engine and warm up to operating temperature.

4. Place the reverse gear controller (in the engineer's cab) in the forward position.

5. Check and adjust engine stall speeds as follows:

   a. Controller in NEUTRAL position: check engine no-load idle speed (750 r.p.m.).

   b. Controller in No. 1 position: check engine idle stall speed (705 $\pm$ 5 r.p.m.).

   c. Controller in No. 2 position: check engine stall speed (1185 $\pm$ 5 r.p.m.).

d. Controller in No. 3 position: check engine stall speed (1460 ± 40 r.p.m.).

e. Controller in No. 4 position: check engine stall speed (1650 ± 50 r.p.m.).

CAUTION: Do not operate the unit in excess of 20 seconds in the higher throttle positions to prevent the drive oil temperature from exceeding 250° F., otherwise the transmission high oil temperature switch will shut the engine down. Temperatures in excess of 250° F. may cause damage within the transmission.

NOTE: If the engine maximum stall speed is low or excessively high, refer to "Trouble Shooting - Transmission" in Section 9.9.0 and "Trouble Shooting - Engine" in Section 15.2.

6. Place throttle controller in No. 2 position and adjust engine speed, if necessary, by moving rod end bearing (327) along the operating beam (324) and by loosening one and tightening the other operating beam adjusting nut until a speed of 1185 ± 5 r.p.m. is obtained.

7. Place throttle controller in NEUTRAL position and readjust idle speed to 750 r.p.m., if necessary.

8. Place throttle controller in No. 2 position and recheck engine speed (1185 ± 5 r.p.m.).

NOTE: Steps 6, 7 and 8 must be repeated until the desired speeds are obtained.

9. Place throttle controller in No. 3 position and check engine speed (1460 ± 40 r.p.m.).

NOTE: The engine stall speeds in No. 2 and No. 3 positions may be varied from the settings given above, if desired, to suit the existing operating conditions. Moving the rod end bearing (327) along the operating beam (324) changes the engine speed for No. 2 and No. 3 controller positions.

10. Repeat all the above steps on the second engine. The engine speeds for the various controller positions should be within 10 r.p.m. on each of the two engines in No. 2 throttle positions.

11. Install generator fuse in regulator locker.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, proceed with engine tune-up as follows:

Adjust Governor Gap

1. With engine stopped, remove governor cover.
2. Place speed control lever (21), Fig. 1, in the FULL FUEL position.
3. Insert a .006'' feeler gage between the spring plunger (44) and the plunger guide (37). If required, loosen lock nut (29) and turn adjusting screw (28) in or out until a slight drag is noted on the feeler gage.
4. Hold adjusting screw and tighten lock nut. Check gap and, if necessary, readjust.
5. Install governor cover.

Position Injector Rack Control Levers

The position of the injector 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 No. 6 injector rack control lever (267) first to establish a guide for adjusting the remaining rack control levers.

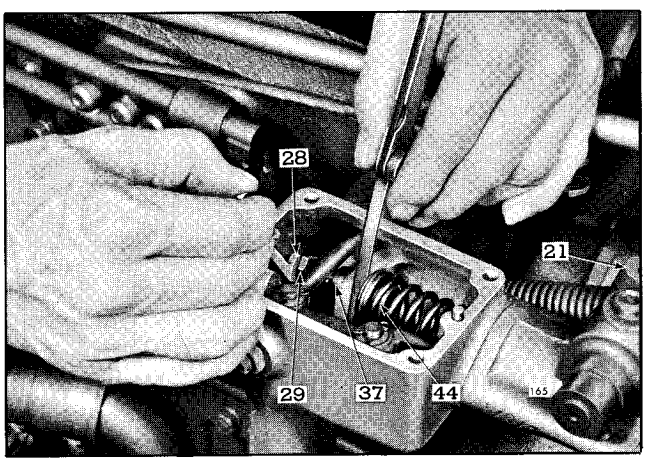


Fig. 1 - Adjusting Governor Gap

21. Lever--Speed Control
28. Screw--Gap Adjusting
29. Lock Nut
37. Guide--Plunger
44. Plunger--Variable Speed Spring

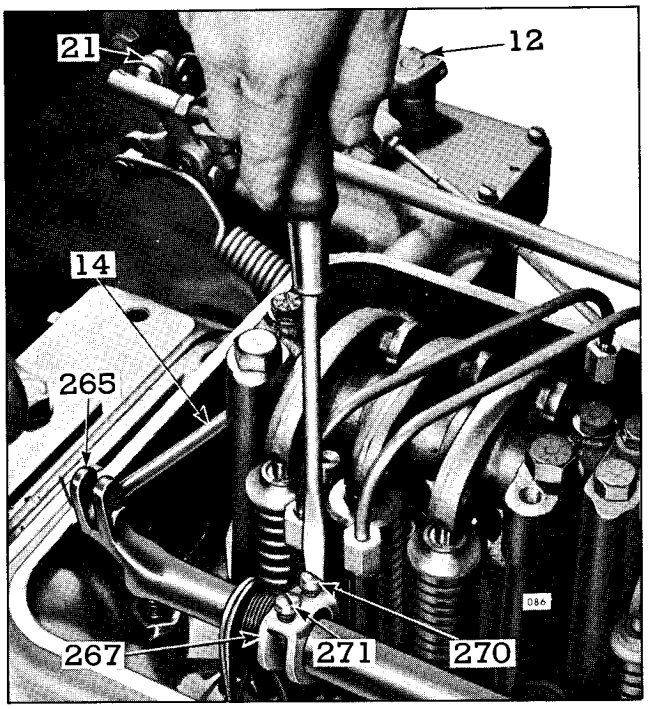


Fig. 2 - Positioning No. 6 Injector Rack Control Lever

12. Lever--Governor Control
14. Rod--Fuel
21. Lever--Speed Control
265. Lever--Injector Control Tube
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)

1. Refer to Fig. 2 and disconnect any linkage attached to control lever (12).
2. Refer to Fig. 3 and loosen lock nut (58) and back out buffer screw (57) approximately 3/8''.
3. Loosen inner and outer adjusting screws (270) and (271), Fig. 2, on each injector rack control lever (267). Be sure all injector rack control levers are free on the injector control tube.
4. Place governor control lever (12) in the RUN position and speed control lever (21) in the FULL FUEL position. Turn inner adjusting screw (270) down until a slight movement of the injector control tube lever (265) is observed. Turn outer adjusting screw (271) down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

   Check for a slight movement of the injector control tube lever (265). This movement should not exceed .005''.

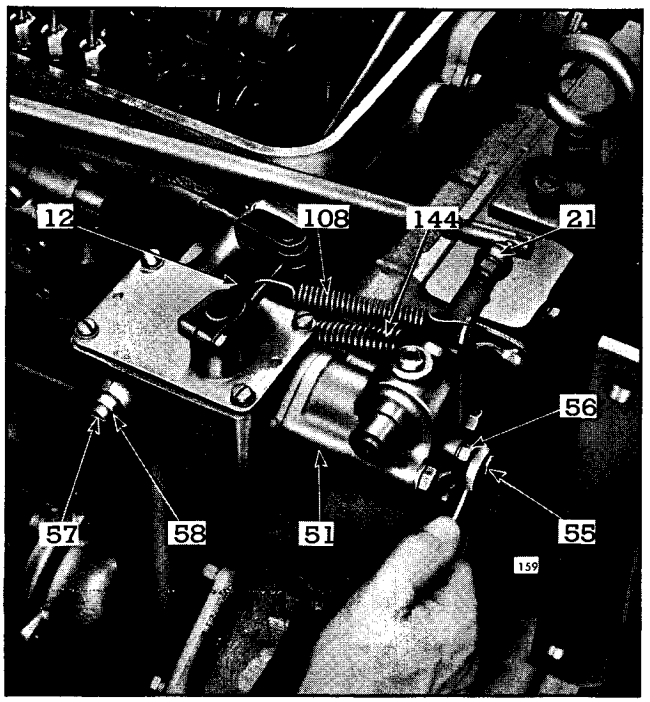


Fig. 3 - Adjusting Engine Idle Speed

12. Lever--Governor Control
21. Lever--Speed Control
51. Housing--Variable Speed Spring
55. Screw--Idle Speed Adjusting
56. Lock Nut
57. Screw--Buffer
58. Lock Nut
108. Spring--Lever Retracting
144. Spring--Variable Speed Booster

If no movement is observed, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

If the movement exceeds that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten inner adjusting screw.

On engines with a two valve cylinder head, when the setting is correct, the tang on the injector rack will contact the injector body and still maintain the movement specified in Item 5.

On engines with a four valve cylinder head, when the setting is correct, the injector rack will be snug on the ball end of the rack control lever and still maintain the movement specified in Item 5.

After No. 6 injector rack control lever has been correctly positioned, do not change its setting while positioning the remaining rack control levers.

5. Disconnect fuel rod (14) from injector control tube lever (265).

6. While manually holding the injector control tube lever (265) in the FULL FUEL position, position No. 5 injector rack control lever by turning inner adjusting screw (270) down until No. 5 injector rack control lever is in the FULL FUEL position. Tighten outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws until tight.

   On a two valve cylinder head, when the settings are correct, the tang on both injector rack control levers must be contacting their respective injectors.

A method of determining whether both injector rack control levers are contacting the injectors is outlined below:

   a. Place a feeler gage between No. 6 injector rack control lever and the injector.

   b. Place another feeler gage of the same thickness between No. 5 injector rack control lever and the injector.

   c. Then while holding injector control tube lever (265) in the FULL FUEL position, move each feeler gage, noting the drag on the feelers. The force required to move either feeler gage should be equal.

   NOTE: Should No. 5 injector rack control lever, or any other, not have the same drag on the feeler gage as No. 6, readjust the inner and outer adjusting screws of the particular injector rack control lever being worked on. Never, under any circumstances, alter the setting of No. 6 injector rack control lever.

   On a four valve cylinder head, when the settings are correct, the rack of both injectors must be snug on their respective rack control levers.

7. Position the remaining injector rack control levers as outlined above.

8. Connect fuel rod (14) to injector control tube lever (265).

9. Reconnect linkage to control lever (12).

Adjust Maximum No-Load Speed

The maximum no-load speed on units equipped with variable speed governors must not be less than 125 r.p.m. or more than 150 r.p.m. above the recommended full load speed.

The preferred method for checking the engine r.p.m. is by use of an accurate hand tachometer.

If required, make the following adjustments:

1. Refer to Fig. 3 and disconnect booster spring (144) from speed control lever (21) and retracting spring (108) from control lever (12).

2. Remove two bolts and withdraw variable speed spring housing (51) and also variable speed spring plunger.

3. Refer to table below and determine the stops and shims required for the desired no-load speed.

No-Load Speed	Stops	Shims
1200 to 1450 r.p.m.	2	Up to .325"
1451 to 1850 r.p.m.	1	Up to .325"
1851 to 2000 r.p.m.	0	Amount required to get necessary speed

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

5. Add shims as required.

   Governor shims are available in .010'' and approximately .078''.

   NOTE: If the maximum no-load speed is raised or lowered more than 50 r.p.m. by the installation or removal of the governor shims, the governor gap should be rechecked.

Adjust Idle Speed

The recommended idle speed is 500 r.p.m. but may vary with special engine applications.

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. Place governor control lever (12) in the RUN position and the speed control lever (21) in the IDLE position as shown in Fig. 3.

2. With the engine operating, loosen lock nut (56). Turn idle adjusting screw (55) until engine is operating at approximately 15 r.p.m. below the recommended idle speed.

3. Hold idle screw and tighten lock nut.

Adjust Buffer Screw

With idle speed properly adjusted, the buffer screw may be adjusted as follows:

1. Turn buffer screw (57) IN until engine runs at the recommended idle speed.

   Do not raise the engine idle speed more than 15 r.p.m. with the buffer screw.

2. Hold buffer screw and tighten lock nut.

Adjust Booster Spring

With idle speed set, the throttle booster spring may be adjusted as follows:

1. Refer to Fig. 3 and loosen booster spring retaining nut on speed control lever (21). Loosen nut and lock nut on eyebolt at opposite end of spring (144).

2. Set bolt in spring hanger lever to form a straight line with center of governor speed control shaft in variable speed spring housing and eyebolt at opposite end of spring. Tighten lock nut.

3. Turn nut on eyebolt until speed control lever will not return to IDLE speed position when released. Then, back off nut until lever will return to IDLE position when released and tighten nut.

HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, proceed with engine tune-up as follows:

Adjust Fuel Rod

1. Remove governor cover. Refer to Fig. 2 and loosen all inner adjusting screws (270) and outer adjusting screws (271). Be sure all injector rack control levers (267) are free on the injector control tube.

2. Loosen fuel rod lock nut (16), Fig. 1, and remove fuel rod knob.

3. Turn lock nut to a position so that 3/16'' of the fuel rod extends beyond the nut. Install fuel rod knob and tighten lock nut.

Position Injector Rack Control Levers

With fuel rod properly adjusted, the injector rack control levers may be adjusted as follows:

1. Turn outer adjusting screw (271), Fig. 2, in until a slight movement of the injector control tube lever (265) is observed. Tighten inner adjusting screw (270).

2. Pull out on fuel rod and check for 1/32'' to 1/16'' movement.

   If movement exceeds that specified, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

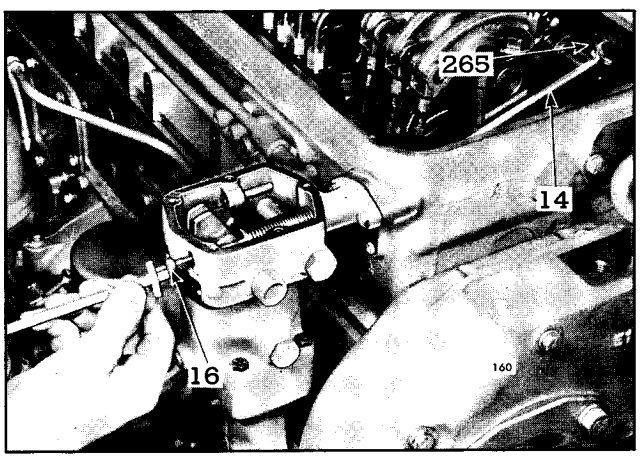


Fig. 1 - Adjusting Fuel Rod

14. Rod--Fuel
16. Lock Nut
265. Lever--Injector Control Tube

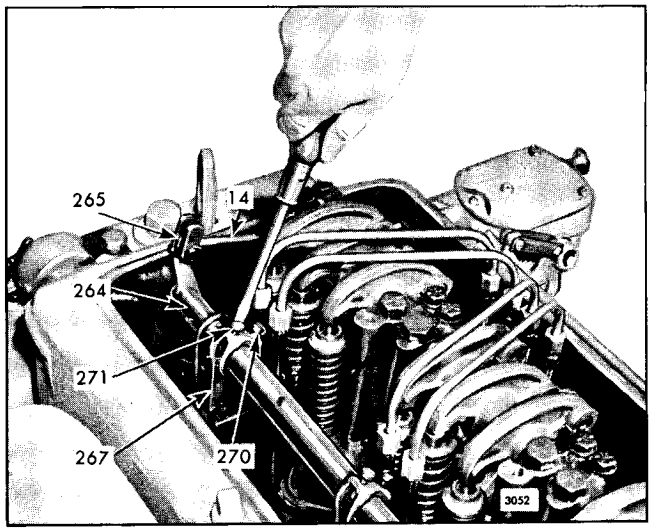


Fig. 2 - Positioning No. 6 Injector Rack Control Lever

14. Rod--Fuel
264. Tube--Injector Control
265. Lever--Injector Control Tube
267. Lever--Injector Rack Control
270. Screw--Control Lever Adjusting (Inner)
271. Screw--Control Lever Adjusting (Outer)

   If movement is less than that specified, back off outer screw approximately 1/8 of a turn and tighten inner adjusting screw.

3. Disconnect fuel rod (14) from injector control tube lever (265).

4. While manually holding No. 6 injector rack in the FULL FUEL position, position No. 5 injector rack control lever by turning inner adjusting screw (270) down until No. 5 injector rack control lever is in the FULL FUEL position. Tighten outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

   On a two valve cylinder head, when the settings are correct, the tang on both injector rack control levers must be contacting their respective injectors.

A method of determining whether both injector rack control levers are contacting the injectors is outlined below:

   a. Place a feeler gage between No. 6 injector rack control lever and the injector.

   b. Place another feeler gage of the same thickness between No. 5 injector rack control lever and the injector.

c. Then, while holding injector control tube lever (265) in the FULL FUEL position, move each feeler gage, noting the drag on the feelers. The force required to move either feeler gage should be equal.

NOTE: Should No. 5 injector, or any other, not have the same drag on the feeler gage as No. 6, readjust the inner and outer adjusting screws of the particular injector rack control lever being worked on. Never, under any circumstances, alter the setting of No. 6 injector rack control lever.

On a four valve cylinder head, when the settings are correct, the rack of both injectors must be snug on their respective rack control levers.

5. Position the remaining rack control levers as outlined above.
6. Connect fuel rod (14) to injector control tube lever (265).

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

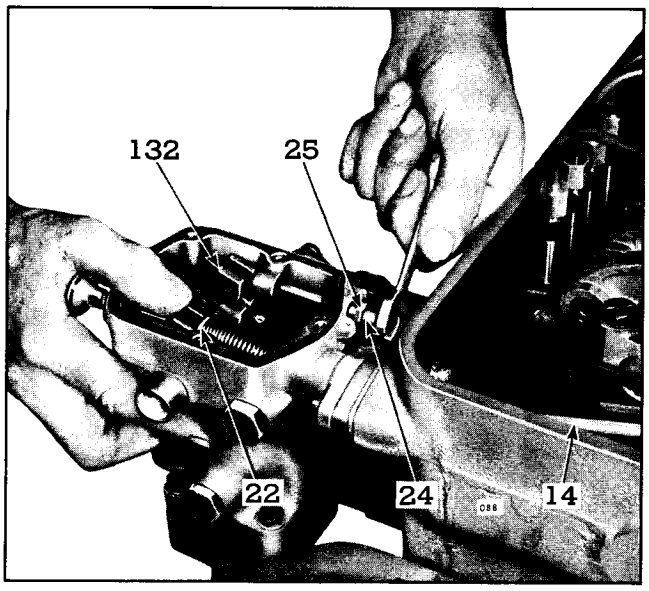


Fig. 3 - Adjusting Load Limit

14. Rod--Fuel
22. Collar--Fuel Rod
24. Screw--Load Limit Adjusting
25. Lock Nut
132. Lever--Terminal

1. Place fuel rod (14) and terminal lever (132) in the FULL FUEL position as shown in Fig. 3.
2. Loosen lock nut (25). Turn adjusting screw (24) until a .020'' space exists between the fuel rod collar (22) and the terminal lever (132). Hold screw and tighten lock nut.

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 readjusted.

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, the fuel rod, injector rack control levers, and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start engine and run 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 lock nut (73), Fig. 5, and back off maximum speed adjusting screw (72) approximately 5/8''.
4. Refer to Fig. 4 and loosen droop adjusting bolt (62). Move bracket (61) so that bolt is midway between ends of slot in bracket. Tighten bolt.

   Be sure the bracket remains on the shoulder of the terminal lever.

5. With the throttle in 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 engine speed after 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 engine and again loosen bolt (62) and move droop adjusting bracket IN toward the engine. Tighten bolt. To increase the speed droop, move droop adjusting bracket OUT, away from 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 engine no-load and full-load speeds shown in the following table.

Full-Load	No-Load
50 cycles 1000 r.p.m.	52.5 cycles 1050 r.p.m.
60 cycles 1200 r.p.m.	62.5 cycles 1250 r.p.m.
50 cycles 1500 r.p.m.	52.5 cycles 1575 r.p.m.
60 cycles 1800 r.p.m.	62.5 cycles 1875 r.p.m.

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

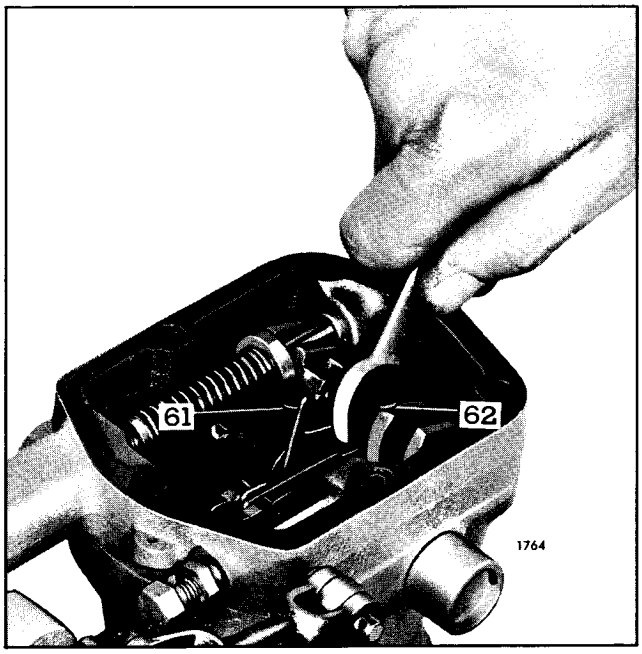


Fig. 4 - Adjusting Speed Droop

61. Bracket--Droop Adjusting 62. Bolt

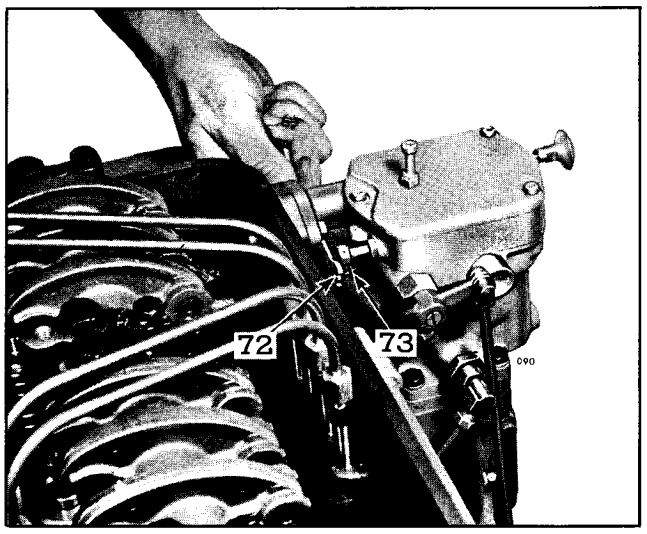


Fig. 5 - Adjusting Maximum No-Load Speed

72. Screw--Maximum Speed Adjusting 73. Lock Nut

Adjust Maximum No-Load Speed

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

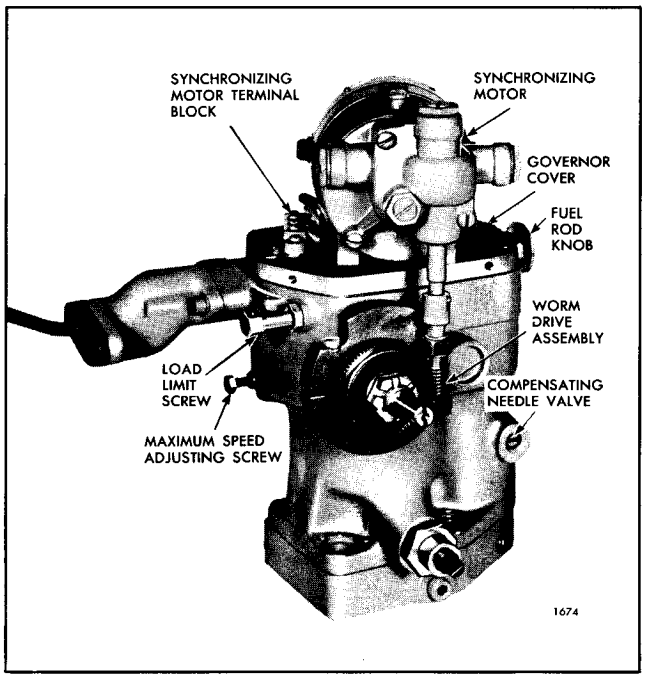


Fig. 6 - Typical Synchronizing Motor Mounting and Drive Assembly

1. With engine operating at no-load, adjust engine speed until engine is operating at approximately 10% higher than the rated full-load speed.

2. Turn maximum speed adjusting screw (72), Fig. 5, in until engine is operating approximately 8% above the rated full-load speed.

3. Hold screw and tighten lock nut (73). Install governor cover.

Governors with Synchronizing Motor

On some hydraulic governors, a reversible electric synchronizing motor is mounted on the governor cover, see Fig. 6. This motor permits close adjustment of engine speed by remote control. This feature is especially valuable when synchronizing two generators from a central control panel.

When the two-way control switch for the unit on the central control panel is closed by the operator, the motor shaft turns the governor speed adjusting shaft by means of the reduction gear and slip coupling. The direction of rotation (clockwise or counterclockwise) is dependent upon the position of the switch. When the desired engine speed is indicated on a tachometer or frequency meter on the panel, the operator returns the switch to the "OFF" position.

Should switch be held in the "Lower Speed" position too long, the synchronizing motor will continue to lower the unit speed until it ultimately shuts the engine down. Should switch be held too long in the "Raise Speed" position, the motor will turn the governor shaft until the shaft strikes the maximum speed adjusting screw, after which the clutch will slip and the motor will continue to run at a slightly reduced speed without further effect.

The adjustments on the governor equipped with a snychronizing motor are the same as on units without a synchronizing motor. The synchronizing motor is used in place of the vernier throttle control knob to raise and lower the engine speed.

The governor cover and motor assembly must be removed when setting the engine droop. The desired engine speeds may be obtained by manually turning the worm drive while the cover is removed.

DUAL HYDRAULIC WOODWARD SGT GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

This dual hydraulic governor is used on certain torque converter applications.

The governor, Figs. 1 and 2, is a compound governor assembly and consists of two sections; one driven conventionally by the engine, and one driven by the torque converter output shaft through a flexible shaft.

The engine governor section has its own floating lever assembly, ball head assembly, pilot valve and spring seat assembly, speeder spring, and droop adjusting bracket assembly. In addition, this section, similar in most respects to the standard hydraulic governor, has a larger oil pressure pump than the standard governor in order to supply sufficient oil to both sections of the governor.

The output shaft governor section also incorporates its own floating lever assembly, ball head assembly, pilot valve and spring seat assembly, speeder spring, and droop adjusting bracket assembly. This section also incorporates an "anti-stall" feature to prevent the output shaft governor from shutting the fuel completely off when the output shaft is rotating at a speed greater than the no-load speed setting of the output shaft governor. Any free falling load such as a loaded clam bucket or a dragline could cause overspeeding of the output shaft. For example, assuming that the operator has placed the remote engine throttle control and the remote output shaft throttle control in the idle and low speed positions respectively; and, that an external force is causing the output shaft to rotate at a speed in excess of the output shaft speed setting -- the weights of the ball head assembly will tend to lift the pilot valve toward the "closed" position. The anti-stall lever, however, will restrict the upward movement of the anti-stall rod, which in turn will limit the upward movement of the pilot plunger. Therefore, the output shaft governor pilot valve will remain in partially open position regardless of the

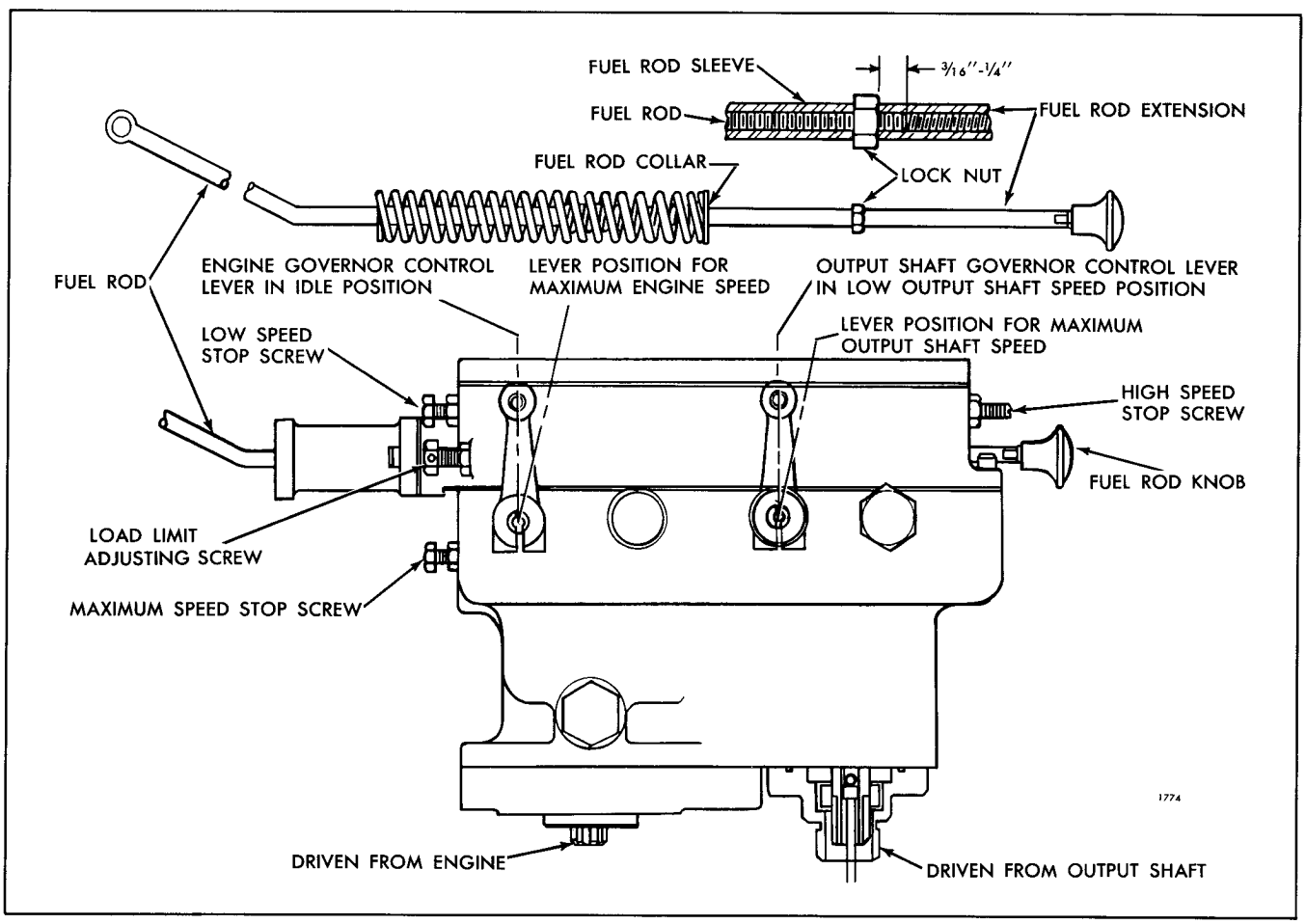


Fig. 1 - Two Lever Dual Hydraulic Governor Assembly

14.7.3 DUAL HYDRAULIC GOVERNOR

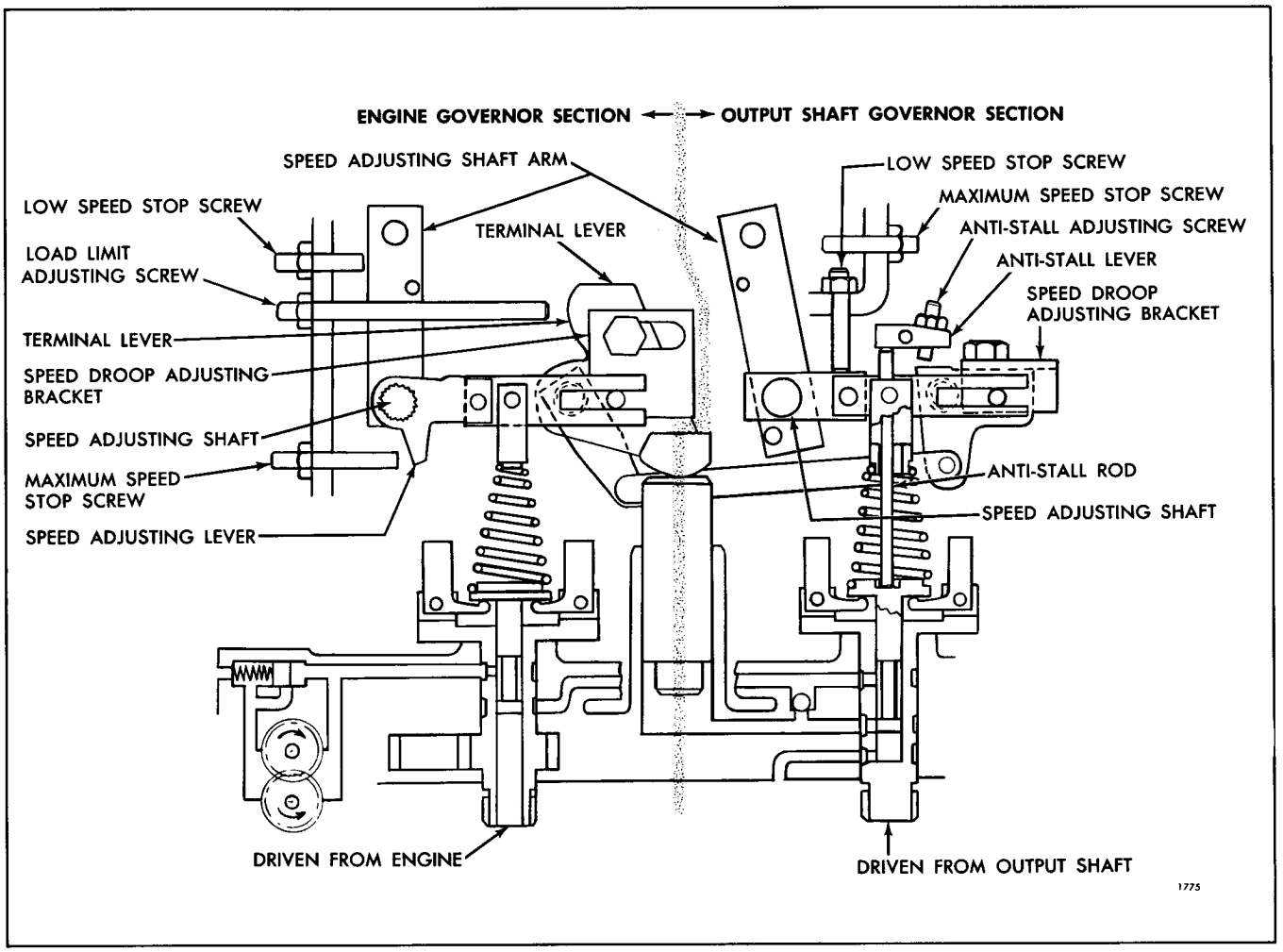


Fig. 2 - Schematic Diagram of Two Lever Governor Assembly

remote output shaft throttle lever setting or the output shaft speed, and thus permit the engine governor to exercise control of the engine in the idle speed range.

The path of the oil, within the governor, is from the pump through the engine governor pilot valve to the output shaft governor pilot valve, then to a single common servo piston. The servo piston operates a conventional terminal lever which in turn controls the position of the fuel rod connected to the injector racks. In general, the governor which has the lowest speed setting will control the fuel rod or fuel input to the engine.

In most applications, such as shovels, drag lines, graders, etc., it is desirable to have the output shaft governor control the fuel input in order to maintain a relatively constant output shaft speed. The output shaft speed will be constant up to full power of the engine except for the amount of the governor droop. For these applications, the speed setting of the engine governor must be higher than the speed setting of the output shaft governor in order that the engine governor will not reduce the fuel input to the engine before full power is demanded by the output shaft governor. As load is applied on the output shaft, the output shaft speed will decrease gradually up to the amount of the output shaft governor droop at full load. At the same time, the engine speed will gradually increase until full load is reached. This amount will be 300 to 1000 r.p.m. above the no-load output shaft speed. The higher the no-load output shaft speed, the less the differential. This amount of engine speed increase above the no-load output shaft speed will vary with the no-load output shaft speed setting, the engine horsepower, and the type of converter used. The engine governor speed setting must, therefore, be equal to the no-load output shaft speed setting plus the amount of engine speed increase plus the engine governor droop.

In some types of operations, such as setting steel, it is desirable to operate the unit with a very low

output shaft speed. This speed could be so low that the output shaft governor ball head assembly would not actuate the output shaft governor pilot valve and spring seat assembly. In such applications, the engine governor control lever would be moved toward the idle speed position sufficiently to provide the desired low output shaft speed. Output shaft speeds down to zero can be obtained through this type of engine governor control. The engine governor would maintain control unless the output shaft speed increased to the speed setting of the output shaft governor.

When it is necessary to stop the engine, pull outward (away from the engine) on the fuel rod knob.

Adjustments

Before changing any of the following settings, be sure that adjustment is necessary.

Adjustments should be made only after the engine reaches normal operating temperature.

The injector racks, injector control tube, and remote control linkage should be checked for freedom of movement before adjusting the governor.

Adjust Fuel Rod (Engine Stopped)

1. Remove governor cover. Refer to Fig. 2 of Section 14.7.1 and loosen all inner adjusting screws (270) and outer adjusting screws (271). Be sure all injector rack control levers (267) are free on the injector control tube.

2. Loosen lock nut on engine governor load limit adjusting screw, Fig. 1. Back the screw out until end of screw is flush with face of boss and tighten lock nut.

3. Loosen fuel rod lock nut and unscrew shut-down knob and rod extension.

4. Turn lock nut so that 3/16'' to 1/4'' of the fuel rod extends beyond nut.

5. Replace fuel rod extension and knob, and tighten extension against lock nut.

Position Injector Rack Control Levers (Engine Stopped)

The position of the injector 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 No. 6 injector rack control lever (267), Fig. 2 of Section 14.7.1, first to establish a guide for adjusting the remaining rack control levers.

With fuel rod properly adjusted, the injector rack control levers may be adjusted as follows:

1. Turn outer adjusting screw (271), Fig. 2 of Section 14.7.1, in until a slight movement of the injector control tube lever (265) is observed. Tighten inner adjusting screw (270).

2. Pull out on fuel rod and check for 1/32'' to 1/16'' movement.

   If movement exceeds that specified, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

   If movement is less than that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten inner adjusting screw.

3. Disconnect fuel rod (14) from injector control tube lever (265).

4. While manually holding No. 6 injector control rack in the FULL FUEL position, position No. 5 injector rack control lever by turning inner adjusting screw (270) down until No. 5 injector rack control lever is in the FULL FUEL position. Tighten outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

   On a two valve cylinder head when the settings are correct, the tang on both injector rack control levers must be contacting their respective injectors.

A method of determining whether both injector rack control levers are contacting the injectors is outlined below.

a. Place a .002'' feeler gage between No. 6 injector rack control lever and the injector.

b. Place another feeler gage of the same thickness between No. 5 injector rack control lever and the injector.

c. Then, while holding injector control tube lever (265) in the FULL FUEL position, move each feeler gage noting the drag on the feelers. The force required to move either feeler gage should be equal.

   NOTE: Should No. 5 injector, or any other, not have the same drag on the feeler gage as No. 6, readjust the inner and outer adjusting screws of the particular injector rack control lever being worked on. Never, under

any circumstances, alter the setting of No. 6 injector rack control lever.

On a four valve cylinder head, when the settings are correct, the rack of both injectors must be snug on their respective rack control levers.

5. Position the remaining rack control levers as outlined above.

6. Connect fuel rod (14) to injector control tube lever (265).

Adjust Load Limit (Engine Stopped)

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place fuel rod and terminal lever in the FULL FUEL position (some improvised method may be employed to hold the fuel rod in FULL FUEL position.)

2. Loosen lock nut on load limit adjusting screw. Turn adjusting screw until .020'' gap exists between terminal lever and fuel rod collar. Hold screw and tighten lock nut.

Adjust Engine Governor (Engine Stopped)

1. Loosen lock nut and back out output shaft governor maximum speed stop screw until it extends approximately 1'' from face of lock nut when nut is tight against housing.

2. Back out output shaft governor anti-stall adjusting screw until 1/2'' of threads project from anti-stall lever.

3. Loosen output shaft governor low speed stop screw lock nut and turn screw until 5/16'' of threads project from upper face of lock nut when nut is tight against governor body. The weights of the output shaft governor ball head assembly should be fully collapsed. This ensures control of the engine by the engine governor since tension on the output shaft governor speeder spring will hold the output shaft governor pilot valve plunger in an open position, thus permitting the oil passing through the engine governor pilot valve to activate the servo piston.

4. Disconnect output shaft governor drive shaft at governor.

5. Position engine governor droop bracket so that adjusting screw is an equal distance from both ends of slot.

Adjust Engine Governor Speeds and Droop (Engine Running)

1. Start and thoroughly warm up engine.

2. Loosen lock nut on engine governor maximum speed stop screw, and turn screw until 5/8'' of screw projects from face of lock nut when nut is tight against governor body.

3. Position governor control lever, using remote throttle control, so that the engine is running at the specified maximum no-load speed, usually shown on the unit name plate. Then turn the maximum speed stop screw until it contacts the speed adjusting lever. Tighten lock nut.

4. Loosen lock nut on engine governor low speed stop screw and run screw out until 3/4'' of screw projects from governor body when nut is tight against governor body.

5. Position governor control lever, using remote throttle control, so that the engine is running at the specified no-load (minimum) speed (idle). Then, turn in low speed stop screw until it contacts the governor speed adjusting shaft arm. Tighten lock nut.

   NOTE: Idle speed should be at least 500 r.p.m.

6. Adjust the governor speed droop bracket, if necessary, to obtain the minimum droop to stabilize engine. A decreasing engine speed as load is picked up, and an increasing speed as load is dropped off is called droop. Insufficient droop will cause ''hunting'' or ''surging'' and result in an unstable engine. It must be remembered, however, that a stable engine may surge three or four times before stabilizing. Moving droop bracket toward engine decreases, and away from engine increases amount of droop. Stop engine.

Adjust Output Shaft Governor (Engine Running)

1. Connect flexible drive shaft to output shaft governor. Set output shaft governor droop bracket in 1/2 position. Start engine. Then ascertain that the ball head assembly of the output shaft governor is turning.

2. Position engine governor control lever, using remote throttle control, in maximum engine speed position.

3. Loosen output shaft governor low speed stop screw lock nut and back out the screw until the desired minimum output shaft no-load speed is obtained. Tighten lock nut.

4. Reconnect output shaft remote throttle linkage and position output shaft governor control lever, using remote throttle control, so that the output shaft is running at the maximum speed desired (usually shown on one of the unit name plates); then turn output shaft governor maximum speed stop screw until it contacts the output shaft governor speed adjusting shaft arm. Tighten lock nut.

5. Adjust the output shaft governor speed droop bracket, if necessary, to obtain the minimum droop while maintaining engine stability. Moving bracket toward engine decreases, and away from engine increases amount of droop. Recheck speeds if droop bracket has been moved.

6. Position output shaft governor control lever in the minimum speed position while maintaining the engine governor control lever in its maximum speed position. Turn anti-stall screw until anti-stall lever just contacts the anti-stall rod. This can be checked by pressing lightly on the outer end of the anti-stall lever (side opposite screw) with a screw driver. The screw will be adjusted correctly when a slight increase in output shaft speed is noted when the lever is depressed slightly with screw driver.

7. Install governor cover.

THROTTLE LINKAGE ADJUSTMENT FOR LOAD EQUALIZATION—TWIN UNITS

Each twin unit consists of two engines connected by clutches to a common gear box. The object of the throttle adjustment is to make each engine of the twin unit carry its share of the load.

THROTTLE LINKAGE ADJUSTMENT FOR LOAD EQUALIZATION ON SIDE-BY-SIDE TWIN UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

Before adjusting the throttle linkage on the twin unit, the individual engines of the unit must be tuned up. The adjustments listed below must be performed on each engine in the order presented.

All adjustments must be made with engines at normal operating temperature. Engines must be in good operating condition. If one or both engines has low compression, faulty injectors, or other causes of low power, it may be impossible to obtain proper load distribution.

Refer to Figs. 1 and 2 and disconnect rod end bearings (303) at each governor control lever (21) by removing attaching bolt (307) and nut (308), then perform the following steps:

I. Adjust Exhaust Valve Clearance.

II. Time Fuel Injectors.

III. Adjust Governor Gap.

IV. Position Injector Racks.

V. Adjust Maximum No-Load Speed.

VI. Adjust Idle Speed.

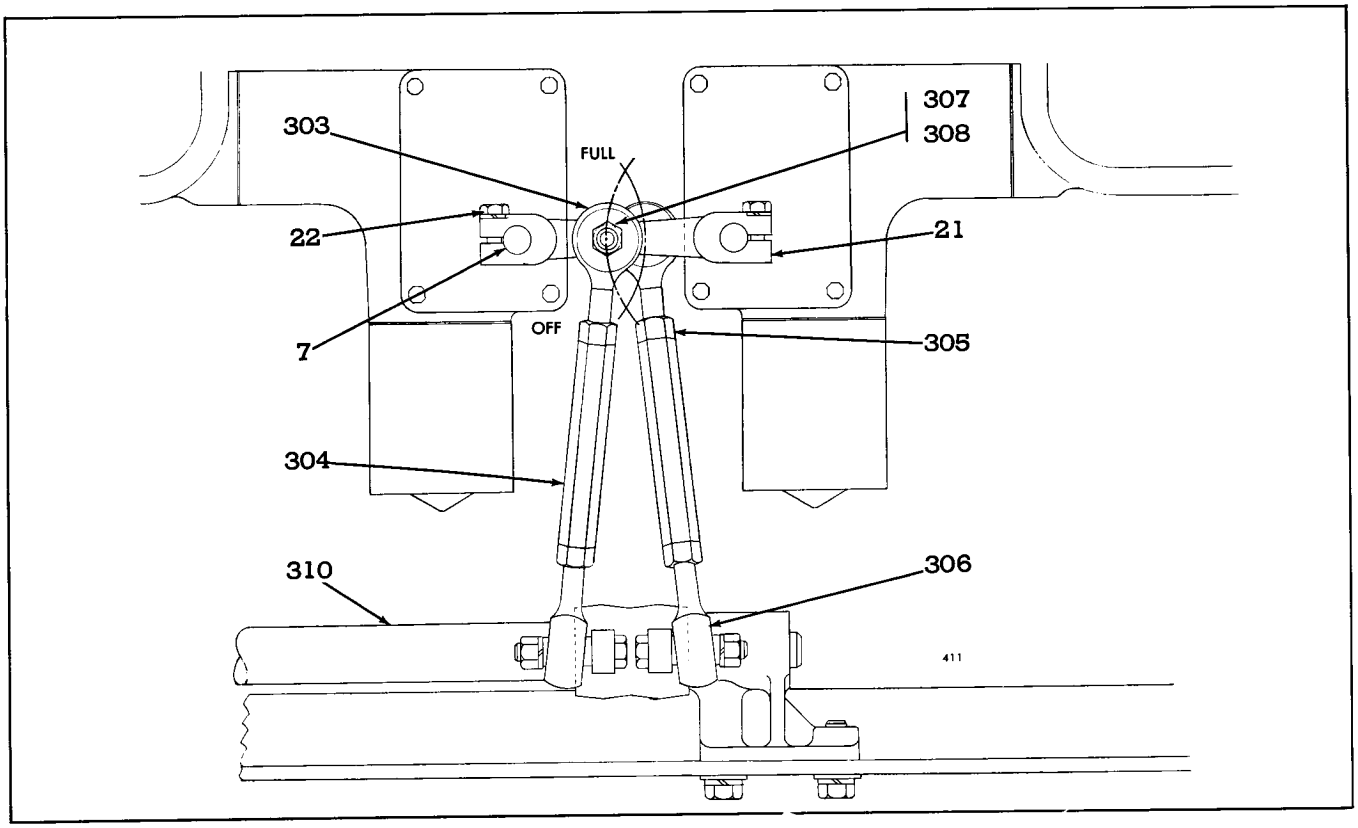


Fig. 1 - Throttle Control Linkage Diagram (Side-by-Side Unit)

7. Shaft--Throttle Control
21. Lever--Throttle Control
22. Bolt--Throttle Control Lever
303. Bearing--Rod End
304. Turnbuckle--Throttle Control
305. Nut--Lock
306. Bearing--Rod End
307. Bolt
308. Nut
310. Tube--Throttle Control Shaft

14.8.1 THROTTLE LINKAGE ADJUSTMENT

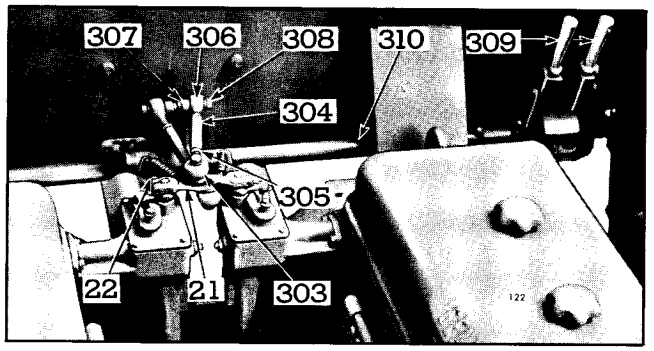


Fig. 2 - Throttle Control Mounting (Side-by-Side Twin Unit)

21. Lever--Throttle Control
22. Bolt--Throttle Control Lever
303. Bearing--Rod End
304. Turnbuckle--Throttle Control
305. Nut--Lock
306. Bearing--Rod End
307. Bolt
308. Nut
309. Lever--Throttle Control (Twin)
310. Tube--Throttle Control Shaft

VII. Adjust Buffer Screw.

The above adjustments, outlined under "Tune-Up Procedures" of Section 14, should be performed on each engine of the unit in such a manner as to ensure uniformity between the two engines.

VIII. Throttle Linkage Adjustment.

With engine stopped and with throttle linkage mechanism well lubricated and free of any bind, refer to Figs. 1 and 2 and perform the following adjustments on both engines:

1. Disconnect linkage from the remote throttle control lever.
2. Engage the individual engine throttle control levers (309) to the master throttle control lever.
3. Lock the master throttle control lever (which controls the individual engine throttle control levers) so that levers connecting throttle control shaft tube (310) to rod end bearings (306) are in a vertical position.
4. If not previously disconnected, remove throttle control lever to rod end bearing attaching bolts (307) at control levers (21).
5. Place the throttle control levers (21) in the IDLE position (the IDLE detent position is about halfway in the travel of the throttle control levers between STOP and FULL FUEL positions), then loosen the clamp screw (22) of both throttle control levers.
6. Make sure that the throttle shafts (7) remain in the IDLE detent position, rotate the control levers (21) so that they are in line and one above the other. Then, tighten the lever bolts (22).
7. Loosen the turnbuckle lock nuts (305) and adjust the turnbuckles (304) so bolts (307) in rod end bearings (303) are in line with holes in levers (21). Then, install lock washers and nuts (308) on bolts (307) and secure rod end bearings to levers. Tighten lock nuts (305) on turnbuckles.
8. With all linkage connected and with individual throttle control levers locked into quadrant, move the master throttle control lever into the FULL FUEL position and lock in place. It is important that each governor control lever reaches the FULL FUEL position simultaneously. However, due to various tolerances, both governor control levers, after having been set together in the IDLE position, may not reach the FULL FUEL position simultaneously. In order to check this condition, unlock individual throttle control levers from quadrant and check to ascertain if either lever can be moved closer to the FULL FUEL position. If necessary, readjust one turnbuckle to bring both governor control levers to the FULL FUEL position simultaneously. Tighten turnbuckle lock nuts (305) and return master throttle control lever to IDLE position.
9. Start engines and warm up to normal operating temperature. Check maximum no-load speed of each engine (clutches disengaged). This speed may be checked by holding an accurate hand tachometer against the end of output shaft and converting reading as required by ratio of transmission. Maximum no-load speed of the two engines should be the same as previously set in Step V above, and should be the same on both engines. If speeds differ over 25 r.p.m. from previously set maximum no-load speed, first recheck throttle adjustment, then recheck maximum no-load speed. If speeds still differ, recheck individual engine tune-up.
10. Move the master control lever to obtain a speed approximately 400 r.p.m. below maximum no-load speed and check the speed on both engines (with clutches disengaged). The speed of the two engines should be within 100 r.p.m. If there is more than 100 r.p.m. difference in speed between the two engines, recheck individual tune-up on both engines.
11. Connect linkage to remote throttle control lever.

THROTTLE LINKAGE ADJUSTMENT FOR LOAD EQUALIZATION ON TANDEM TWIN UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

Before adjusting the throttle linkage on the twin unit, the individual engines of the unit must be tuned up. The adjustments listed below must be performed on each engine in the order presented.

All adjustments must be made with engines at normal operating temperatures. Engines must be in good operating condition. If one or both engines has low compression, faulty injectors, or other similar causes of low power, it may be impossible to obtain proper load distribution.

Refer to Fig. 3 and disconnect throttle control tube (310) from each governor throttle control lever (21) by removing attaching bolts (307) and nuts (308), then perform the following steps:

I. Adjust Exhaust Valve Clearance.

II. Time Fuel Injectors.

III. Adjust Governor Gap.

IV. Position Injector Racks.

V. Adjust Maximum No-Load Speed.

VI. Adjust Idle Speed.

VII. Adjust Buffer Screw.

The above adjustments, outlined under "Tune-Up Procedures" in Section 14, should be performed on each engine in the unit in such a manner as to ensure uniformity between the two engines.

VIII. Throttle Linkage Adjustment.

With engines stopped and throttle control mechanism well lubricated and free of any binds, refer to Fig. 3 and perform the following adjustments on both engines.

1. Engage the individual engine throttle control levers (309) to the master throttle control lever (302).

2. Lock the throttle control levers in the IDLE position.

3. Remove throttle control tube ball joint to governor throttle control lever attaching bolt (307) and nut (308), if not previously disconnected.

4. Loosen governor control lever clamping screw (22), retaining sufficient drag on governor control shaft to rotate the shaft.

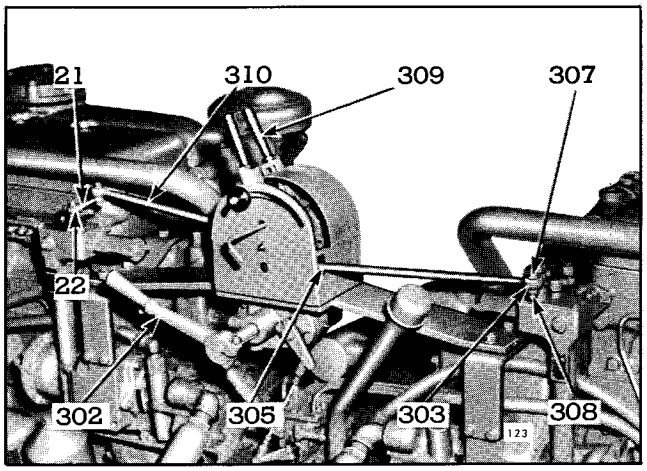


Fig. 3 - Throttle Control Mounting (Tandem Twin Unit)

21. Lever--Throttle Control
22. Bolt--Throttle Control Lever
302. Lever Assy.--Throttle Control (Master)
303. Bearing--Rod End
305. Nut--Lock
307. Bolt
308. Nut
309. Lever--Throttle (Twin)
310. Tube--Throttle Control Shaft

5. Place the governor control levers in the IDLE position.

6. Adjust length of throttle control tube ball joint (303) so bolt hole is aligned with governor lever bolt hole.

7. Making sure that the governor control lever shafts remain in the IDLE position, rotate the governor throttle control levers (21) until bolts (307) can be dropped freely through holes in governor control levers and rod end bearings (303). Then, tighten the governor control lever clamp screws (22), and screw lock washers and nuts (308) on bolts (307).

8. With all linkage connected and with individual throttle control levers locked into quadrant, move the master throttle control lever into the FULL FUEL position and lock in place.

   It is important that each governor control lever reaches the FULL FUEL position simultaneously. However, due to various tolerances, the governor control levers, after having been set together in the IDLE position, may not reach the FULL FUEL position simultaneously. In order to check this condition, unlock the individual throttle control levers from quadrant

and check to ascertain if either lever can be moved closer to the FULL FUEL position. If necessary, readjust one turnbuckle to bring both governor control levers to the FULL FUEL position simultaneously. Tighten turnbuckle lock nuts (305) and return the master throttle control lever to IDLE position.

9. Return throttle control lever for each engine to idle.

10. With the clutches disengaged, move the master throttle control lever (302) to the IDLE position and start each engine.

11. Install the valve rocker covers and warm up engines until they are at their normal operating temperature.

12. Check maximum no-load speed of each engine. This speed may be checked by holding an accurate hand tachometer against the end of output shaft and converting reading as required by ratio of transmission. This speed should be the same as that which was previously set in Step V above, and should be the same on both engines. If the speed differs over 25 r.p.m. from the previously set maximum no-load speed, first recheck throttle adjustment, then recheck maximum no-load speed. If speeds still differ, recheck individual engine tune-up.

13. Move the master control lever to obtain a speed of approximately 400 r.p.m. below maximum no-load speed and check the speed on both engines (with clutches disengaged). The speed of the two engines should be within 100 r.p.m. If there is more than 100 r.p.m. difference in speed between the two engines, recheck individual tune-up on both engines.

THROTTLE LINKAGE ADJUSTMENT FOR LOAD EQUALIZATION ON TANDEM TWIN UNITS USING VARIABLE SPEED MECHANICAL GOVERNORS

Before adjusting the throttle linkage on the twin unit, the individual engines of the unit must be tuned up. The adjustments listed below must be performed on each engine in the order presented.

All adjustments must be made with engines at normal operating temperature. Engines must be in good operating condition. If one or both engines has low compression, faulty injectors, or other similar causes of low power, it may be impossible to obtain proper load distribution.

Refer to Fig. 4 and place master control lever (302) in NEUTRAL position and remove rocker covers. Then, disconnect equalizer links (355) from injector control tube levers (356) and (358). Disconnect throttle control rod from each governor speed control lever (21) by removing clevis pin (361) from clevis (360), then perform the following steps:

I. Adjust Exhaust Valve Clearance.

II. Time Fuel Injectors.

III. Adjust Governor Gap.

IV. Position Injector Racks.

V. Adjust Maximum No-Load Speed.

VI. Adjust Idle Speed.

VII. Adjust Buffer Screw.

The above adjustments, as outlined under "Tune-Up Procedure" in Section 14, should be performed on each engine in the unit in such a manner as to ensure uniformity between the two engines.

VIII. Throttle Linkage Adjustment.

With engines stopped and throttle control mechanism well lubricated and free of any binds, refer to Fig. 4 and perform the following adjustments on both engines.

1. Engage the individual engine throttle control levers (309) to the master throttle control lever (302).

2. Lock the throttle control levers in the IDLE position as shown in Fig. 4.

3. Loosen lock nut (362) and disconnect throttle control rod clevis (360) from each governor speed control lever (21) by removing clevis pin (361), if not previously disconnected.

4. Hold governor speed control levers in IDLE position.

5. Adjust length of each throttle control rod by turning clevis so that clevis pin holes are in line with hole in speed control lever. Then, insert clevis pins in place.

6. With all linkage connected and with individual throttle control levers locked into quadrant,

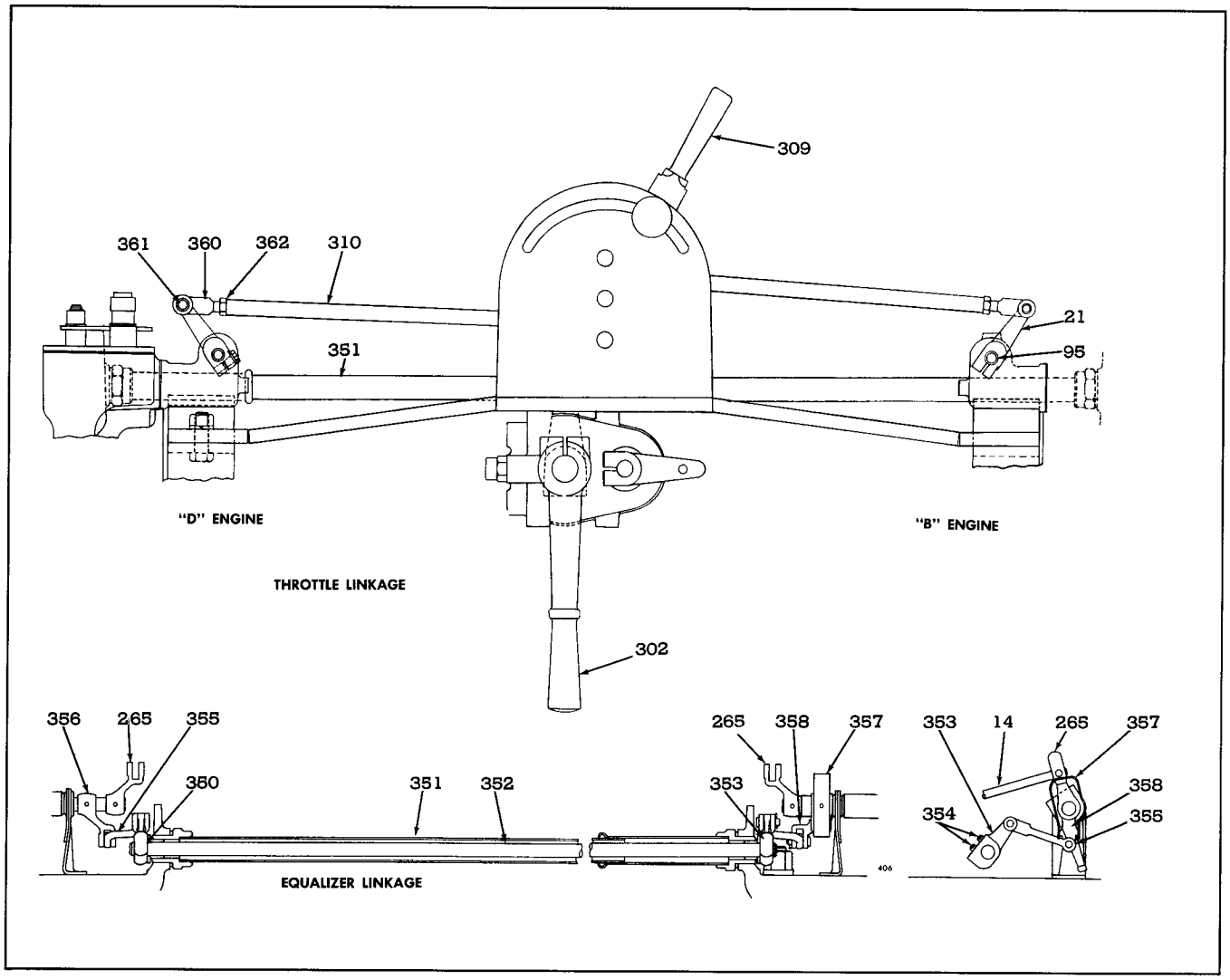


Fig. 4 - Throttle Control and Equalizer Linkage Diagram (Tandem Twin Unit)

14. Rod--Fuel
21. Lever--Speed Control
95. Shaft--Speed Control Lever
265. Lever--Injector Control Tube
302. Lever Assy.--Throttle Control (Master)
309. Lever--Throttle Control (Twin)
310. Tube--Throttle Control Shaft
350. Lever--Equalizer Shaft Clamping
351. Tube--Equalizer Shaft Cover
352. Shaft--Equalizer
353. Lever--Equalizer Shaft Adjusting
354. Screw--Adjusting
355. Link--Equalizer
356. Lever--Injector Control Tube (Equalizer)
357. Spring--Equalizer
358. Lever--Injector Control Equalizer Spring
360. Clevis
361. Pin--Clevis
362. Lock Nut

move the master throttle control lever into the FULL FUEL position and lock in place.

It is important that each governor control lever reaches the FULL FUEL position simultaneously. However, due to various tolerances, the governor control levers, after having been set together in the IDLE position, may not reach the FULL FUEL position simultaneously. In order to check this condition, unlock the individual throttle control levers from quadrant and check to ascertain if either lever can be moved closer to the FULL FUEL position. If necessary, readjust one clevis to bring both governor control levers to the FULL FUEL position simultaneously. Tighten clevis lock nuts (362) and install cotter pins; then, return the master throttle control lever to IDLE position.

7. Return throttle control lever for each engine to idle.

8. With clutches disengaged, start each engine.

9. Install the valve rocker covers and warm up engines until they are at their normal operating temperature.

10. Check maximum no-load speed of each engine. This speed may be checked by holding an accurate hand tachometer against the end of output shaft and converting reading as required by ratio of transmission. This speed should be the same as that which was previously set in Step V above, and should be the same on both engines. If the speed differs over 25 r.p.m. from the previously set maximum no-load speed, first recheck throttle adjustment, then recheck maximum no-load speed. If speeds still differ, recheck individual engine tune-up.

11. Move the master control lever to obtain a speed of approximately 400 r.p.m. below maximum no-load speed and check the speed on both engines (with clutches disengaged). The speed of the two engines should be within 100 r.p.m. If there is more than 100 r.p.m. difference in speed between the two engines, recheck individual tune-up on both engines.

IX. Equalizer Linkage Adjustment.

With individual engines tuned-up and throttle linkage adjusted, the equalizer linkage may be adjusted as follows:

1. Remove valve rocker covers (engines stopped).

2. Secure the master throttle control lever in the FULL FUEL position.

3. Connect equalizer links (355) to injector control tube levers (356) and (358), see Fig. 4.

4. Loosen bolt on equalizer shaft clamping lever (350) on "D" engine so the lever can turn freely on the equalizer shaft (352).

5. Turn both the adjusting screws (354) into the equalizer shaft adjusting lever (353), on "B" engine, the same number of threads until they contact the flats on the equalizer shaft.

6. Move equalizer link (355), which is connected to the equalizer shaft adjusting lever on "B" engine, with the adjusting screws until equal clearance (approximately .020") exists between each leg of the equalizer spring (357) and its adjacent boss on the injector control equalizer lever (358); then tighten screws.

7. While holding the equalizer link in this position, tighten the clamping bolt on lever (350) of "D" engine.

8. Recheck the clearance between legs of equalizer spring and bosses. If clearance is not the same on both sides, loosen equalizer shaft lever clamping bolt and readjust the equalizer shaft adjusting lever (353) with screws (354) until clearance is equal, then tighten clamping bolt.

9. Lubricate the clevis joints of the equalizer linkage with a few drops of engine oil; then, move the master throttle control lever (302) back and forth to check for binding in the linkage. Correct any binding that exists.

10. Install valve rocker covers. Then, place master throttle control lever in IDLE position, start engines, and run until normal operating temperature has been reached.

11. Move master throttle control lever to the FULL FUEL position and check the maximum no-load speed on each engine. This speed should be the same as the individual maximum no-load speeds previously set.

12. Move master throttle control lever to the IDLE position and check the idle speed of each engine. Again, the individual idle speeds should be the same as previously set.

13. If the speeds in Steps 11 and 12 above are not as previously set, adjust lever (353) by means of set screws (354), with engine running, until previously set idle and no-load speeds are obtained.

TUNE-UP PROCEDURE FOR ENGINES EQUIPPED WITH A HYDRAULIC OUTPUT SHAFT GOVERNOR

An output shaft governor, as the name implies, is used on engines to control the speed of the output shaft. The output shaft governor, driven by the output shaft, is used to maintain a constant speed on the output shaft within the governor droop and the load capabilities of the engine. It should be remembered in adjusting a unit which incorporates an output shaft governor, that proper engine performance is obtained when both the engine limiting speed governor throttle control lever and output shaft governor terminal shaft lever are in the same relative position in their respective arcs of travel. Therefore, the governors should be adjusted, through their connecting linkages, so that these levers are both in the FULL FUEL position at the same time.

ENGINE GOVERNOR AND EXTERNAL LINKAGE ADJUSTMENTS ON UNITS WITH ENGINE MOUNTED AIR CLEANERS

For the adjustment of a Roots blower 110 engine equipped with dual engine mounted air cleaners, refer to Fig. 1 and proceed as follows:

1. On units so equipped, disengage the forward disconnect clutch.

2. Disconnect adjustable linkage from pillow block to limiting speed governor throttle control lever at the lever.

3. Tune-up engine and limiting speed governor as outlined in the engine tune-up procedure.

   a. After the engine's limiting speed governor has been satisfactorily adjusted, position the governor throttle control lever, as shown, and check to see that its travel, between idle and full speed, is equal on either side of an imaginary line parallel to the engine crankshaft. Should adjustment be required, it may be done by loosening the clamp bolt and rotating the lever on its shaft. Retighten clamping bolt.

   b. To facilitate governor adjustment, the throttle control lever return spring and clip may have been removed; reinstall as shown.

4. Loosen the two lock nuts on the adjustable linkage, and adjust the turnbuckle until there is approximately 8-5/8'' distance between the end bearing centers.

5. Loosen the bolts retaining the terminal shaft lever contacting legs on the overrule lever and move the contacting legs to a position where they will not interfere with the travel of the terminal shaft lever.

   NOTE: These contacting legs may be removed at this time, if necessary.

6. Loosen the retaining bolt and remove the terminal shaft lever from its serrated shaft on the output shaft governor.

7. Reinstall the adjustable linkage to the throttle control lever. Retighten lock nuts.

8. Remove the output shaft governor cover, and using a screw driver, pry up on the terminal lever until it contacts the boss in the governor subcap.

9. While holding the output shaft governor in the FULL FUEL position, manually force the connecting linkage so that the engine limiting speed governor is also in the FULL FUEL position, and reinstall the terminal shaft lever onto its serrated shaft.

   a. The terminal shaft lever should be installed so that it points upward and slightly to the rear of the governor.

   b. In order to match the serrations when the terminal shaft lever is installed on its serrated shaft, it may be necessary to slack off slightly on the connecting linkage, thus taking the limiting speed governor out of the FULL FUEL position. If this becomes necessary, reposition the governor in the FULL FUEL position by holding the terminal lever of the output shaft governor against its boss in the subcap, and loosen the retaining bolt in the throttle control lever. Insert a 3/16'' Allen wrench in the pipe plug in the throttle control shaft and rotate the shaft in a clockwise direction until it contacts its stop at full fuel. Retighten the throttle control lever onto the shaft.

10. Position terminal shaft lever contacting legs in overrule lever.

14.11 HYDRAULIC OUTPUT SHAFT GOVERNOR

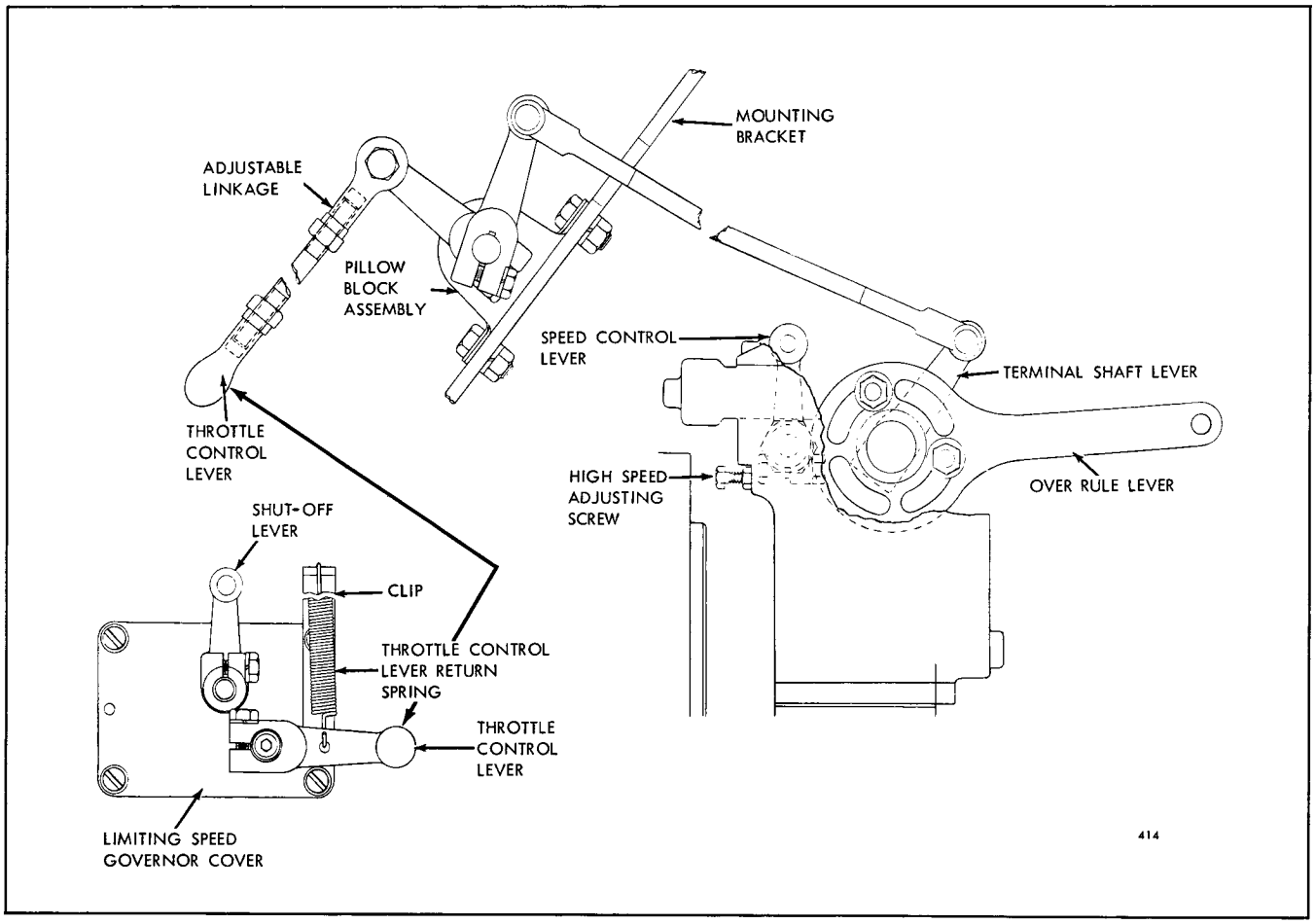


Fig. 1 - Output Shaft Governor and Linkage for Units with Engine Mounted Air Cleaners

11. The terminal lever contacting legs of the overrule lever may be installed on the lever in any 2 of the 4 slots provided. They should be installed so that they do not interfere with the terminal shaft lever travel, from the IDLE to the FULL FUEL position, when the overrule lever is in its run position. The legs should be positioned on the overrule lever so that the terminal shaft lever can be overruled in either the IDLE or FULL FUEL directions.

12. Set output shaft speed as outlined under "Hydraulic Output Shaft Governor Speed Adjustment".

ENGINE GOVERNOR AND EXTERNAL LINKAGE ADJUSTMENTS ON UNITS WITH REMOTE MOUNTED AIR CLEANERS

For the adjustment of a Roots blower 110 engine equipped with remote mounted air cleaners, refer to Fig. 2 and proceed as follows:

1. On units so equipped, disengage the forward disconnect clutch.

2. Disconnect tailshaft governor to limiting speed governor throttle control lever linkage at the throttle control lever.

3. Tune-up engine and limiting speed governor as outlined in the engine tune-up procedure.

   a. After the engine's limiting speed governor has been satisfactorily adjusted, position the governor throttle control lever, as shown, and check to see that its travel, between idle and full speed, is equal on either side of an imaginary line parallel to the rear of the cylinder block. Should adjustment be required, it may be done by loosening the

clamp bolt and rotating the lever on its shaft. Retighten clamping bolt.

b. To facilitate governor adjustment, the throttle control lever return spring and clip may have been removed; reinstall as shown.

4. Loosen the bolts retaining the terminal shaft lever contacting legs on the overrule lever and move the contacting legs to a position where they will not interfere with the travel of the terminal shaft lever.

   NOTE: These contacting legs may be removed at this time, if necessary.

5. Loosen the retaining bolt and remove the terminal shaft lever from its serrated shaft on the output shaft governor.

6. Remove the output shaft governor cover, and using a screw driver, pry up on the terminal lever until it contacts the boss in the governor subcap.

7. While holding the output shaft governor in the FULL FUEL position, manually force the connecting linkage so that the engine limiting speed governor is also in the FULL FUEL position, and reinstall the terminal shaft lever onto its serrated shaft.

   a. The terminal shaft lever should be installed so that it points downward slightly to the rear of the governor.

   b. In order to match the serrations when the terminal shaft lever is installed on its serrated shaft, it may be necessary to slack off slightly on the connecting linkage, thus taking the limiting speed governor out of the FULL FUEL position. If this becomes necessary, reposition the governor in the FULL FUEL position by holding the terminal lever of the output shaft governor against its boss in the subcap and loosen the retaining bolt in the throttle control lever. Insert a 3/16'' Allen wrench in the pipe plug in the throttle control shaft and rotate the shaft in a clockwise direction until it contacts its stop at full fuel. Retighten the throttle control lever onto the shaft.

8. Position terminal shaft lever contacting legs in overrule lever.

9. The terminal lever contacting legs of the overrule lever may be installed on the lever in any

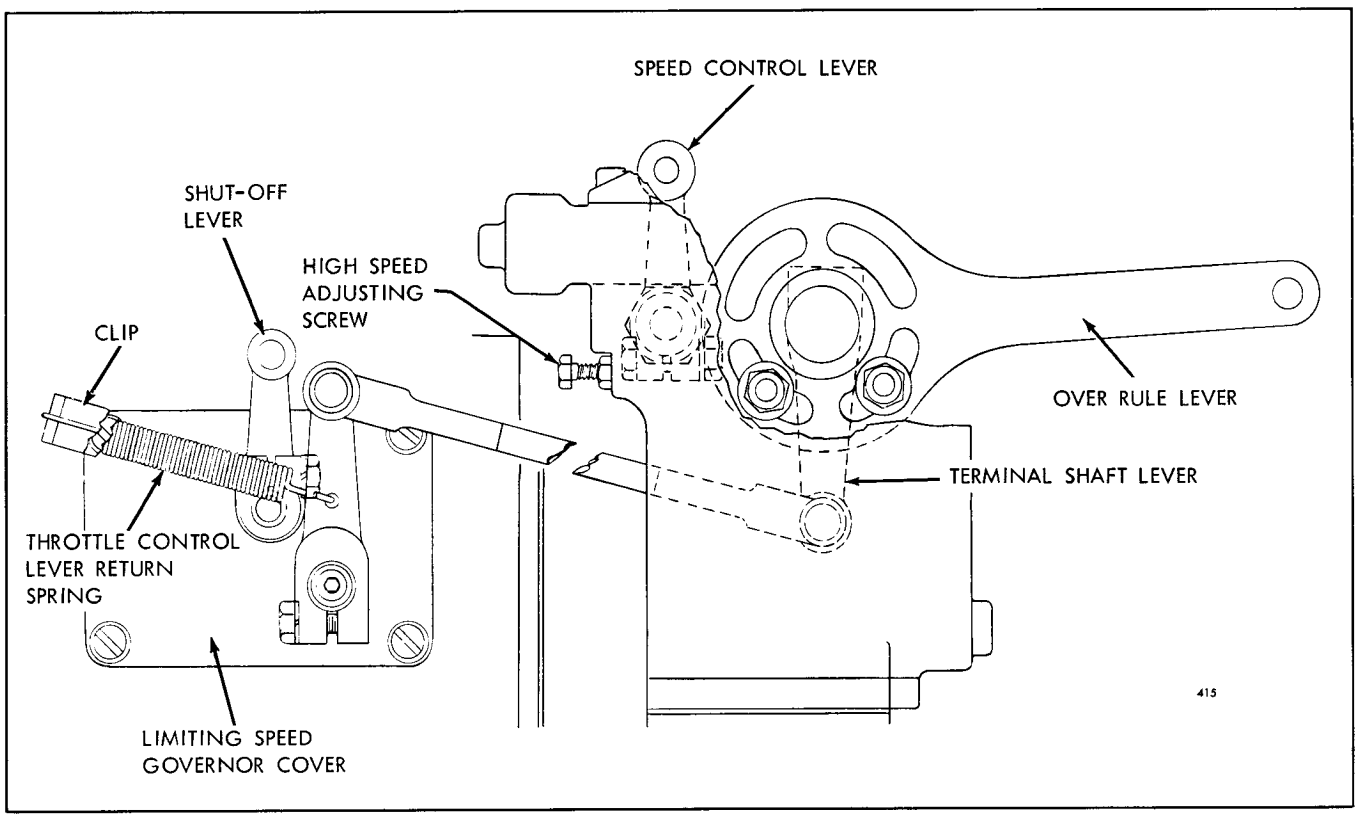


Fig. 2 - Output Shaft Governor and Linkage for Units with Remote Mounted Air Cleaners

2 of the 4 slots provided. They should be installed so that they do not interfere with the terminal shaft lever travel, from the IDLE to the FULL FUEL position, when the overrule lever is in its run position. The legs should be positioned on the overrule lever so that the terminal shaft lever can be overruled in either the IDLE or FULL FUEL directions.

10. Set output shaft speed as outlined under "Hydraulic Output Shaft Governor Speed Adjustment".

HYDRAULIC OUTPUT SHAFT GOVERNOR SPEED ADJUSTMENT

The hydraulic output shaft governor may be adjusted to obtain one of three possible operating conditions. The desired method of setting the speed of the governor will depend upon the type of equipment in which the unit is installed. The three methods are:

Fixed Output Shaft Speed

When it is desired to operate the output shaft at a fixed speed, the low speed adjusting screw can be used to lock internally the speed adjusting lever in a fixed position.

Semi-fixed Output Shaft Speed

When it is desired to operate the output shaft at a fixed speed for a particular operation, and still perform other operations at different speeds, the governor should be adjusted according to the following method. The low and high speed adjusting screws should be set for the minimum and maximum output shaft speeds respectively, and the knurled knob on the side of the governor used to set the desired operating speeds between these minimum and maximum settings.

Adjustable Output Shaft Speed

When it is desired to change from one output shaft speed to another, from the operators compartment, the governor should be adjusted according to the following method. The low and high speed adjusting screws should be set for the minimum and maximum output shaft speeds respectively and a Bowden wire should be connected to the external speed control lever of the governor.

1. Place the overrule lever in a neutral position so that it does not restrict the operation of the governor terminal shaft lever.
2. Start engine and set the output shaft governor speed control lever in the maximum speed position. Loosen the maximum speed adjusting screw lock nut and adjust the maximum speed screw to obtain the desired output shaft speed.

   a. The output shaft no-load speed should be approximately 150-200 r.p.m. above the required full load speed. Turning the adjusting screw in (away from engine) reduces the output shaft speed. Turning the maximum speed screw out (towards engine) increases the output shaft speed.

3. Retighten the maximum speed adjusting screw lock nut.
4. Set droop bracket in output shaft governor.

   When making the droop bracket adjustment, the best operating performance will be obtained when the bracket is set so that stable operation is obtained after three or four surges of the terminal lever when a load is applied to the output shaft. This is the most acceptable compromise between sluggish engine performance and excessive surging.

   This may be accomplished without loading the engine by manually disturbing the terminal lever, inside the governor, or external linkage and allowing the lever to return to stable operation.

5. Reinstall the output shaft governor cover, and adjust the low speed adjusting screw.
6. To adjust the low speed adjusting screw:

   a. Loosen low speed adjusting screw lock nut, and back screw out of governor cover a few turns.

   b. Advance the speed control lever until the desired no-load minimum output shaft speed is obtained.

   c. Turn low speed adjusting screw in until the screw contacts the speed control linkage assembly inside the governor housing. This will be noted by an increase in engine speed or a resistance to movement of the adjusting screw.

   d. Tighten low speed adjusting screw lock nut.

TROUBLE SHOOTING

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

The trouble shooting charts are presented to help minimize the time required to locate and correct trouble that may occur during operation of the unit.

Each trouble shooting chart is numbered in its upper left-hand corner. These numbers are used only to permit ease of reference between charts. Charts that appear to be missing are not applicable to 71 engines and have been omitted from this manual.

Satisfactory engine operation depends primarily upon:

1. The presence of 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, 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 temperatures.

2. Remove the valve cover.

3. Run the engine at IDLE speed and check the valve clearance. The clearance should be .009" (two valve cylinder head) or .014" (four valve cylinder head).

4. Hold the No. 1 injector follower down with a screw driver, see Fig. 1, to prevent 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 follower is held down. This is similar to short-circuiting a spark plug in a gasoline engine.

5. If cylinder No. 1 is firing properly, repeat the procedure on the other cylinders until the faulty one has been located.

6. Providing that the injector operating mechanism of the faulty cylinder is functioning satisfactorily, remove the fuel injector and install a new one as follows:

   a. Disconnect and remove the fuel pipes from the injector and fuel connector, see Fig. 2.

      Immediately after disconnecting the fuel pipes from the injector, install shipping caps on the filter caps to prevent dirt from entering the injector.

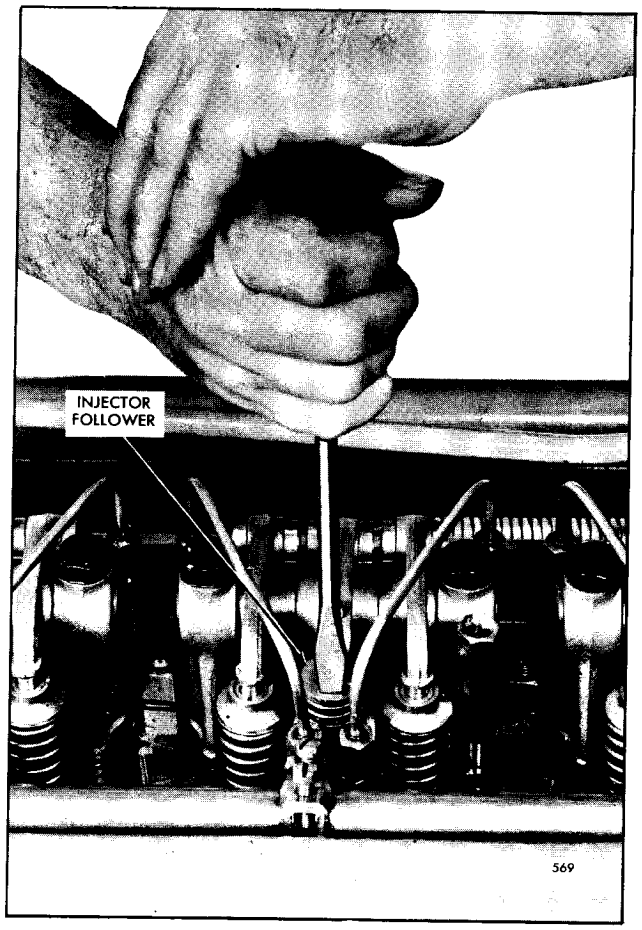


Fig. 1 - Locating a Misfiring Cylinder

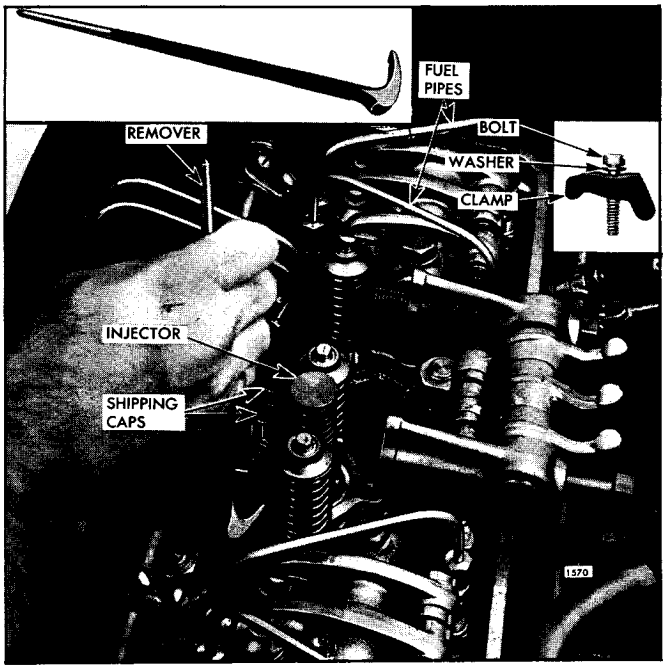


Fig. 2 - Removing Injector from Cylinder Head

b. Bar the engine or crank the engine with the starting motor, if necessary, to bring the push rod end of the three rocker arms in line horizontally.

c. Loosen the two rocker arm bracket bolts holding the brackets to the cylinder head and swing the rocker arm assembly over away from the valves and injectors.

d. Remove the injector hold-down nut, washer, and injector clamp.

e. Free the injector from its seat with the remover (Fig. 2) and lift it from the cylinder head; at the same time disengage the injector control rack.

f. Install the new injector by following the procedure outlined in section 2.1.

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

Checking Compression Pressure

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

2. With the engine stopped, remove the fuel pipes from the injector and fuel connectors.

3. Remove the injector from No. 1 cylinder and install an adaptor and the pressure gage, J 1319-02, in its place as shown in Fig. 3.

4. Use one of the two fuel pipes as a jumper connection between the fuel inlet and return manifold to permit fuel to flow directly to the return manifold.

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

   Do not crank the engine with the starting motor when checking the compression pressure.

6. Perform the compression pressure check on each cylinder. The compression pressure in any one cylinder should not be less than the minimum prescribed for the particular engine at the given altitude above sea level. In addition, the variation in compression pressure between cylinders of the engine must not exceed 25 p.s.i. at 600 rpm.

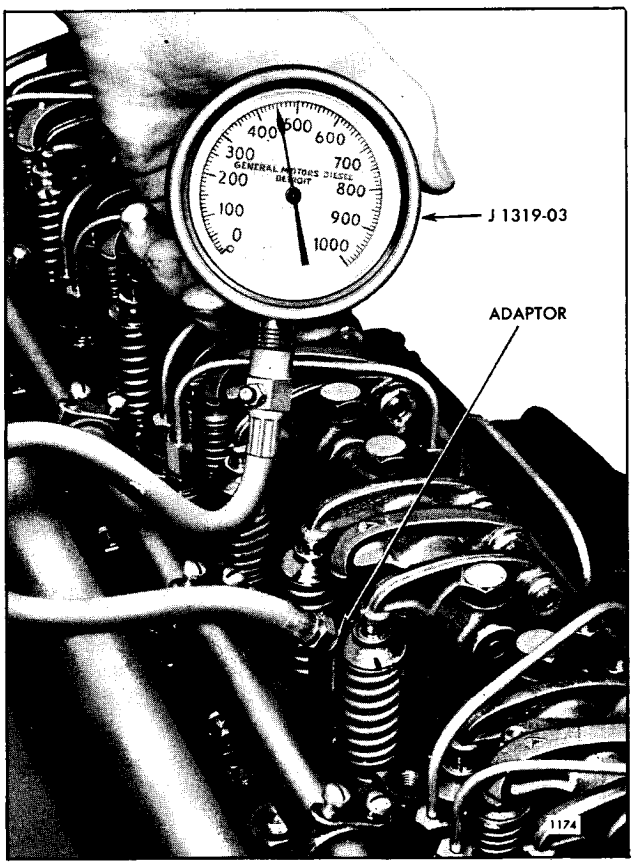


Fig. 3 - Checking Compression Pressure

Minimum Compression Pressure p.s.i. (600 rpm)				Altitude, Feet Above Sea Level
Engine				
71	71E	71N	71T	
390	425	515	400	0
360	395	480	370	2,500
335	365	440	340	5,000
310	340	410	315	7,500
285	315	380	295	10,000

If the compression pressure readings of an engine 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 determined and corrected.

Cylinder	Gauge Reading
1	445 p.s.i.
2	440 p.s.i.
3	405 p.s.i.
4	435 p.s.i.
5	450 p.s.i.
6	445 p.s.i.

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

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

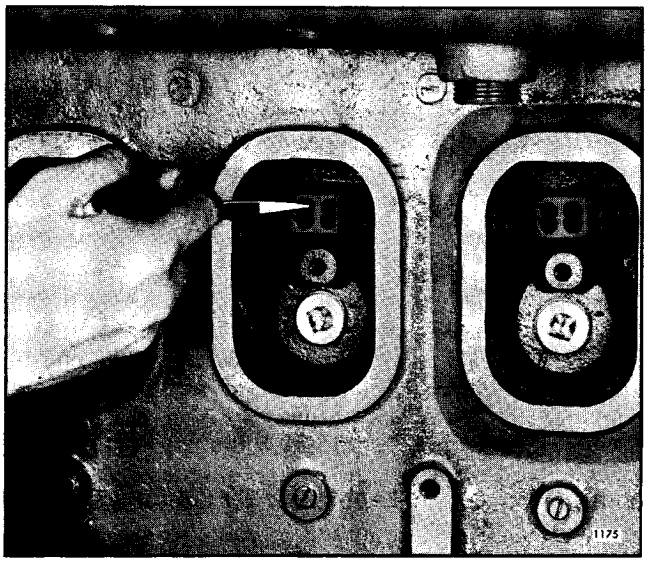


Fig. 4 - Inspecting for Broken Piston Rings Through Cylinder Liner Air Ports

Fig. 5 - Measuring Fuel Flow from Fuel Return Manifold

Low compression pressures may result from any one of several causes:

a. Piston rings may be stuck or broken. To determine the condition of the rings, inspect them as shown in Fig. 4.

b. Compression may be leaking past the cylinder head gasket, the valve seats, the injector tubes, or through a hole in the piston.

To correct any of these conditions, consult the section in this manual which covers the faulty item.

Fuel Flow Test

Refer to the "Engine Operating Conditions" charts; Section 13.2, for the gallons per minute fuel flow that is applicable to the particular engine being tested. Then proceed as follows:

1. Disconnect the fuel return tube and hold the open end of the tube in a suitable receptacle, see Fig. 5.

2. Start and run the engine at approximately 1200 rpm and measure the fuel flow from the return tube for one minute.

3. Be sure all tube 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 tube into 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

Refer to the Engine Operating Conditions, Section 13.2, for the crankcase pressures that apply to the particular engine at the engine speeds indicated.

A crankcase pressure reading indicates the amount of air that has passed between the oil control rings and the cylinder liner into the crankcase. Most of this air is clean air from the air box. A slight pressure in the crankcase is needed to keep dust out. A loss of engine lubricating oil through the governor breather tube, crankcase ventilator, or dipstick hole in the cylinder block is an indication of an excessive crankcase pressure.

Some of the causes of high crankcase pressure may be traced to an excessive blow-by due to worn piston rings, a hole or crack in a piston crown, loose piston pin retainers, defective blower, cylinder head 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 the manometer in the engine diagnosis test kit J 7333-04. 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 specifications in the Operating Conditions Chart 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.

High exhaust pressure is 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 the manometer in the engine diagnosis test kit J 7333-04. The manometer is connected to the exhaust manifold by removing the 1/8" pipe plug which is usually provided for that purpose. However, if there is no opening provided, one can be made by drilling an 11/32" hole in the exhaust manifold companion flange and tapping a 1/8" pipe thread.

Check the readings obtained at various speeds (at no load) with the specifications in the Operating Conditions Chart 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 intake restriction, damaged blower rotors, an air leak from the air box (such as leaking end plate gaskets), a clogged blower air inlet screen. Lack of power, or black or grey exhaust smoke are indications of low air box pressure.

To check the air box pressure, connect the manometer from engine diagnosis test kit J 7333-04 to the air box of the cylinder block by removing one of the 1/4" pipe plugs located beneath the hand hole cover on the side of the engine opposite the blower, or to an air box drain.

Check the readings obtained at various speeds with the specifications in the Operating Conditions Chart in Section 13.2.

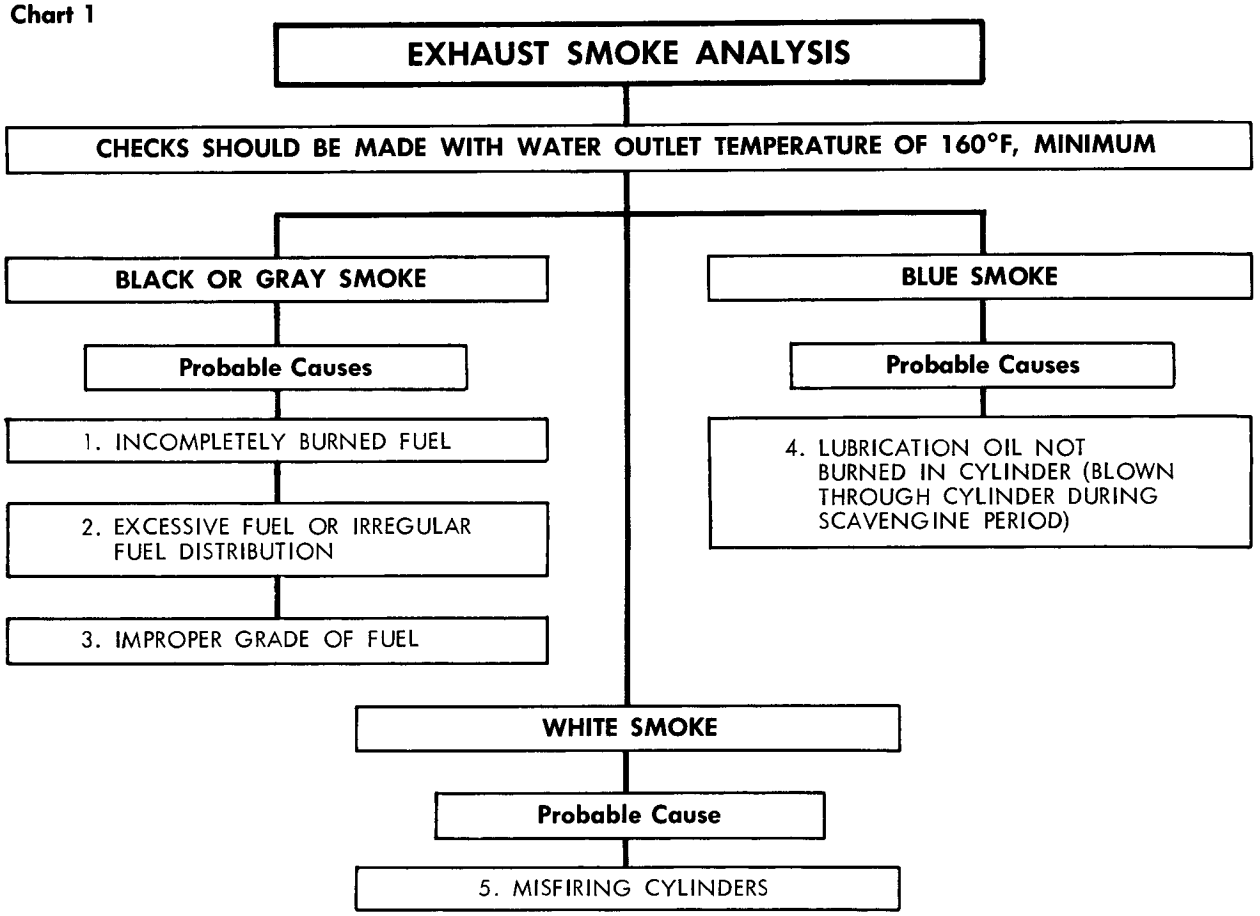
Air Intake Restriction

Excessive restriction of the air intake 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 intake restriction.

The air intake restriction may be checked with the manometer from the engine diagnosis test kit J 7333-04. Connect the manometer to the blower air inlet assembly in the drilled and tapped hole provided for the cold weather starting aid connection. On earlier units in which the hole is not provided, use a current stock air inlet assembly for the test.

Check the normal air intake vacuum at various speeds (at no load) and compare the results with the Operating Conditions Chart in Section 13.2.

Chart 1



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 to air inlet screen. These items should be cleaned. Check the emergency stop to see 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 unit as outlined in "Engine Operation."

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

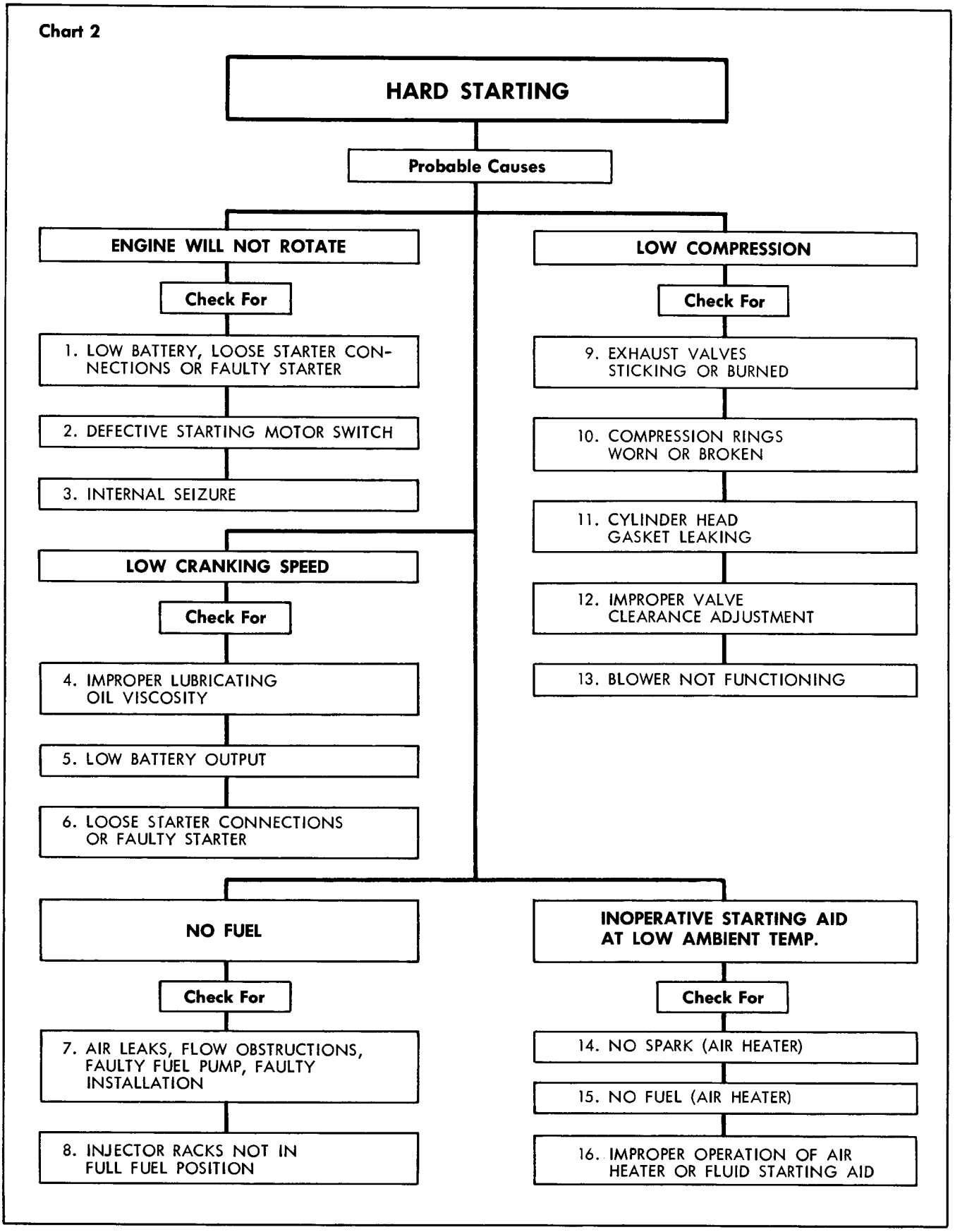

HARD STARTING
Probable Causes
ENGINE WILL NOT ROTATE
Check For
1. LOW BATTERY, LOOSE STARTER CONNECTIONS OR FAULTY STARTER
2. DEFECTIVE STARTING MOTOR SWITCH
3. INTERNAL SEIZURE
LOW CRANKING SPEED
Check For
4. IMPROPER LUBRICATING OIL VISCOSITY
5. LOW BATTERY OUTPUT
6. LOOSE STARTER CONNECTIONS OR FAULTY 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. NO SPARK (AIR HEATER)
15. NO FUEL (AIR HEATER)
16. IMPROPER OPERATION OF AIR HEATER OR 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 lubricating oil viscosity 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.

   Properly connect the leads after replacing the terminals that are damaged or corroded.

   At low ambient temperatures the 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 binding governor to injector linkage 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. 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 assembly if the rings are badly worn or broken.

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

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

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

14. Check for loose or shorted connections, a defective coil, inoperative points, cracked electrode porcelain, or an inoperative or improperly adjusted pressure switch. Adjust or replace the faulty parts.

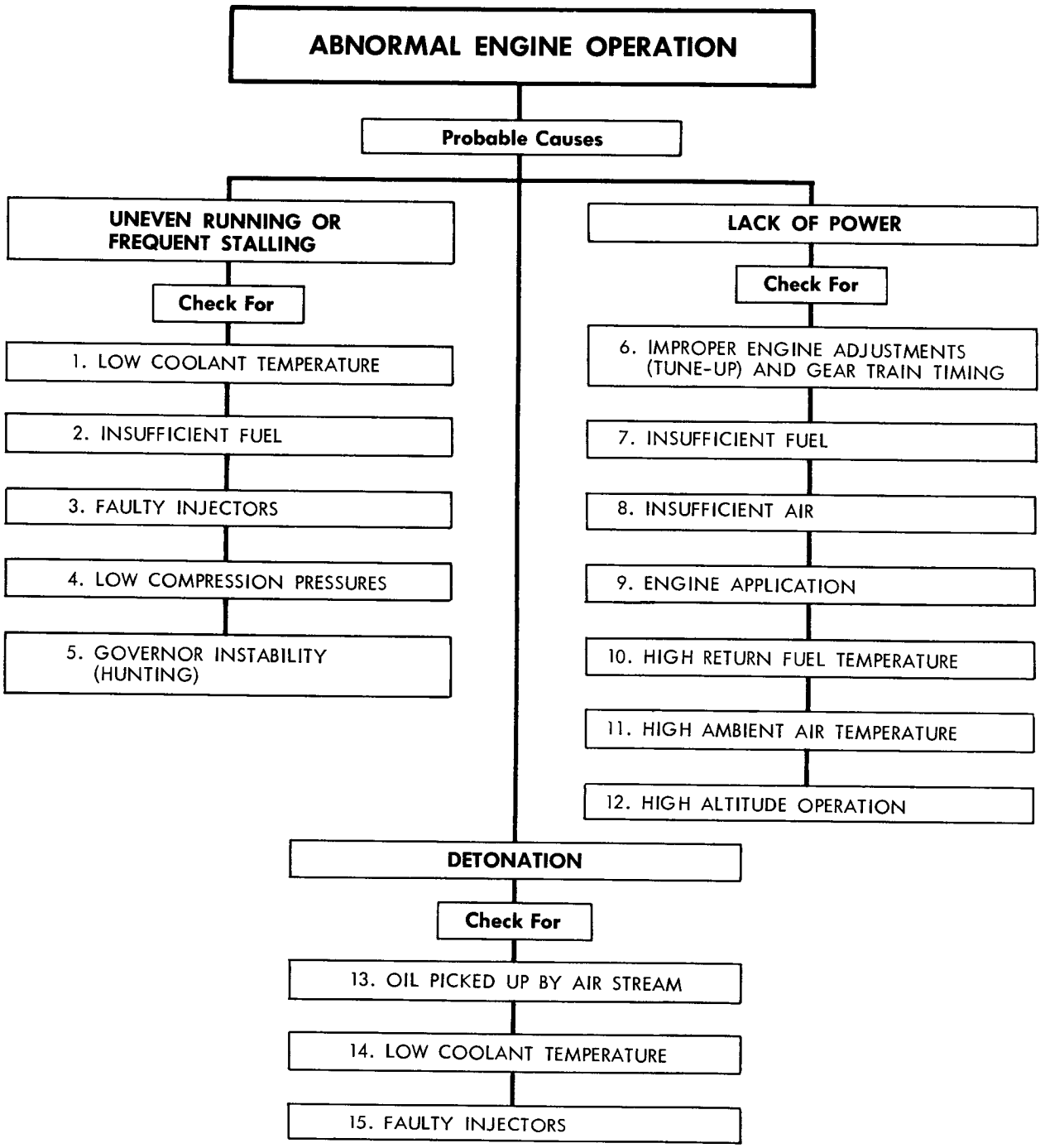
15. Check the valve and seals of hand pump, spray nozzle, fuel filter, and valve in pump suction line. Clean the valves, spray nozzle, and filter and replace the seals and defective parts.

    If the ambient temperature is less than 10°F. above the pour point of the fuel oil, consult and follow the "Fuel Oil Specifications".

    Check the installation of the starting aid components and assemble the items correctly.

16. Operate the starting aid according to the instructions under "Cold Weather Starting Aids".

Chart 3



SUGGESTED REMEDY

1. Watch the engine cooling temperature gage and if the temperature does not reach 160°F 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 that specified for the particular engine (see Section 13.2) 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 cylinders and consult the "Hard Starting" chart if the compression pressures are low.

5. Engine hunting may be caused by binding governor-to-injector operating linkage 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. Check engine fuel spill back and if the return is less than that specified for the particular engine (see Section 13.2) consult the "No Fuel or Insufficient Fuel" chart.

8. Check for damaged or clogged 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 plugged 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 unit may result in excessive loads on the engine. Operate the unit according to approved procedures outlined in "Engine Operation".

10. Refer to item 16 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 unit is operating.

13. Check the 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

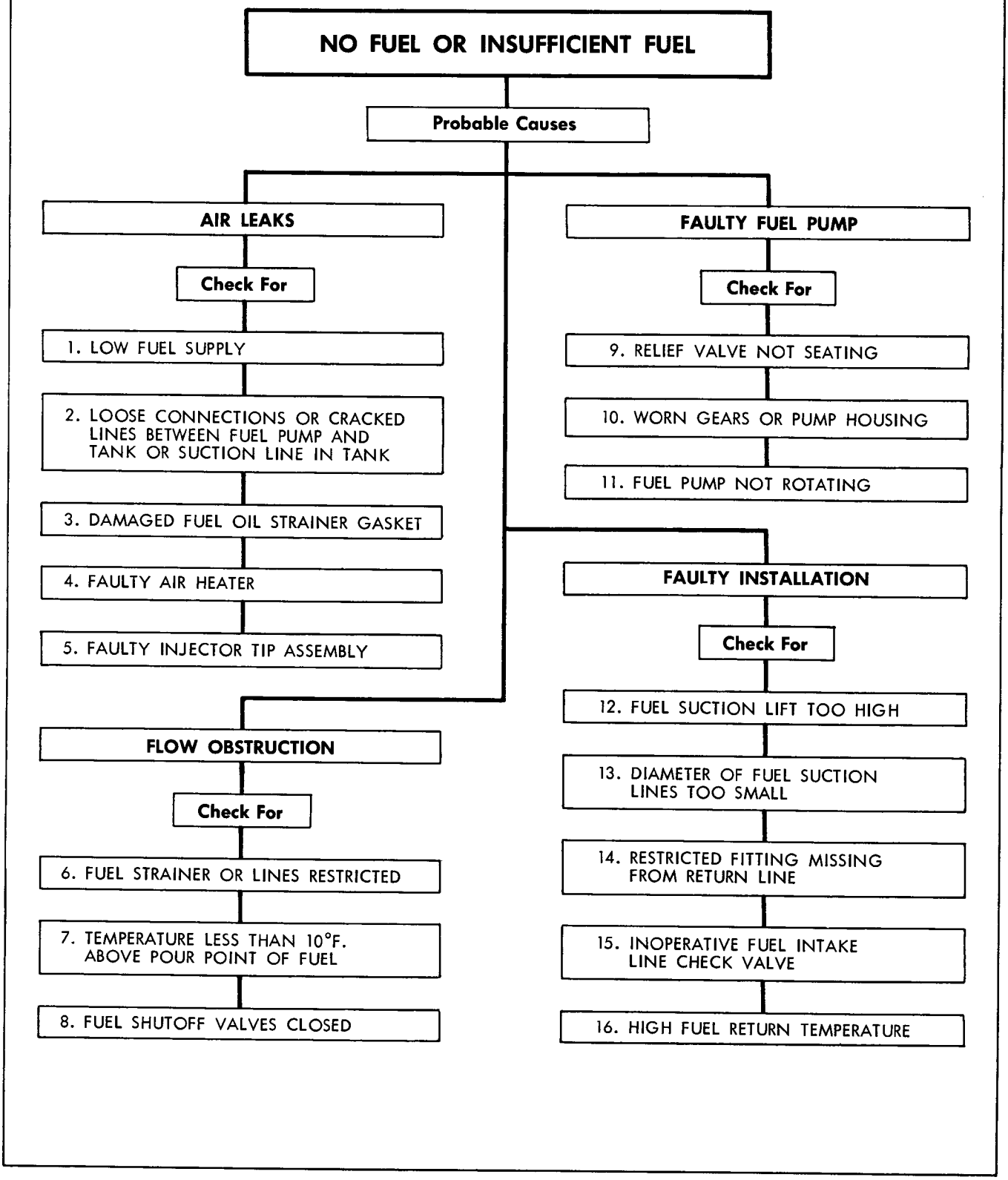

NO FUEL OR INSUFFICIENT FUEL
Probable Causes
AIR LEAKS
Check For
1. LOW FUEL SUPPLY
2. LOOSE CONNECTIONS OR CRACKED LINES BETWEEN FUEL PUMP AND TANK OR SUCTION LINE IN TANK
3. DAMAGED FUEL OIL STRAINER GASKET
4. FAULTY AIR HEATER
5. FAULTY INJECTOR TIP ASSEMBLY
FLOW OBSTRUCTION
Check For
6. FUEL STRAINER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

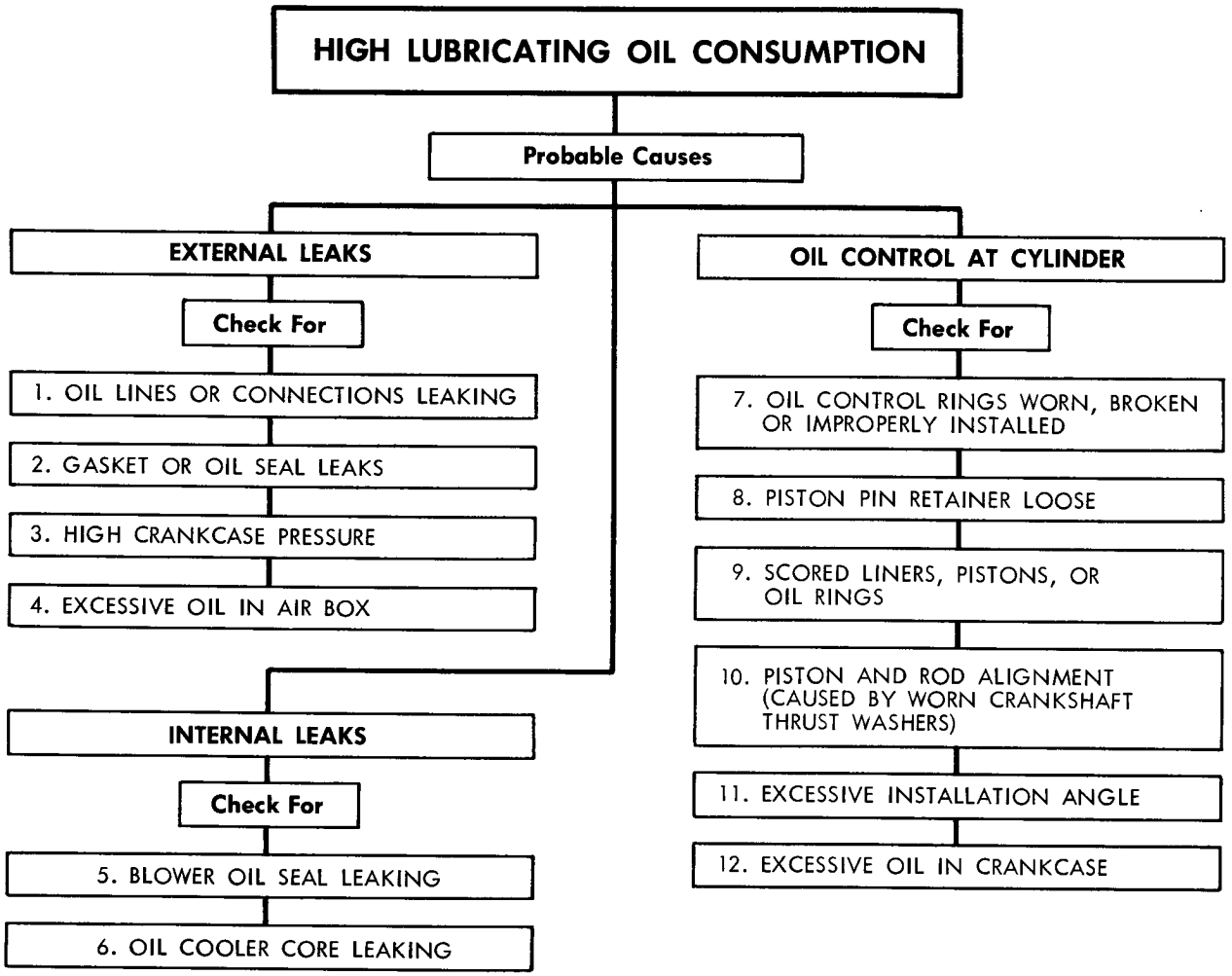
Chart 4 (Cont'd.)

NO FUEL OR INSUFFICIENT FUEL (Cont'd.)

SUGGESTED REMEDY

1. The fuel tank should be filled above the level of the engine 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. Check for and correct air leaks in hand pump and suction lines.
5. Perform a "Fuel Flow Test" and, if air is present with all fuel lines and connections assembled correctly, check for and replace faulty injectors.
6. Perform a "Fuel Flow Test" and replace the fuel strainer and filter elements, also fuel lines as necessary.
7. Consult the "Fuel Oil Specifications" and use the fuel oil recommended.
8. Open fuel shut-off valves.
9. Perform a "Fuel Flow Test" and, if inadequate, clean and inspect the valve seat assembly.
10. Replace the gear and shaft assembly or the pump body.
11. Check the condition of the fuel pump drive and blower drive and replace the defective parts.
12. Maximum lift of the fuel pump is 48" at sea level; reduce vertical lift of fuel if suction lift is higher.
13. Replace with larger tank-to-unit fuel lines when fuel supply is remotely mounted from unit.
14. Install a restricted fitting in the return line.
15. See that the 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.
16. 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, reducing the pump lift to 48" at sea level or less, or relocating the fuel tank to a cooler position.

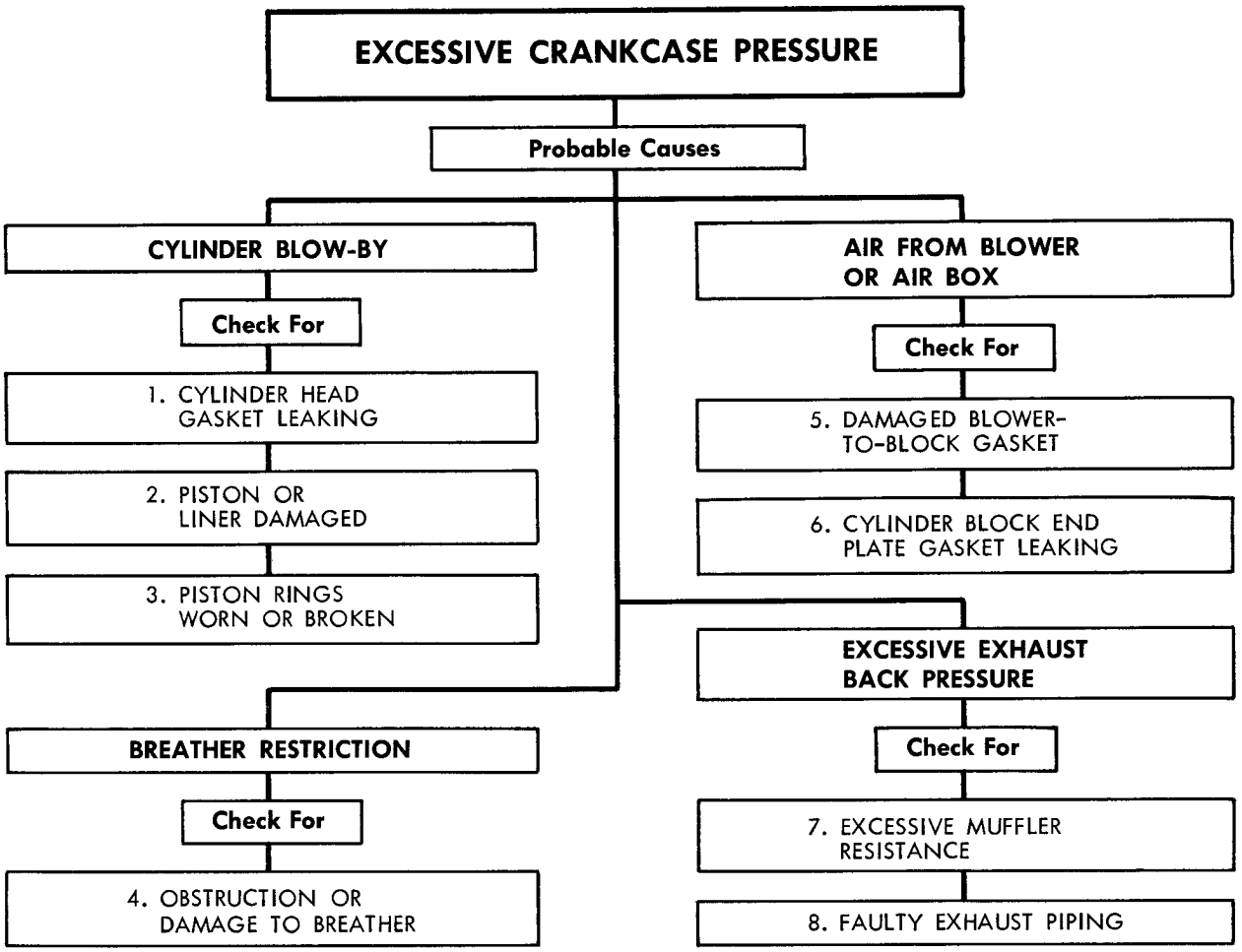
Chart 5



SUGGESTED REMEDY

1. Tighten or replace the defective parts.
2. Replace defective gaskets or oil seals.
3. See the "High Crankcase Pressure" chart.
4. See 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. Check 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, even if only one cylinder has low compression, remove the cylinder head and replace the head gaskets.
2. Inspect the piston and liner and replace the 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

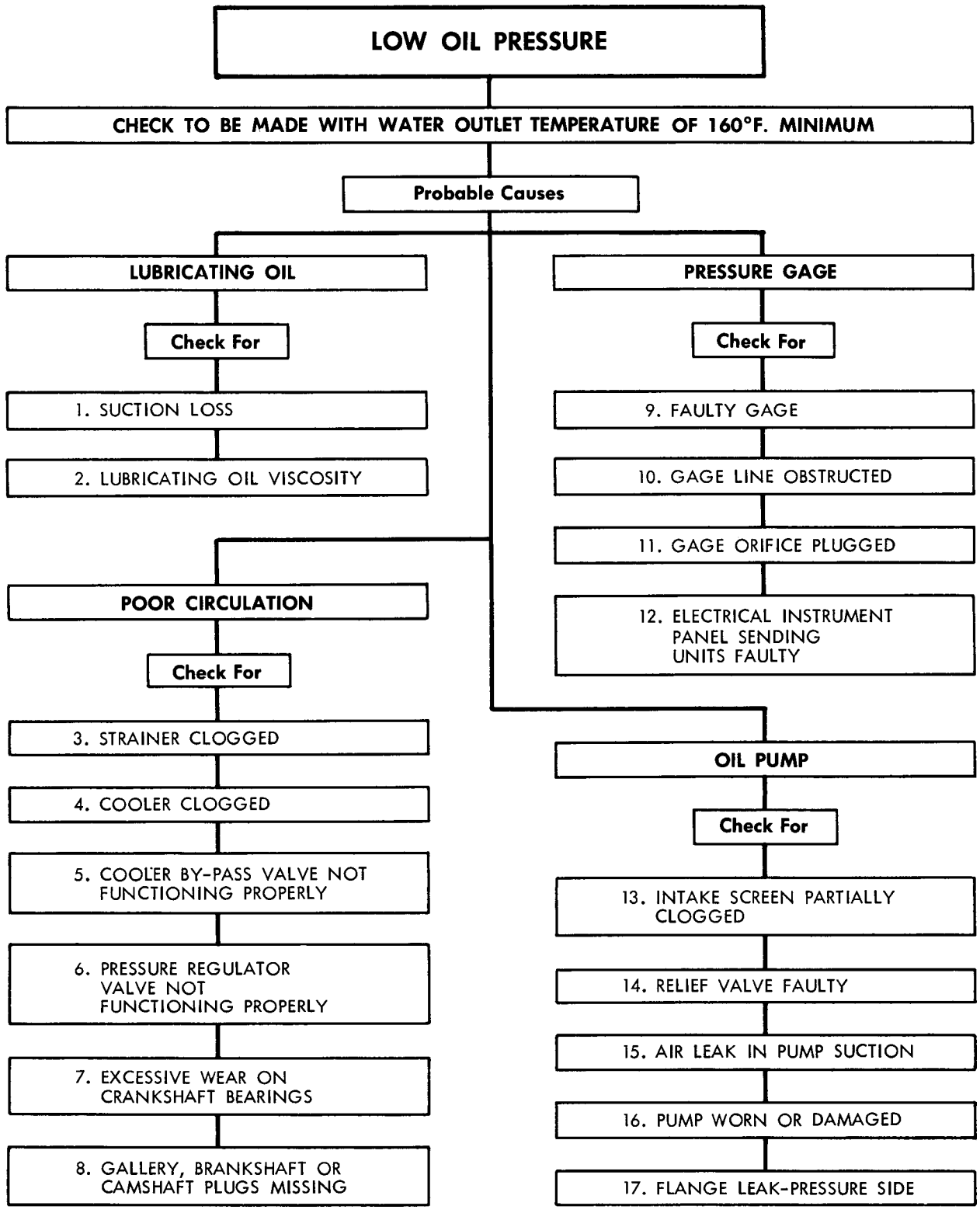

LOW OIL PRESSURE
CHECK TO BE MADE WITH WATER OUTLET TEMPERATURE OF 160°F. MINIMUM
Probable Causes
LUBRICATING OIL
Check For
1. SUCTION LOSS
2. LUBRICATING OIL VISCOSITY
POOR CIRCULATION
Check For
3. STRAINER CLOGGED
4. COOLER CLOGGED
5. COOLER BY-PASS VALVE NOT FUNCTIONING PROPERLY
6. PRESSURE REGULATOR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

Chart 7(Cont'd.)

LOW OIL PRESSURE (Cont'd.)

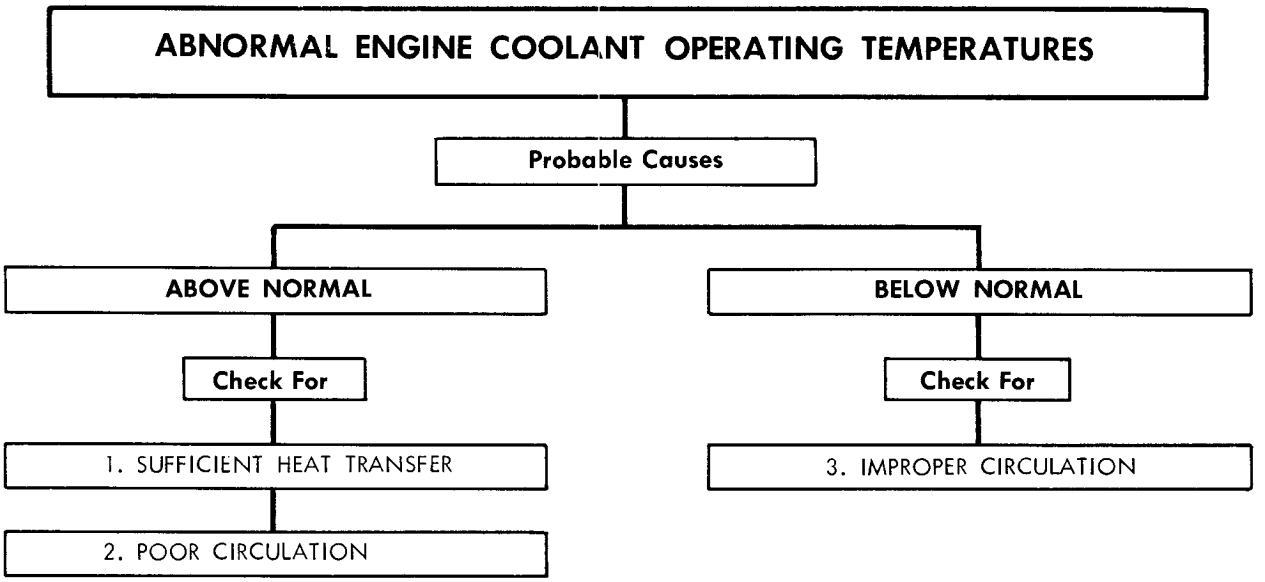
SUGGESTED REMEDY

1. Check the oil quantity and bring to the proper level on dipstick or correct the installation angle.
2. Wrong viscosity of lubricating oil being used; consult "Lubricating Oil Specifications".

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

   Check for fuel leaks at the injector seal ring and fuel pipe connections. Leaks at these points will cause lubricating oil dilution.
3. Remove and clean the oil strainer.
4. A plugged oil cooler is indicated by an excessively high lubricating oil temperature. Remove and clean the oil cooler core.
5. Remove the by-pass valve and clean the valve and valve seat and inspect. Replace the defective parts.
6. Remove the pressure regulator valve, clean the valve and valve seat and inspect them. Replace the defective parts.
7. Change the bearings. Consult the "Lubricating Oil Specifications" for the proper grade of oil to use and change the oil filters.
8. Replace any missing plug(s).
9. Check the oil pressure with a reliable gage and replace the gage if found faulty.
10. Remove and clean the line; replace it if necessary.
11. Remove and clean the orifice.
12. Repair or replace defective equipment.
13. 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.
14. Remove and inspect the valve, valve bore and spring; replace the faulty parts.
15. Disassemble the piping and install new gaskets.
16. Remove the pump, clean and replace defective parts.
17. 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 adjust inoperative shutters.

   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 it 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 head gaskets replaced if combustion gases are entering the cooling system.

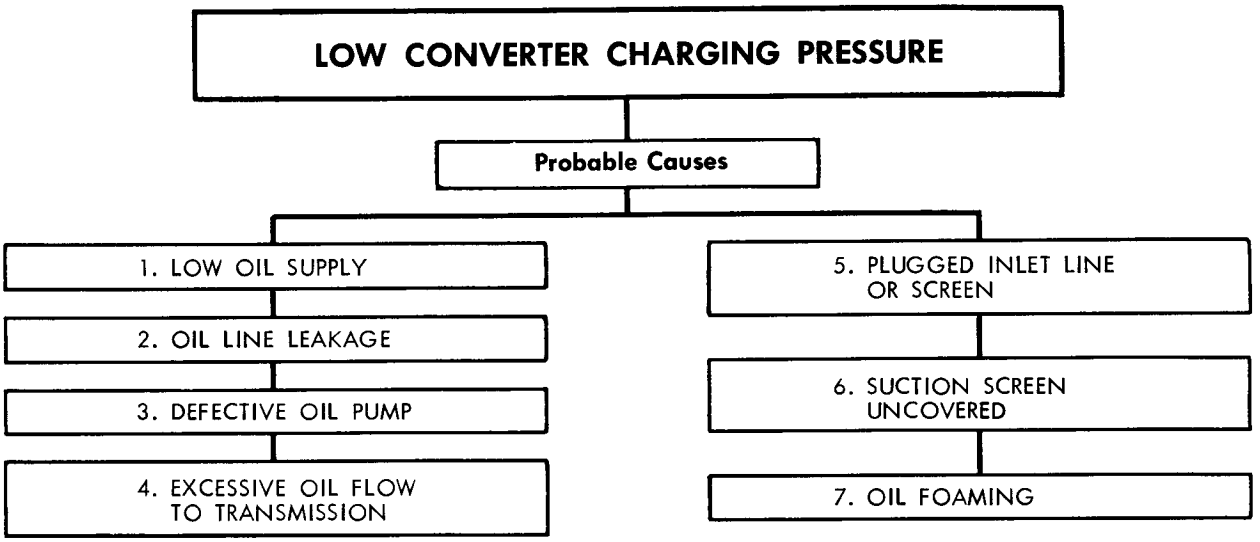
   Check for an air leak on the suction side of the water pump. Replace defective parts.

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

   Check the thermostat seal. Replace it if necessary.

   Check for an improperly installed heater.

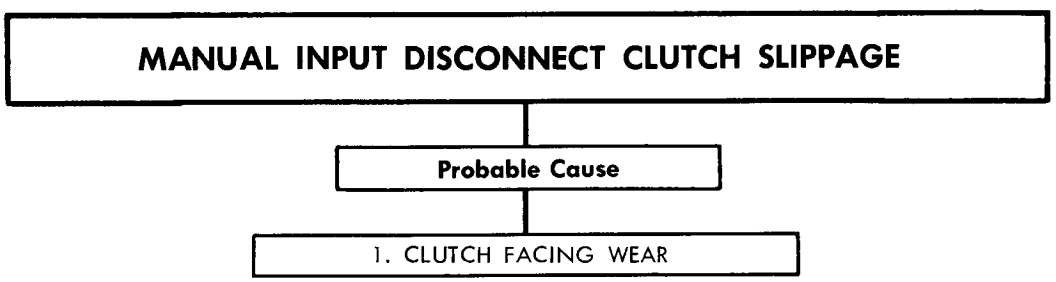
Chart 17



SUGGESTED REMEDY

1. Add oil. Refer to the Lubrication and Preventive Maintenance Chart.
2. Check for air leaks in the suction lines and oil leaks in the pressure lines.
3. Check for wear in the oil pump. Check for high stall speed. (See the specific Torqmatic Converter Maintenance Manual).
4. Check the operation of the selector valve, check the valve, by-pass valve and transmission driven pump. (Series 400 through 900 converters).
5. Check the inlet line and screen. Clean them if necessary. (Series 400 through 900 converters).
6. A low oil level or improper installation of screen. (Series 400 through 600 converters).
7. The oil return line is not below the oil level in the sump.

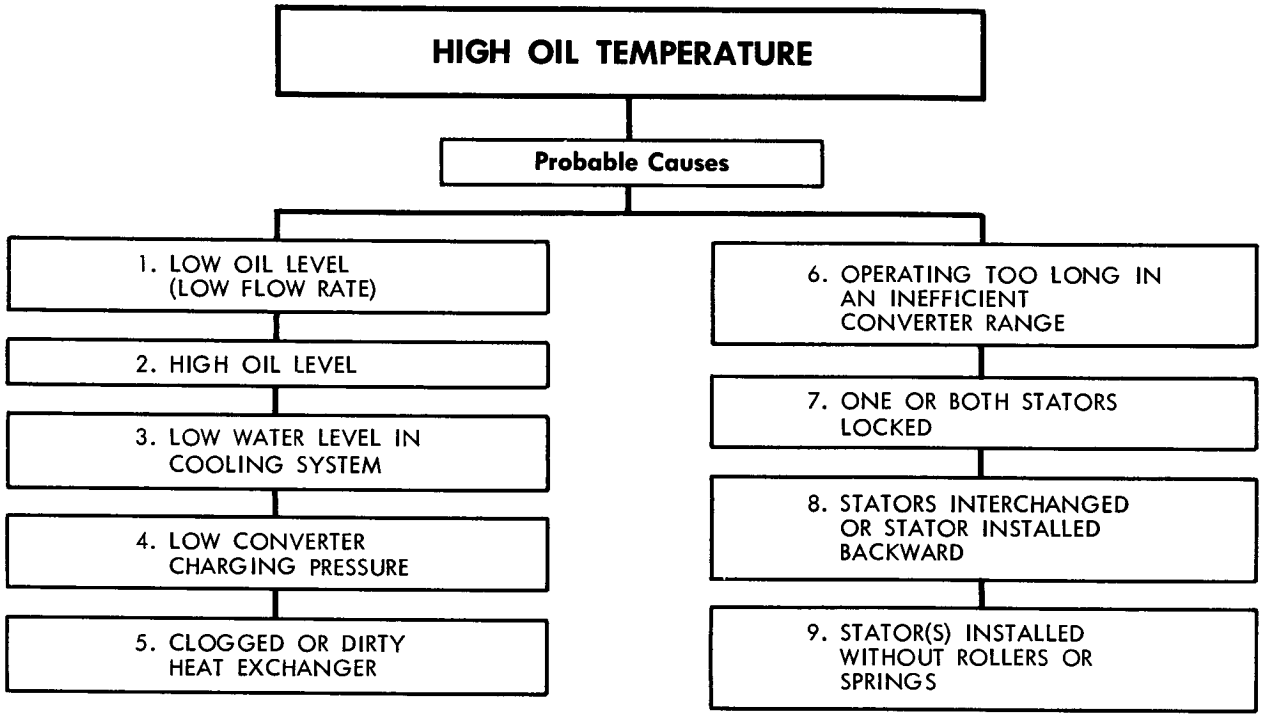
Chart 18



SUGGESTED REMEDY

1. Adjust the clutch.

Chart 19



SUGGESTED REMEDY

1. Add oil. Refer to the Lubrication and Preventive Maintenance Chart.

2. Drain oil to the proper level.

3. Add water. Check for leaks.

4. Refer to Chart 17.

5. Clean or replace it as necessary.

6. Readjust the work cycle to allow operation in an efficient converter range.

7. Check for the low maximum speed of operating equipment.

   The maximum converter "OUT" oil temperature is 250°F.

   If it should become necessary to check for locked stator(s) by observing the temperature drop rate, increase the converter "OUT" temperature to 230°F. by stalling the converter output shaft at full throttle. Release the converter output shaft and immediately check the rate of temperature drop with no load on the converter and a maximum input rpm. The temperature should start to drop after 15 seconds.

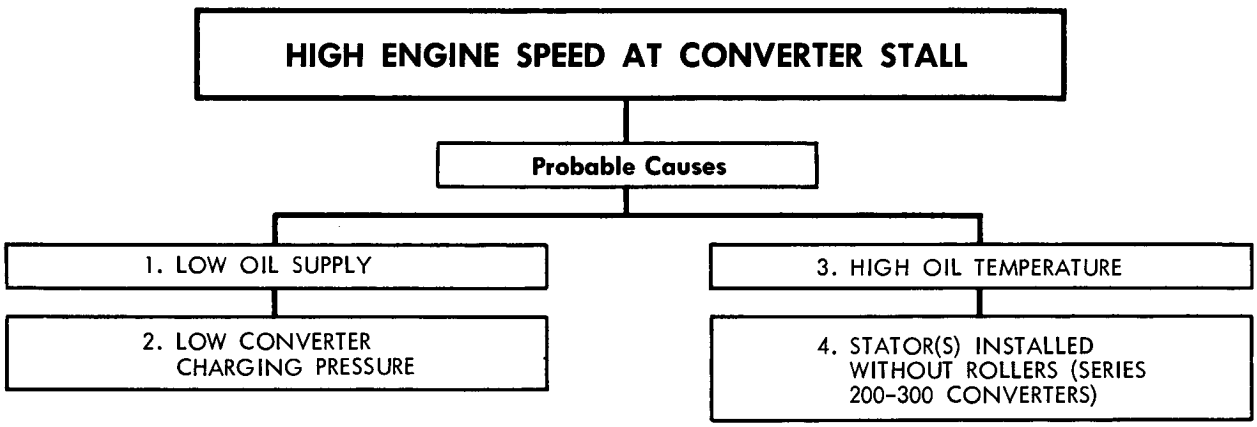
   A slow temperature drop rate may indicate locked stator(s). A rapid temperature drop rate indicates a normal stator operation.

8. Check for a lack of power at converter stall. Refer to Chart 17.

   Disassemble the converter and check the stators (refer to the specific Torqmatic Converter Maintenance Manual).

9. Disassemble the converter and install the missing parts (see Item 4 in Charts 20 and 21).

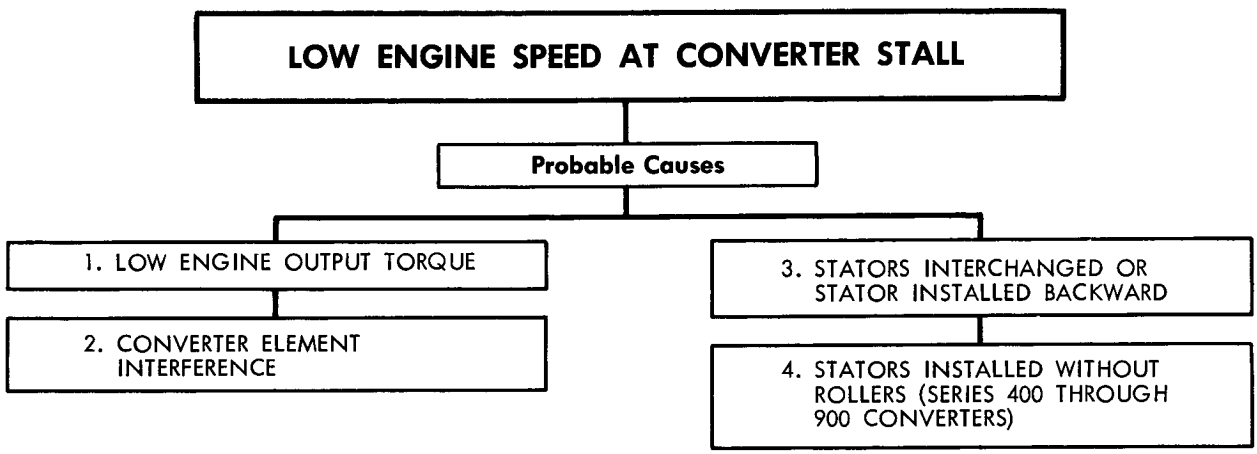
Chart 20



SUGGESTED REMEDY

1. Add oil. Refer to the Lubrication and Preventive Maintenance Chart.
2. Refer to Chart 17.
3. Refer to Chart 19.
4. Disassemble the converter and install the rollers (refer to the specific Torqmatic Converter Maintenance Manual).

Chart 21



SUGGESTED REMEDY

1. Tune the engine and check the output.
2. Check for noise at stall. Overhaul the converter if necessary.
3. Check for a lack of power at the converter stall (see the specific Torqmatic Converter Maintenance Manual).

   Disassemble the converter and check the stators.
4. Disassemble the converter and install the rollers.

15.2 TROUBLE SHOOTING—TORQMATIC CONVERTER

Chart 22

LOSS OF POWER

Probable Causes

1. STATORS INTERCHANGED (SERIES 300 THROUGH 900)
2. STATOR INSTALLED BACKWARD (SERIES 200)
3. STATOR(S) INSTALLED WITHOUT ROLLERS (HIGH STALL SPEED, SERIES 200; LOW STALL SPEED, SERIES 300 THROUGH 900)
4. LOW CONVERTER CHARGING PRESSURE
5. LOW ENGINE SPEED, AT CONVERTER STALL

SUGGESTED REMEDY

1. Check for a lack of power at the stall (see the specific Torqmatic Converter Maintenance Manual).

   Disassemble the converter and check the stators.

2. Check for a lack of power at the stall.

   Disassemble the converter and check the stator.

3. Disassemble the converter and install the rollers.
4. Refer to Chart 17.
5. Refer to Chart 21.

Chart 23

LOW LOCK-UP CLUTCH PRESSURE

Probable Causes

1. FAULTY LOCK-UP CLUTCH LINKAGE ADJUSTMENT
2. LOCK-UP CLUTCH SELECTOR VALVE NOT WORKING PROPERLY
3. FAILED OR WORN SEAL RINGS
4. STOPPAGE IN PASSAGE FROM OIL PUMP TO LOCK-UP PISTON

SUGGESTED REMEDY

1. Adjust the linkage.
2. Remove the charging oil pump cover and check the clutch selector valve.
3. Disassemble the converter. Replace the failed or worn seal rings.
4. Disassemble the converter and clean the passage. Inspect the converter for dirt.

OPERATING CONDITIONS

The following charts are included as an aid to trouble shooting. Any variations from the conditions as listed may be indicative of an abnormal situation demanding correction. Make sure that readings represent true values, and that instruments are accurate, before attempting to make corrections to the engine.

SERIES 2, 3 & 4-53 (2-VALVE CYLINDER HEAD)

	1800 r.p.m.	2000 r.p.m.	2200 r.p.m.
Lube Oil Pressure--p.s.i. (Normal)	40-50	40-50	40-50
Lube Oil Pressure--p.s.i. (Minimum for Safe Operation)	30	30	30
Air Box Pressure--inches mercury (Minimum with zero exhaust back pressure)			
2-53	3.8	5.2	
3-53 & 4-53	3.8		6.2
Air Box Pressure--inches mercury (Minimum, with maximum exhaust back pressure)			
2-53	5.5	7.2	
3-53 & 4-53	5.5		8.6
Air Inlet Restriction--inches water (Maximum, Air Cleaner Dirty, Oil Bath or Dry Type)			
2-53	13.4	16.0	
3-53 & 4-53	13.4		18.8
Air Inlet Restriction--inches water (Maximum, Air Cleaner Clean)			
2-53 Oil Bath Type	7.7	9.0	
3-53 & 4-53 Oil Bath Type	7.7		10.5
2-53 Dry Type with Precleaner Section	6.8	7.5	
3-53 & 4-53 Dry Type with Precleaner Section	6.8		7.5
Crankcase Pressure--Inches water (Maximum)	.5	.5	.5
Exhaust Back Pressure--inches mercury (Maximum)			
2-53	2.1	2.5	
3-53 & 4-53	2.1		3.0
Fuel Pressure--p.s.i. (Normal, at cylinder head inlet passage)	55-70	55-70	55-70
Fuel Pressure--p.s.i. (Minimum, at cylinder head inlet passage)	35	35	35
Compression Pressure-525 p.s.i. at 600 r.p.m. (Average, new engine at sea level)			
Compression Pressure--475 p.s.i. at 600 r.p.m. (Minimum, at sea level)			
Coolant Temperature--Degree F. (Normal)	160-185	160-185	160-185
Lube Oil Temperature--Degrees F. (Normal)			
2-53	190-220	190-225	
3-53 & 4-53	200-235	200-235	200-235

13.2 OPERATING CONDITIONS

SERIES 3, 4 & 6V-53 ENGINES (4-VALVE CYLINDER HEAD)

	2500 r.p.m.	2800 r.p.m.
Lube Oil Pressure--p.s.i. (Normal)	40-50	40-50
Lube Oil Pressure--p.s.i. (Minimum for Safe Operation)	32	32
Air Box Pressure--inches mercury (Minimum, with zero exhaust back pressure)	4.8	6.1
Air Box Pressure--inches mercury (Minimum, with maximum exhaust back pressure)	8.0	9.3
Air Inlet Restriction--inches water (Maximum, Air Cleaner Dirty, Oil Bath or Dry Type)	23.0	23.0
Air Inlet Restriction--inches water (Maximum, Air Cleaner Clean)		
Oil Bath Type	13.0	13.0
Dry Type with Precleaner Section	10.5	10.5
Crankcase Pressure--inches water (Maximum)	.9	1.0
Exhaust Back Pressure--inches mercury (Maximum)	4.0	4.0
Fuel Pressure--p.s.i. (Normal, at cylinder head inlet passage)	55-70	55-70
Fuel Pressure--p.s.i. (Minimum, at cylinder head inlet passage)	35	35
Compression Pressure--525 p.s.i. at 600 r.p.m. (Average, new engine at sea level)		
Compression Pressure--475 p.s.i. at 600 r.p.m. (Minimum, at sea level)		
Coolant Temperature--Degrees F. (Normal)	160-185	160-185
Lube Oil Temperature--Degrees F. (Normal)	200-235	205-240

ENGINE OPERATING CONDITIONS

These charts are included as an aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represent true values before attempting to make corrections to the engine.

	Idle	1200 rpm	1800 rpm	2100 rpm
71 ENGINES				
Lubricating Oil Pressure--p.s.i.				
Normal		30-60	38-60	40-60
Minimum for safe operation.		18	27	30
Air Box Pressure--inches mercury (Minimum)				
At zero exhaust back pressure . . . 3, 4-71.		3.3	7.3	10.0
6-71		3.7	8.1	11.0
At maximum full load exhaust back pressure . . . 3, 4-71.		4.8	10.6	14.1
6-71		5.2	11.4	15.1
Air Inlet Restriction--inches water (Maximum)				
Dirty air cleaner--Oil Bath or Dry		12.4	25.0	30.0
Clean air cleaner--Oil Bath or Dry (With Precleaner)		9.0	15.0	18.0
Crankcase Pressure--inches water (Maximum)				
3-71 engine		1.2	1.8	2.1
4-71 engine		1.8	2.5	2.8
6-71 engine		2.0	2.8	3.1
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.8	4.0	5.0
No Load		1.2	2.8	3.5
Fuel Pressure--inlet manifold--p.s.i				
Normal				
.055" and .080" Restrictions		45-65	45-65	45-65
.1065" Restriction		35-50	45-65	45-65
Minimum		30	30	30
Fuel Spill, no load-g.p.m. (Minimum)				
.055" Restriction		.5	.6	.6
.080" and .1065" Restrictions.		.8	.9	.9
Compression Pressure--p.s.i. at 600 rpm (at sea level)				
Average, new engine	440			
Minimum	390			
71E (2-VALVE HEAD) ENGINES				
Lubricating Oil Pressure--p.s.i.				
Normal		30-60	38-60	40-60
Minimum for safe operation.		18	27	30
Air Box Pressure--inches mercury (Minimum)				
At zero exhaust back pressure		2.0	5.1	6.5
At maximum full load exhaust back pressure		3.5	8.4	10.6
Air Inlet Restriction--inches water (Maximum)				
Dirty air cleaner--Oil Bath or Dry		12.4	25.0	30.0
Clean air cleaner--Oil Bath or Dry (With Precleaner)		9.0	15.0	18.0
Crankcase Pressure--inches water (Maximum)				
4-71E		1.8	2.5	2.7
6-71E		2.0	2.8	3.0
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.8	4.0	5.0
No Load		1.2	2.8	3.5
Fuel Pressure--inlet manifold--p.s.i.				
Normal		45-65	45-65	45-65
Minimum		30	30	30
Fuel Spill, no load-g.p.m. (Minimum)				
.055" Restriction		.5	.6	.6
.080" Restriction		.8	.9	.9
Compression Pressure--p.s.i.-at 600 rpm (at sea level)				
Average, new engine	475			
Minimum	425			

13.2 ENGINE OPERATING CONDITIONS

	Idle	1200 rpm	1800 rpm	2000 rpm
71E (4-VALVE HEAD) ENGINES				
Lubricating Oil Pressure--p.s.i.				
Normal		30-60	38-60	40-60
Minimum for safe operation		18	27	30
Air Box Pressure--inches mercury (Minimum)				
At zero exhaust back pressure		1.7	4.3	6.0
At maximum full load exhaust back pressure		3.2	7.6	10.1
Air Inlet Restriction--inches water (Maximum)				
Dirty Air Cleaner--Oil Bath or Dry		12.5	25.0	30.0
Clean Air Cleaner--Oil Bath or Dry (With Precleaner)		9.0	15.0	18.0
Crankcase Pressure--inches water (Maximum)				
4-71 engine		1.8	2.5	2.8
6-71 engine		2.0	2.8	3.1
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.8	4.0	5.0
No Load		1.2	2.8	3.5
Fuel Pressure--inlet manifold--p.s.i.				
Normal		45-65	45-65	45-65
Minimum		30	30	30
Fuel Spill, No Load-g.p.m. (Minimum)				
.055" Restriction		.5	.6	.6
.080" Restriction		.8	.9	.9
Compression Pressure--p.s.i. at 600 rpm (at sea level)				
Average, new engine	475			
Minimum	425			
71N ENGINES				
Lubricating Oil Pressure--p.s.i.				
Normal		30-60	38-60	40-60
Minimum for safe operation		18	27	30
Air Box Pressure--inches mercury (Minimum with zero exhaust back pressure)				
Full Load		1.7	4.3	6.0
No Load		0.5	1.6	1.8
Air Box Pressure--inches mercury (Minimum with maximum exhaust back pressure)				
Full Load		3.2	7.6	10.1
No Load		1.3	4.2	5.0
Air Inlet Restriction--inches water (Maximum)				
Dirty Air Cleaner--Oil Bath or Dry		12.4	25.0	30.0
Clean Air Cleaner--Oil Bath or Dry (With Precleaner)		9.0	15.0	18.0
Crankcase Pressure--inches water (Maximum)				
4-71 engine		1.8	2.5	2.8
6-71 engine		2.0	2.8	3.1
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.5	3.3	4.0
No Load		1.0	2.1	2.6
Fuel Pressure--inlet manifold--p.s.i.				
Normal				
.080" Restriction		45-65	45-65	45-65
Minimum		30	30	30
Fuel Spill, no load-g.p.m. (Minimum)				
.080" Restriction		.8	.9	.9
Compression Pressure--p.s.i. at 600 rpm (at sea level)				
Average, new engine	565			
Minimum	515			

	Idle	1800 rpm	2100 rpm	2300 rpm
71T ENGINES				
Lubricating Oil Pressure--p.s.i.				
Normal		40-60	40-60	40-60
Minimum for safe operation		28	30	30
Air Box Pressure--inches mercury (Minimum, 4, 6-71, clean ports, maximum exhaust back pressure)--Full Load				
Injectors--90 cu. mm.		15.0	20.9	25
Injectors--80 cu. mm.		13.4	18.8	22.5
Injectors--70 cu. mm.		17.1	23.0	27.1**
Minimum--No Load--10.0 at 2225 rpm				
Minimum--No Load--12.0 at 2425 rpm				
Air Intake Restriction--inches water (Maximum)				
Dirty Air Cleaner--Oil Bath or Dry				
4-71M5 and 6-71M10		12.3	16.7	20.0
6-71M5		14.7	20.0	-
Clean Air Cleaner--Oil Bath				
4-71M5 and 6-71M10		9.8	13.3	16.0
6-71M5		11.8	16.0	-
Clean Air Cleaner--Dry (No Precleaner)				
4-71M5 and 6-71M10		5.0	6.5	8.0
6-71M5		6.0	8.0	-
Clean Air Cleaner--Dry (With Precleaner)				
4-71M5 and 6-71M10		7.5	10.0	12.0
6-71M5		9.0	12.0	-
Crankcase Pressure--inches water (Maximum)				
4-71 engine		.5	.6	.6
6-71 engine		.9	1.0	1.0
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load 4-71M5 and 6-71M10		1.5	2.1	2.5
6-71M5		1.8	2.5	-
No Load 4-71M5 and 6-71M10		1.1	1.5	1.8
6-71M5		1.3	1.8	-
Fuel Pressure--inlet manifold--p.s.i.				
Normal				
.055" and .080" Restrictions		45-60	50-65	50-65
.1065" Restriction		40-55	45-60	45-60
Minimum		30	30	30
Fuel Spill, No Load--g.p.m. (Minimum)				
.055" Restriction		.6	.6	.6
.080" Restriction		.9	.9	.9
.1065" Restriction		1.2	1.2	1.2
Compression Pressure--p.s.i. at 600 rpm (at sea level)				
Average, New engine	450			
Minimum	400			
* Compressor Outlet Pressure--inches mercury				
Full Load		11.1	14.7	17.1
No Load		.8	1.3	2.0
# Turbine Inlet Pressure--inches mercury				
Full Load		12.0	16.8	20.0
No Load		5.0	7.2	8.8

* Turbocharger pressures should be measured at location shown in Fig. 1.

Operating conditions may vary these pressures by 10%. Factors affecting performance are air temerpature, barometer pressure, high intake restriction and high back pressure. Turbocharger pressures listed above apply to performance at elevations below 8,000 feet.

** 4-71M5 Turbocharger only

13.2 ENGINE OPERATING CONDITIONS

	ALL SPEEDS
ALL 71 ENGINES	
Fuel Pump Lift, (Maximum)--Feet	4
Coolant Temperature--Engine, Degrees F. (Normal)	160-185
Lubricating Oil Temperature--Engine, Degrees, F. (Normal)	200-225
Lubricating Oil Temperature--71T Engine, Degrees F. (Normal)	200-235
ALL ENGINE UNITS	
Torque Converter Charging Pressure--p.s.i.	
Series 400, 500, (Minimum)--at stall	50
Series 600, 800, 900 (Minimum)--at stall	60
Series 400, 500, 600, 800, 900 (Maximum)--no load	120
Torque Converter Oil Temperature--Degrees F. (Maximum)	250
Railcar Transmission Converter Charging Pressure p.s.i.	
Minimum	115
Maximum	130
Railcar Transmission Converter Oil Temperature--Degrees F. (Maximum)	265
Torqmatic Marine Gear Oil Pump Pressure--p.s.i.	
M and MH Type (Maximum)--single Engine	125
M and MH Type (Minimum)--Single Engine	90
M Type (Maximum) Multiple Engines	100
M Type (Minimum) Multiple Engines	60
MH Type (Maximum) Multiple Engines	125
MH Type (Minimum) Multiple Engines	90
Constant Flow Type (Maximum)--All Engines	150
Constant Flow Type (Minimum)--All Engines	90
Torqmatic Marine Gear Oil Temperature	
Degrees F. (Maximum) Reverse	225
Degrees F. (Average) Forward	200
Paragon Marine Gear Oil Pressure--p.s.i.	
Minimum	90
Maximum	150
Paragon Marine Gear Oil Temperature Maximum--Degrees F.	250

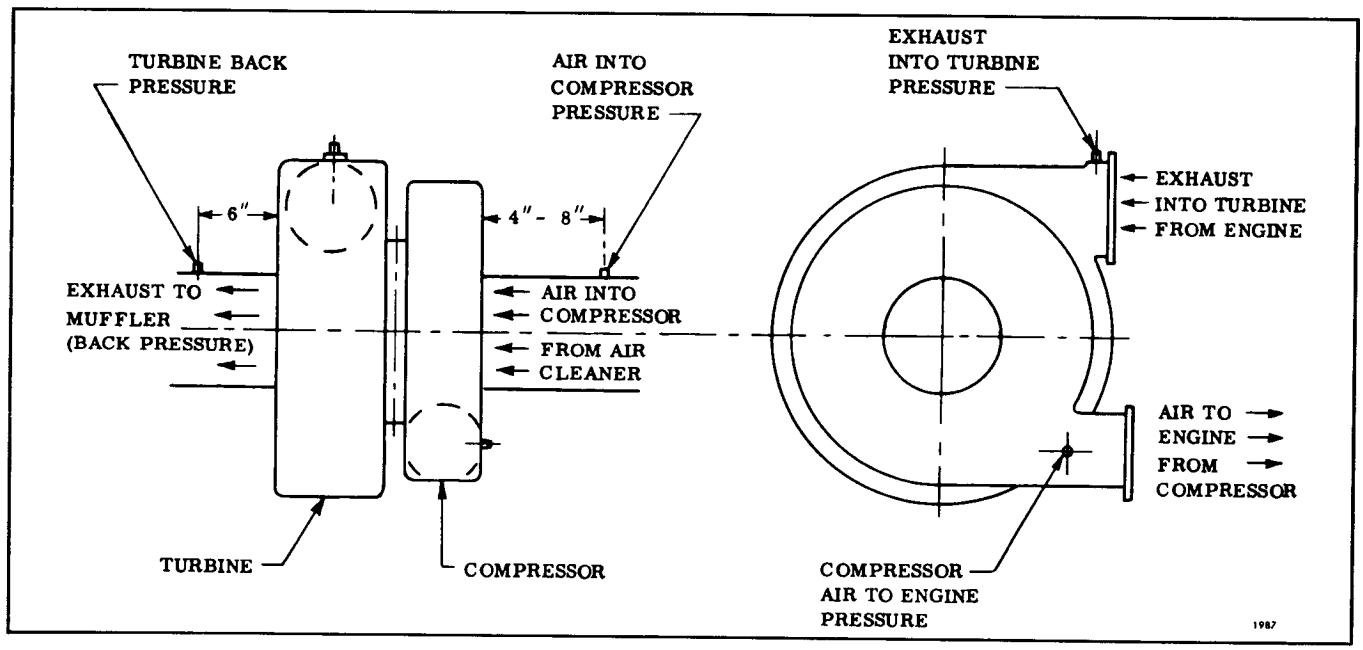


Fig. 1 - Points to Measure Intake and Exhaust Restriction

ENGINE OPERATING CONDITIONS

These charts are included as an aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represent true values before attempting to make corrections to the engine.

	ENGINE SPEED (rpm)			
	600	1200	1800	2100
V-71 TWO VALVE HEAD ENGINE				
Air Box Pressure--inches mercury (Minimum)				
Zero Exhaust Back Pressure (full load)		1.7	4.4	6.2
Maximum Exhaust Back Pressure (full load)		2.9	7.0	9.4
Air Inlet Restriction--inches water (Maximum)				
Dirty Air Cleaner (Oil bath or dry type)		12.4	25.2	30.0
Clean Air Cleaner (Oil bath or dry type with precleaner)		9.0	15.0	18.0
Compression Pressure--p.s.i. (at sea level)				
Average, New Engine	475			
Minimum	425			
Coolant Temperature--degrees F. (Normal)		160-185	160-185	160-185
Crankcase Pressure--inches water (Maximum)		0.2	0.7	1.0
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.5	3.3	4.0
No Load		1.0	2.1	2.6
Fuel Pressure--p.s.i. (Inlet manifold)				
Normal (.080" orifice)		45-65	45-65	45-65
Minimum		30	30	30
Fuel Pump Lift--feet (Maximum)		4	4	4
Fuel Spill--g.p.m., (Minimum) no load		.8	.9	.9
Lubricating Oil Pressure--p.s.i.				
Normal		35-55	50-70	50-70
Minimum for safe operation		25	28	30
Lubricating Oil Temperature--degrees F. (Normal)		200-235	200-235	200-235
V-71 FOUR VALVE HEAD ENGINE				
Air Box Pressure--inches mercury (Minimum)				
Zero Exhaust Back Pressure (full load)		1.1	3.8	5.0
Maximum Exhaust Back Pressure (full load)		2.6	5.5	8.2
Air Inlet Restriction--inches water (Maximum)				
Dirty Air Cleaner (Oil bath or dry type)		12.4	25.2	30.0
Clean Air Cleaner (Oil bath or dry type with precleaner)		9.0	15.0	18.0
Compression Pressure--p.s.i. (at sea level)				
Average, New Engine	475			
Minimum	425			
Coolant Temperature--degrees F. (Normal)		160-185	160-185	160-185
Crankcase Pressure--inches water (Maximum)		0.5	1.1	1.5
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.5	3.3	4.0
No Load		1.0	2.1	2.6
Fuel Pressure--p.s.i. (inlet manifold)				
Normal (.080" orifice 6, 8 & 12V)		45-65	45-65	45-65
(.070" orifice 16V)		35-50	50-70	50-70
Minimum		30	30	30
Fuel Pump Lift--feet (Maximum)		4	4	4
Fuel Spill--g.p.m., (Minimum) no load		.8	.9	.9
Lubricating Oil Pressure--p.s.i.				
Normal		35-55	50-70	50-70
Minimum for safe operation		25	28	30
Lubricating Oil Temperature--degrees F. (Normal)		200-235	200-235	200-235

13.2 ENGINE OPERATING CONDITIONS

	ENGINE SPEED (rpm)			
	600	1200	1800	2100
V-71"N" ENGINE				
Air Box Pressure--inches mercury (Minimum)				
Zero Exhaust Back Pressure (full load)		1.1	3.8	5.0
Maximum Exhaust Back Pressure (full load)		3.3	6.4	8.2
Air Inlet Restriction--inches water (Maximum)				
Dirty Air Cleaner (Oil bath or dry type)		12.4	25.2	30.0
Clean Air Cleaner (Oil bath or dry type with precleaner)		9.0	15.0	18.0
Compression Pressure--p.s.i. (at seal level)				
Average New Engine	565			
Minimum	515			
Coolant Temperature--degrees F. (Normal)		160-185	160-185	160-185
Crankcase Pressure--inches water (Maximum)		0.5	1.1	1.5
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.5	3.3	4.0
No Load		1.0	2.1	2.6
Fuel Pressure--p.s.i. (inlet manifold)				
Normal (.070" orifice 16V)		45-65	45-65	45-65
(.080" orifice 6, 8 & 12V)		35-50	50-70	50-70
Minimum		30	30	30
Fuel Pump Lift--feet (Maximum)		4	4	4
Fuel Spill--g.p.m., (Minimum) no load		.8	.9	.9
Lubricating Oil Pressure--p.s.i.				
Normal		35-55	50-70	50-70
Minimum for safe operation		25	28	30
Lubricating Oil Temperature--degrees F, (Normal)		200-235	200-235	200-235

	ENGINE SPEED (rpm)			
	600	**1800	2100	2300
V-71"T" ENGINE				
Air Box Pressure--inches mercury (Minimum)				
Zero Exhaust Back Pressure (clean ports full load)		27.2	32.0	40.0
Maximum Exhaust Back Pressure (clean ports-full load)				
S80 Injectors--12V Engine		-	22.0	29.0
Air Box Pressure--inches mercury (Maximum)				
Maximum Exhaust Back Pressure (clean ports-full load)		30.4	35.5	44.0
Air Inlet Restriction--inches water (Maximum) 8V Engine				
Clean Air Cleaner		10.0	12.0	16.0
Dirty Air Cleaner		12.2	15.1	20.0
Air Inlet Restriction--inches water (Maximum) 12V Engine				
Clean Air Cleaner		-	13.3	16.0
Dirty Air Cleaner		-	16.7	20.0
Compression Pressure--p.s.i. (at sea level)				
Average, New Engine	475			
Minimum	425			
Compressor Discharge Pressure--inches mercury (Minimum)		*18.0	*20.5	*24.6
Compressor Discharge Pressure--inches mercury (Maximum)		*20.5	*23.0	*27.5
Coolant Temperature--degrees F (Normal)		160-185	160-185	160-185
Crankcase Pressure--inches water (Maximum)				
8V Engine		1.2	1.3	1.5
12V Engine			1.2	1.5
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.5	1.9	2.5
No Load		1.1	1.4	1.8
Fuel Pressure--p.s.i. (inlet manifold)				
Normal 8V Engine		50-70	50-70	50-70
12V Engine		-	40-60	40-60
Minimum		20	20	20
Fuel Pump Lift--feet (Maximum)		4	4	4
Fuel Spill--g.p.m., (Minimum) no load		.8	.9	.9
Lubricating Oil Pressure--p.s.i.				
Normal		**40-60	40-60	40-60
Minimum for safe operation		30	30	30
Lubricating Oil Temperature--degrees F (Normal)		-	200-235	200-235
(Maximum)		*250	*250	*250

*Reading for 8V-71"T" Engine only
**No readings at 1800 rpm for 12V-71"T" Engine

ENGINE OPERATING CONDITIONS

The following charts are included as an aid to engine operation and trouble shooting. Any variations from the conditions as listed may be indicative of an abnormal situation demanding correction. Make sure that readings represent true values before attempting to make corrections to the engine.

SERIES 110 ROOTS BLOWER ENGINE (2-VALVE HEAD)

	1200 rpm	1800 rpm	2000 rpm
LUBRICATION SYSTEM			
Lubricating Oil Pressure--p.s.i. (Normal)	35-45	45-55	45-60
Lubricating Oil Pressure--p.s.i. (Minimum for Safe Operation)	30	40	40
Lubricating Oil Temperature--°F. (Normal Range)	200-235	200-235	200-235
AIR SYSTEM			
Air Inlet Restriction--Maximum, Inches of Water			
Dirty Air Cleaner (Oil Bath or Dry Type)	10.0	20.0	24.0
Clean Air Cleaner (Oil Bath Type)	6.5	13.0	15.5
Clean Air Cleaner (Dry Type with Pre-Cleaner Section)	6.8	12.7	15.0
Clean Air Cleaner (Dry Type with no Pre-Cleaner)	4.5	8.5	10.0
Air Box Pressure--Minimum, Inches of Mercury			
Zero Exhaust Back Pressure	3.9	9.2	11.0
Maximum Full Load Exhaust Back Pressure (with clean Ports)	5.0	11.7	14.0
Exhaust Back Pressure--Maximum, Inches of Mercury			
Full Load	1.4	3.2	4.0
No Load	1.0	2.3	2.8
Crankcase Pressure--Maximum, Inches of Water	0.5	1.2	1.5
FUEL SYSTEM			
Fuel Pressure at Inlet Manifold (.1065" orifice)--p.s.i.			
Normal	40-45	55-65	55-65
Minimum	22	41	45
Fuel Spill--Minimum, gpm			
No Load (.1065" Restriction)	0.8	1.0	1.0
Fuel Pump Lift--Maximum, Feet	4	4	4
COOLING SYSTEM			
Coolant Temperature--Engine, °F. (Normal Range)	160-185	160-185	160-185
Raw Water Pump			
Inlet Restriction--Maximum, Inches of Mercury	2.1	5.0	5.0
Outlet Pressure--Maximum, p.s.i.	4.2	10.0	10.0
Keel Cooler Pressure Drop--Maximum through System, p.s.i.	2.5	6.0	6.0

13.2 ENGINE OPERATING CONDITIONS

SERIES 110 ROOTS BLOWER ENGINE (4-VALVE HEAD)

	1200 rpm	1800 rpm	2000 rpm
LUBRICATION SYSTEM			
Lubricating Oil Pressure--p.s.i. (Normal)	35-45	45-55	45-60
Lubricating Oil Pressure--p.s.i. (Minimum for Safe Operation)	30	40	40
Lubricating Oil Temperature--°F. (Normal Range)	200-235	200-235	200-235
AIR SYSTEM			
Air Inlet Restriction--Maximum, Inches of Water			
Dirty Air Cleaner (Oil Bath or Dry Type)	10.0	20.0	24.0
Clean Air Cleaner (Oil Bath Type)	6.5	13.0	15.5
Clean Air Cleaner (Dry Type with Pre-Cleaner Section)	6.8	12.7	15.0
Clean Air Cleaner (Dry Type with no Pre-Cleaner)	4.5	8.5	10.0
Air Box Pressure--Minimum, Inches of Mercury			
Zero Exhaust Back Pressure	2.4	5.4	6.7
Maximum Full Load Exhaust Back Pressure (with Clean Ports)	3.5	7.9	9.7
Exhaust Back Pressure--Maximum, Inches of Mercury			
Full Load	1.4	3.2	4.0
No Load	1.0	2.3	2.8
Crankcase Pressure--Maximum, Inches of Water	0.5	1.2	1.5
FUEL SYSTEM			
Fuel Pressure at Inlet Manifold (.1065" Orifice)--p.s.i.			
Normal	40-45	55-65	55-65
Minimum	22	41	45
Fuel Spill--Minimum, gpm			
No Load (.1065" Restriction)	0.8	1.0	1.0
Fuel Pump Lift--Maximum, Feet	4	4	4
COOLING SYSTEM			
Coolant Temperature--Engine, °F. (Normal Range)	160-185	160-185	160-185
Raw Water Pump			
Inlet Restriction--Maximum, Inches of Mercury	2.1	5.0	5.0
Outlet Pressure--Maximum, p.s.i.	4.2	10.0	10.0
Keel Cooler Pressure Drop--Maximum through System, p.s.i.	2.5	6.0	6.0

SERIES 110 ROOTS BLOWER ENGINE (TURBO-CHARGED)

	1800 rpm	2000 rpm
LUBRICATION SYSTEM		
Lubricating Oil Pressure--p.s.i. (Normal)	45-55	45-60
Lubricating Oil Pressure--p.s.i. (Minimum for Safe Operation)	40	40
Lubricating Oil Temperature--°F. (Normal Range)	200-235	200-235
AIR SYSTEM		
Air Inlet Restriction--Maximum, Inches of Water		
Dirty Air Cleaner (Oil Bath or Dry Type)	19.5	24.0
Clean Air Cleaner (Oil Bath Type)	16.3	20.0
Clean Air Cleaner (Dry Type with Pre-Cleaner Section)	11.7	14.3
Clean Air Cleaner (Dry Type with no Pre-Cleaner)	7.8	9.5
Air Box Pressure--Minimum, Inches of Mercury		
Maximum Full Load Exhaust Back Pressure (with Clean Ports)		
Injectors: 120 CU MM	15.2	19.0
110 CU MM	14.3	18.0
100 CU MM	13.4	17.0
No Load at 2190 rpm = 8.5 Inches of Mercury		
Turbocharger:		
Turbine Inlet Pressure--Minimum, Inches of Mercury		
No Load	4.8	6.0
Full Load	12.0	15.3
Compressor Outlet Pressure--Minimum, Inches of Mercury		
No Load	0.9	1.2
Full Load	12.0	14.8
Exhaust Back Pressure--Maximum, Inches of Mercury		
No Load	1.5	1.8
Full Load	2.0	2.5
Crankcase Pressure--Maximum, Inches of Water	2.6	2.8
FUEL SYSTEM		
Fuel Pressure at Inlet Manifold (.1065" Orifice)--p.s.i.		
Normal	55-65	55-65
Minimum	41	45
Fuel Spill--Minimum, gpm (No Load, .1065" Restriction)	1.0	1.0
Fuel Pump Lift--Maximum (Feet)	4	4
COOLING SYSTEM		
Coolant Temperature--Engine, °F. (Normal Range)	160-185	160-185
Raw Water Pump		
Inlet Restriction--Maximum, Inches of Mercury	5.0	5.0
Outlet Pressure--Maximum, p.s.i.	10.0	10.0
Keel Cooler Pressure Drop--Maximum through System, p.s.i.	6.0	6.0

13.2 ENGINE OPERATING CONDITIONS

SERIES 110 CENTRIFUGAL BLOWER (11.75:1 RATIO) ENGINE

	1200 rpm	1800 rpm	2000 rpm
LUBRICATION SYSTEM			
Lubricating Oil Pressure--p.s.i. (Normal)	35-45	45-50	45-60
Lubricating Oil Pressure--p.s.i. (Minimum for Safe Operation)	30	40	40
Lubricating Oil Temperature--°F. (Normal Range)	200-225	200-225	200-225
AIR SYSTEM			
Air Inlet Restriction--Maximum, Inches of Water			
Dirty Air Cleaner	7.0	16.0	20.0
Clean Air Cleaner	6.0	13.0	16.0
Air Box Pressure--Minimum, Inches of Mercury			
Zero Exhaust Back Pressure	4.0	12.0	15.0
Maximum Full Load Exhaust Back Pressure (with Clean Ports)	4.5	13.0	16.0
Exhaust Back Pressure--Maximum, Inches of Mercury			
Full Load	1.7	3.2	4.0
No Load	1.3	2.3	2.8
Crankcase Pressure--Maximum, Inches of Water	0.5	1.2	1.5
FUEL SYSTEM			
Fuel Pressure at Inlet Manifold (.1065" Orifice)--p.s.i.			
Normal	40-45	55-65	55-65
Minimum	22	41	45
Fuel Spill--Minimum, gpm (No Load, .1065" Restriction)	0.8	1.0	1.0
Fuel Pump Lift--Maximum, Feet	4	4	4
COOLING SYSTEM			
Coolant Temperature--Engine, °F. (Normal Range)	160-185	160-185	160-185
Raw Water Pump			
Inlet Restriction--Maximum, Inches of Mercury	2.1	5.0	5.0
Outlet Pressure--Maximum, p.s.i.	4.2	10.0	10.0
Keel Cooler Pressure Drop--Maximum through System, p.s.i.	2.5	6.0	6.0

SERIES 110 CENTRIFUGAL BLOWER (13.15:1 RATIO) ENGINE

	1200 rpm	1800 rpm
LUBRICATION SYSTEM		
Lubricating Oil Pressure--p.s.i. (Normal)	35-45	45-55
Lubrication Oil Pressure--p.s.i. (Minimum for Safe Operation)	30	40
Lubricating Oil Temperature--°F. (Normal Range)	200-225	200-225
AIR SYSTEM		
Air Inlet Restriction--Maximum, Inches of Water		
Dirty Air Cleaner	9.0	20.0
Clean Air Cleaner	7.0	16.0
Air Box Pressure--Minimum, Inches of Mercury		
Zero Exhaust Back Pressure	5.3	13.8
Maximum Full Load Exhaust Back Pressure (with Clean Ports)	6.0	15.0
Exhaust Back Pressure--Maximum, Inches of Mercury		
Full Load	1.8	4.0
No Load	1.2	2.8
Crankcase Pressure--Maximum, Inches of Water	0.5	1.5
FUEL SYSTEM		
Fuel Pressure at Inlet Manifold (.1065" Orifice)--p.s.i.		
Normal	40-45	55-65
Minimum	22	41
Fuel Spill--Minimum, gpm (No Load, .1065" Restriction)	0.8	1.0
Fuel Pump Lift--Maximum, Feet	4	4
COOLING SYSTEM		
Coolant Temperature--Engine, °F. (Normal Range)	160-185	160-185
Raw Water Pump		
Inlet Restriction--Maximum, Inches of Mercury	2.1	5.0
Outlet Pressure--Maximum, p.s.i.	4.2	10.0
Keel Cooler Pressure Drop--Maximum through System, p.s.i.	2.5	6.0

13.2 ENGINE OPERATING CONDITIONS

ALL SERIES 110 ENGINES

	All Speeds
Torque Converter Charging Pressure--Minimum, p.s.i. (Series 500)	50
Torque Converter Charging Pressure--Minimum, p.s.i. (Series 800, 900)	60
Torque Converter Charging Pressure--Maximum, p.s.i. (Series 500, 800, 900)	120
Torque Converter Oil Temperature--Maximum, °F	250
Hydraulic Marine Gear Pump Pressure--p.s.i	
Model MH (Maximum)	150
Model MH (Minimum)	90
Hydraulic Marine Gear Oil Temperature--°F	
Reverse (Maximum)	225
Forward (Average)	200

MINIMUM COMPRESSION PRESSURE VERSUS ALTITUDE

Engine (at 600 rpm)	Altitude Above Sea Level (Feet)				
	0	2,500	5,000	7,500	10,000
110 Roots (2-Valve Head)	500	465	430	395	370
110 Roots (4-Valve Head)	450	415	385	355	330
110 Roots (Turbocharged)	440	410	375	350	325
110 Centrifugal (13.15:1 Blower)	500	465	430	395	370
110 Centrifugal (11.75:1 Blower)	480	445	410	380	355

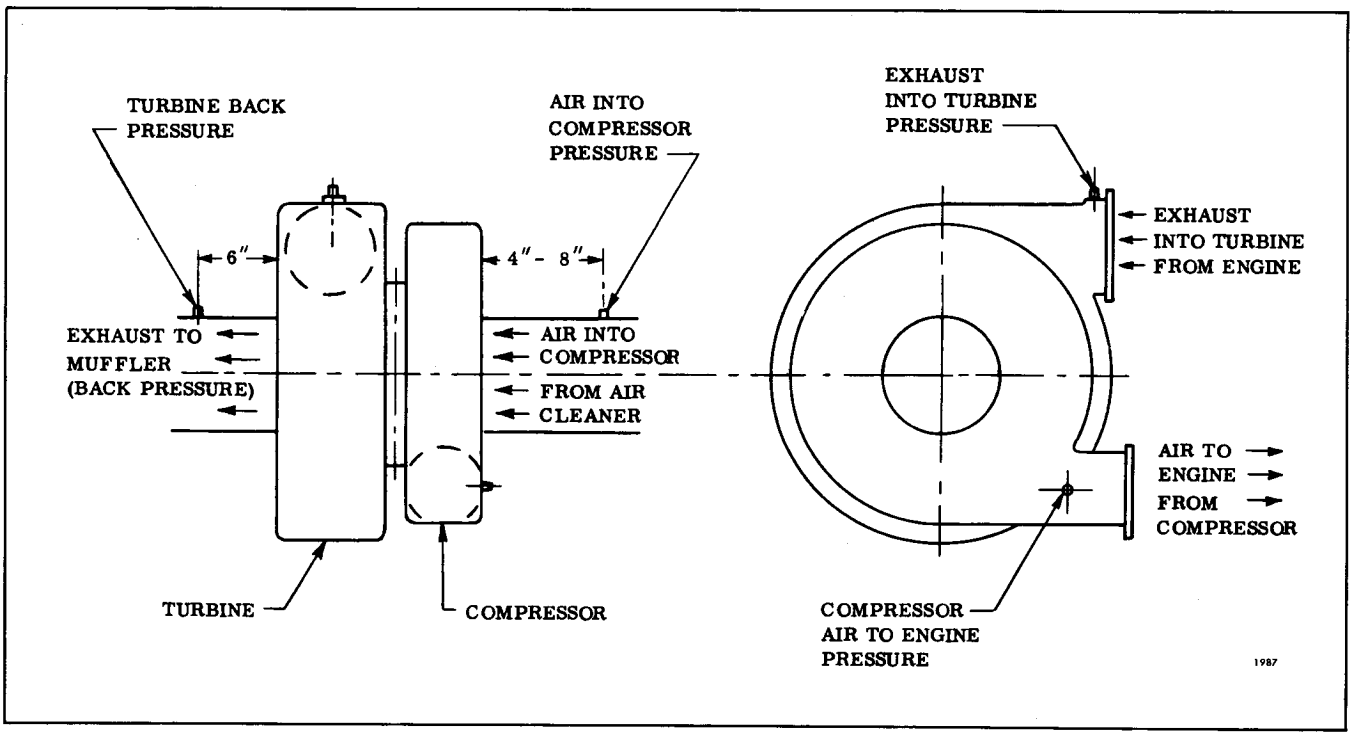


Fig. 1 - Points To Measure Intake And Exhaust Restriction.

DIESEL FUEL OIL SPECIFICATIONS

The quality of the fuel oil used for high-speed diesel engine operation is a major factor for satisfactory engine performance and life. The fuel oils selected must be clean, completely distilled, stable, and non-corrosive. Enlist the aid of your supplier in obtaining proper fuel oil. The responsibility for clean, efficient engine operation lies with the fuel supplier as well as the operator.

DISTILLATION RANGE, CETANE NUMBER, AND SULFUR CONTENT are three of the most important properties in the selection of diesel fuels for optimum combustion and minimum wear. Engine speed, load, and atmospheric temperature influence the selection of the fuels with respect to distillation range and cetane number. THE SULFUR CONTENT OF THE FUEL MUST BE AS LOW AS POSSIBLE, to avoid excessive deposit formation and premature wear.

Diesel fuels are generally marketed according to ASTM DESIGNATION D975-60T and only distillate fuels No. 1D and 2D are considered satisfactory for GM Diesel engines. These fuels should not be confused with the domestic type furnace oils ASTM D396-60T which have similar properties but are not always satisfactory for engine use due to their varying composition, cetane number, and distillation range.

As a guide to the selection of the proper fuel oil for various applications refer to the fuel oil selection chart and the ASTM Classification.

ASTM Classification of Diesel Fuel Oils

	No. 1-D	No. 2-D
Flash Pt.; °F Min.	100	125
Carbon Residue; %	0.15	0.35
Water and Sediment; (% by Volume) Max.	Trace	0.10
Ash; % by Wt.; Max.	0.01	0.02
Distillation, °F 90% Pt.; Max.	550	675
Min.	-	540
Viscosity at 100°F; centistokes Min.	1.4	2.0
Max.	2.5	5.8
Sulfur; % Max.	0.5	1.0
Cetane No; Min.	40	40

Engine operation at altitudes above 5000 feet requires use of next lighter class of fuel oil than would normally be used.

During cold weather engine operation, the "cloud point" (the temperature at which wax crystals begin to form in the fuel oil) should be 10°F. below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

At temperatures below -20°F. consult your GM Diesel Sales and Service Outlet, since particular attention must be given the cooling system, lubricating system, fuel system, electrical system, and cold weather starting aids for efficient engine operation.

FUEL OIL SELECTION CHART

Type of Engine Service	Typical Application	General Fuel Classification	Distillation 90% Boiling Point (Max.)	Distillation Final Boiling Point (Max.)	Cetane Number (Min.)	Sulfur Content (Max.)
Light Load and speed with considerable idling.	City Buses	No. 1-D	500°F	550°F	45	0.30%
Light Load and speed.	Generator sets, industrial and automotive equipment in city and suburban operation.	Winter No. 1-D	500°F	550°F	45	0.30%
		Summer No. 1-D	550°F	600°F	40	0.50%
Medium Load and speed.	Marine Pleasure Craft, Tractors, Industrial equipment.	Winter No. 1-D	550°F	600°F	45	0.50%
		Summer No. 2-D*	625°F	675°F	40	0.50%
Heavy Load and high speed with idling.	Highway Trucks	Winter No. 2-D*	625°F	675°F	45	0.50%
		Summer No. 2-D*	625°F	675°F	40	0.50%
Heavy Load and high speed.	Heavy Duty Off-the-road Equipment, Trucks, Tractors.	No. 2-D*	675°F	—	40	0.50%

*NOTE: For most satisfactory engine life, use only those No. 2-D diesel fuel oils containing 0.50% or less sulfur; where minimum exhaust smoke is required or where long periods of idling or cold weather conditions below 32°F. are encountered, the more volatile or light distillate fuels are recommended.

BREAK-IN OILS AND ADDITIVES

The use of proprietary blends of supplementary additive or concentrates such as engine oil supplements, break-in oils, tune-up compounds and friction reducing compounds is not recommended in lubricating oils used in GM Diesel engines unless given official GM part numbers and made available for use in appropriate service applications.

DIESEL LUBRICATING OIL SPECIFICATIONS

OIL QUALITY

Satisfactory long-time operation of Heavy-Duty Engines requires the use of additive type "Heavy-Duty Lubricating Oils". These oils provide better lubrication, possess more heat resistance, and counteract sludge formation more effectively than the straight mineral type oils.

A list of these "Heavy-Duty Lubricating Oils" of MIL-L-2104A, S-1, and Series 3 types, grouped in accordance with their ability to meet common service requirements, has been compiled by and may be obtained from the INTERNAL COMBUSTION ENGINE INSTITUTE, 201 NORTH WELLS ST., CHICAGO 6, ILLINOIS.

The presence or omission of a brand name on the list is not necessarily a recommendation, disapproval, or guarantee of any petroleum product by GM Diesel. Responsibility for quality and performance lies with the oil supplier.

Selection of a reliable oil supplier, strict observance of his oil change period recommendations, and proper filter maintenance will assure good lubrication which contributes to longer engine life.

RECOMMENDATION

Supplement 1 (S-1) Lubricating Oils

Supplement 1 Lubricating Oils are recommended for all GM Diesel engines in every type of service. It is also recommended that this type of oil be used first, before deviating to other types.

SPECIAL OPERATING CONDITIONS

The following types of lubricating oils have been used in special circumstances. However, before using these oils consult your supplier and obtain his assurance of satisfactory performance for your operation.

MIL-L-2104A Lubricating Oils

MIL-L-2104A lubricating oils, if used, should be for light or intermediate engine operation, where the sulfur content of the fuel oil does not exceed 0.5%.

Series 3 (S-3) Lubricating Oils

Series 3 lubricating oils are not normally required or recommended for GM Diesel engines since they tend to deter proper run-in and, being more highly compounded with additives, tend to form excessive ash deposits resulting in valve burning and top ring sticking.

Multi-Graded Lubricating Oils

Multi-Graded lubricating oils are not normally recommended. They may be used to facilitate starting when prolonged exposure of the engine to temperatures below freezing is unavoidable. Consult your supplier regarding the performance characteristics of this type of oil and obtain his assurance of adequate lubrication before subjecting the engine to heavy-duty service.

COLD WEATHER OPERATION

The proper lubricating oil viscosity grade when operating at temperatures above +30°F. is SAE 30. It is permissible to use a lighter grade of oil in order to facilitate starting as shown in the following table:

Ambient Temperature	Viscosity Grade
+30° to 0°F.	SAE 20-20W
0° to -20°F.	SAE 10W

For complete cold weather starting instructions consult your nearest Authorized GM Diesel Sales and Service Outlet.

OIL CHANGES

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 the oil supplier (based on analysis of the drained oil) until the most practical oil change period for the particular service has been established.

Solvents should not be used as flushing oils in running engines. Dilution of the fresh refill oil supply can occur which may be detrimental.

OIL FILTRATION

Heavy sludge deposits found on the oil filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. The removal of abrasive dust, metal particles, and carbon must be ensured by replacement of the oil filter elements at the time of an oil change.

> **NOTE:** The manufacturer's warranty applicable to GM Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's lubricating recommendations indicated above may not be within the coverage of the warranty.

LUBRICATION AND PREVENTIVE MAINTENANCE

To obtain the long life and best performance from a GM 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 a unit and not to a new unit or one that has not been operated for a considerable period of time. For new or stored units, carry out instructions given under PREPARATION FOR STARTING ENGINE FIRST TIME.

The time intervals given in the chart on the following page are actual operating hours of a unit. If the lubricating oil is drained immediately after a unit 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
LUBRICATION SYSTEM									
1. Engine Oil	X								
2. Oil Filter *									
COOLING SYSTEM									
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								
FUEL SYSTEM									
8. Fuel Tank	X						X		
9. Fuel Strainer & Filter	X					X			
AIR SYSTEM									
10. Air Cleaners		X				X			
11. Air Box Drains								X	
12. Crankcase Breather								X	
13. Blower Screen								X	
ELECTRICAL SYSTEM									
14. Starting Motor *									
15. Battery-Charging Generator				X	X		X		X
16. Battery				X					
MISCELLANEOUS									
17. Tachometer Drive				X					
18. Throttle Controls					X				
19. Engine Tune-Up								X	
20. Drive Belts							X		
21. Hydrostarter System									X
22. Power Generator				X		X			
23. Power Take-off		X	X				X		
24. Torqmatic Converter	X		X					X	
25. Marine Gear	X				X†		X§	X**	
26. Reduction Gear (Single Engine Units)		X	X				X	X	
27. Reduction Gear (Multiple Engine Units)	X				X				
28. Turbocharger	X							X	
29. Overspeed Governor							X		

* See items on following pages.
§ Twin Disc Marine Gear.
† Allison Torqmatic Marine Gear.
** Snow-Nabstedt Marine Gear.

Item 1

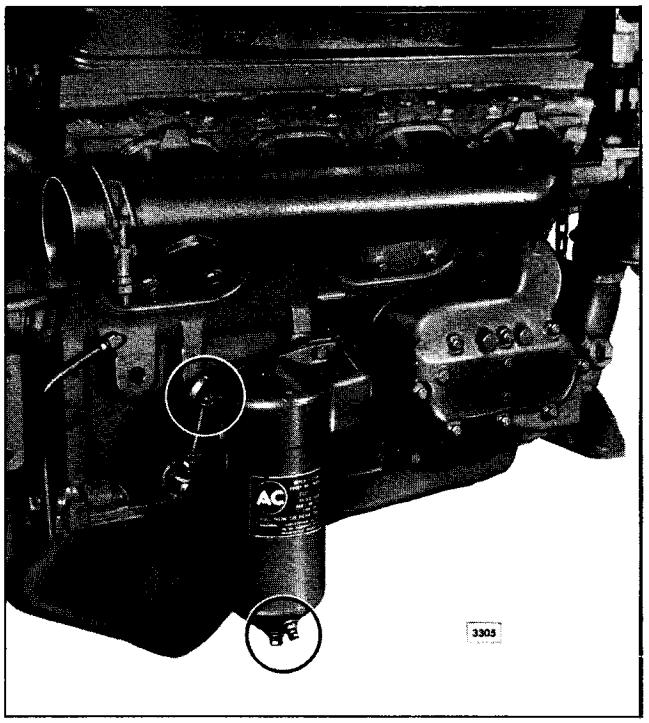
Check the oil level daily before starting the engine. Add oil, if necessary, to bring it to the proper level on the dipstick.

Select the proper grade of oil in accordance with the instructions given 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 oil supplier (based upon the oil sample analysis) until the most practical oil change period has been established.

Item 2

Install new oil filter elements and gaskets each time the engine oil is changed. Check for oil leaks after starting the engine.



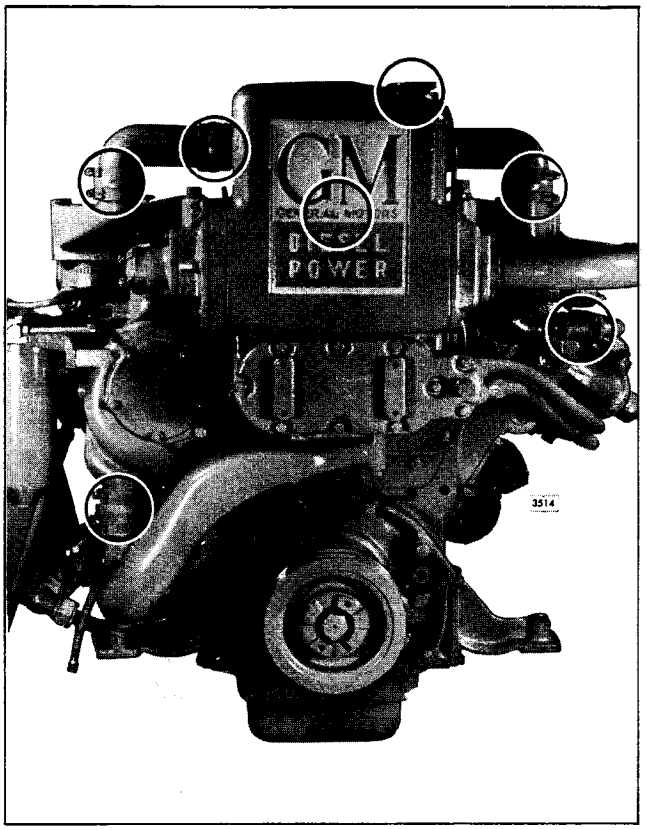
Items 1 and 2

Item 3

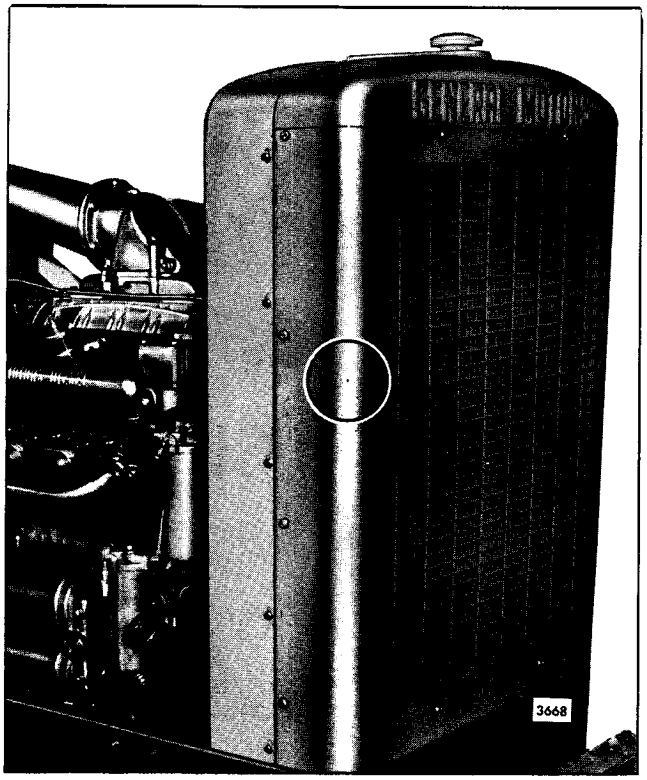
Check the coolant level daily and maintain it near the top of the heat exchanger tank or the radiator upper tank.

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 compound container. After cleaning, 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 anti-freeze. With the use of a proper anti-freeze 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 water filter and conditioner, and anti-freeze is introduced into the system, the element must be removed, since the anti-freeze and element are not compatible. If an anti-freeze solution is not required, the water filter element should be changed every 500 hours or 15,000 miles of engine operation. Also, buff the lower corrosion resistor plate bright each time the element is changed, or replace the plate if excessive metal loss is evident. This plate will periodically pit to the extent that it must be replaced.



Items 3 and 4



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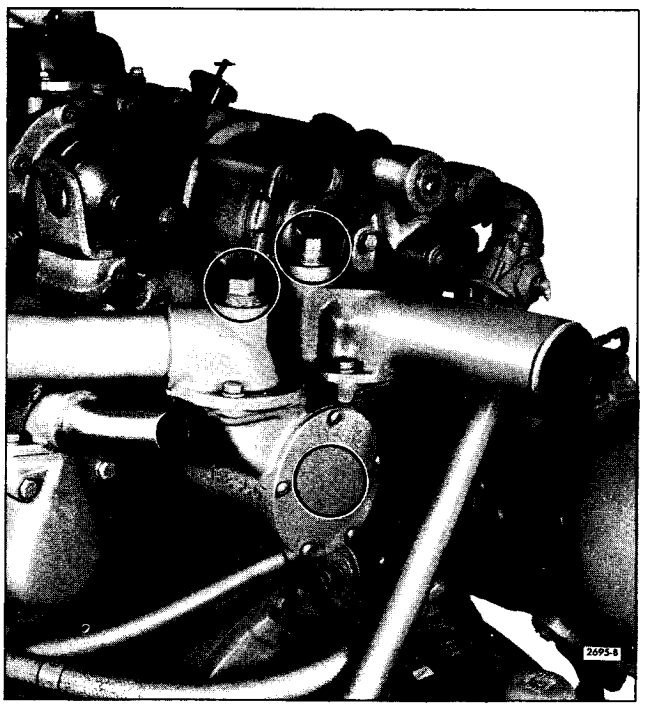


Items 6 and 7

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

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 (never use fuel oil, kerosene, or gasoline) and compressed air. It may be necessary to clean the radiator more frequently if the engine is being operated in 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 electrode 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.

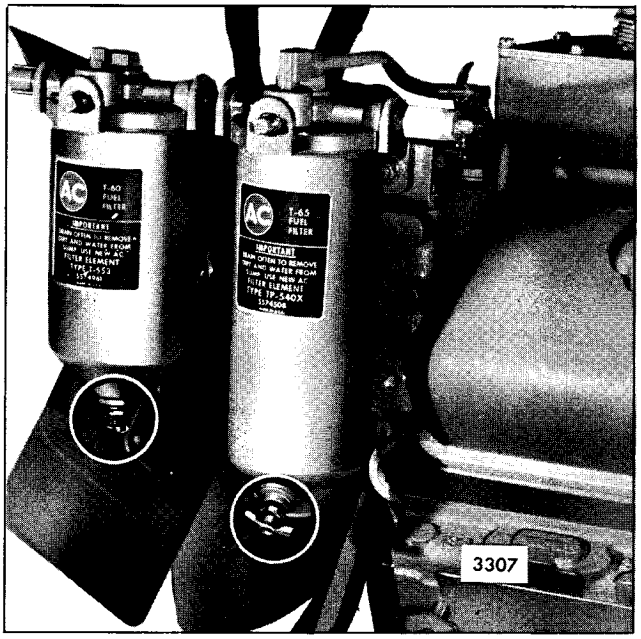
Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1,000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, clean the core as outlined in Section 5.5.

Item 7

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

Item 8

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the "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

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 the shell. Install new elements every 300 hours or 9,000 miles or when the fuel pressure drops below the minimum given in the fuel system section. Refer to the fuel system section for instructions on replacing the elements.

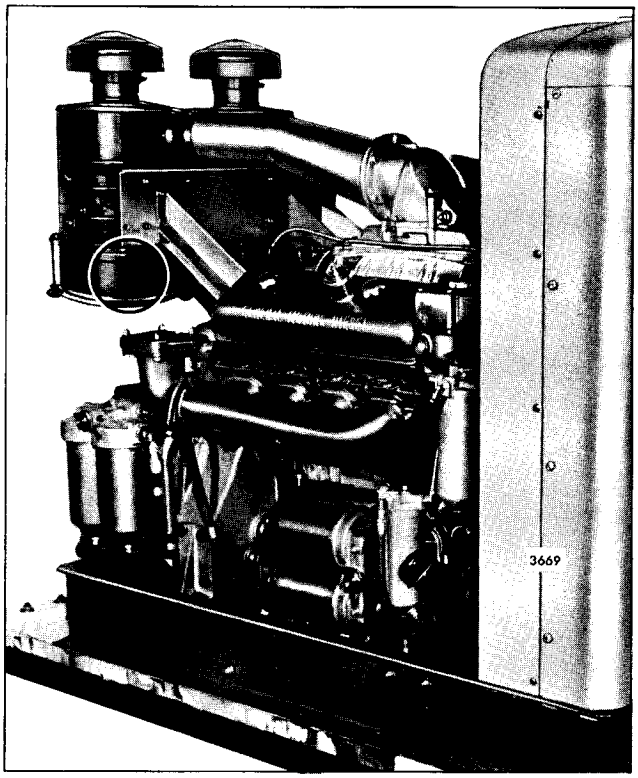
Item 10

Remove the dirty oil and sludge from the air cleaner cups and center tubes every 8 hours (every 9,000 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 of HEAVY-DUTY oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions.

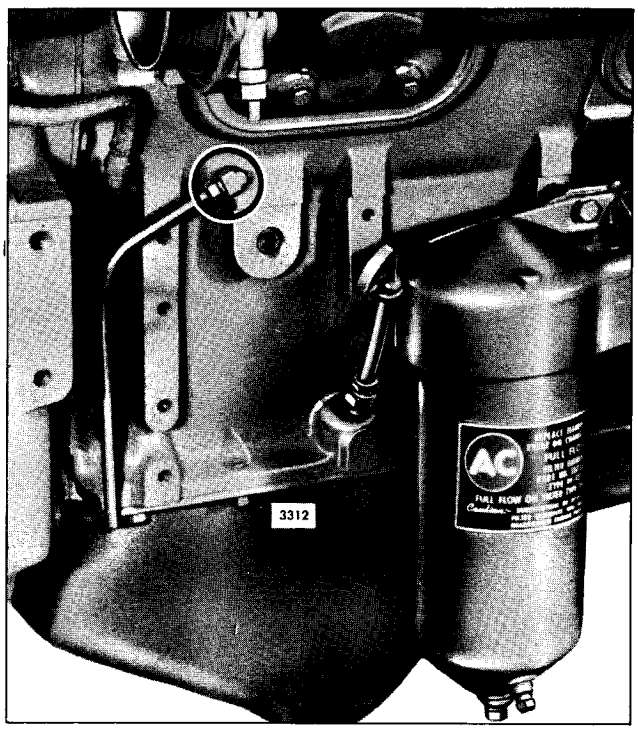
Replace the element in the dry-type air cleaner when the air intake restriction at the blower inlet reaches 28" of water or when indicated by the air cleaner restriction indicator.

Item 11

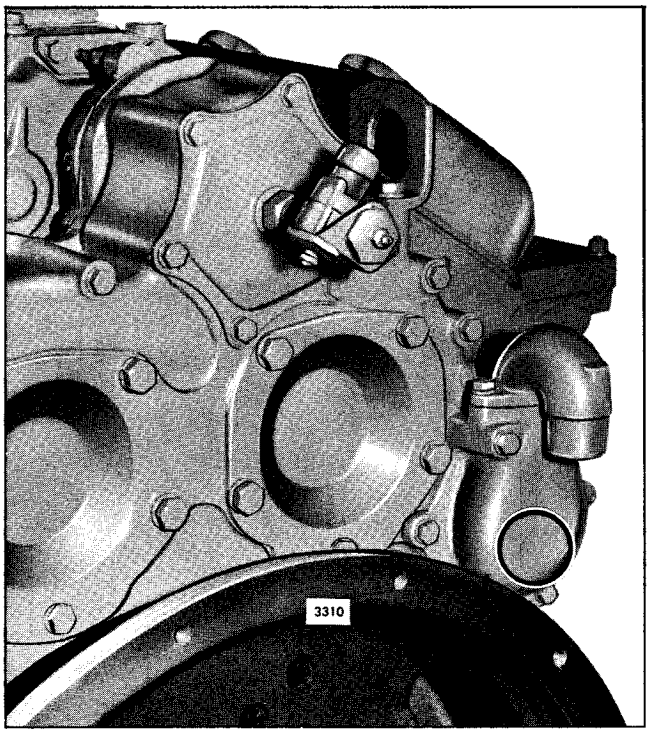
With the engine running, check for flow of air from the air box drain tubes every 1,000 hours or 30,000 miles. If the tubes are clogged, remove, clean, and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent. If the engine is equipped



Item 10



Item 11



Item 12

with an air box drain tank, drain the sediment periodically.

Item 12

Clean the crankcase breather, if it is mounted on the flywheel housing, every 1,000 hours or 30,000 miles. Remove crankcase breather from the engine and wash the steel mesh pads in fuel oil and dry them with compressed air. This cleaning period may be reduced or lengthened according to severity of service.

Item 13

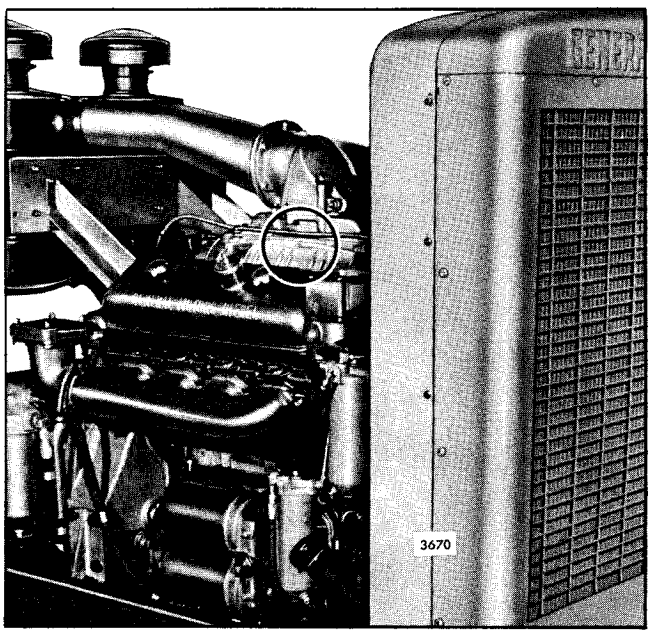
Inspect the blower screen every 1,000 hours or 30,000 miles and, if necessary, clean the screen in fuel oil and dry it with compressed air.

Item 14

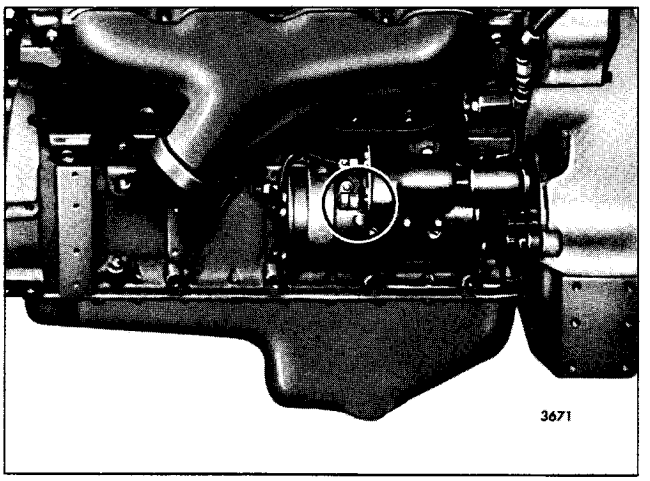
The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken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

The Bendix drive mechanism should be lubricated with a small amount of light engine oil whenever the starting motor is removed from the engine for servicing.

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

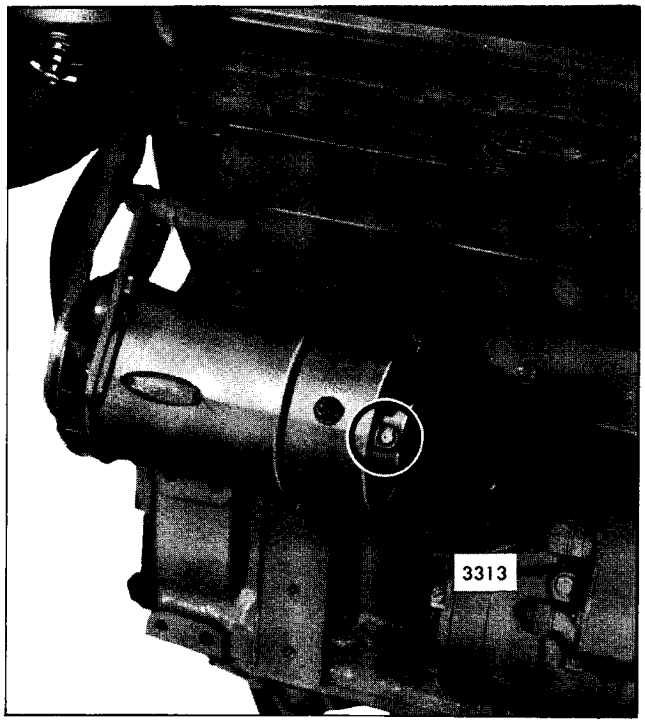
Item 15

Lubricate the generator bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours or 6,000 miles. Generators equipped with grease cups should have the caps turned down one full turn every 100 hours or 3,000 miles of operation. The grease cups should be kept filled with Delco-Remy Cam and Ball Bearing Lubricant or its equivalent. Care should be taken to avoid excessive lubrication since this may cause lubricant to be forced onto the commutator where it would gum and cause poor commutation. Such a condition results in reduced generator output and increased commutator and brush wear.

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

On D.C. generators, inspect the commutator and brushes every 500 hours or 15,000 miles. Examine the commutator and brushes every 2,000 hours or 60,000 miles and clean the commutator, 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, 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.



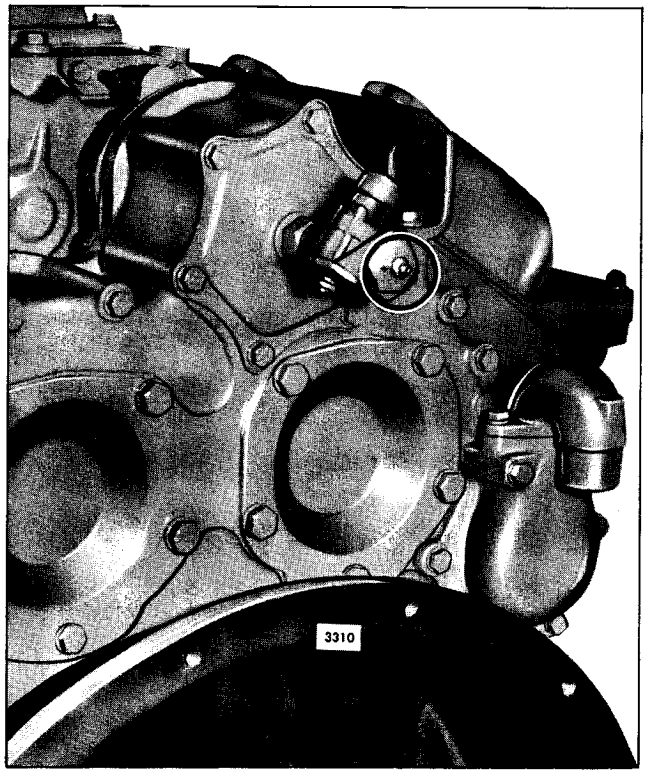
Item 15

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

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.



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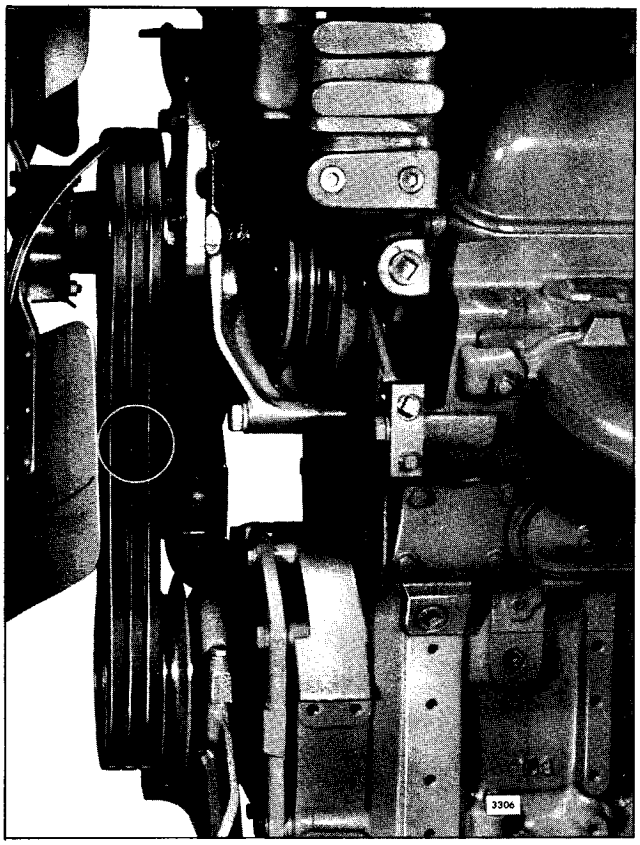
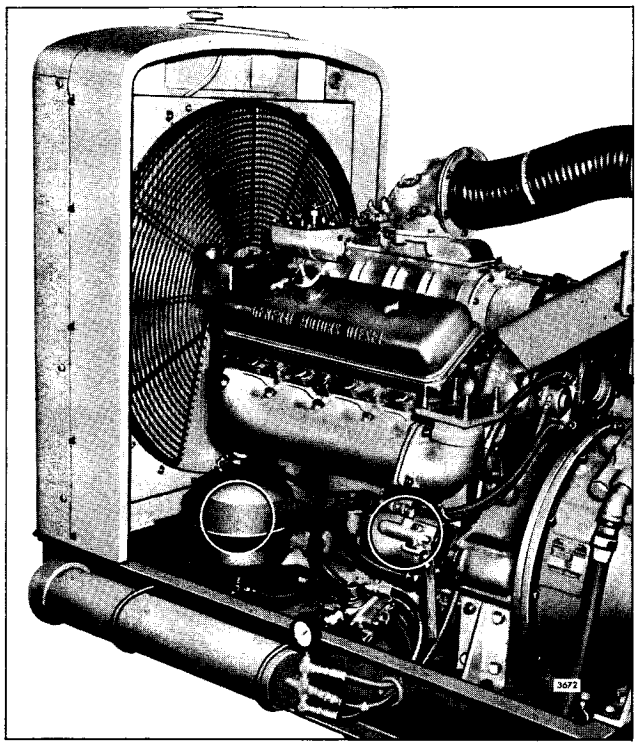


Item 20



Item 21

Item 18

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

Item 19

Approximately 100 hours or 3,000 miles after the initial start and thereafter at 1,000 hour or 30,000 mile intervals and after an engine overhaul, check the engine tune-up.

Item 20

Every 500 hours or 15,000 miles check the tension of the battery-charging generator, fan drive or pump drive belts and adjust, if necessary. Belts should be just tight enough to drive the moving parts without slipping. Too tight a belt is destructive to bearings of the driven part. Adjust for 3/4" slack from a straight line over the outer diameter of the drive and driven pulleys, midway between the pulleys.

Item 21

On units equipped with a Hydrostarter, inspect the system periodically for leaks. Primarily, examine the high pressure lines, connections, fittings and the control valve on the starter. Make certain the oil level in the reservoir is sufficient to completely cover the filter element at the bottom of the tank. Make this check after the accumulator is charged and the engine driven pump is by-passing oil to the reservoir.

Remove the Hydrostarter motor from the engine every 2,000 hours and apply a coating of Lubriplate,

Type 130-AA, or its equivalent, on the drive clutch pinion to make sure the clutch slides freely while compressing the spring. Also apply Lubriplate or its equivalent on the fingers of the clutch and on the spool of the clutch yoke engaged by the fork. This lubrication period may be reduced or lengthened according to the severity of service.

Before removing the Hydrostarter, release the pressure in the system, using the relief valve in the hand pump; then, remove the three bolts which retain the starting motor to the flywheel housing. Remove the starter from the flywheel housing without disconnecting the hydraulic lines. This will prevent dirt and air from entering the hydraulic system.

Remove the pipe plug from the starter drive housing and saturate the shaft oil wick with engine oil. Reinstall the plug.

After lubricating, replace the starter and recharge the accumulator with the hand pump.

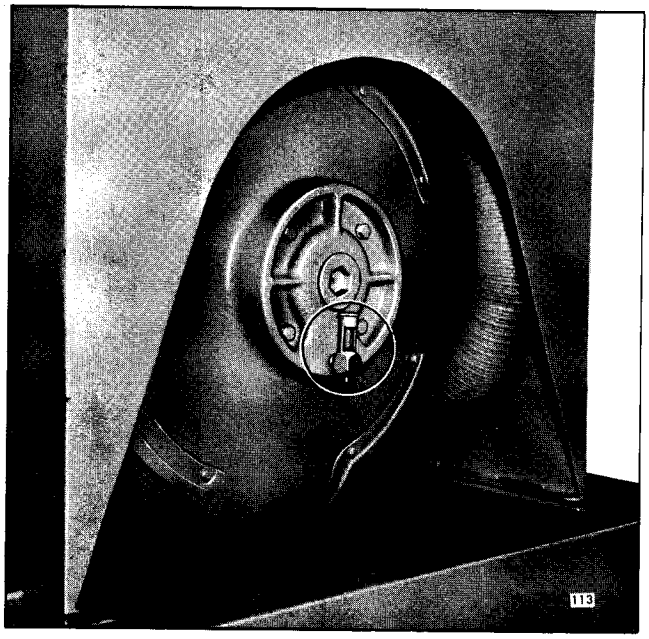
Every 2,000 hours, or as conditions warrant, drain the reservoir and remove the filter from the bottom of the reservoir. Flush out the reservoir and clean the reservoir filter and reservoir filler cap.

Remove the bowl and element from the filter and wash them in clean fuel oil and reassemble.

Drain the remaining hydraulic fluid from the system by disconnecting the lines from the Hydrostarter components. Reconnect all the hydraulic lines.

> **NOTE:** Make sure the lines and fittings are clean before any connections are made. With the exception of the thread nearest the open end, Permatex No. 2 or its equivalent should be applied in a small amount to the male threads ONLY. Never apply Permatex to the female threads. Work the Permatex into the threads and wipe off the excess with a clean, lint-free cloth so the Permatex will not be washed into the system.

Fill the Hydrostarter system with new clean fluid (a mixture of 75% diesel fuel and 25% SAE 10 or 30 lubricating oil). Purge the Hydrostarter system of air in accordance with the prescribed procedure (Section 12.6.1).



Item 22

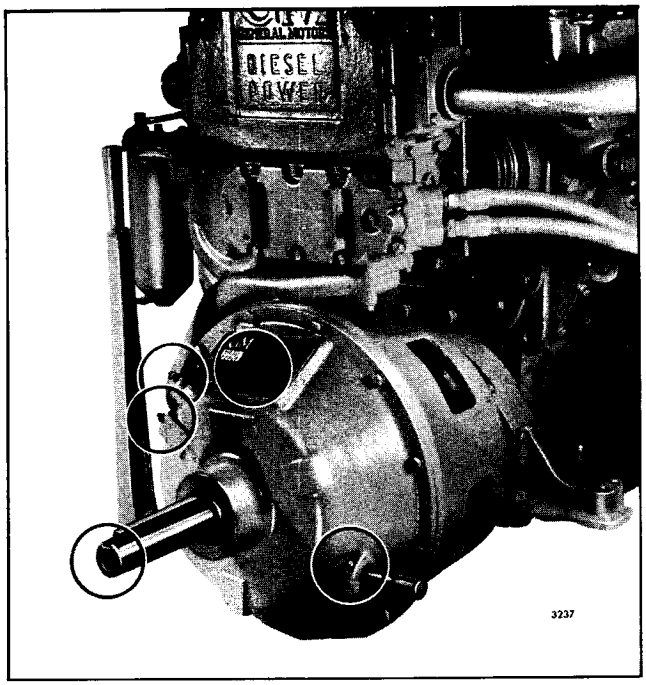
On units with a remote starting device, check the fluid level in the master cylinder every 2,000 hours and refill with the same diesel fuel used by the engine. Lubricate the master cylinder pedal periodically with all purpose grease.

Item 22

Check the oil level in the power generator sight gage every 300 hours; change the oil every six months. Use the same grade of oil as specified for the engine. Maintain the oil level to the line on the sight gage; do not overfill.

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 p.s.i. maximum). Remove all greasy dirt with a cloth.



Item 23

Item 23

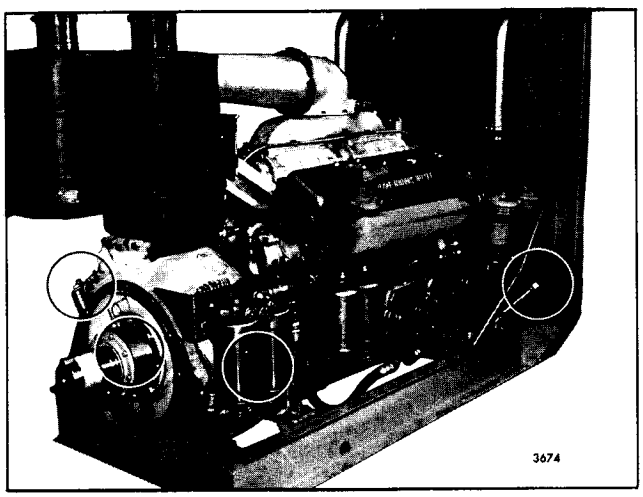
Lubricate all the power take-off bearings with an all purpose grease such as Shell Alvania No. 2 or its equivalent. Lubricate sparingly to avoid getting grease on the clutch facings.

Lubricate the clutch release bearing every 8 hours. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required.

Lubricate the power take-off main bearing, also the outboard bearing if the unit is so equipped, every 50 hours. Frequency of lubrication will depend on the working conditions of the bearing, shaft speeds, and bearing loads. It may be necessary to lubricate this bearing more often than every 50 hours. Lubricate the front power take-off clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and oil the clutch release levers and link pins sparingly every 500 hours. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours.

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



Item 24

Item 24

Check the oil level in all Torqmatic converters and supply tanks daily. The oil level must be checked while the converter is operating and the engine is idling. If the converter is equipped with an input disconnect clutch, the clutch must be engaged.

Check the oil level after running a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-1" or automatic transmission fluid Type A, suffix A (see chart). Use HEAVY-DUTY SAE 10 oil only if these fluids are not available. Do not overfill the converter, as too much oil will cause foaming and high oil temperature.

The oil should be changed every 1,000 hours for Series 500 through 900 converters. 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.

Prevailing Ambient Temperature	Recommended Oil Specification
Above -10°F.	Hydraulic Transmission Fluid, Type C-1
-10°F. to -25°F.	Automatic Transmission Fluid, Type A, Suffix A Identification*
Below -25°F.	Hydraulic Transmission Fluid, Type C-1 or Automatic Transmission Fluid, Type A, Suffix A Identification* Note: Auxiliary preheat required to raise temperature in sump and external circuit.

*The term "Suffix A Identification" refers to the Armour Qualification Number used to identify approved "Type A" Fluids that meet their latest specifications. Example "AQ-ATF-696A"—"Type C-1" fluids are not tested by the Armour Foundation, therefore they will not bear a Qualification Number.

Lubricate the input clutch release bearing and ball bearing every 50 hours with an all purpose grease. Two grease fittings are 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.

The strainer (in the Torqmatic transmission) and the hydraulic system filters should be replaced or cleaned with every oil change.

Item 25

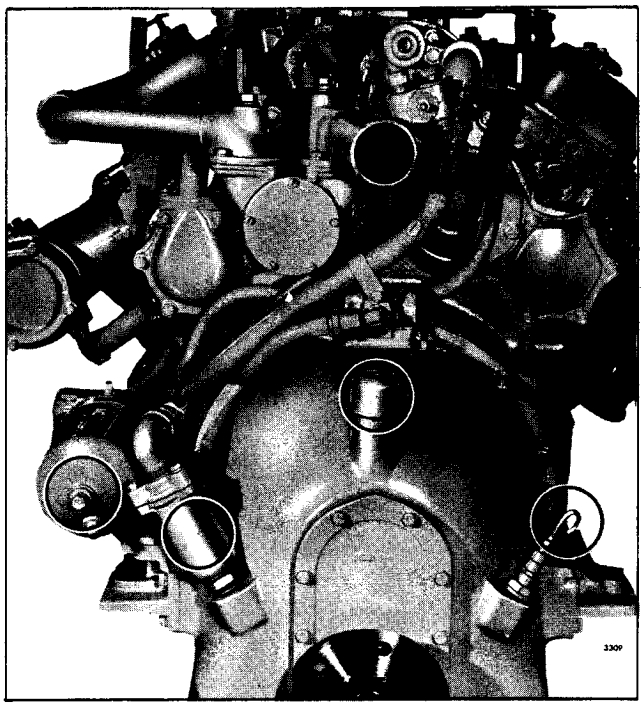
TORQMATIC MARINE GEAR (6 and 8V):

Check the oil level daily in the marine gear and add oil as required to bring level to the proper level on the dipstick. Use oil of the same HEAVY-DUTY grade and viscosity that is used in the engine. Drain the oil every 200 hours and flush the gear with light engine oil.

NOTE: Series 3 oil should not be used in the marine gear.

When refilling after an oil drain, bring the oil up to the proper level on the dipstick; then, run the engine at light load for three or four minutes, stop the engine and check the oil level again. Bring the level up to the proper level on the dipstick.

Every time the marine gear oil is changed, remove the oil strainer element, rinse it thoroughly in fuel oil, dry it with compressed air and reinstall it.



Item 25

TWIN DISC MARINE GEAR (12V):

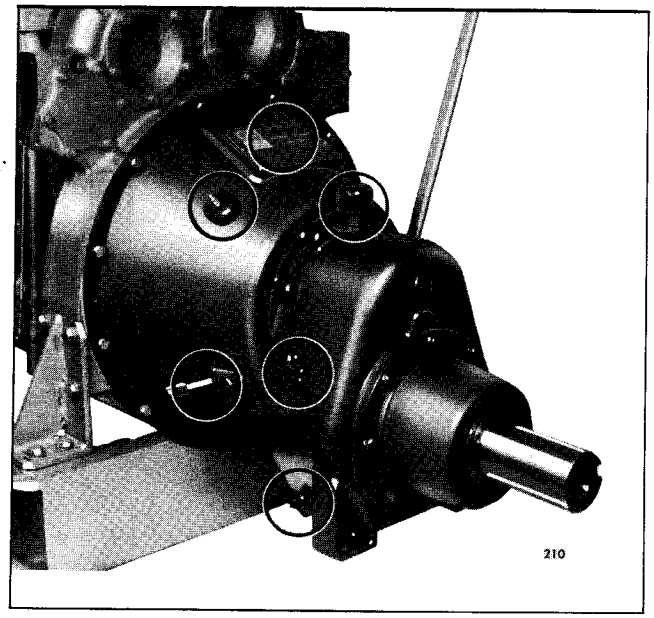
Check the oil level daily. The oil level may be checked with the unit running or standing still. Keep the oil level up to the proper level on the dipstick. Use oil of the same HEAVY-DUTY grade and viscosity that is used in the engine.

A complete oil change every 500 hours is recommended. After removing the oil from the unit, the removable oil screen should be thoroughly cleaned before refilling the transmission with oil.

SNOW NABSTEDT MARINE GEAR (16V):

Check the oil level daily. If necessary, stop engine. Also, turn the handle of the filter in the suction line daily or more often, if convenient (this is a knife edge filter, and a turn of the handle wipes the accumulated sediment from the edge of the filter discs).

Change the oil every 1,000 hours or at the end of each season, whichever occurs first. At each oil change, remove the plug from the bottom of the filter to drain the sediment. If the filter is extremely dirty, remove the screws holding the sediment bulb to the flange at the top of the filter and remove the bulb for thorough cleaning. When replacing the bulb, be sure to tighten the screws evenly and securely to prevent air leaks in the suction line. Use oil of the same HEAVY-DUTY grade and viscosity that is used in the engine.



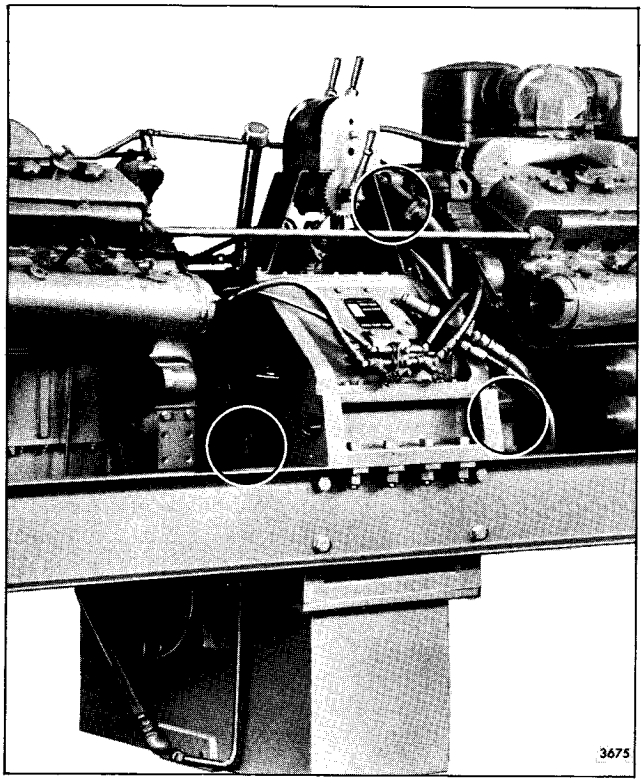
Item 26

Item 26

Check the oil level in the reduction gear every 8 hours and add oil as required to bring the oil to the proper level on the dipstick. Drain the oil every 1,000 hours, flush the housing with light engine oil, and refill to the proper level with the same grade and viscosity HEAVY-DUTY oil that is used in the engine. This oil change period should be reduced under severe operating conditions.

Lubricate the clutch release bearing through the grease fitting on the side of the housing every 8 hours of operation. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required. Lubricate the front reduction clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and oil the clutch release levers and link pins sparingly every 500 hours. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours.



Item 27

Item 27

Reduction Gear (24V):

The oil level in the reduction gear should be checked while it is running. Keep the oil level at the operating level on the dipstick.

Drain the oil every 200 hours of operation. Flush with light engine oil and refill to the proper level on the dipstick (approximately 21 gallons).

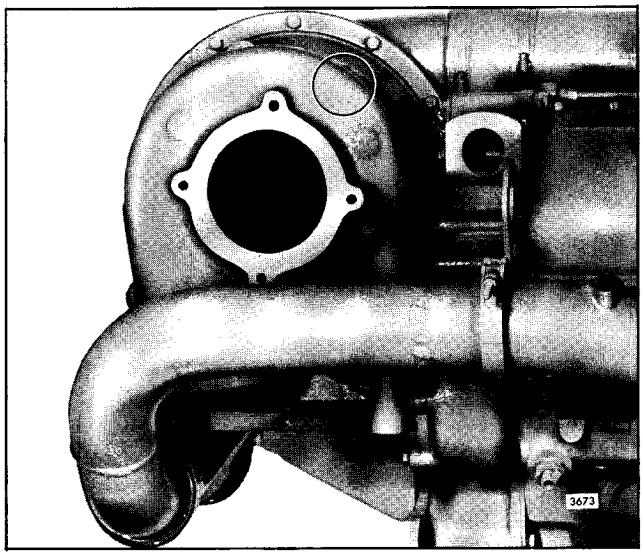
> **NOTE:** Series 3 oil should not be used in the reduction gear.

Use oil of the same HEAVY-DUTY grade and viscosity that is used in the engine.

Every time the oil is changed, remove the element from each oil strainer and rinse it thoroughly in clean fuel oil, dry it with compressed air and reinstall.

The filter element of each marine gear oil filter should be removed, the element shell cleaned, and a new element and gasket installed every time the reduction gear oil is changed.

When refilling after an oil drain, bring the oil up to the proper level on the dipstick; then, run the engines to fill the system with oil. Check the oil level on the reduction gear with the engines and gear operating. Bring the oil level up to the proper level on the dipstick. Do not overfill.



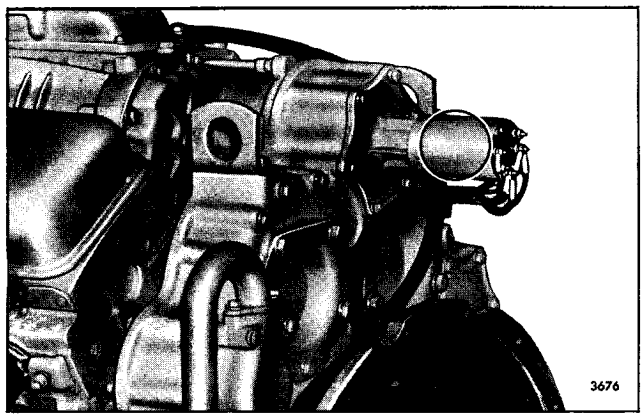
Item 28

Item 28

Check the turbocharger daily for leaks, excessive vibration, or any unusual noise. Make sure the engine crankcase breather is free of any restriction.

The turbocharger should be thoroughly cleaned and inspected every 1,000 hours or 30,000 miles.

> **CAUTION:** If the rotating parts are not cleaned properly, the bearings will be damaged by the unbalanced condition.



Item 29

Item 29

Lubricate the overspeed governor, if it is equipped with a hinge 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.