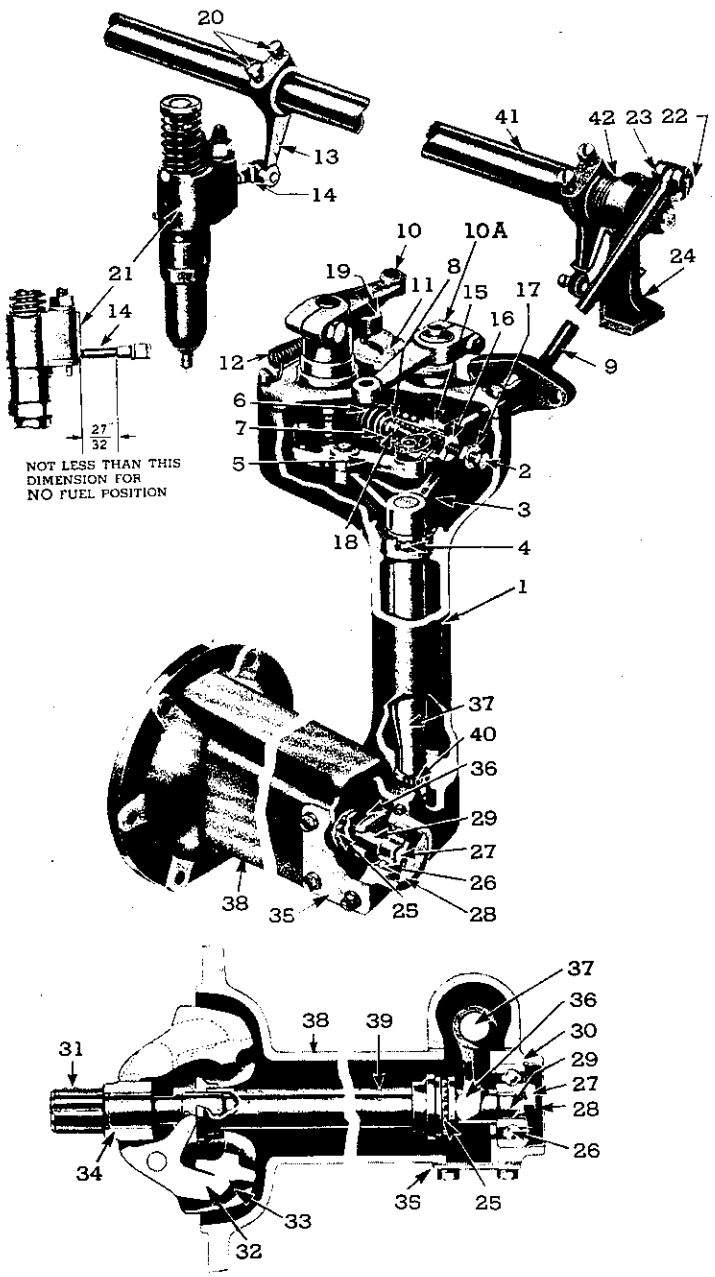
MECHANICAL AND HYDRAULIC GOVERNORS



1. Governor Control Housing
2. Low-Speed Spring Cap Adjusting Screw
3. Operating Lever.
4. Operating Shaft Upper Bearing.
5. Differential Lever.
6. High-Speed Spring.
7. Low-Speed Spring Plunger.
8. Low-Speed Spring.
9. Control Link.
10. Control Levers.
10A. Stop Lever.
11. Control Cam.
13. Rack Control Lever.
14. Injector Rack.
15. Low-Speed Spring Plunger Support (Integral with Control Housing).
16. Low-Speed Spring Cap.
17. Low-Speed Spring Cap—Screw Lock Nut.
18. Low-Speed Spring Seat.
19. Pedal Control Lever.
20. Rack Control Lever Adjusting Screw.
21. Injector.
22. Control Link Pin.
23. Control Tube Lever.
24. Control Tube Bracket.
25. Shaft (Weight Shaft) Thrust Bearing.
26. Shaft Bearing.
27. Shaft Bearing Retainer Screw.
28. Weight Housing Cap.
29. Shaft (Weight Shaft).
30. Shaft Bearing Lock Ring.
31. Splined End of Governor Shaft.
32. Weight—High-Speed.
33. Weight—Low-Speed.
34. Weight Carrier.
35. Weight Housing Cover.
36. Operating Fork (Yoke).
37. Operating Shaft.
38. Weight Housing.
39. Riser.
40. Operating Shaft Lower Bearing.
41. Injector Control Tube.
42. Control Tube Return Spring.

Fig. 1—Mechanical Governor Assembly—Limiting Speed.

Since the horsepower requirements on the engine continually vary, due to fluctuating loads, some means must be provided to control the amount of fuel required and hold the engine speed reasonably constant during such load fluctuations. To accomplish this control, a ***governor*** is inserted in the linkage between the hand throttle and the fuel injectors. This governor may be either a ***mechanical*** or ***hydraulic*** type.

In the mechanical governor, force is transmitted from hinged, mechanical rotating weights through the governor operating mechanism to the injector control racks, which are connected to the governor by a link. Forces created by the rotating weights are counter-balanced by springs in the governor, the tension of which determines the engine speed.

In the hydraulic governor, control to the injector racks is brought about by oil from the engine lubricating system being admitted under pressure to an oil pump in the governor. The oil pressure created by the governor pump actuates a servo piston which in turn transmits motion to the injector racks through a system of levers and a link. Oil flow to the servo piston is controlled by a pilot valve, which is actuated by a set of rotating weights balanced by adjustable tension on a light spring. Complete description and operation of the hydraulic governor is described on page 24.

Both of these governor types are used on the multiple cylinder series 71 engines and will be treated separately in this text.

Mechanical Governors—The multiple Cylinder Series 71 engines use three different models of Mechanical governors depending on the type of engine duty required. These three models and the main characteristics of each are:

1. **Limiting Speed**—Used principally on engines for automotive vehicles. This governor has the following characteristics:
   (a) Controls the engine idling speed.
   (b) Limits maximum engine speed.
   (c) Manual control between maximum engine speed and idling.
   (d) Permits return of injectors to no fuel position at speeds above idling range.
2. **Constant Speed**—Used principally on engines driving industrial generators or wherever a constant speed is required. This governor has the following characteristics:
   (a) Controls the engine idling speed.
   (b) Maintains the engine at a constant operating speed.
3. **Variable Speed**—Used principally on engines for tractors, shovels, etc., or wherever requirements demand that engine speed be controlled by the governor at any speed between idle and maximum. This governor has the following characteristics:
   (a) Controls the engine speed throughout the entire range from 450 R. P. M. up.

NOTE: All illustrations in this section show the governor for LC, LD, RC, and RD engine models, unless otherwise specified in the caption. Governors on other engine models show identical relationship of all parts, but as an assembly, do not look quite the same.

LIMITING SPEED MECHANICAL GOVERNOR

Description—The limiting speed governor shown in Fig. 1 is the mechanical type with two high speed and two low speed weights; each set of weights having a fixed stop for the inner and outer positions. A high and a low speed spring is also employed in this governor; the former works in conjunction with the high speed weights to limit the maximum engine speed, the latter works in conjunction with both the low and high speed weights to control the engine idling speed.

The motion produced by the travel of the governor weights, between their inner and outer positions, is transmitted to the injector racks by a system of cams and levers on which can be superimposed a manual control.

The governor, which is mounted at the front of the blower, is divided into three main assemblies embodied in separate housings. These assemblies are: The governor weights and housing, the control mechanism, and the cover.

The two sets of weights are carried on a horizontal shaft inside the governor weight housing. The weight carrier shaft is mounted on an annular ball bearing at one end and is supported inside and driven by the hollow rotor shaft at the other end. The blower end of the governor shaft is serrated and engages with corresponding serrations inside the blower shaft, which drives the governor shaft and weights.

The control mechanism transmits the motion of the governor weights to the injector racks. This mechan-

ism consists of a vertical shaft mounted inside a housing, with a fork or yoke fixed at the lower end, an operating lever fixed at the upper end, and a high and low speed governing spring with suitable adjustments. The vertical shaft is mounted on an annular ball bearing at the upper end and a roller bearing at the lower end.

The motion of the governor weights is transmitted to the vertical shaft through a movable riser on the weight carrier shaft and the fork on the lower end of the vertical shaft. This motion is, in turn, transmitted to the injector control tube by means of the operating and differential levers on the upper end of the vertical shaft.

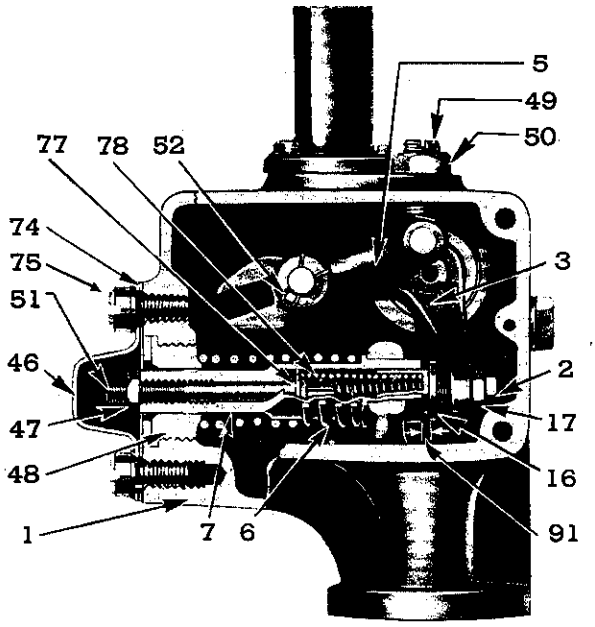
The cover assembly serves as a carrier for the stop lever and the hand throttle control lever, and closes the top of the control mechanism housing.

The specifications of this governor change according to the duty required of the engine; for this reason, certain definite information must be supplied the factory when ordering a replacement governor for a specific engine. A name plate will be found at rear end of the cylinder block, which shows the engine number. This number must be furnished the factory when ordering a replacement Mechanical Governor.

Lubrication—The lower portion of the governor is lubricated by means of a slinger attached to the front end of the blower lower rotor shaft. This slinger dips into a well of oil dammed up in the blower housing cover and throws the oil onto all the parts within the governor weight housing. The upper portion of the governor, including the vertical shaft bearings and the control mechanism, is lubricated partly by splash from oil slinger on weight carrier shaft and partly by return oil through the vertical shaft housing from the cylinder head.

Operation—As stated heretofore, the limiting speed governor controls the maximum speed of the engine and also the idle speed. Intermediate speeds are controlled manually through the governor linkage.

In the low speed range, the low speed weights, shown in Fig. 1, and the high speed weights, operate together. The outward motion of these weights is translated into linear motion by the bell-crank extension on the high speed weights, and is applied to the riser. This riser transmits the force through the ball thrust bearing to the forked lever on the lower end of a vertical shaft. The upper end of this shaft has a bell crank (operating lever), one end of which bears against a low speed spring cap and works against the low speed spring, and the other end carries a bearing for the differential lever, which is connected to the injector control through a link. The upper limit of the low speed governing range is

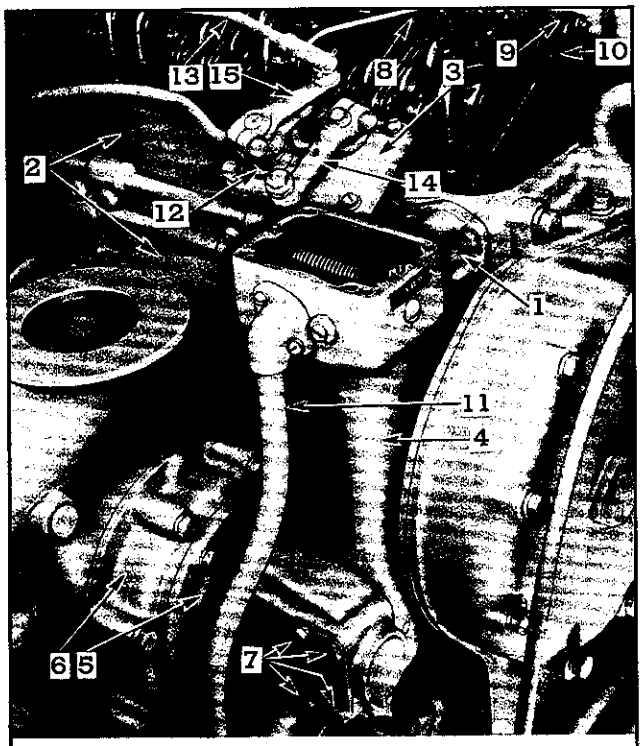


1. Governor Control Housing.
2. Low-Speed Spring Cap Adjusting Screw.
3. Operating Lever.
5. Differential Lever.
6. High-Speed Spring.
7. Low-Speed Spring Plunger.
16. Low-Speed Spring Cap.
17. Lock Nut—Low-Speed Spring Cap Adjusting Screw.
46. Cover—Low-Speed Adjusting Screw.
47. Lock Nut—Low-Speed Spring Screw.
48. High-Speed Spring Retainer Nut.
49. Buffer Screw
50. Lock Nut.
51. Low-Speed Adjusting Screw.
52. Pin Clip.
74. Gasket—Low-Speed Spring Screw Cover.
75. Fillister Head Screw.
77. Low-Speed Spring Seat.
78. Low-Speed Spring.
91. Low-Speed Spring Gap.

Fig. 2—Top View of Governor Control Mechanism. (LA, RA, LB, and RB Engines)

reached when the projection on the low speed weight, on the side of the pin opposite the main part of the weight, comes in contact with the weight carrier and stops. The position of the low speed spring cap may be varied by means of the screw at the end of the bell crank arm. When the screw is correctly set the gap between the cap and high speed spring plunger closes at the same time the low speed weight comes to its stop against the weight carrier. This, in effect, removes both the low speed weight and the low speed spring from operation. The engine then goes into the intermediate speed range; in which the speed control is entirely manual.

When the speed of rotation of the weights becomes high enough so that the force on the high speed weights, as transmitted through the riser, the forked lever, the vertical shaft, and the bell crank to the high speed spring, is sufficient to overcome the preload on the high speed spring and again cause motion at the control mechanism; this motion automatically controls the maximum speed.



1. Bolting Flange—Governor-to-Cylinder Head.
2. Cylinder Head
3. Governor Cover.
4. Governor Control Housing.
5. Governor Weight Carrier Housing.
6. Blower.
7. Through Bolt—Carrier Housing-to-Control Housing.
8. Injector Control Tube.
9. Injector Control Tube Lever.
10. Governor Control Link.
11. Breather Pipe.
12. Bowden Wire.
13. Throttle Control Rod.
14. Stop Lever.
15. Control Lever.

Fig. 3—Governor Mounting.

The motion produced by the travel of the governor weights is transmitted to the injector racks by means of the differential lever which is pivoted to the bell crank (operating lever). One end of the differential lever is slotted to receive a pin on the throttle control lever; the other end is connected through a link to the injector rack control. The slotted end of the lever from the pivot point is much shorter than the opposite end.

When the pin on the throttle control lever is held fixed, as in the idle or full throttle positions, the governor motion from either the low or high speed weights, applied at the pivot point of the lever, causes the long end of the lever, which is connected to the injector racks, to control the speed of the engine. Under these conditions injector control is entirely by the governor.

If the pivot on the bell crank at the intermediate point of the lever is stationary, the engine speed is controlled manually by moving the forked end of the lever by means of the pin at the end of the control lever. The bell crank is stationary when the engine is not running and the governor weights are at their inner position, and is again stationary at the end of the idle range when the low speed weights and spring are on the stops and the high speed weights have not yet overcome the preload on the high speed spring. Under these conditions, control is entirely manual.

Service—Governor faults are usually manifest in speed variations of the engine, but it does not necessarily follow that all such speed variations indicate governor faults. Therefore, when improper speed variations appear, the following procedure should be carried out:

1. Check the load to be sure that the speed changes observed are not the result of load fluctuations.
2. If the load is uniform, carefully check the engine to be sure that all cylinders are firing properly.
3. See that no bind exists in any of the governor mechanism or operating linkage between governor and engine; also, that no bind is manifest in the injector control rack shaft or its mounting brackets.

If all cylinders are not firing properly, remove and check the injector from the faulty cylinder. The injector check should consist of "popping" the injector as described on Page 11, Sec. 15. If this test shows any of the holes in the spray tip to be plugged, remove and clean the tip as described under "Inspecting and Cleaning Injector Spray Tip," Page 6, Sec. 15. With the governor control link connected to the injector rack control shaft, the mechanism should be free from bind throughout the entire travel of injector racks. Should friction exist in the mechanism, it may be located and eliminated as follows:

1. Injector racks may stick or move too hard. This may be due to the injector hold down clamp being too tight or not positioned properly, and can often be eliminated by tapping the foot of the clamp lightly with a small hammer and a long punch or screwdriver. An injector which has been in service a long time may get sticky due to an accumulation of gum and sludge. This can be corrected by washing in a pail of clean gasoline (See Injector Service, Page 5, Sec. 15.)
2. Injector rack may stick due to being cramped by the rack control lever being out of position or cocked. Loosen the screws in the rack control lever, and if this relieves the binding, move the lever endways on the control tube until the rack control lever no longer cramps the injector rack. Cocking of the rack control lever may also be due to damage to the ends of the adjusting screws or the surfaces which they contact, and may be corrected by filing. After the trouble has been remedied, the rack control lever must again be adjusted for proper position.

3. Control tube may stick or turn hard in its small ball bearings. These bearings must be free from chips, dirt, or sludge, and must be lubricated. Binding due to poor alignment of the bearing supports can be corrected by loosening the bearing support cap screws and realigning the bearing supports.

   When the injector rack control tube is free of bind and operating the injector racks, the shaft should return freely to the no fuel position by the tube return spring only. Any time the control tube bearing supports have been loosened, the adjustment of rack control levers should be checked.

CAUTION: Never stretch or tamper with rack control spring to change the tension. If spring is not standard, replace.

4. Control tube may have too much friction due to control tube spring being bent. Replace with a standard spring.

5. Pin in link connecting governor to control tube may be binding in the control tube lever. Remove bind.

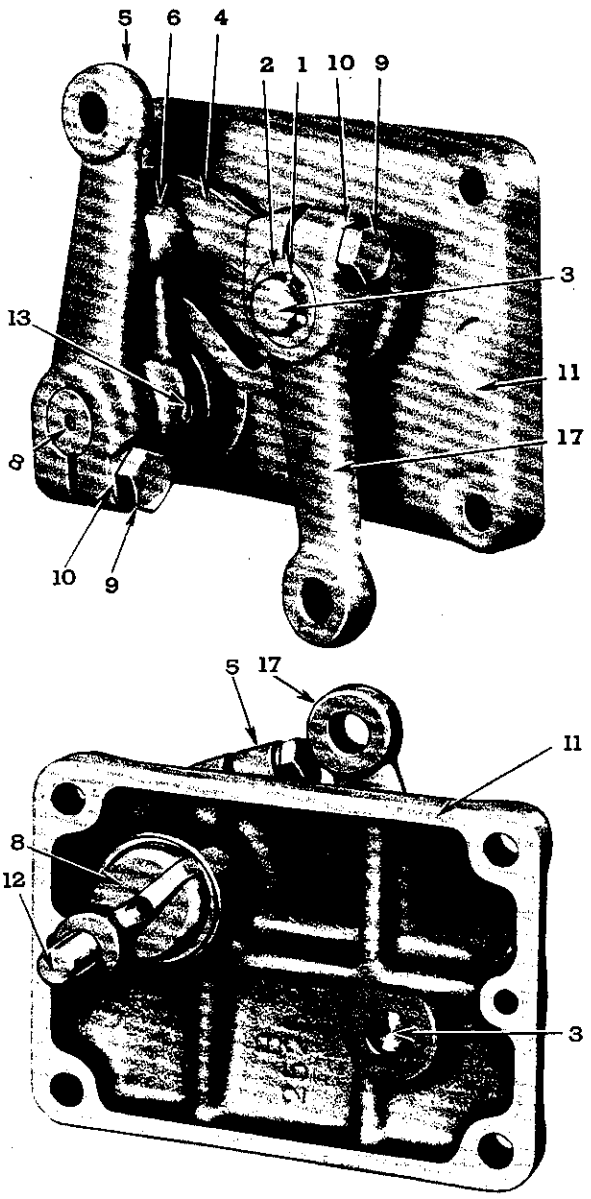
Having made all the above checks and the governor still fails to control the engine properly, the governor may be worn or otherwise unfit for further use until the unit has been completely torn down, inspected, and rebuilt or replaced.

If removal and overhaul of governor is necessary, the instructions given below will simplify and shorten the operations.

Remove Governor From Engine—In cases of major repairs or a complete governor change, the unit may be removed from the engine as follows:

1. Remove engine valve rocker cover.
2. Disconnect control rods at governor throttle and stop levers.
3. Remove four screws which attach governor control housing cover to weight housing and remove cover.
4. Disconnect governor to control tube link from both the differential lever and the control tube lever and remove link.
5. Remove two screws which attach governor control housing to cylinder head.
6. Remove four cap screws which attach cover and control housing to weight carrier housing and remove cover plate.

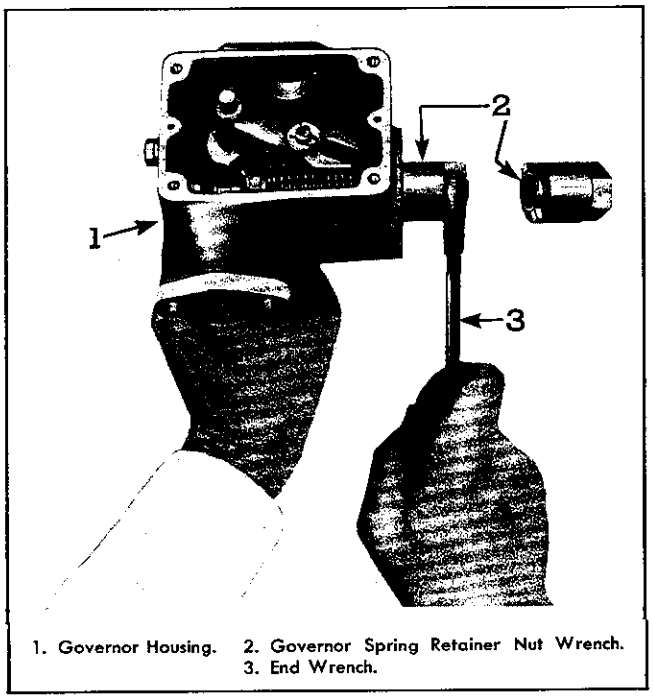
NOTE: Two dowels are used at the junction of vertical housing and weight housing. Do not bend upper housing too far away from cylinder head without removing lower end at the same time.



1. Pin Clip—Governor Cam Hub.
2. Special Washer
3. Control Cam Shaft.
4. Control Cam Assembly.
5. Operating Lever.
6. Pedal Control Lever.
8. Throttle Shaft.
9. Clamp Bolts.
10. Lockwashers.
11. Control Housing Cover.
12. Governor Fulcrum Lever Pin.
13. Taper Pin.
17. Stop Lever.

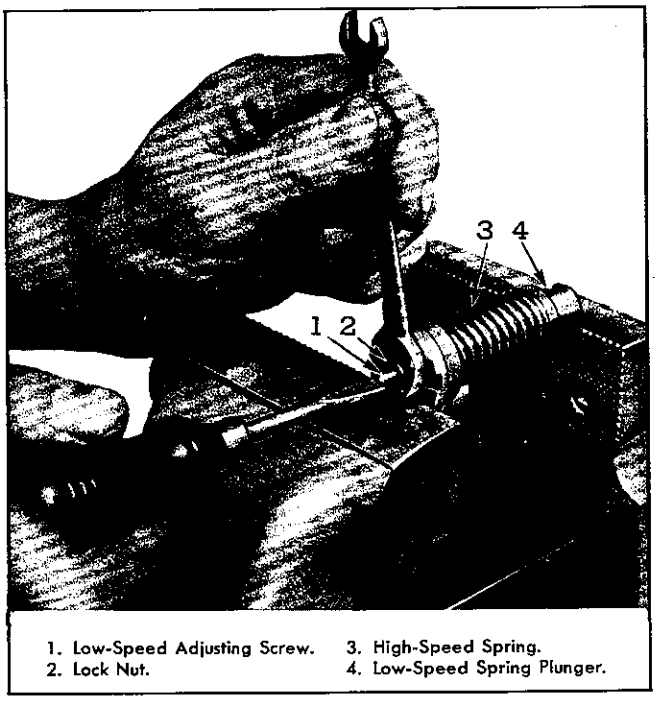
Fig. 4—Top and Bottom Views of Governor Control Housing Cover Assembly.

7. Remove six cap screws which attach weight carrier housing to front end of blower and separate governor shaft from front blower shaft by pulling straight out. The rear cap screw may be easily removed by using the special wrench shown in Fig. 37, Sec. 15, for removing fuel pump inner cap screw.



1. Governor Housing. 2. Governor Spring Retainer Nut Wrench. 3. End Wrench.

Fig. 5—Removing Governor High Speed Spring Retainer Nut with Tool J-1652.



1. Low-Speed Adjusting Screw. 2. Lock Nut. 3. High-Speed Spring. 4. Low-Speed Spring Plunger.

Fig. 6—Removing Adjusting Screw from Governor Spring and Plunger Assembly.

Disassemble Mechanical Limiting Type Governor—For purposes of simplicity, the governor assembly described above has been divided into sub-assemblies and illustrated below, as follows:

I. Control housing cover assembly.

II. Springs and plunger assembly.

III. Control housing assembly.

IV. Weight and housing assembly.

Disassembly of the governor will be carried out in the above order.

I. **Control Housing Cover Disassembly**—With governor cover removed from control housing, cover disassembly may be carried out as follows:

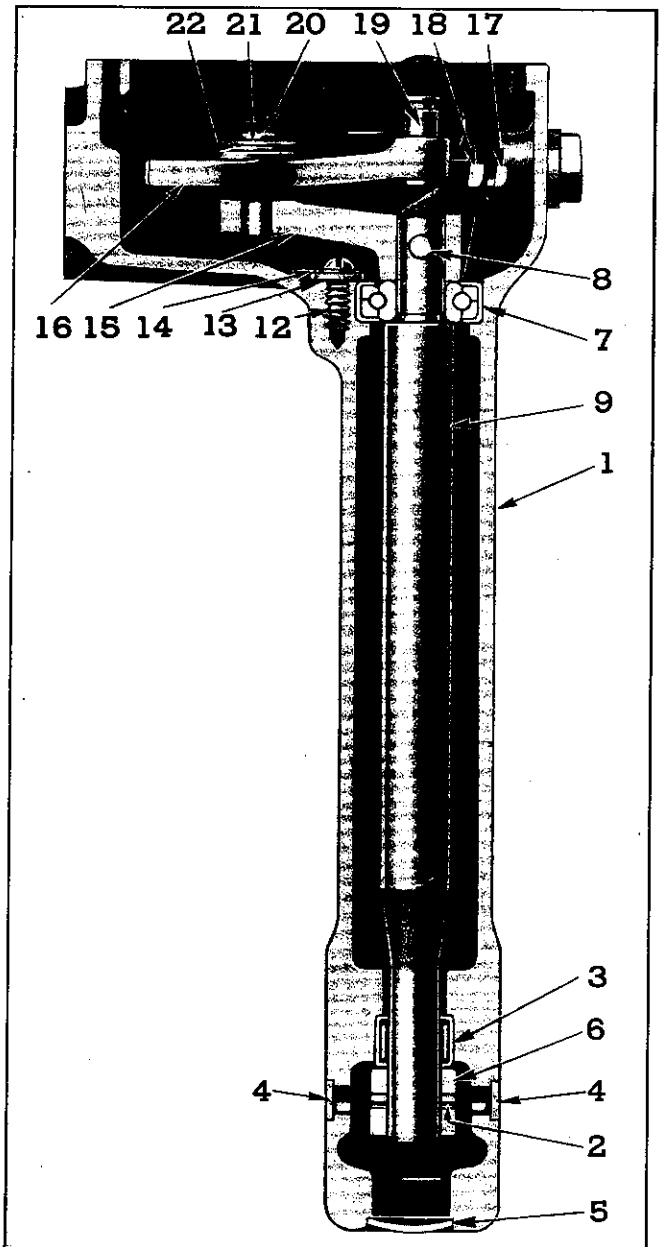
1. Remove pin clip (1) and special washer (2) from control camshaft (3). Loosen clamp bolts (9) on both operating and stop lever, (5) and (17), and remove the two levers. (See Fig. 4.)

NOTE: Some governor models have no stop lever included in the cover assembly.

2. Using small punch and hammer, remove taper pin (13) from pedal control lever hub (6) and remove lever.
3. Remove control cam assembly (4).
4. Pull throttle shaft assembly (8) down through bottom side of cover (11). Remove two plain washers and packing washer. At this stage of disassembly, wash cover and roller bearings (bearings assembled in cover) thoroughly in gasoline or fuel oil and inspect bearings for wear or damage. If bearings are satisfactory for further use, removal is unnecessary.
5. If bearing removal is necessary, support cover in soft jaws of bench vise or suitably on a work bench. Then by means of a small punch and hammer, drive lower bearing (16) down through bottom of cover and upper bearing out through top of cover. (See Fig. 19.)

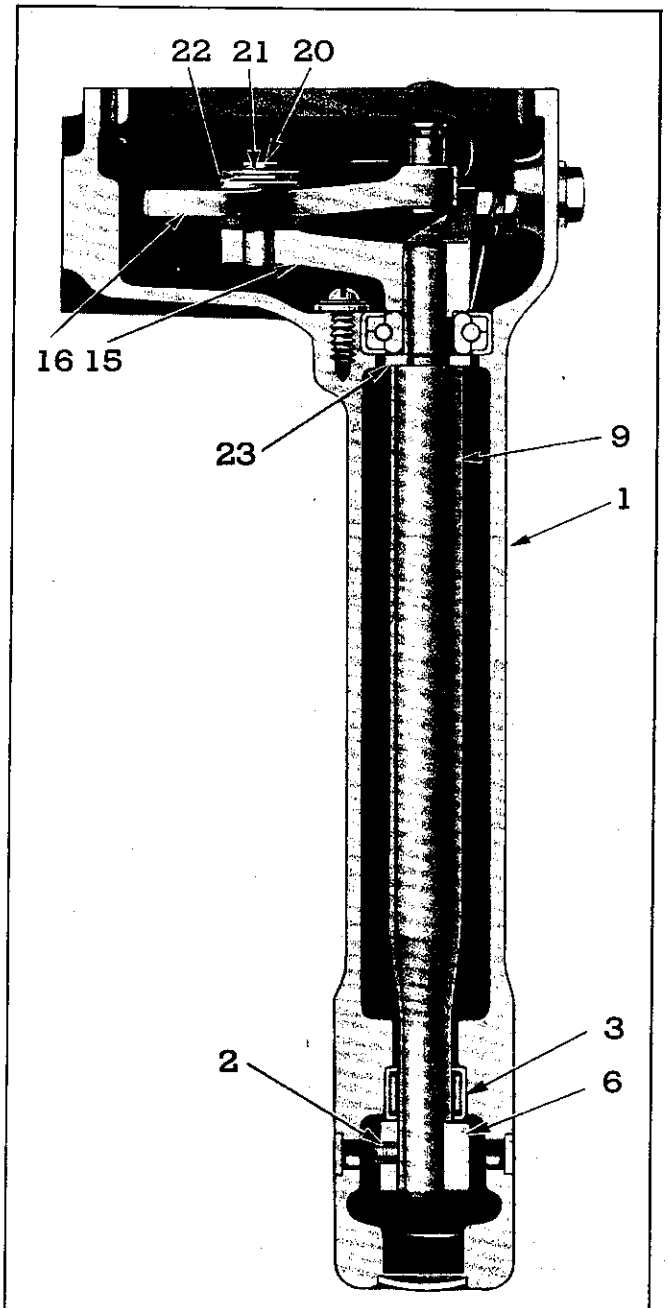
II. **Spring and Plunger Disassembly**—With the governor control housing detached from the weight housing, the spring assembly may be removed from the control housing as follows:

1. Refer to Fig. 7 and remove pin clip (21) and washer (22) from differential lever pin (20) then raise lever (16) from pin.
2. Remove two retaining screws and washers from low-speed adjustment cover (46, Fig. 2) at upper end of housing and withdraw cover and gasket.
3. Support control housing in vise, and using Tool J-1652, as shown in Fig. 5, remove high-speed spring retainer nut, (48) Fig. 2, then remove retainer and spring assembly from housing.



1. Control Housing.
2. Taper Pin (Lower).
3. Operating Shaft Lower Bearing.
4. Expansion Plug.
5. Expansion Plug.
6. Operating Fork (Yoke).
7. Operating Shaft Upper Bearing.
8. Taper Pin (Upper).
9. Operating Shaft.
12. Screw.
13. Flat Washer.
14. Lockwasher.
15. Operating Lever.
16. Differential Lever.
17. Low-Speed Spring Cap Adjusting Screw.
18. Lock Nut.
19. Operating Lever Pin.
20. Differential Lever Pin.
21. Pin Clip (Lock).
22. Washer.

Fig. 7—Governor Control Housing Assembly, Including Control Mechanism. (Early "Handy" Model)



1. Control Housing.
2. Lock Screw Allen.
3. Operating Shaft Lower Bearing.
6. Operating Fork (Yoke).
9. Operating Shaft.
15. Operating Lever.
16. Differential Lever.
20. Differential Lever Pin.
21. Pin Clip (Lock).
22. Washer.
23. Operating Shaft Washer.

Fig. 8—Governor Control Housing, Including Control Mechanism. ("Delco" and Late "Handy" Models)

4. Refer to Fig. 2 and remove low-speed cap (16), spring (6), and spring seat from plunger (7).

5. Compress the spring assembly in a vise, as shown in Fig. 6, then loosen the locknut (2) and remove the low-speed adjusting screw (1) from the low-speed spring plunger (4).

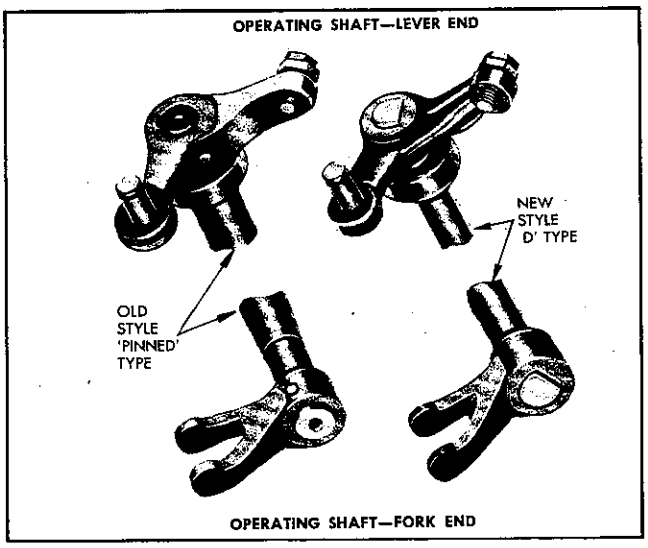


Fig. 9—Comparison of New and Old Style Shaft and Lever Assemblies.

III. **Control Housing Disassembly**—With control housing removed from weight carrier housing, and spring and plunger assembly removed, the operating shaft and associated parts may be removed as follows:

1. Refer to Fig. 7 and remove pin clip (21), washer (22) and differential lever (16) off lever pin (20) of the operating lever (15).
2. Remove operating shaft (9), operating lever (15) and upper ball bearing (7) as an assembly from the housing as follows:
   (a) Dislodge the two small expansion plugs (4) from each side at lower end of housing by driving from the inside with a small bent punch, to expose taper pin (2), and drive pin from operating fork (6) and shaft with small punch and hammer, as shown in Fig. 10.

NOTE: Mechanical governors carrying the name "DELCO" on the identification plate and late model assemblies with the name "HANDY" have an Allen set screw holding the operating fork onto a "D" shaped shaft in place of the taper pin. Refer to Figures 8 and 9 for details.

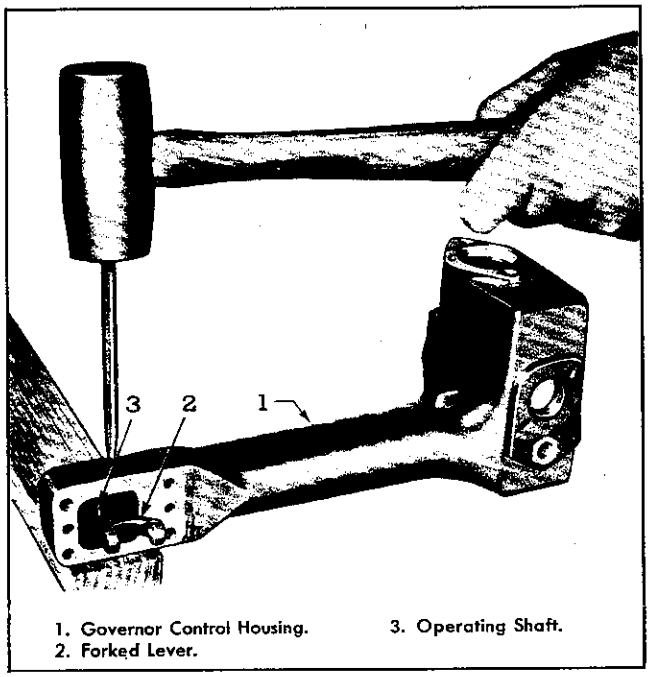
   (b) Remove lockscrew (12) plain washer (13) and lockwasher (14) retaining upper ball bearing (7).
   (c) Lift shaft (9), operating lever (15) and upper ball bearing (7) out through top of housing; then yoke (6) will slip from lower end of shaft and from lower roller bearing (3).
3. Should the roller bearing assembly (3) need replacing, which is rarely necessary, remove plug (5) and drive bearing assembly down through bottom of housing, using long rod down through top of control housing as shown in Fig. 11.
4. Should the operating shaft, ball bearing, or operating lever require replacing, the operating lever (15) must be removed by driving taper pin (8) from hub of operating lever, using small punch and hammer, and then lifting lever and tapping ball bearing from shaft (See Fig. 7.)

NOTE: On "Delco" and late model "Handy" governors, the operating lever is pressed onto the upper end of the shaft. The shaft is "D" shaped at the top, same as the bottom, and no retaining pin is used. The shaft may be pressed out of the lever using a suitable arbor and arbor press.

IV. **Weight and Housing Disassembly**—Before removing any part from the weight housing assembly, the unit should be thoroughly washed in gasoline or fuel oil, dried with compressed air, and then inspected for worn, damaged, or binding parts. If all parts are in good working order, disassembly will be unnecessary. If bearings only need replacing, then removal of weights from the carrier will not be necessary. When complete disassembly is essential, the various steps are as follows. (See Fig. 12.)

1. Support the governor weight housing in a vise and remove bearing cap by driving a screwdriver through cap and prying from place. (See Fig.14.)

CAUTION: Do not insert screwdriver too far through cap so end of screwdriver will damage ball bearing beneath cap.



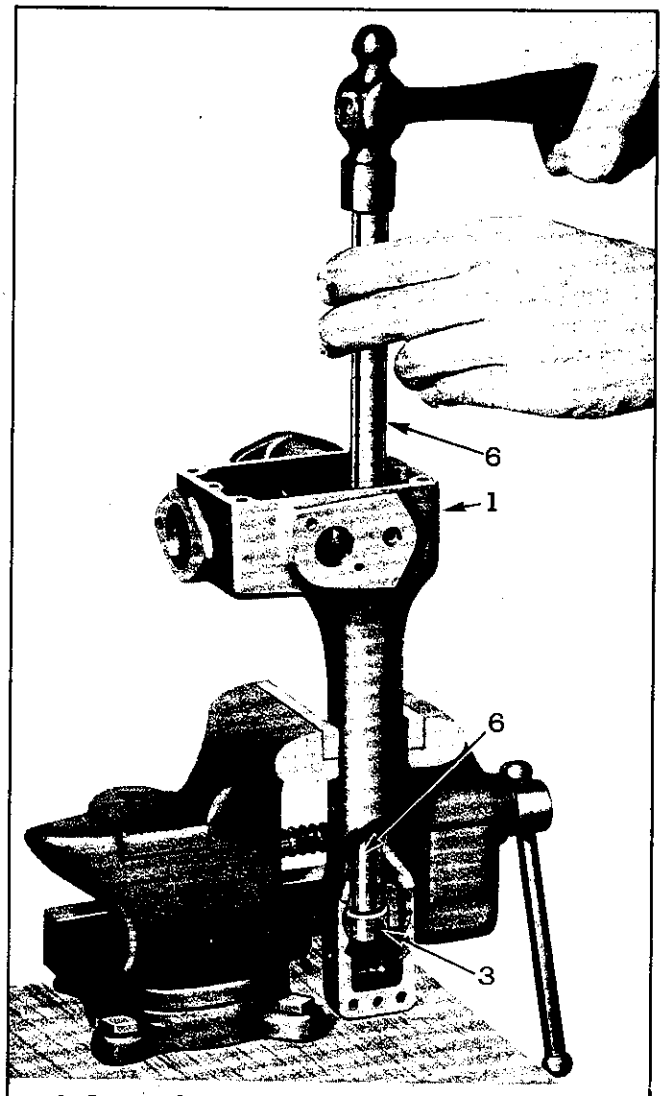
1. Governor Control Housing.
2. Forked Lever.
3. Operating Shaft.

Fig. 10—Removing Taper Pin from Governor Operating Shaft and Fork.

NOTE: Late model governor assemblies have a threaded cap screwed into the bearing end of the weight carrier housing, as shown in Fig. 13. This threaded cap screws tight against the bearing outer race thus acting as a bearing retainer and replacing the lockring used on earlier models. A hex wrench head on the cap makes removal a simple operation. A gasket between bearing outer race and plug keeps oil from seeping through the threads.

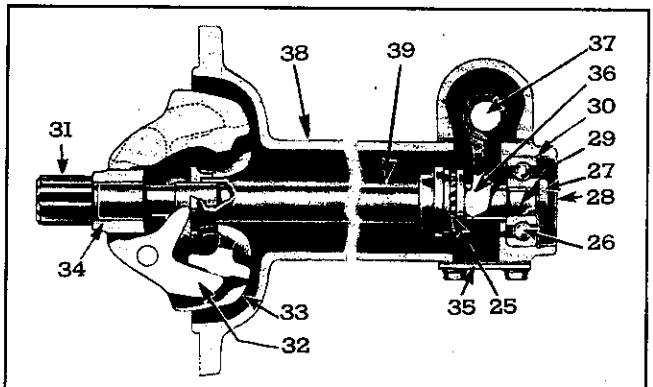
2. Straighten lip on lockwasher and remove lock screw (27) from outer end of weight carrier shaft (29). (See Fig. 12.)

3. Using Tool J-1234, as shown in Fig. 15, screw threaded end of tool into tapped hole at end of weight carrier shaft, and remove shaft from bearing by tapping weight against shoulder on rod.



1. Governor Control Housing.
3. Roller Bearing.
6. Rod for Removing Bearing.

Fig. 11—Removing Operating Shaft Lower Roller Bearing from Governor Control Housing.



25. Ball Thrust Bearing.
26. Annular Ball Bearing.
27. Lock Screw.
28. End Cap.
29. Weight Carrier Shaft.
30. Lock Ring.
31. Splined End of Governor Shaft.
32. Weight (High-Speed).
33. Weight (Low-Speed).
34. Weight Carrier.
35. Weight Housing Cover.
36. Forked Lever (Yoke).
37. Vertical Operating Shaft.
38. Weight Carrier Housing.
39. Riser.

Fig. 12—Governor Weight and Housing Assembly.

4. Slide the thrust ball bearing (25) and riser (39) from the weight carrier shaft (See Fig. 12).

5. Mark weights and carrier with center punch for identification, also note position of thin washers between weights, so parts can be replaced in their original locations; then remove Allen set screws, weight pivot pins and weights from carrier. The governor weight carrier is only serviced with the shaft and should not be removed.

6. Dislodge ball bearing lock ring from outer end of housing with sharp-pointed tool and jar or press bearing from housing. Usually

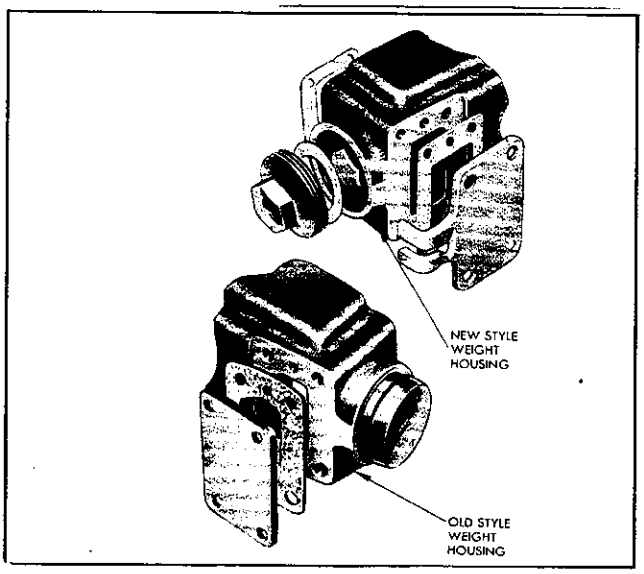
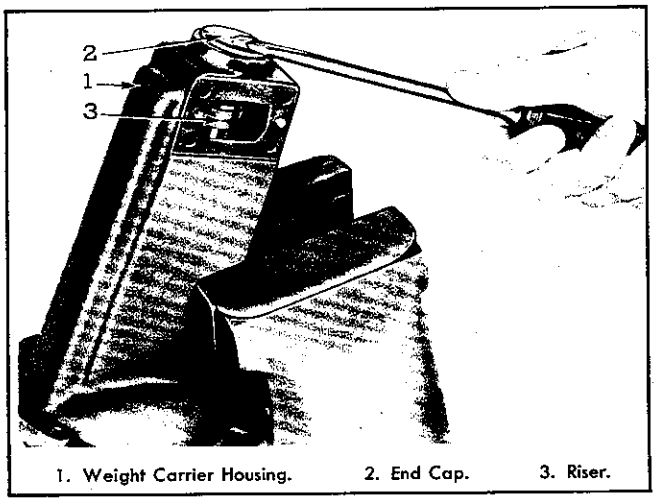


Fig. 13—Comparison of Weight Housing End Plug Arrangements on Early and Late Governor Models.



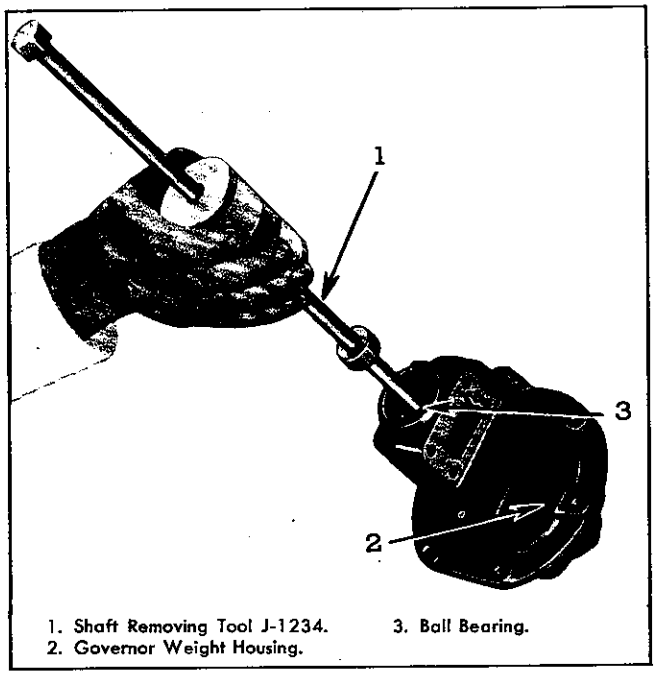
1. Weight Carrier Housing. 2. End Cap. 3. Riser.

Fig. 14—Removing End Cap from Governor Weight Housing. (Early Models.)

very little pressure is required for bearing removal.

Inspection of Governor Parts—All the governor parts having been washed in clean gasoline or fuel oil and dried with compressed air, the parts may be inspected for further fitness.

Since the function of the governor is to control the fuel injection by means of suitable linkage within the governor and inter-connected linkage between the governor and the injector control, the freedom of all moving parts within the governor, as well as the inter-connecting linkage, is of the utmost importance.



1. Shaft Removing Tool J-1234.
2. Governor Weight Housing.
3. Ball Bearing.

Fig. 15—Removing Weight Carrier Shaft from Ball Bearing with Tool J-1234.

When inspecting governor parts, therefore, bear in mind that all parts must work freely with their mating parts.

Annular and thrust ball bearings should be thoroughly cleaned in gasoline or fuel oil and blown out with compressed air. After such treatment, hold in fingers and revolve outer race of annular bearings slowly for any indication of rough spots. Balls and races that have corroded or pitted surfaces should be replaced with new parts.

The rollers and races of roller bearings should be inspected for loose fit of rollers in races or corrosion on rollers.

Examine journals on shafts at roller bearing locations, and if journals are worn excessively, replace shafts.

Examine all sleeves, pins, shaft journals, and links for wear; also for fits, and, if necessary, dress with crocus cloth for proper fit. The weights should be suspended in their carrier sufficiently free to fall from the extended to the inner position by their own weight, and the suspending pins should not be used if worn more than .002" out of round.

Governor Assembly—The governor may be assembled by reversing the sequence of operations for disassembly. The work will be much simplified by close reference to the various detailed illustrations accompanying the following text on "Governor Assembly." Having thoroughly inspected each part, to the various illustrations, and assembled the governor as follows:

I. **Weight and Housing Assembly**—

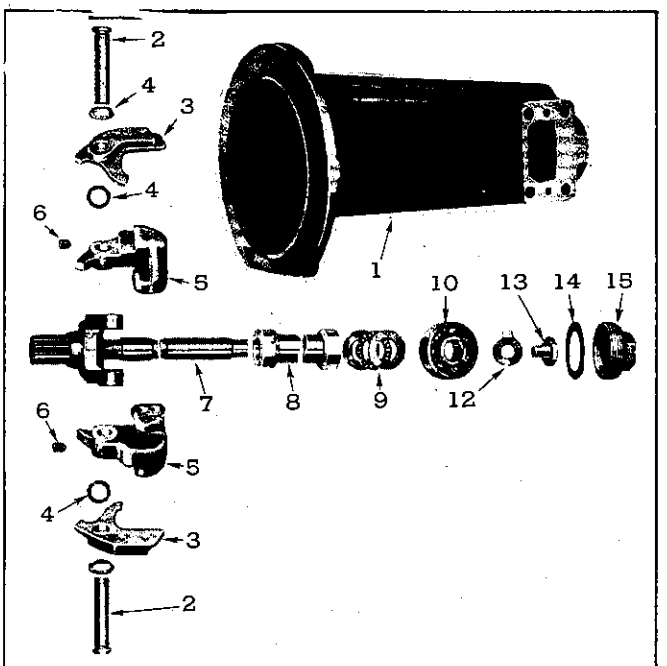
1. Using wood block, tap ball bearing (10) into outer end of weight housing (1) and install lock ring (12) into groove to lock bearing in place. (See Fig. 16.) If the opening in the housing to the bearing seat is internally threaded, no lock ring will be used to hold the bearing. The threaded plug and a gasket screwed up tight against the bearing outer race serve to hold the bearing in position.
2. Heeding marks previously placed on governor weights and carrier, also noting position of washers between weights, attach weights (3 and 5) to carriers (7) and lock each pin (2) with the Allen set screw (6). Stake Allen screws at two places after replacing.
3. Support serrated end of shaft (7) vertically in vise between copper jaws and slip riser (8), then thrust bearing (9) onto upper end of shaft. Drop carrier housing (1) over shaft, then using block of wood on inner race of ball bearing, drive shaft through bearing tight against shoulder on shaft. Install lock-

washer (13) over lock screw (14) and screw latter securely into end of shaft; then lock screw securely into place by bending ear of washer (13) over head of screw.

4. Install new cap (15) into weight housing (1) over end of shaft to retain oil and protect bearing or, if governor is of the later design, place a new gasket next to bearing and turn the threaded plug down snugly against the bearing outer race. Cap should be tightened to the proper position at the time the locking plate is being installed.

II. **Control Housing Assembly—Early "Handy" Models**—The vertical shaft operating lever and forked lever (yoke) at lower end of shaft are serviced as an assembly only. Levers removed from the shaft may be replaced, but new levers cannot be installed on used shafts or vice-versa in the field; as it is necessary to drill and ream holes for taper pins with parts in the proper relation. (See Fig. 17 for relative location of parts of governor control housing.)

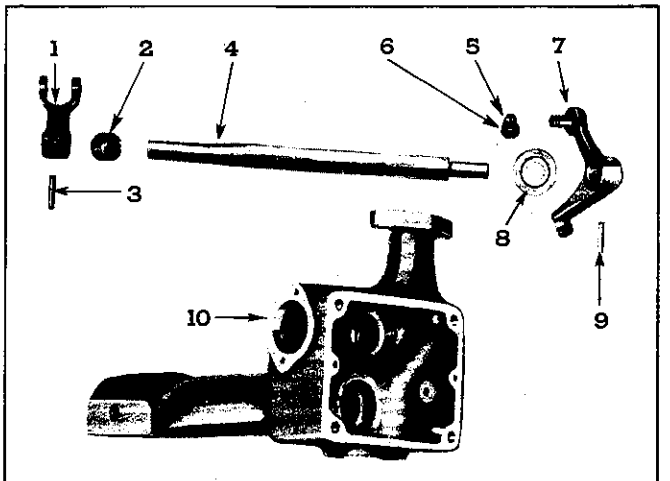
1. If operating lever and bearing were removed from operating shaft, support lower end of shaft vertically, in soft jaws of bench vise, then tap ball bearing (8) onto shaft. With pivot pin on operating lever (7) pointing up, align pin hole in lever with hole in shaft, and drive lever down tight against bearing. Drive taper pin (9) in place, locking lever to shaft.
2. Apply engine oil to the rollers, and tap roller bearing assembly (2) in place at lower end of housing for operating shaft. Install new plug (5).
3. Lubricate ball bearing and insert operating shaft assembly down through roller bearings. Refer to Fig. 1, and position the fork lever (yoke) so machined surfaces of fork will bear against ball bearing thrust washer. When lower end of control shaft appears through the lower bearing, put fork in position and slide shaft assembly down through hub of fork (1).
4. Revolve shaft or fork to align holes and lock fork to shaft with taper pin (3). Lock upper ball bearing (8) from endwise motion with screw (5), plain washer (6), and lockwasher. Replace the two expansion plugs (4) at lower end of control housing.
5. Refer to Fig. 7 and position the differential lever (16) so slotted end points away from ball bearing at upper end of control shaft, then put lever over pivot pin in operating lever, and lock with plain washer (22) and pin clip (21).



1. Weight Carrier Housing.
2. Weight Pin.
3. High-Speed Weight.
4. Plain Washer.
5. Low-Speed Weight.
6. Allen Set Screw.
7. Weight Shaft and Carrier.
8. Riser.
9. Thrust Bearing Assembly.
10. Annular Ball Bearing.
12. Lock Ring.
13. Lockwasher.
14. Lock Screw.
15. End Cap.

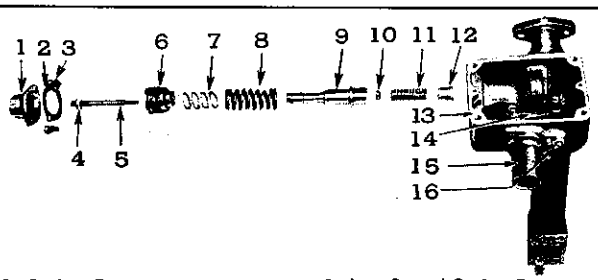
Fig. 16—Governor Weight and Housing Details and Relative Location of Parts (Early Models).

IIA. **Control Housing Assembly—"Delco" and Late "Handy" Models**—Due to the flatted shaft ends and the "D" holes in the hub of both the lower forked lever and the upper operating



1. Forked Lever (Yoke).
2. Roller Bearing.
3. Taper Pin.
4. Vertical Operating Shaft.
5. Ball Bearing Lock Screw.
6. Washer (Plain).
7. Operating Lever (Bell Crank).
8. Ball Bearing.
9. Taper Pin.
10. Governor Control Housing.

Fig. 17—Governor Control Housing Details and Relative Location of Parts.



1. Spring Cover.
2. Gasket.
3. Fillister-Head Screw.
4. Lock Nut.
5. Low-Speed Spring Adjusting Screw.
6. Spring Retainer.
7. High-Speed Spring Shim.
8. High-Speed Spring.
9. Low-Speed Spring Plunger.
10. Low-Speed Spring Seat.
11. Low-Speed Spring.
12. Low-Speed Spring Cap.
13. Control Housing.
14. Differential Lever.
15. Breather Pipe.
16. Buffer Screw.

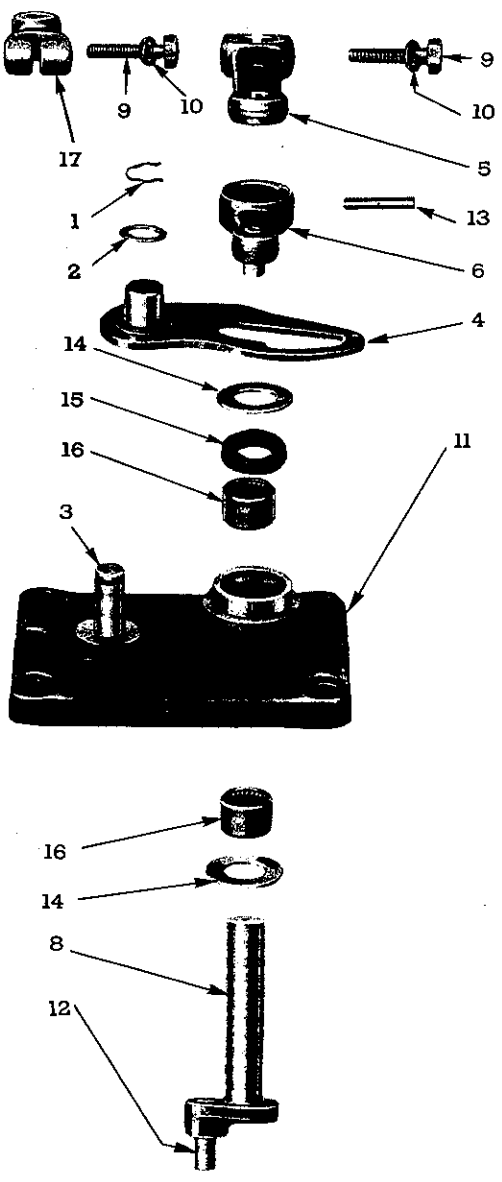
Fig. 18—Governor Control Spring Details and Relative Location of Parts.

lever, the necessity for taper pins to properly locate the levers on the shaft has been eliminated. Through this later method of establishing the proper relationship between operating lever, shaft, and yoke, any one of the three pieces may be replaced without changing the relationship of the system.

1. If operating lever, bearing, and washer were removed from the shaft, set the washer in place against shaft shoulder, tap or press bearing onto shaft then, using an arbor press, replace operating lever against ball bearing inner race. Pin in one arm of operating lever should point toward top of governor when in the installed position.
2. Same as "2" above, under Assembly of Early "Handy" Models.
3. Same as "3" above, under Assembly of Early "Handy" Models.
4. Push forked lever onto shaft just far enough to contact the lower roller bearing assembly then back off just enough to make the shaft movement perfectly free. Tighten set screw securely with an Allen wrench. The walls of the forked lever should be staked down tight against the set screw using a pointed anvil and a pointed punch. After the installation of the shaft and levers in the housing is completed, hold the upper operating lever and with the heel of the hand, gently force the lower operating fork in the direction of normal loading in order to properly seat the operating lever and fork on the shaft. A torque of about 300 inch pounds should be applied to the shaft.

III. **Spring and Plunger Assembly**—Refer to Fig. 18, for relative location of parts and assemble the spring and plunger assembly as follows:

1. Back off lock nut (4) at outer end of adjusting screw (5) to within 1/8" of slotted end of screw.
2. Slip high-speed spring (8) over plunger (9), shim (if used) (7) onto inner end of retainer nut (6), and set nut down on spring. Start adjusting screw (5) into plunger (9)



1. Clip—Governor Lever Pin.
2. Special Washer (Plain).
3. Control Camshaft.
4. Control Cam Assembly.
5. Control Lever.
6. Pedal Control Lever.
8. Throttle Shaft.
9. Clamp Bolts.
10. Lockwashers.
11. Control Housing Cover.
12. Fulcrum Lever Pin.
13. Taper Pin.
14. Cover Packing Retainer.
15. Cover Packing Washer.
16. Throttle Shaft Bearing.
17. Engine Stop Lever.

Fig. 19—Governor Control Housing Cover Details and Relative Location of Parts.

3. Install the low speed spring seat (10) on the inner end, and the spring cap (12) on the outer end of the low speed spring (11) and insert the assembly into the hollow plunger (9).

4. Using the same tool as was used for removal and shown in Fig. 5, screw retainer nut (6) and spring assembly into control housing.

IV. **Control Housing Cover Assembly**—Refer to Fig. 19 for names and relative location of parts, and assemble control housing cover as follows:

1. If bearings for throttle shaft were removed from cover, start either upper or lower bearing (16) straight in the cover by hand; then, using a block of wood on end of bearing, press into position. Install other bearing in the same manner.

NOTE: Lower bearing is pressed in flush with lower end of bearing boss. Upper bearing is pressed in flush with counterbore for the throttle lever.

2. Lubricate roller bearings with a liberal amount of good cup grease, slide thin plain washer (14) over the throttle shaft next to eccentric shoulder on lower end of shaft, and slide shaft (8) through bottom of cover into position through bearings.

3. Insert felt washer (15) into counterbore for roller bearing at upper side of cover. Put plain washer (14) over shaft and next to felt.

4. Lubricate camshaft (3) and install cam (4) over shaft with boss on cam directed away from cover. Position stop lever (17) over operating cam assembly and insert bolt (9) and washer (10). Install plain washer (2) over shaft (3) and insert clip (lock) (1). On installations or models on which the stop lever is not used, disregard instructions on assembly of the lever.

NOTE: After governor has been attached to the engine, and the Bowden wire stop lever control is about to be connected, it may be necessary to reposition the stop lever. Do not tighten bolt (9) too securely.

5. Align holes in throttle shaft (8) and pedal control lever (6) and press lever onto upper end of shaft with pin at outer end of lever down in slot of cam. Lock lever to shaft with taper pin (13).

6. Position control lever (5) on shaft over pedal control lever, and lock with clamp bolt (9).

Install Governor to Engine—Difficulties will be encountered if attempting to install the complete governor assembly to the engine without first separating the control housing from the weight housing. Therefore, if a replacement governer, as received from stock is to be installed on the engine, the two housings must be separated. If a governor being rebuilt is to be installed, installation may be carried out before the two housings are joined together, as follows:

1. Shellac a gasket to the governor weight housing attaching flange, and slide the housing assembly up against the front end of the blower with splined end of governor shaft entering the hollow upper blower rotor shaft. Put attaching bolts in place finger tight only. (See Fig. 2, Sec. 14.)

2. Using a gasket between the two assemblies, set the control housing and shaft assembly on dowels and against the weight housing; then put weight carrier housing cover and gasket in position, and lock cover, gaskets and the two housings together with four bolts and lockwashers.

IMPORTANT: Be sure that forked lever is assembled with machined faces bearing on outer thrust washer and NOT between washer and balls. (See Fig. 12.)

NOTE: On late model "Handy" and all "Delco" Governor Assemblies, the weight carrier housing cover has an extension on it which contacts the threaded end plug and locks the plug in position. Before the cover is installed therefore, the plug must be turned to a position providing proper contact between lock and plug.

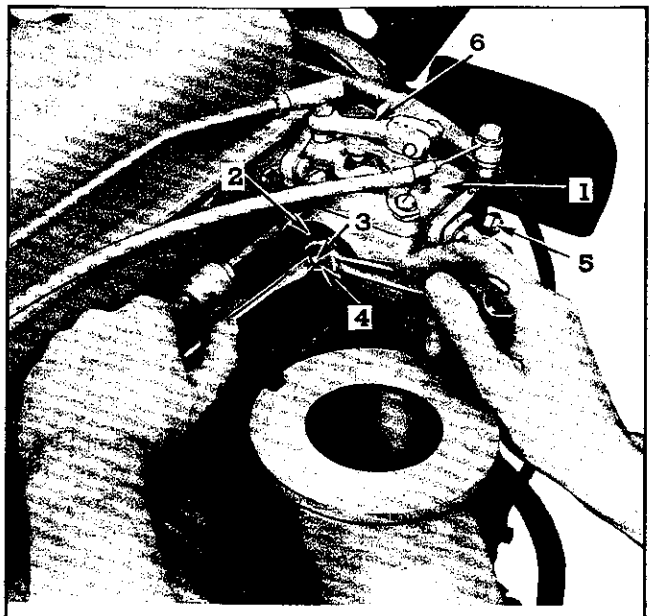
3. Using a new gasket, attach upper end of housing to cylinder head with two bolts and lockwashers.

4. Tighten the six bolts that attach weight housing to end of blower, using the special wrench KMO-326-A, shown in Fig. 37, Sec. 15, for tightening the inner bolt.

5. Pour at least ½ pint of engine oil into top of governor, lubricating all parts thoroughly.

6. At this stage of the governor assembly and before replacing the cover, the low-speed spring plunger gap-space between the low-speed spring plunger (6) and the low-speed cap (7) as shown in Fig. 17 may be checked and if necessary adjusted. When the engine is not running this space should be approximately .170". To adjust the gap, if necessary, proceed as directed under "Adjust Low-Speed Spring Plunger Gap," page 14, Sec. 15.

7. **Install Governor Control Link,** using clevis pin and cotter pins at injector control tube, and plain washer and pin clip at governor control lever.



1. Governor.
2. Governor Spring Retainer.
3. Low-Speed Spring Adjusting Screw.
4. Lock Nut.
5. Buffer Screw.
6. Throttle Control Lever.

Fig. 20—Governor Low-Speed Adjustment.

8. **Attach Control Housing Cover,** as follows:

   (a) Affix gasket to cover bolting flange.

   (b) Set cover on control housing over dowels with pin on lower end of throttle control lever engaging with slot in the differential lever. Replace cover screws and lockwashers.

   (c) Attach throttle control link to governor operating lever and, if manual shutdown is used on the installation, attach Bowden wire to governor stop lever. The position of the operating and stop levers may be changed if necessary to facilitate these connections.

ADJUSTMENTS— LIMITING SPEED GOVERNOR

The four following adjustments are necessary on the limiting speed governor.

I. Adjust gap between low speed spring cap and high speed spring plunger.

II. Adjust engine idling speed.

III. Adjust buffer spring tension for limiting OFF travel of differential lever.

IV. Adjust load limit screw if installation requires limiting the engine maximum output.

The high speed spring setting has been established at the factory for the particular maximum engine R. P. M. for which the unit is used. No further adjustment is necessary or possible.

As previously stated in the governor "Service" section of this text: "Governor faults are usually manifest in speed variations of the engine, but it does not necessarily follow that all such speed variations indicate governor faults." Therefore, before adjusting the governor to correct speed variations, first carry out the instructions for checking the engine as described under governor "Service" up to "Remove Governor from Engine," Page 4. Note that these checks will include:

(a) Lashing valves as outlined on Page 2, Sec. 11.

(b) Timing injectors as outlined on Page 12, Sec. 15.

(c) Positioning injector control racks, as outlined on Page 13, Sec. 15, which should be checked before any governor adjustments are attempted.

I. **Adjust Governor Gap**—Once this adjustment is properly established no further attention should be necessary until the governor assembly is repaired or replaced. When the adjustment is required it may be carried out as described on Page 14, Sec. 15.

II. **Low Speed Adjustment**—The desirable idling speed on these engines is approximately 400 R. P. M. Even though the low speed adjustment is set at the factory before the engine is shipped, it may be desirable either to raise or lower the idling speed of the engine, in which case the adjustment is made as follows: The engine should be running at operating temperature while making this adjustment.

   (a) Remove low speed adjustment cover at rear side of governor control housing as shown in Fig. 2.

   (b) Loosen lock nut and turn buffer screw OUT (when used) until screw projects about $\frac{5}{8}$" beyond lock nut. Set throttle control lever in idling position and start engine. If engine "gallops" or "rolls" after it has become thoroughly warmed up, gradually turn buffer spring screw IN until "roll" disappears, or nearly so. If engine doesn't "roll," leave buffer screw backed out until after low speed adjustment has been completed.

   (c) Loosen lock nut on idling adjustment screw.

   (d) Adjust screw IN (clockwise) for higher, and OUT (counter-clockwise) for lower speed. (See Fig. 20.)

   (e) Tighten lock nut and replace cover.

III. **Buffer Spring Adjustment**—Some mechanical governors are equipped with buffer springs, others are not. If so equipped, its purpose is to

prevent low speed engine "roll" or "stalling," which is manifest on some engines and absent on others. To adjust after the screw has been backed out as directed for the low speed adjustment, turn screw IN until engine idling speed is increased slightly (not to exceed 20 R.P.M.), thus insuring spring contact with the differential lever.

IV. **Load Limit Screw Adjustment**—Some mechanical governors are equipped with this screw, others are not. If so equipped, its purpose is to stop the injector racks to prevent further opening at any desired position before maximum fuel position has been reached. If loading conditions on engine are such that maximum rack opening is inadvisable, adjust load limit screw accordingly. To set load limit screw for maximum fuel position:

(a) Back out load limit screw and with injector racks held in full fuel position (way in), turn screw IN until racks move out (toward no fuel position) 1/64" to 1/32".

(b) Tighten lock nut on rack control stop screw.

CONSTANT SPEED MECHANICAL GOVERNOR

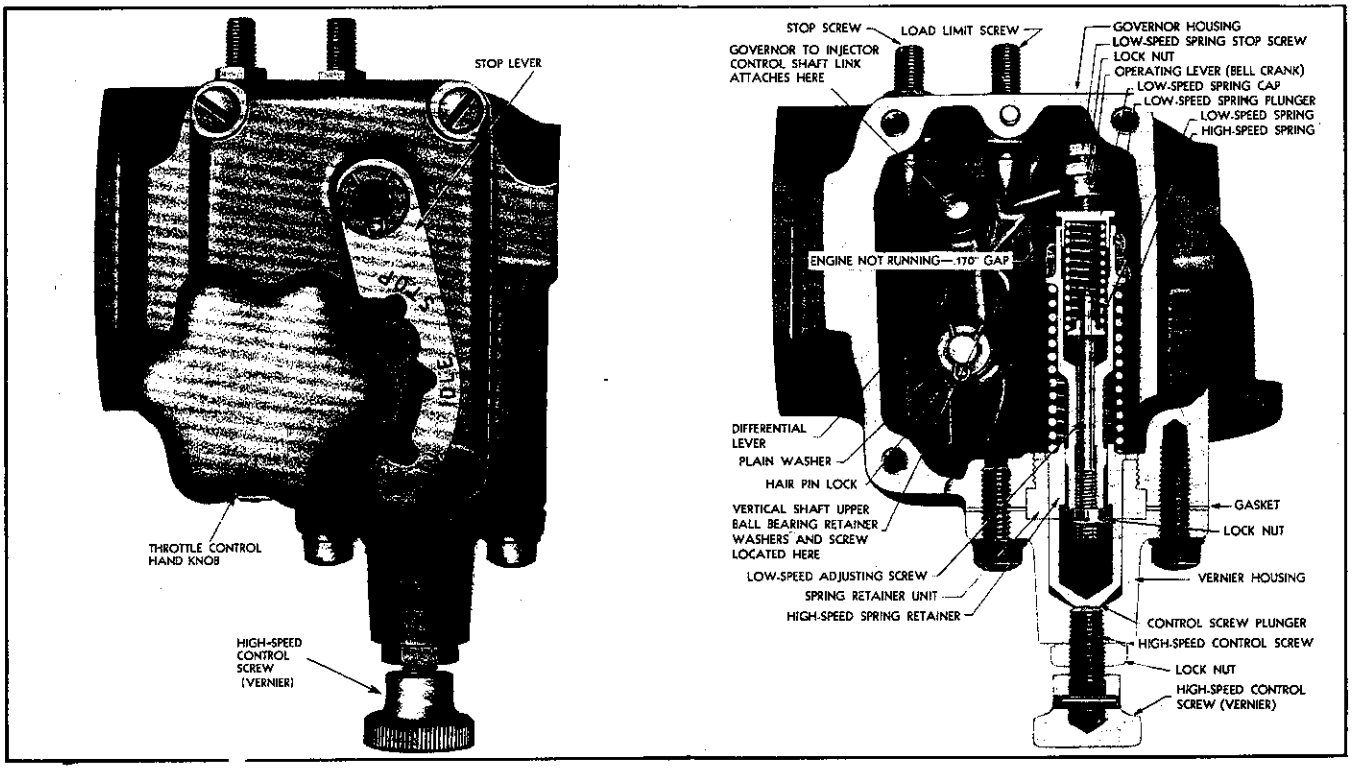


Fig. 21—Constant Speed Mechanical Governor Springs, Control and Cover Assembly.

Description—Fundamentally, the constant speed mechanical governor, displayed in Figs. 21 and 22, is the same as the limiting speed mechanical type. The main differences being that the constant speed has only one set of weights and a close manual regulation of the high speed spring whereby the high speed may be varied within a range of approximately 120 engine R.P.M.; whereas the limiting speed has two sets of weights, and the high speed is fixed by the characteristics of the spring, and no high speed engine changes are possible without internal physical changes within the governor.

To provide free movement for the weights, they are suspended on roller bearings. The bore in the hub of the weight serves as the outer race for the rollers, and the hardened pin as the inner race. A series of 22 rollers are used at each end of the hub with a spacer between the two sets; a plain washer over the pin, and at each end of the weight hub, serves as an outer retainer for the rollers.

Since there is no intermediate or manually controlled range between high and low engine governor speeds in the constant speed governor, there is no call for two sets of weights. The only requirements for this governor being to control the engine idling speed, and maintain a constant operating speed.

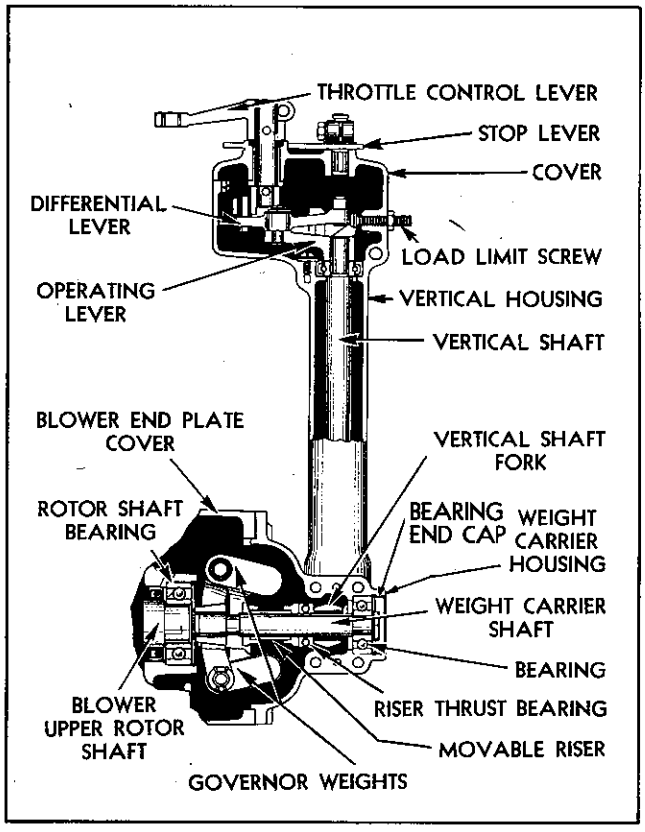


Fig. 22—Constant Speed Mechanical Governor Assembly.

Operation—Since there is no intermediate or manually controlled range in the constant speed governor, the throttle is set in either the low speed or running position for engine operation, and engine control is automatic by the governor for both of these positions.

When the throttle is set in the idling position engine control is entirely through the low speed spring, the tension on which may be varied to suit engine requirements. Since low and high speed requirements are met by low and high speed springs respectively, a limit must be established when the low speed spring ceases to function and the high speed spring comes into operation.

The upper limit of the low speed governing range is reached when the low speed spring plunger to high speed spring plunger gap closes, as shown in Fig. 23. After this condition has been obtained, the engine control is taken over by the high speed spring. This gap may be varied to meet these conditions by means of a screw on the end of the bell crank arm.

This adjustment is described later under "Governor Adjustments—Constant Speed," Page 18.

When the speed of rotation of the weights becomes high enough so that the force on the weights, as transmitted through the riser, the forked lever, the vertical shaft, and the bell crank to the high speed spring, is sufficient to overcome the preload on the high speed spring and again cause motion at the control mechanism, this motion automatically controls the maximum speed.

Service—Before performing any service work or making any adjustments on this governor, refer to the instructions and checks outlined under "Service," Page 0, for the limiting type governor, which also applies to the constant speed type.

Remove Governor From Engine—The removal of this governor from the engine is the same as for the limiting type, refer therefore, to "Remove Governor from Engine," Page 5.

Disassemble Mechanical Constant Speed Type Governor—Because of the similarity in design of the constant speed and limiting type mechanical governors, the procedure for disassembly is somewhat similar. The same order of disassembly will be used here and any differences noted below. Before removing any parts from the governor assembly the entire unit should be thoroughly washed in clean gasoline, dried with compressed air, and then inspected carefully for worn, damaged parts, or bind in any of the parts that cannot be corrected without disassembly. Disassembly need be carried out only far enough to correct those difficulties which interfere with proper governor operation.

I. **Control Housing Cover Disassembly**—Owing to the similarity in design of the cover on all three mechanical governors described, refer to "Control Housing Cover Disassembly," Page 6.

II. **Control Housing Disassembly**—With the governor control housing detached from the weight housing, the former may be disassembled as follows:

1. Remove hairpin lock (52) and washer from differential lever pivot pin and raise lever from pin. (See Fig. 2.)
2. Remove two retaining screws and washers from control adaptor at upper end of housing and withdraw adaptor assembly and gasket.
3. The remaining operations are the same as for the limiting speed governor. Refer, therefore, to "Control Housing Disassembly," Page 8.

III. **Weight and Housing Disassembly—Constant Speed Governor**—With the control housing assembly separated from the weight and housing assembly the latter may be disassembled as follows:

4. Items 1 to 4 inclusive are the same as for "Weight and Housing Disassembly" for limiting governor, Page 8.

5. Mark weights and carrier with center punch so weights can be replaced in their original locations, then remove hairpin lock from one end of each pin. Hold the weight and carrier assembly over a clean container to catch the rollers inside the weight hubs, and withdraw pins and weights from the carrier.

6. Dislodge bearing lock ring from outer end of housing with sharp-pointed tool, and jar or press bearing from housing. Usually the bearing is not a tight fit in housing and very little pressure is required for removal.

Inspection of Governor Parts—What has been said on Page 10, regarding the inspection of governor parts before those parts are reassembled, applies also to the constant speed governor. Refer, therefore, to "Inspection of Governor Parts," Page 10.

Governor Assembly—The governor may be assembled by reversing the sequence of operations for disassembly. Owing to the similarity in design of the constant speed and the limiting type governors, only those portions of the latter that differ from the former assembly will be discussed in this chapter.

The assembly of this governor will follow the same order as was used on the limiting type, that is:

I. Weight and Housing Assembly.

II. Control Housing Assembly.

III. Control Housing Cover Assembly.

1. **Weight and Housing Assembly**—Refer to Fig. 24, and assemble weights, shaft and bearings into housing as follows:

   1. Using wood block, tap ball bearing (D) into outer end of weight housing, place shim (F) next to bearing and install snap ring (J) into groove to lock bearing in place.

   2. Apply a liberal amount of cup grease to the spacer (L) which is positioned between the two rows of roller bearings inside the weight hubs, and to the rollers (P), and install 22 rollers in each end of the weight hub. Heed the marks previously placed on weights and carrier, position weights (N) between forks of carrier so pivot pin (K) can be dropped into position. Put a plain washer (O) next to hairpin (M) at one end of pin and drop pin through carrier and inside of rollers in weight hub. Put plain washer (O) on free end of pin and lock with hairpin.

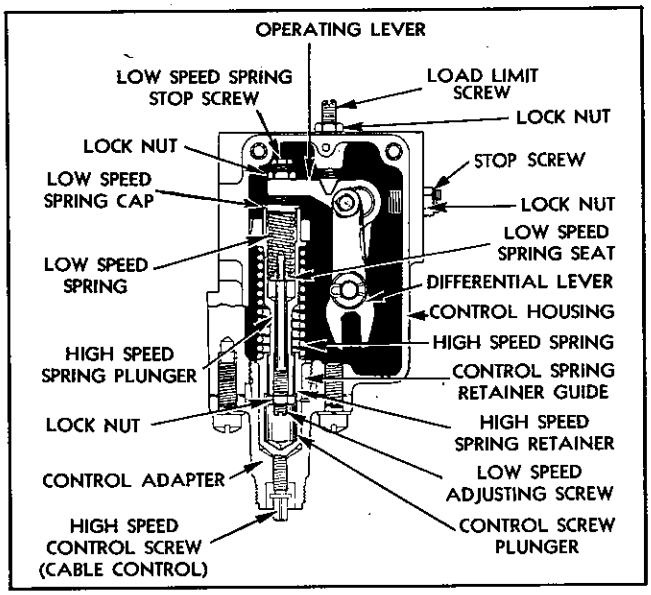


Fig. 23—Constant Speed Governor Operating Mechanism with Low Speed Spring Gap Closed.

3. As balance of the assembly is the same as for the limiting type governor, refer to items 3 and 4, "Weight and Housing Assembly," Page 10.

II. **Control Housing Assembly**—Refer to Fig. 21, for relative location of parts in connection with springs and governor control, then follow the instructions under "Control Housing Assembly," for the limiting type governor as outlined on Page 11.

III. **Control Housing Cover Assembly**—For instructions relative to servicing this assembly see: "Control Housing Cover Assembly" for limiting speed governor, Page 13, which applies also to this unit.

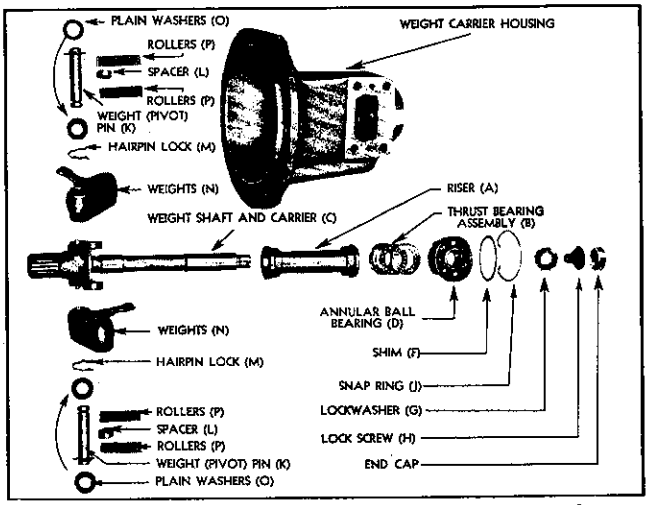


Fig. 24—Constant Speed Mechanical Governor Weight and Housing Details.

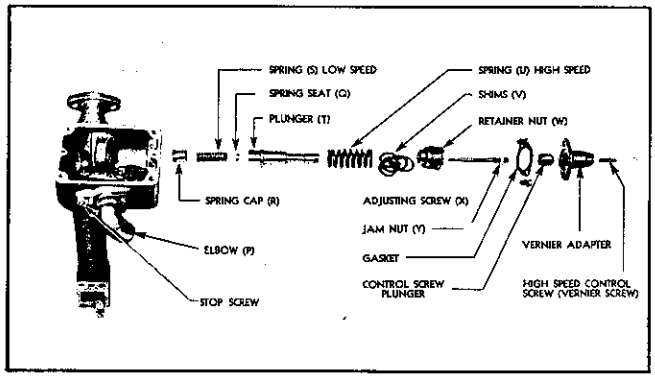


Fig. 25—Constant Speed Mechanical Governor Control Housing Details.

Governor Adjustments—Constant Speed—Five adjustments are necessary on the constant speed governor, as follows:

1. Low speed spring gap adjustment for setting governor linkage.
2. Stop screw adjustment for limiting OFF travel of differential lever.
3. Low speed adjustment for controlling engine idling speed.
4. High speed spring adjustment for controlling engine operating speed.
5. Load Limit Screw adjustment for limiting engine maximum output.

Before attempting any governor adjustments, the following inspections and adjustments should be made:

1. Set Valve lash to .011″ GO and .013″ NO GO.
2. Time injectors according to instructions under "Timing Fuel Injectors," Page 12, Sec. 15.
3. Position injector control racks according to instructions under "Positioning Control Racks," Page 13, Sec. 15.

The five governor adjustments should be made in the order listed, and the following procedure may be used as a guide:

1. **Low Speed Spring Gap Adjustment**—This adjustment is set at the factory and should require no further change except from parts wear, which takes place slowly. Therefore, unless the adjustment has been tampered with, alterations should not be required. To make this adjustment:

   (a) With engine stopped, remove control housing cover and governor link.

   (b) Remove vernier adapter from upper end of governor control housing (See Fig. 25). Loosen lock nut and turn low speed adjusting screw IN until about 1/16″ projects from lock nut.

   (c) Set throttle lever in idling notch. Turn load limit screw way OUT and tighten lock nut.

   (d) Check gap between low speed spring plunger and seat which should measure .170″ or exactly 11/64″ as shown in Fig. 0. If gap is not correct, adjust by loosening lock nut and turning screw until correct gap is obtained. Tighten lock nut.

   (e) Install governor link, being sure link is locked at both ends.

   (f) Install governor cover.

   (g) If low speed spring gap was changed, the injector control racks must be reset after such change. This is done by repeating "Positioning Control Racks," as described on Page 13, Sec. 15.

2. **Stop Screw Adjustment**—

   (a) Loosen stop screw lock nut and back screw out until it projects 5/8″ beyond nut.

   (b) Hold injector control tube to position control racks in NO FUEL position.

   (c) Turn stop screw IN until injector racks have moved IN about 1/32″ from the extreme NO FUEL position. Tighten lock nut.

   (d) Check to see that distance from injector rack collar to injector body is at least 27/32″.

3. **Low Speed Adjustment**—The idling speed on the constant speed governor is not so important as on the limiting speed type and may range, therefore, from 350 to 400 R.P.M.

   Even though the low speed adjustment is set at the factory before the engine is shipped, it may be desirable, at times, either to raise or lower the idling speed of the engine, in which case the adjustment is made as follows: (The engine should be hot and running while making this adjustment.)

   (a) Remove vernier adaptor from upper end of governor control housing, as shown in Fig. 25, and loosen lock nut on low speed adjusting screw.

   (b) Adjust screw IN (clockwise) for higher, and OUT (counter-clockwise) for low speed.

   (c) Tighten lock nut and replace vernier adaptor.

4. **High Speed Spring Adjustment**—The governor is adjusted at the factory for the normal operating speed required by the electric generator, which device is usually driven when the constant speed governor is used. The vernier screw provides an adjustment approximately 60 engine R.P.M. above and below this normal speed.

   (a) Adjust by turning hand knob on engine instrument panel clockwise for higher, and counter-clockwise for lower engine speeds.

5. **Load Limit Screw Adjustment**—To accommodate certain kinds of loads, it may be desirable to limit the maximum engine output by stopping the injector racks at some position short of full open.

   When these conditions are desirable, the load limit screw is adjusted as follows:

   (a) Start and bring engine up to operating temperature.

   (b) Loosen load limit screw lock nut and turn screw way OUT.

   (c) Throw the desired load on the engine.

   (d) Turn load limit screw IN until speed just starts to drop, then back off slightly on screw until engine is operating at governed speed. Tighten lock nut.

VARIABLE SPEED MECHANICAL GOVERNOR

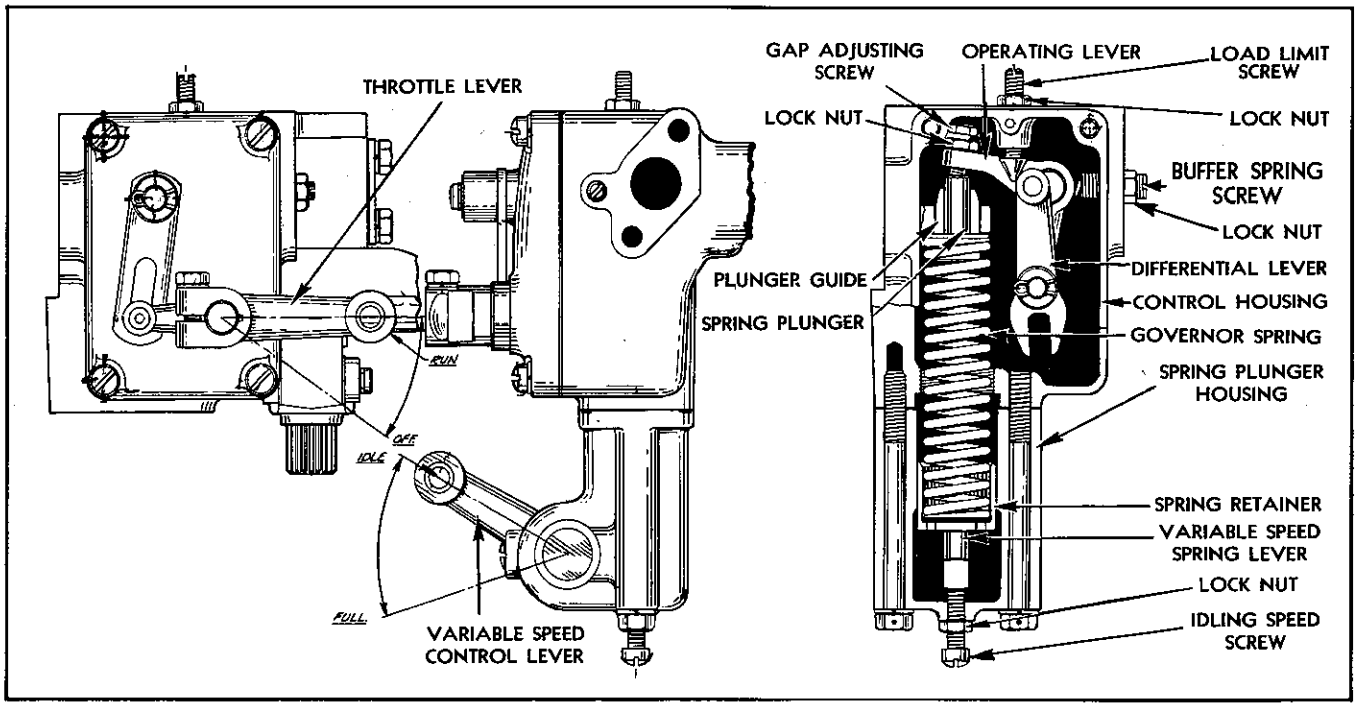


Fig. 26—Variable Speed Mechanical Governor Spring Control and Cover Assembly.

Description—Like the constant speed mechanical governor, the variable speed type has but one set of weights. Unlike the former, however, only one spring is necessary. The governor linkage mechanism consisting of the vertical shaft, its bearings, its allied parts, buffer screw for differential lever and load limit screw are the same for both types.

The plunger at one end of the single spring bears against the operating lever, the opposite end is retained and guided inside a spring retainer which in turn bears against a variable control speed lever, as shown in Fig. 26.

This governor is designed to control the engine at a constant speed at any point within the limitations of the governor spring that the operator may desire. Such control is made possible by the idling screw for the low engine speeds, and imposing more or less tension on the spring by means of the variable speed control lever for higher speeds. The greater the tension on the spring, the higher the engine speed and vice versa.

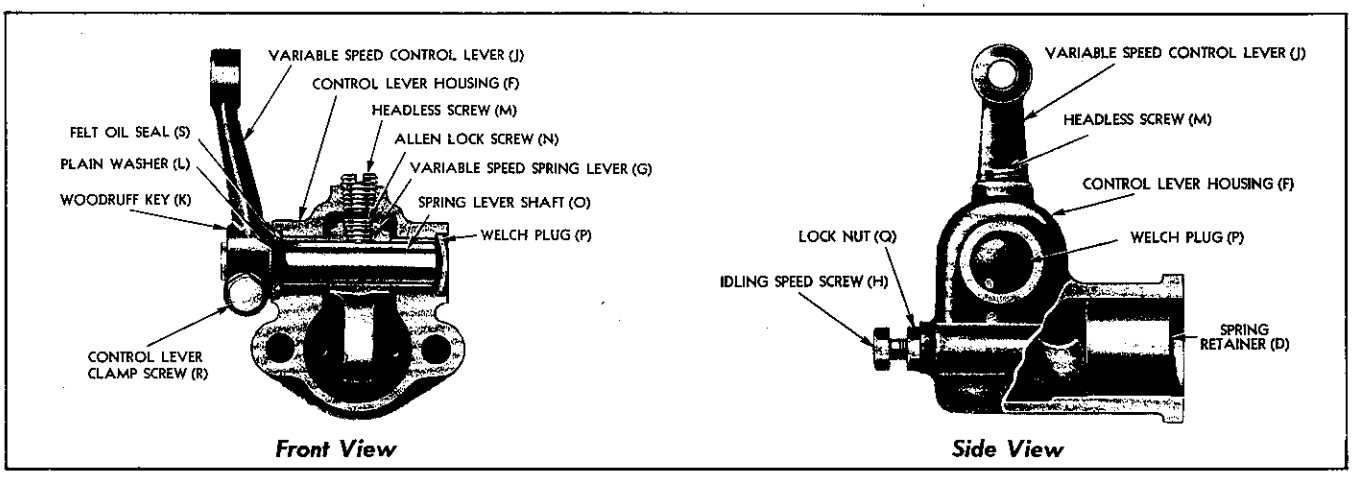


Fig. 27—Variable Speed Governor Control Housing and Lever Assembly.

Lubrication—The lubrication of this governor is exactly the same as the limiting speed type explained on Page 3.

Operation—The operation of the variable speed governor mechanism is similar to that of the limiting speed type described on Page 3. Two manual controls are provided; the throttle control lever for starting and stopping the engine, and the speed control lever for regulating the operating speed (See Fig. 26). For starting, the throttle lever is moved to the running position which moves the injector racks to full fuel position. Then, immediately upon starting, the governor moves the injector racks OUT to the position required for idling. The engine is then brought up to any desired operating speed, within the limitations of the spring, by increasing the tension on the spring by means of the speed control lever. As heretofore stated, increasing the tension on the spring raises the governor speed. The engine speed control is entirely automatic from this point on, depending upon spring tension. The engine may be stopped by moving the throttle lever to the OFF position.

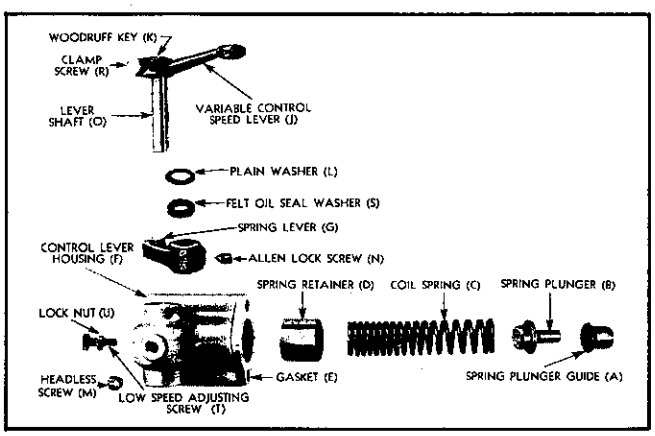


Fig. 28—Variable Speed Governor Control Housing Spring and Lever Details.

Service—The remarks made relative to "Service" on Page 4, apply equally as well to the variable speed governor. They should, therefore, be carefully reviewed before attempting any governor adjustments or repairs.

Remove Governor From Engine—Removal of governor from the engine is the same as for the previous two types of mechanical governors discussed in this section, therefore, reference is made to "Remove Governor from Engine," Page 5.

Disassemble Governor—The similarity in design of the variable speed governor to the other two mechanical governors discussed above obviates the necessity of complete tear down operations here. The one sub-assembly which differs slightly from the two previous types is the spring housing and lever assembly. Procedure for disassembly of this sub-assembly is as follows:

1. With the spring housing and lever assembly removed from the governor control housing, loosen the control lever clamp screw and slip lever from shaft. Also, remove Woodruff key (See Fig. 27).
2. Slip plain washer and felt oil seal off lever end of shaft.
3. Remove headless screw from housing then by means of a 3/32 Allen wrench through opening from which screw was removed, back out Allen screw.
4. Pull shaft endwise from housing thus releasing the spring lever from shaft.

Inspection of Governor Parts—For inspection of governor parts, refer to section by the same heading on Page 10. The instructions outlined here apply equally as well in this case.

Governor Assembly—Barring the spring housing and lever assembly, displayed in Figs. 27 and 28, the governor assembly is the same as for the constant speed mechanical governor discussed on Page 10.

To assemble the spring and housing and lever assembly on this variable speed governor, refer to Fig. 28, for relative location of parts and use the following outline as a guide:

1. Support control lever housing (F) in bench vise and place spring lever (G) in position through opening at flange so that arm on lever points toward opening and lever shaft (O) can slip through hub of lever (See Fig. 27).
2. Apply some engine oil to shaft journals, and with end of shaft for key pointing out, put shaft (O) in position, so Allen lock screw (N) will enter bevel seat in shaft. Lock screw tight. Install headless screw (M).
3. Crowd felt oil seal washer (S) into counter-bore of housing at lever end of shaft and set plain washer (L) next to felt.
4. Crowd plain washer down tight against felt and place Woodruff key (K) in shaft.
5. Position speed control lever (J) with off-set at outer end of lever away from housing, and slip lever over end of shaft tight against plain washer. Tighten clamp screw (R).
6. **Attach Control Lever Housing to Control Housing,** as follows:
   (a) With cover removed from control housing, put spring plunger (B) inside spring plunger guide (A) and install in bracket of housing with small diameter of plunger next to adjusting screw of bell crank (see Fig. 27).
   (b) Slip loosely wound end of coil spring (C) over end of plunger with opposite end protruding from housing.
   (c) Lubricate and place spring retainer (D) inside of control lever housing with hollow portion facing finished bolting flange.
   (d) Shellac a gasket (E) to bolting flange of control lever housing and slide housing assembly into position against control housing with spring entering spring retainer. Secure with two cap screws and lockwashers.
   (e) Pour about ½ pint of engine oil over governor mechanism.
   (f) Replace governor cover and gasket and make sure that throttle control lever to differential lever pin is assembled in the differential lever slot.

Governor Adjustments—Variable Speed—Three adjustments are necessary on the variable speed mechanical governor, as follows:

1. Spring plunger gap adjustment for setting governor linkage.
2. Low speed adjustment for controlling idling speed.
3. Buffer spring adjustment for limiting OFF travel of differential lever.

Before any governor adjustments are attempted the following engine inspections and adjustments should be made:

(a) Set valve lash as outlined on Page 2, Sec. 11.

(b) Time injectors as outlined on Page 12, Sec. 15.

(c) Position injector control racks as outlined on Page 13, Sec. 15.

1. **Spring Plunger Gap Adjustment.**
   (a) With engine stopped, remove control housing cover assembly.
   (b) Set speed control lever for about ½ speed.
   (c) Check clearance between spring plunger shoulder and seat, which should measure from .010" to .020".
   (d) If clearance is correct, install control housing cover and proceed to adjust idle and buffer screws. If adjustment is required, loosen the gap adjusting screw lock nut and turn screw to obtain proper clearance. Tighten lock nut.
   (e) If adjustment was made, the injector racks must be repositioned as follows:
      (1) Place throttle lever in running position.
      (2) Set speed control lever at about ½ speed.
      (3) Turn out buffer screw until it projects ⅝" from side of control housing.
      (4) Carry out remaining operations under "Positioning Injector Control Racks," Page 13, Sec. 15.
2. **Low Speed Adjustment**—
   (a) Back out buffer spring screw until it projects ⅝" beyond lock nut.
   (b) With speed control lever in idling position start engine.
   (c) Loosen idling screw lock nut at end of speed control lever housing and adjust screw until engine speed is approximately 425 R.P.M. Turning screw IN (clockwise) raises, and OUT (counter-clockwise) lowers engine speed. Tighten lock nut.
3. **Buffer Spring Adjustment**—Turn in buffer spring until engine idles at 430 to 450 R.P.M.

Fig. 29—Hydraulic Governor Assembly Including Starting Solenoid and Governor Drive Mechanism.

1. Limit Pin.
13. Fuel Rod.
14. Fuel Rod Collar—Small.
15. Knob—Shut-Down.
16. Lock Nut—Shut-Down Knob.
17. Sub Cap.
20. Spacer—Fuel Rod.
21. Bushing—Fuel Rod.
24. Short Spring.
25. Ballhead.
26. Pin—Ball Arm.
27. Flyweight.
29. Base.
30. Servomotor Piston.
31. Terminal Lever.
32. Droop Adjusting Bracket.
33. Plunger—Pilot Valve.
34. Speed Adjusting Sleeve.
36. Governor Case.
37. Shaft—Speed Adjusting.
38. Lock Nut.
39. Droop Adjusting Screw.
40. Governor Cover.
41. Cotter Pin.
43. Cotter Pin—$\frac{3}{32}$ x $\frac{5}{8}$".
44. Spring Seat.
46. Spacer Cap.
48. Lock Wire.
49. Spring Fork.
51. Gasket—Governor Case-to-Governor Base.
52. Gasket—Cover-to-Sub Cap and Sub Cap-to-Case.
53. Thrust Bearing.
55. Dowel Pin.
56. Thrust Washer.
57. Collar—Drive Shaft.
58. Pipe Plug.
60. Screws—Cover and Sub Cap-to-Case.
63. Screw — High Speed Limit Adjusting.
64. Screw — Maximum Fuel Adjusting.
65. Speeder Spring.
66. Gear—Pump Idler.
67. Gear—Pump Drive.
72. Lock Nut.
74. Solenoid—Starting.
75. Stud.
76. Link.
77. Spacer.
78. Nut—Link-to-Stud.
79. Adapter — Starting Solenoid to-Governor Cover.
80. Bolts.
81. Lock Washers.
82. Nuts.
83. Bolt.
84. Spring.
85. Nut.
86. Lock Washer.
87. Housing—Governor Drive.
90. Pipe Plug.
91. Gear — Governor Drive — Driven.
92. Bearing—Driven Gear.
93. Sleeve—Driven Gear.
94. Groove Pin.
95. Bolts—Conical Point.
96. Washer (Leather).
97. Lock Wire.
98. Gear—Drive (Governor Drive).
99. Bearing—Drive Gear.
100. Pin.
101. Bolt—Bearing Retaining.
102. Lock Washer.
103. Spacer.
104. Plain Washer—Bearing Retaining.
105. Gasket—Governor Assembly-to-Governor Drive Assembly.
107. Gasket—Governor Drive-to-Blower Assembly.
108. Bolts — Governor Drive-to-Blower Assembly.
109. Lock Washers.
114. Lock Washers.
115. Bolts—Sub Cap-to-Cylinder Head.
120. Lever—Speed Adjusting.
121. Floating Lever.
122. Relief Valve Assembly.
125. Thrust Washer—Upper.
132. Injector Control Tube.
133. Lever—Injector Control Tube.
141. Fuel Injector.
142. Conductor—Solenoid-To-Ground.

HYDRAULIC GOVERNOR

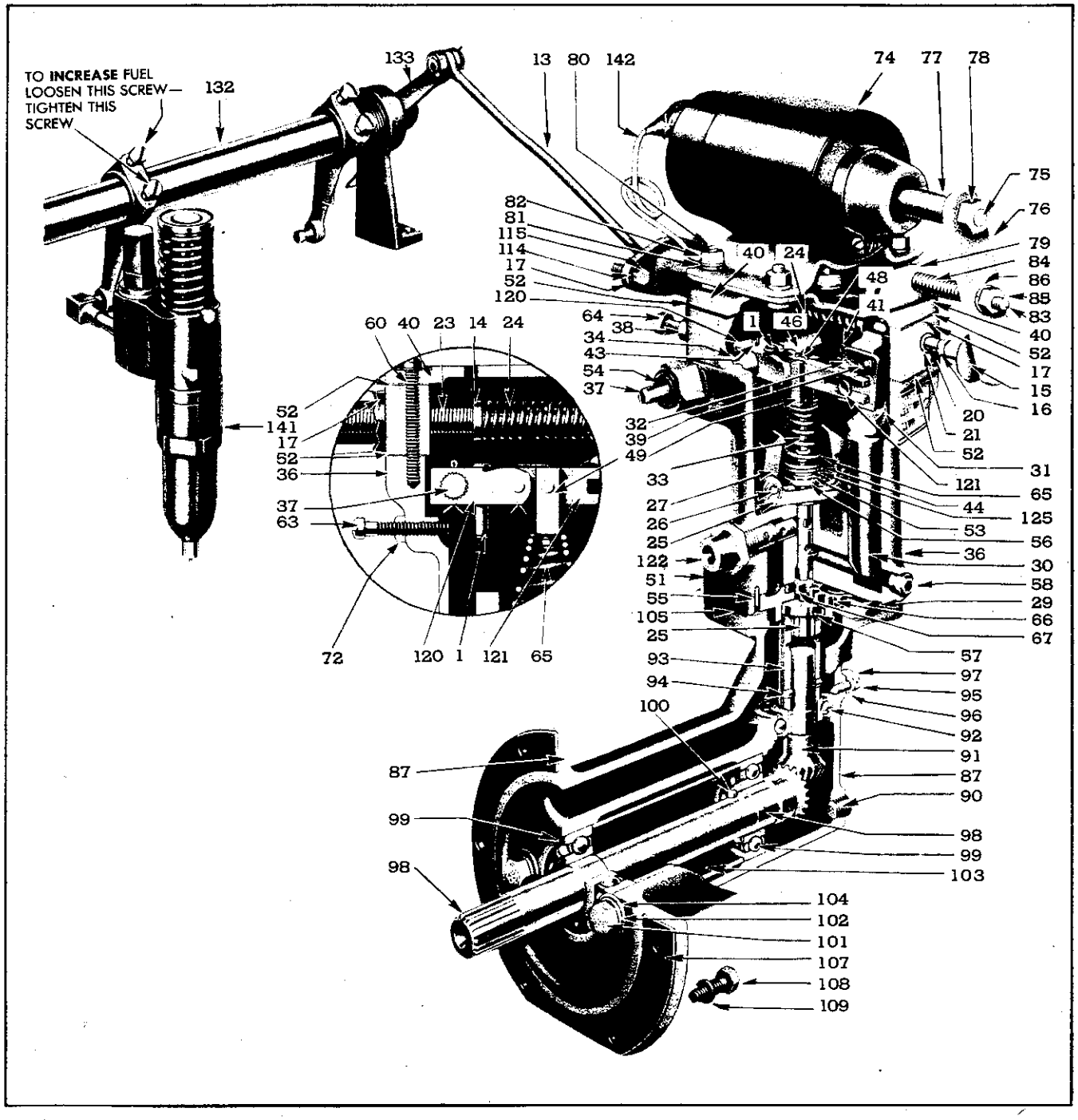
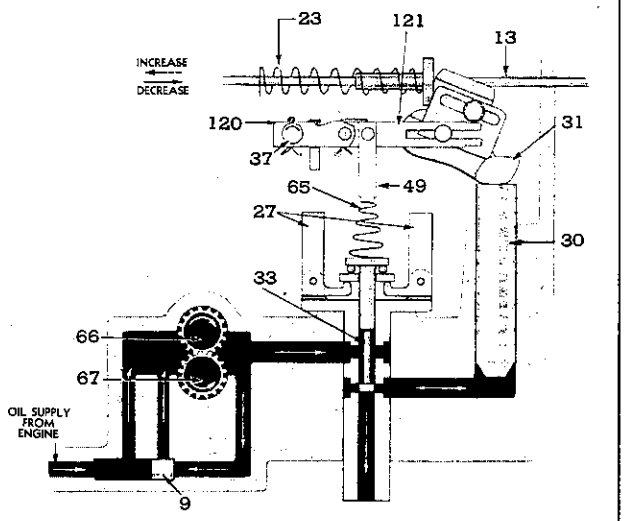


Fig. 29—Hydraulic Governor Assembly Including Starting Solenoid and Governor Drive Mechanism.

Description—The governor displayed in Fig. 29, is the hydraulic type with speed droop stabilization. The hydraulic feature is brought about by oil from the engine lubricating system being admitted, under pressure, to an auxiliary oil pump in the governor. The auxiliary pump furnishes the necessary oil pressure to actuate the governor mechanism. (See Schematic Diagram, Fig. 30.)



9. Plunger—Relief Valve.
13. Fuel Rod.
23. Spring.
27. Flyweight.
30 Servo Piston
31 Terminal Lever
33. Plunger—Pilot Valve.
37. Shaft—Speed Adjusting.
49. Spring Fork.
65. Speeder Spring.
66. Gear—Pump Idler.
67. Gear—Pump Drive.
120. Lever—Speed Adjusting.
121. Floating Lever.

Fig. 30—Schematic Diagram Showing Working Principle of the Hydraulic Governor.

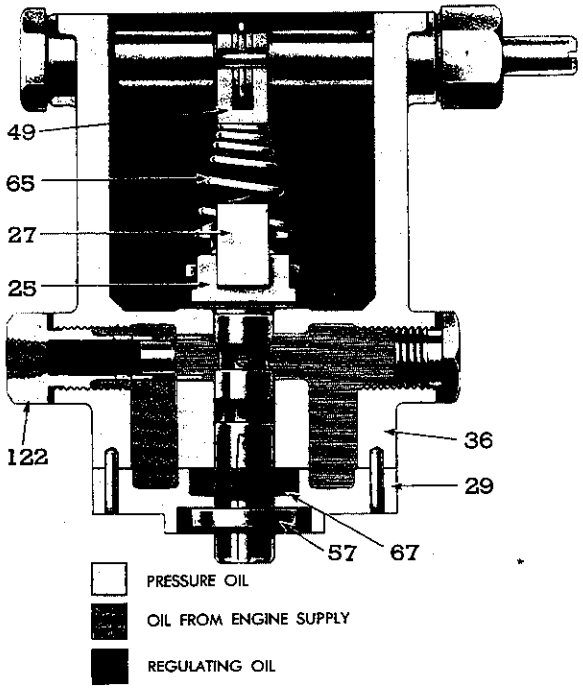
In this governor, the fuel is decreased by action of a fuel rod spring and increased by the opposing action of a hydraulic servo cylinder, the admission of oil to which is controlled by a pilot valve. The pilot valve is controlled by the flyweights of the governor. The flyweights are mounted on a vertical shaft and driven through a pair of miter gears from the upper rotor shaft of the blower at 1.9375 times engine speed. (See Fig. 29.) The centrifugal force of these flyweights in rotation is opposed by a so-called "speeder spring," the compression of which determines the speed at which the governor will control the engine. The compression on the speeder spring is varied by the throttle on the control cabinet panel.

In order that the governor operation may be stable, (that is, without hunting) "speed droop," adjustable in amount, is introduced into the governing system. By speed droop is meant, the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop may easily be adjusted to suit conditions as will be described in a later paragraph.

The mechanical connection of the governor to the fuel injectors is by means of a fuel rod or link attached to a lever on the injector control tube. When the engine is stopped, the fuel rod spring forces the fuel rod, and with it the injector racks, to the "Fuel Off" position.

In starting a cold engine, it takes considerable time for the lubricating oil pressure to become great enough to operate the governor and thus open the throttle so the engine can start. As this delay in starting is considered objectionable, the starting time can be shortened by pressing in on the knob which projects from the side of the governor. This knob is on the fuel rod, which connects directly to the injector control tube, and pushing the knob in takes the control away from the governor. To accomplish this, a starting solenoid is provided as shown in Fig. 29. This solenoid is wired directly to the starting motor and is actuated each time the starting motor is used.

In a similar manner, the engine can be stopped, regardless of the governor, by pulling out on the fuel rod knob. Considerable force must be exerted to do this as the oil pressure against the servo piston



25. Ballhead.
27. Flyweights.
29. Governor Base.
36. Governor Case.
49 Spring Fork
57. Collar—Drive Shaft.
65. Speeder Spring.
67. Gear—Pump Drive.
122. Relief Valve Assembly.

Fig. 31—Cross Section of Governor Showing Function of Pressure Relief Valve.

must be overcome. The knob thus functions also as a stopping device for the engine.

Aside from its function of holding the engine speed constant under varying load conditions, the hydraulic governor acts as an automatic engine shut-down device in case of lubricating oil pressure failure. Should the engine fail to supply oil to the governor, the servo-position will drop, letting the fuel rod return to "NO FUEL" position, thus shutting down the engine.

NOTE: Slight detail differences exist in the early and late hydraulic governors; fundamentally the two are the same, however. On the early models the speed droop adjusting lever is on the outside, and on the later models on the inside of the governor. Otherwise, both are substantially the same. The later type only is discussed in this text.

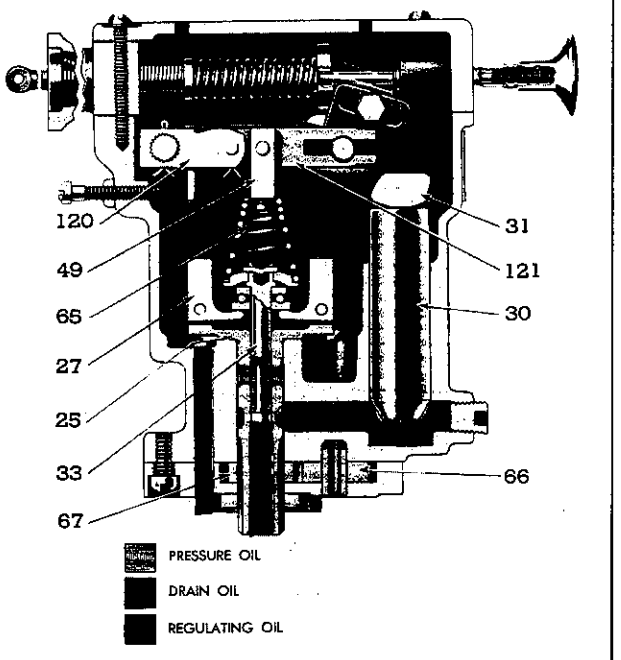
Operation—As the engine runs, oil from the lubricating system is admitted to the gear pump in the governor base. The governor gear pump then raises the oil pressure to a value determined by the spring in the relief valve assembly opposing the relief valve plunger as shown in Fig. 31. The oil, now under pressure, is maintained in the annular space between the small diameter of the pilot valve plunger (33) and the bore in the ballhead (25) as shown in Fig. 32.

For any given throttle setting, the speeder spring (65) has a definite compression force which is opposed by the centrifugal force of the flyweights (27). When these two forces are in equilibrium, the land on the pilot valve plunger exactly covers the lower ports in the ballhead, thus producing a constant speed condition as shown in Fig. 32.

Refer to Fig. 33 and assume now that a load increase is applied to the engine. The engine speed will drop and the governor flyweights will be forced inward, thus lowering the pilot valve plunger. Oil under pressure of the pump will now be admitted underneath the servo piston which will rise. Upward motion of the piston is transmitted through the terminal lever (31) and fuel rod (13) to the injector control racks, causing the fuel setting of the engine to be increased.

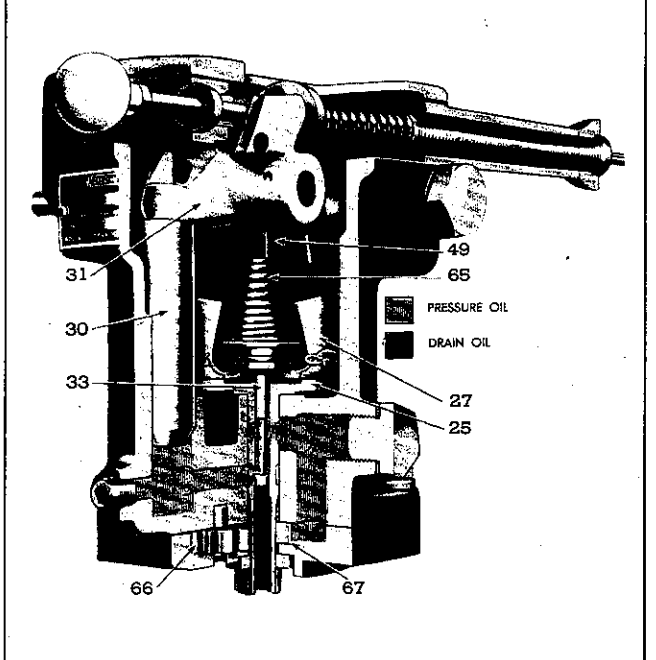
Simultaneous with the upward movement of the servo piston, the pin on the droop adjusting bracket (32) moves upward and raises the floating lever (121) which pivots about the spring fork pin (42) in the speed adjusting lever (120).

When the load was increased the engine speed began to drop and as a consequence the centrifugal force on the flyweights decreased, allowing them to move inward under the opposing force of the speeder spring. Now as the floating lever rises, the compres-



25. Ballhead.
27. Flyweight.
30. Servo Piston.
31. Terminal Lever.
33. Plunger—Pilot Valve.
49. Spring Fork.
65. Speeder Spring.
66. Gear—Pump Driven.
67. Gear—Pump Drive.
120. Lever—Speed Adjusting.
121. Floating Lever.

Fig. 32—Stable Position of Governor Mechanism When Load on Engine Is Constant.



25. Ballhead.
27. Flyweight.
30. Servo Piston.
31. Terminal Lever.
33. Plunger—Pilot Valve.
49. Spring Fork.
65. Speeder Spring.
66. Gear—Pump Driven.
67. Gear—Pump Drive.

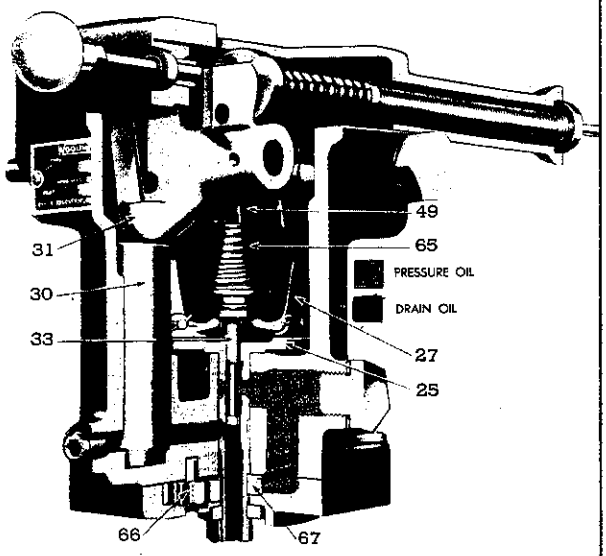
Fig. 33—Position of Governor Mechanism as Load Increases and Engine Speed Tends to Decrease.

sion load on the speeder spring is reduced, which enables the flyweights to again move out and assume their normal vertical position. The land on the pilot valve plunger then again exactly covers the ports in the ballhead and the servo piston stops moving at a position corresponding to an increased fuel setting of the engine. The engine now carries the increased load at a slightly reduced speed because of the slight decrease in speeder spring compression.

Figure 34 illustrates the reaction of the governor as the load on the engine is decreased and the engine speed starts to increase.

Lubrication—The governor is lubricated by oil seeping into the governor housing past the servo piston and pilot valve plunger, where it is broken up into a fog by the governor flyweights. Oil which collects on the floor of the governor, drains into the bevel gear drive beneath the governor. After reaching a certain level in the governor drive housing, the oil returns through the drive gear bearings to the oil reservoir in the blower housing, thence to the engine oil pan.

Service—***Governor faults are usually manifest in speed variations of the engine, but it does not necessarily follow that all such speed variations indicate governor faults.*** Therefore, when improper speed variations appear, the following procedure should be carried out:



25. Ballhead.
27. Flyweight.
30. Servo Piston.
31. Terminal Lever.
33. Plunger—Pilot Valve
49. Spring Fork.
65. Speeder Spring.
66. Gear—Pump Driven.
67. Gear—Pump Drive.

Fig. 34—Position of Governor Mechanism as Load Decreases and Engine Speed Tends to Increase.

1. Check the load to be sure that the speed changes observed are not the result of load fluctuations.
2. If the load is uniform, carefully check the engine to be sure that all cylinders are firing properly.
3. See that no bind exists in any of the governor mechanism or operating linkage between governor and engine; also, that no bind is manifest in the injector control tube or its mounting brackets.

If all cylinders are not firing properly, remove and check the injector from the faulty cylinder. See "Testing Injector," Page 11, Sec. 15. If these tests show injector difficulties, service the injector as described under "Injector Service," Page 5, Sec. 15. With the governor control link connected to the injector rack control tube, the mechanism should be free from bind throughout the entire travel of injector racks. Should friction exist in the mechanism, it may be located and eliminated as follows:

1. Injector racks may stick or move too hard. This may be due to the injector hold down clamp being too tight or not positioned properly, and can often be eliminated by tapping the foot of the clamp lightly with a small hammer and a long punch or screwdriver. An injector which has been in service a long time may get sticky due to an accumulation of gum and sludge. This can be corrected by washing in a pail of clean gasoline. (See Injector Service, Page 5, Sec. 15.)
2. Injector rack may stick due to being cramped by the rack control lever being out of position or cocked. Loosen the screws in the rack control lever, and if this relieves the binding, move the lever endways on the control tube until the rack control lever no longer cramps the injector rack. Cocking of the rack control lever may also be due to damage to the ends of the adjusting screws or the surfaces which they contact, and may be corrected by filing. After the trouble has been remedied, the rack control lever must again be adjusted for proper position.
3. Control shaft may stick or turn hard in its small ball bearings. These bearings must be free from chips, dirt, or sludge, and must be lubricated. Binding due to poor alignment of the bearing supports can be corrected by loosening the bearing support bolts and realigning the bearing supports.

   When the injector rack control tube is free of bind and operating the injector racks, the tube should return freely to the no fuel position by the tube return spring only. Any time the control tube bearing supports have been loosened, the adjustment of rack control levers should be checked.

CAUTION! Never stretch or tamper with rack control spring to change the tension. If spring is not standard, replace.

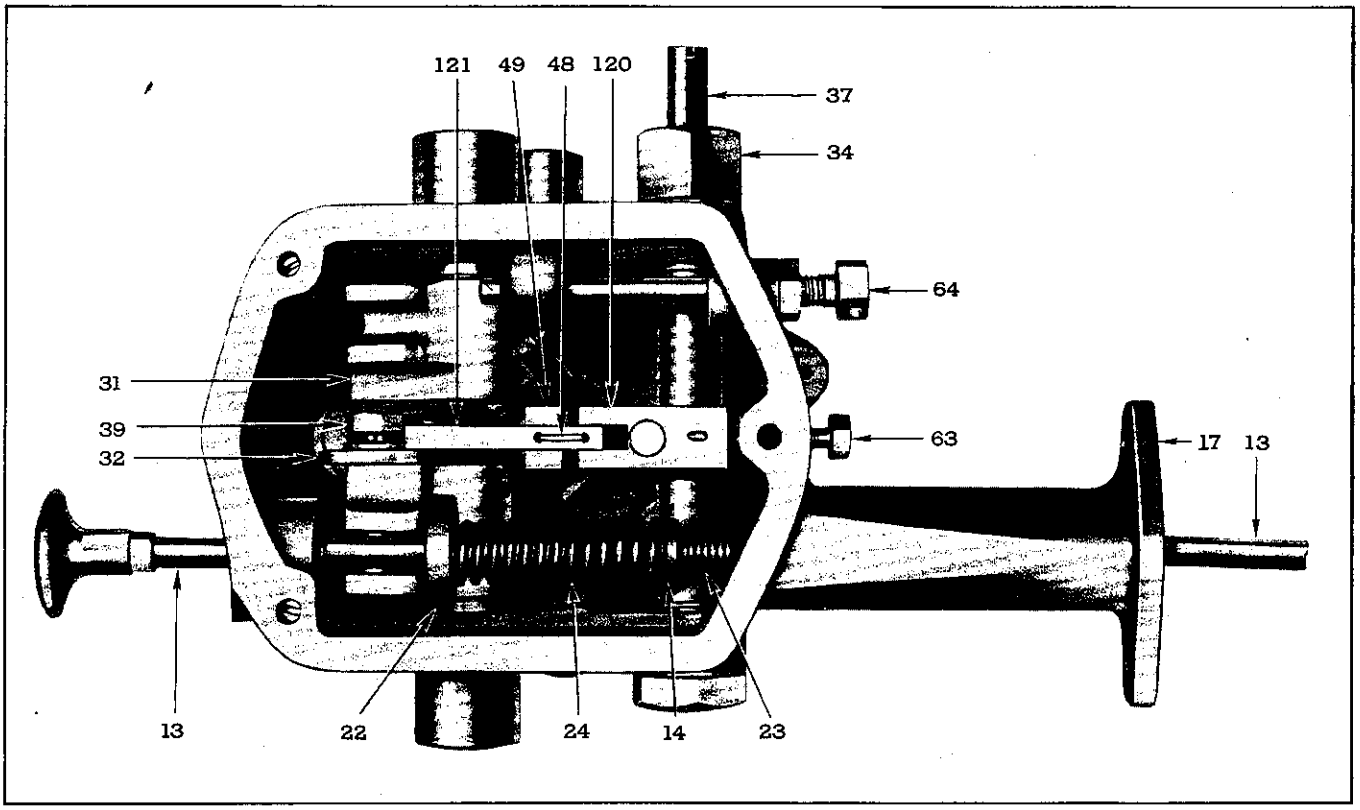


Fig. 35—Top View of Governor With Cover Removed.

13. Fuel Rod.
14. Fuel Rod Collar—Small.
17. Sub Cap.
22. Fuel Rod Collar—Large.
23. Long Spring.
24. Short Spring.
31. Terminal Lever.
32. Bracket—Droop Adjusting.
34. Sleeve—Speed Adjusting.
37. Shaft—Speed Adjusting.
39. Screw—Droop Adjusting.
48. Lock Wire.
49. Spring Fork.
63. Screw — High Speed Limit Adjusting.
64. Screw—Maximum Fuel Adjusting.
120. Lever—Speed Adjusting.
121. Floating Lever.

4. Control shaft may have too much friction due to control shaft spring being bent. Replace with a standard spring.
5. Pin in link connecting governor to control tube may be binding in the control tube lever. Remove bind.

If neither load nor engine irregularities are found to be the cause of the speed variations, it may be either in the governor or the drive. If the speed changes in regular oscillations (a hunt) this can possibly be corrected by increasing the droop. This applies only in cases of governor overhaul or where the droop adjustment has been changed from the original factory setting. All governors are set with the correct droop before leaving the factory. When governor is overhauled, see "Governor Adjustments" at conclusion of this section for correct droop adjustment.

If the speed variations are erratic but small in magnitude, the fault may lie in the governor drive. Excessive back-lash in the coupling or the miter drive gears, or too tight meshing of the latter, may cause this condition. If, for any reason, such as worn blower rotor bearings or rubbing of the rotors on the housing, or the load on the flexible coupling between the blower and the engine varies erratically, this variation will be transmitted to the governor as a speed change, and it, in turn, will attempt to compensate for this by changing the fuel rod position. No amount of adjustment or other work on the governor can correct this condition.

If the speed variations are large and erratic, and unaffected (except, perhaps, in magnitude) by changes of speed droop adjustment, or if the governor fails to control at all, it should be repaired or replaced.

As a last resort, to prove whether the governor or engine is at fault, a master governor may be installed on the engine. If this is done, see that the master governor bears the same type number as the one being removed.

If the above checks show that a governor overhaul is necessary, the instructions outlined below will apply.

Remove Governor from Engine—In cases of major repairs or a complete governor change, the unit may be removed from the engine as follows:

1. Remove the valve rocker cover and the clevis pin which holds the fuel rod (13) to the injector control tube lever (133). (See Fig. 36.)

2. Disconnect, at the governor, the oil line (129) between cylinder block and governor case.
3. Disconnect conductor (131) from the solenoid.
4. Lift end of retriever spring from the clevis pin in the throttle-to-governor linkage (130) and remove the clevis pin, leaving the governor control lever attached to the speed adjusting shaft of the governor.
5. Remove four nuts (82) and lockwashers (81) holding starting solenoid to the adaptor on the governor cap. Also remove nut (85) and lockwasher holding link (76) in place on the guide bolt. Lift the starting solenoid assembly off and away from the governor.
6. Remove three screws (60) and two lockwashers (71) (Fig. 29) holding governor cap and subcap to the governor case and also remove the two bolts (115) and lockwashers holding governor subcap to the cylinder head. Lift up on the subcap assembly until a definite snap indicates that the fuel rod has been released from the terminal lever within the governor case and then remove the subcap assembly, pulling the fuel rod out of the hole in the cylinder head. Remove gasket between subcap and governor case.
7. Remove the four stud nuts (106) holding governor assembly to governor drive assembly and lift the governor off the studs and away from engine. Remove the gasket between governor and governor drive.

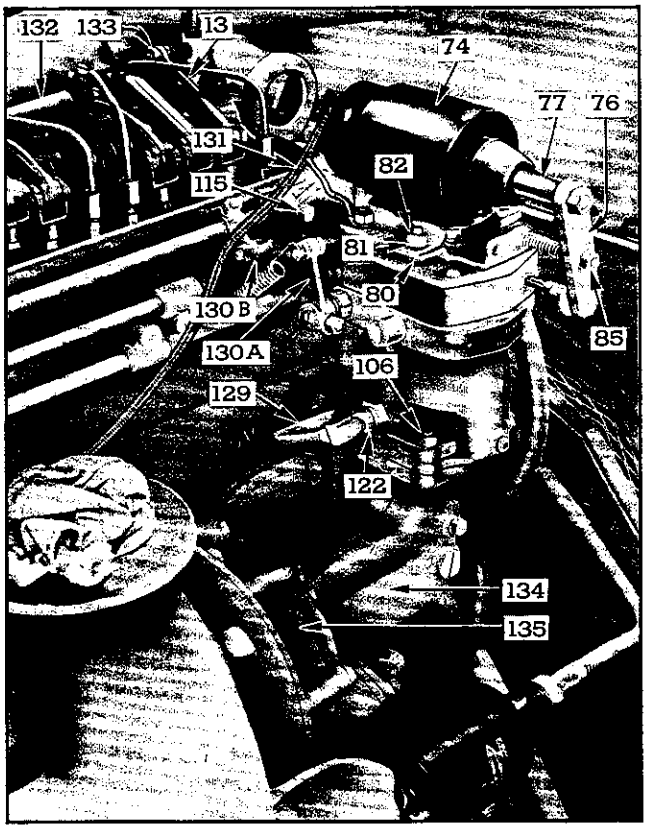


Fig. 36—Governor Mounting.

13. Fuel Rod.
74. Starting Solenoid Assembly.
76. Link.
77. Spacer.
80. Bolt—Solenoid Assembly-to-Adapter.
81. Lock Washer.
82. Nut.
85. Nut—Link-to-Guide Bolt.
106. Stud Nuts — Governor-to-Governor Drive Assembly.
115. Bolts — Governor-to-Cylinder Head.
122. Relief Valve Assembly.
129. Oil Line—To Governor.
130. Linkage — Throttle-to-Governor.
130A. Lever—Governor Control.
130B. Link—Throttle Control.
131. Conductor — Starting Solenoid-to-Starting Motor.
132. Injector Control Tube.
133. Injector Control Tube Lever.
134. Governor Drive Assembly.
135. Blower Assembly.

NOTE: At all times use care in handling and setting down of the governor; especially avoid striking the end of the drive shaft a sharp blow. Such treatment might move the collar on the drive shaft and result in excessive end play of the ballhead and shaft. This care is only necessary when governor is to be reinstalled without removing and replacing the drive shaft.

Disassemble Governor—After removal from the engine, refer to Figs. 29 and 41 and disassemble the governor as follows:

1. **Disassemble Sub-Cap as follows:**
   (a) Unscrew shut-down knob (15) and lock nut (16) from fuel rod (13). Remove fuel rod spacer (20).
   (b) Pull shut-down rod from sub-cap through neck where sub-cap bolts to cylinder head, thus separating rod from fuel rod collar (22), short spring (24), collar (14), and long spring (23).
   (c) Remove fuel rod seal (59) from counter bore at outer face of sub-cap.
   (d) If bushing is worn sufficiently to need replacing, support sub-cap in arbor press as shown in Fig. 37 and press bushing (21) from place, using a suitable 5/16" diameter bar on outer end of bushing.
   (e) If there is any call for doing so, support sub-cap in arbor press with inner end resting on bed of press as shown in Fig. 38 and press sub-cap plug (19) from sub-cap.
   (f) Loosen jam nut (38) and back out maximum fuel screw (64).
2. Remove the nut, lock washer and clamp bolt holding governor control lever (130A), Fig. 36, on speed adjusting shaft (37) and pull lever off shaft.
3. Remove limit pin (1) from speed adjusting lever (120).

4. Unscrew speed adjusting sleeve (34) and remove together with copper washer (68). Remove two neoprene seals (54) from sleeve. Unscrew and remove spacer cap (46) and copper washer (68) in the same manner.
5. Remove speed droop adjusting screw (39) and plain washer (70), then droop adjusting bracket assembly (32) from terminal lever (31).
6. Remove cotter pin (43) holding speed adjusting shaft (37) to speed adjusting lever (120).
7. Remove two cotter pins (41) locking terminal lever (31) to short terminal shaft (50) and long terminal shaft (71), respectively.
8. Remove speed adjusting shaft (37) from speed adjusting lever (120).
9. Lift pilot valve assembly, including plunger (33), bearing (53), spring seat (56), spring fork (49), lever (120), floating lever (121), fork pins (42) and lock wire (48) straight up out of case (36) and ball head (25).
10. If speeder spring (65) or plunger (33) are to be changed, unscrew spring seat (44) from spring and then spring from spring fork (49).
11. If there is any call for doing so, the lock wire (48) may be removed from the speed adjusting lever (120) and floating lever (121), then the two pins (42) separating parts (120), (121) and (49).
12. **Remove Terminal Lever as follows:**
    (a) Support governor case between soft jaws in bench vise as shown in Fig. 39, and using a $\frac{3}{8}$" or $\frac{1}{2}$" bar on inner end and at opening in terminal lever, strike bar sharply with hammer and drive adjusting sleeve (35) flush with inner wall of governor case.

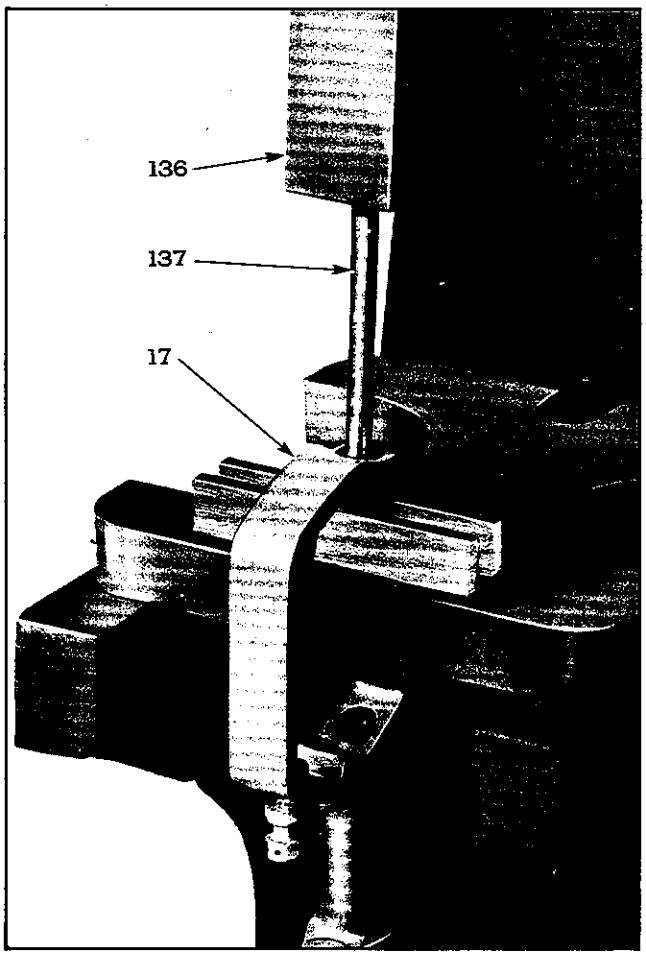


Fig. 37—Removing Fuel Rod Bushing from Sub-Cap.

17. Sub-Cap.
136. Arbor Press.
137. Bushing Removing Tool.

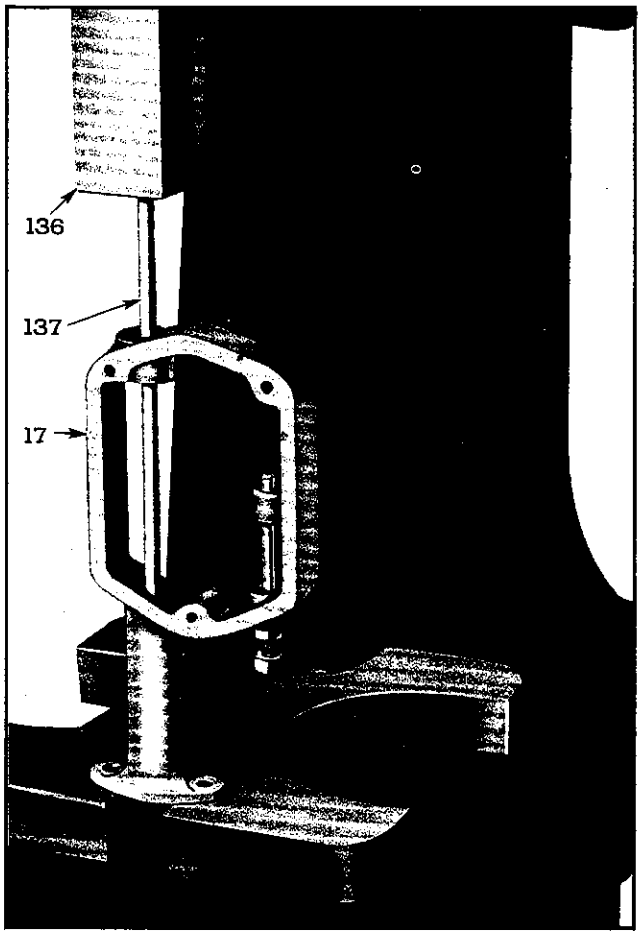


Fig. 38—Removing Sub-Cap Plug from Sub-Cap.

17. Sub-Cap.
136. Arbor Press.
137 Plug Removing Tool.

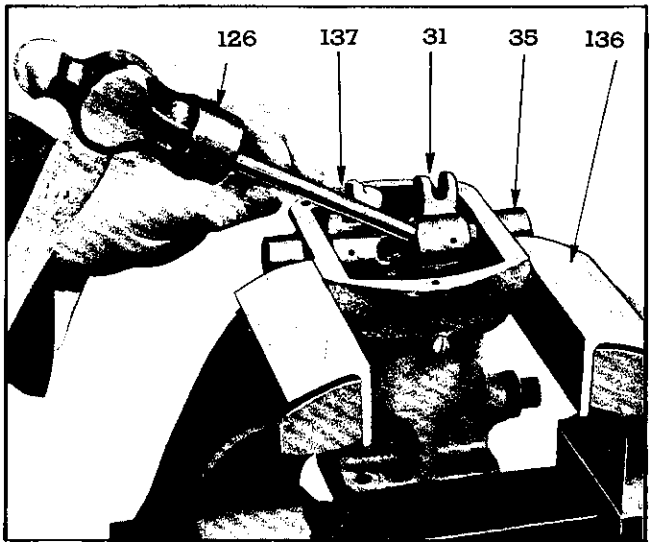


Fig. 39—Removing Terminal Sleeve and Welch Plug from Governor Case. (Operation 1.)

31. Terminal Lever.
35. Terminal Sleeves.
126. Hammer.
136. Vise.
137. Driving Tool.

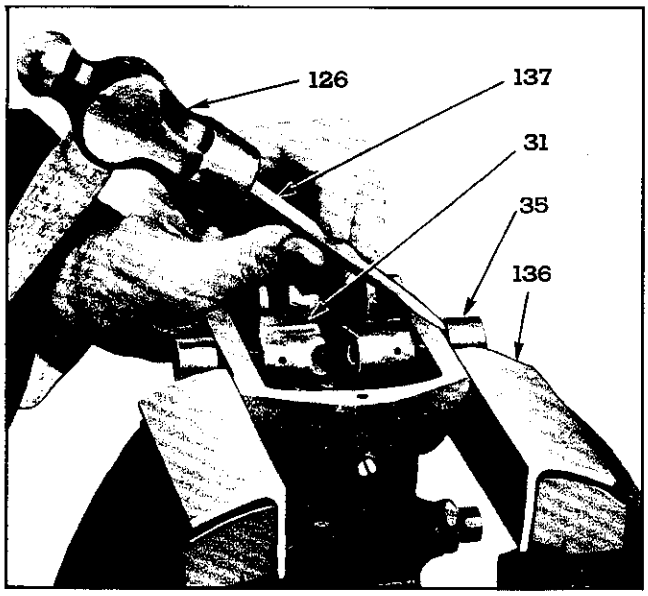


Fig. 40—Removing Terminal Sleeve and Welch Plug from Governor Case. (Operation 2.)

31. Terminal Lever.
35. Terminal Sleeves.
126. Hammer.
136. Vise.
137. Driving Tool.

(b) Now using special driving bar against shoulder on sleeve (35), as shown in Fig. 40, drive sleeve and Welch plug (73) as an assembly from the case. Remove opposite sleeve and Welch plug in the same manner. Shafts (50) and (71) may now be removed from the case.

13. If there is any call for doing so, the Welch plugs (73) may be driven from the terminal shafts by inserting a bar into inner end of shaft and against plug, then striking with a hammer.
14. Withdraw servo piston (30) from governor case.
15. With a 7/8 socket wrench, remove relief valve assembly (122) and copper gasket (68). No attempt should be made to disassemble the relief valve. If the valve is inoperative, the entire assembly should be replaced.

Fig. 41—Hydraulic Governor Details and Relative Location of Parts

1. Limit Pin.
4. Lock Washers.
13. Fuel Rod.
14. Fuel Rod Collar—Small.
15. Knob—Shut-Down.
16. Lock Nut—Shut-Down Knob.
17. Sub Cap.
19. Sub Cap Plug.
20. Spacer—Fuel Rod.
21. Bushing—Fuel Rod.
22. Fuel Rod Collar—Large.
23. Long Spring.
24. Short Spring.
25. Ballhead.
26. Pin—Ball Arm.
27. Flyweight.
29. Base.
30. Servomotor Piston.
31. Terminal Lever.
32. Droop Adjusting Bracket.
33. Plunger—Pilot Valve.
34. Speed Adjusting Sleeve.
35. Terminal Sleeve.
36. Governor Case.
37. Shaft—Speed Adjusting.
38. Jam Nut.
39. Droop Adjusting Screw.
40. Governor Cover.
41. Cotter Pin.
42. Spring Fork Pins.
43. Cotter Pin 3/32" x 5/8".
44. Spring Seat.
45. Plug.
46. Spacer Cap.
47. Idler Gear Stud.
48. Lock Wire.
49. Spring Fork.
50. Short Terminal Shaft.
51. Gasket — Governor Case-to-Governor Base.
52. Gasket—Cover-to-Sub-Cap and Sub-Cap-to-Case.
53. Thrust Bearing.
54. Neoprene Oil Seal.
55. Dowel Pin.
56. Thrust Washer.
57. Collar—Drive Shaft.
58. Pipe Plug.
59. Fuel Rod Seal.
60. Screws—Cover and Sub-Cap-to-Case.
62. Screws — Governor Base-to-Governor Case.
63. Screw—High Speed Limit Adjusting.
64. Maximum Fuel Adjusting Screw.
65. Speeder Spring.
66. Gear—Pump Idler.
67. Gear—Pump Drive.
68. Copper Gasket.
69. Lock Washer — Governor to Drive Stud Nut.
70. Washer — Droop Adjusting Screw.
71. Long Terminal Shaft.
72. Lock Nut.
73. Welch Plugs.
74. Solenoid—Starting.
75. Stud.
76. Link.
77. Spacer.
78. Nut—Link-to-Stud.
79. Adapter — Starting Solenoid-to-Governor Cover.
80. Bolts.
81. Lock Washers.
82. Nuts.
83. Bolts.
84. Spring.
85. Nut.
86. Lock Washer.
87. Housing—Governor Drive.
88. Studs — Governor Case-to-Drive Assembly.
89. Pipe Plug—7/8".
90. Pipe Plug—1/2".
91. Gear — Governor Drive — Driven.
92. Bearing—Driven Gear.
93. Sleeve—Driven Gear.
94. Groove Pin.
95. Bolts—Conical Point.
96. Washer—Leather.
98. Gear—Governor Drive—Drive.
99. Bearing—Drive Gear.
100. Pin.
101. Bolt.
102. Lock Washer.
103. Spacer.
104. Plain Washer.
105. Gasket — Governor Assembly-to-Governor Drive Assembly.
106. Stud Nut — Governor-to-Drive.
107. Gasket—Governor Drive-to-Blower Assembly.
108. Bolts — Governor Drive-to-Blower Assembly.
109. Lock Washer.
120. Lever—Speed Adjusting.
121. Floating Lever.
122. Relief Valve Assembly.
125. Thrust Washer—Upper.

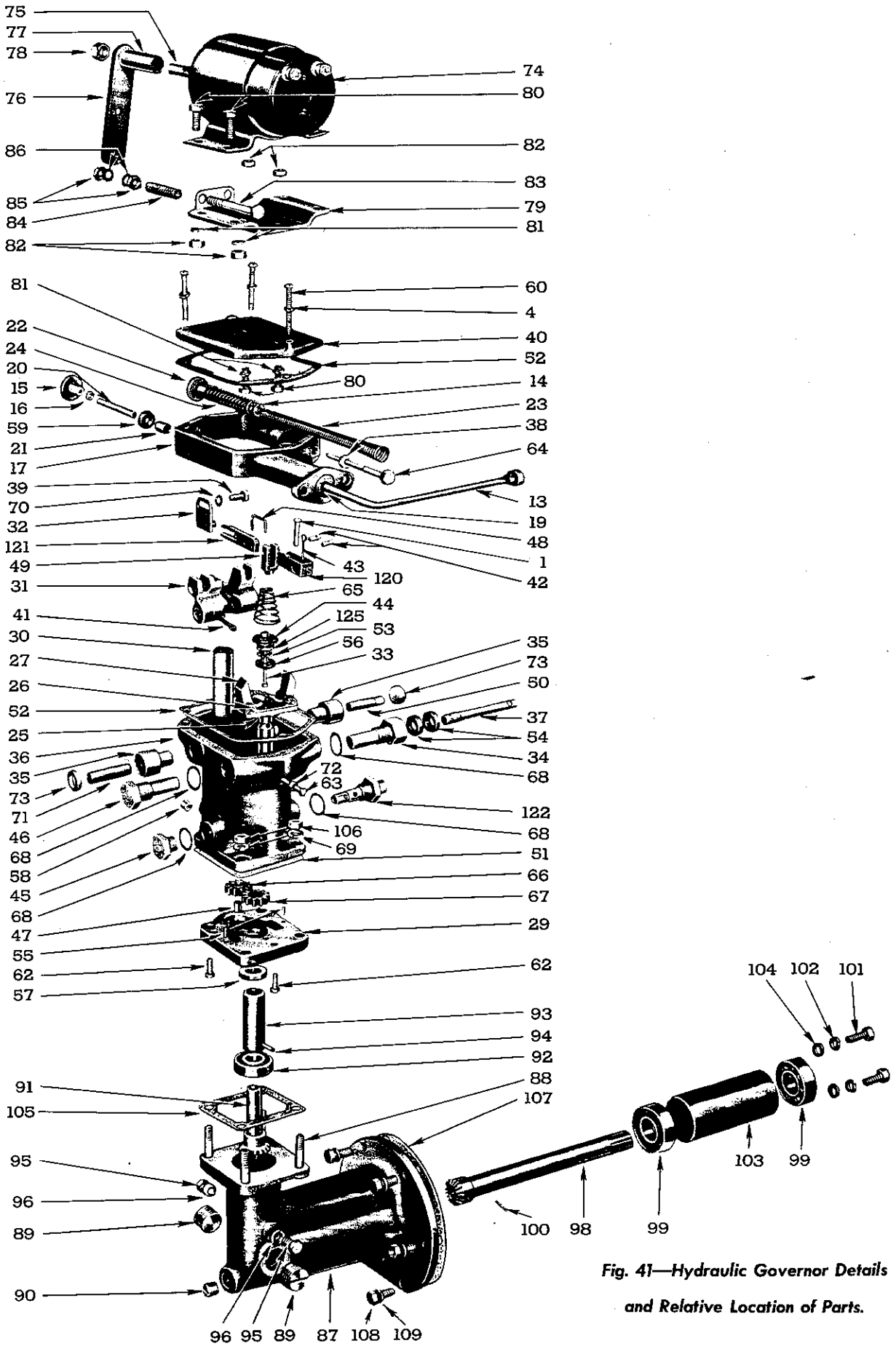


Fig. 41—Hydraulic Governor Details and Relative Location of Parts.

16. Set governor case, top side down, on bench and with a soft hammer and a brass rod, drive the shaft of the ball head (25) out of the drive shaft collar (57) (as shown in Fig. 42) and remove ball head and collar from case.
17. Remove three fillister head screws (62) holding base (29) (oil pump gear housing) to governor case. Base is doweled to governor case and

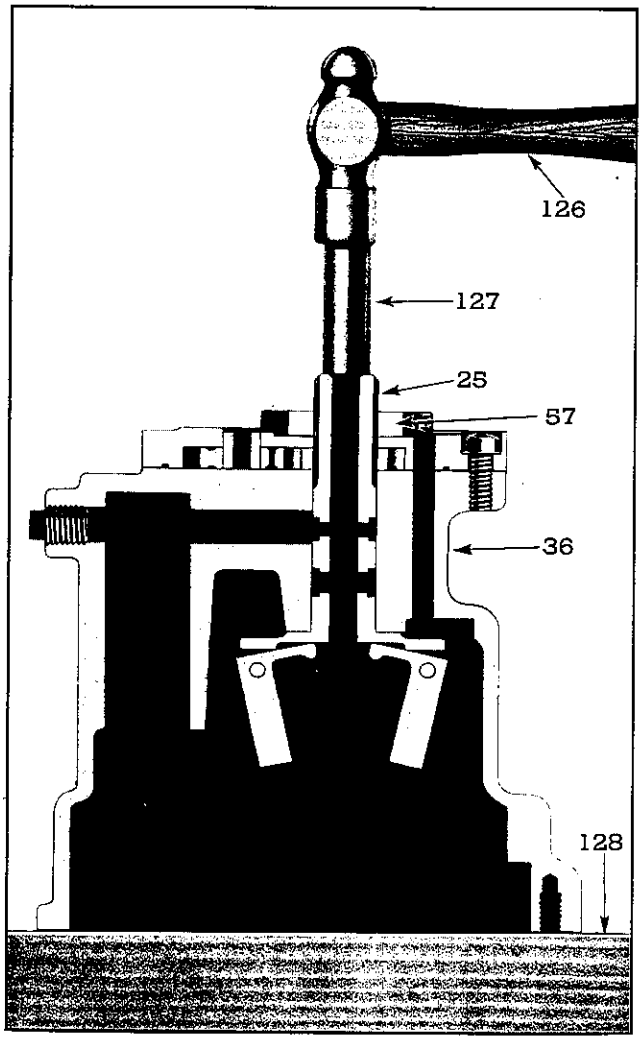


Fig. 42—Separating Ballhead Drive Shaft from Drive Shaft Collar.

25. Shaft—Ballhead Drive.
36. Governor Case.
57. Collar—Drive Shaft.
126. Hammer.
127. Brass Rod.
128. Bench.

must be tapped and pried away from the case carefully so dowels will not be bent or damaged. Oil pump drive and idler gear (66) and (67) may now be lifted from place, being careful not to damage the sharp edges of the gears.

18. The remaining plugs and screws may be removed to assist in cleaning the governor case.

NOTE: For disassembly and details of starting solenoid see Page 22, Sec. 18.

Inspection—Before reassembling the governor, wash all parts in clean gasoline and carefully inspect for wear.

The servo piston should move freely in the cylinder, but the clearance between piston and cylinder should not be excessive. The pilot valve plunger should move freely in the governor ball head shaft. If the plunger has become damaged or scratched on the outside surface, it may be dressed off with crocus cloth. If crocus cloth is used the sharp edges of the cut-off, at the lower end of the plunger, should not be rounded.

The governor ball head should rotate freely in the governor body when the governor base, including the oil pump, is installed. Bind might occur in the ball head shaft either from slight misalignment of the governor base with the governor body, or from the collar, rubbing against the governor base at lower end of the shaft. This latter condition may be corrected by tapping the lower end of the shaft with a block of wood. The collar should be pressed onto the shaft just far enough to provide free shaft movement without shaft end play.

The flyweights should work freely on their supporting pins for satisfactory governor action. All joints and bearings in connection with the floating lever, speed droop adjusting link, and speed adjusting shaft, should move freely when in place.

Governor Assembly—All parts having been cleaned and inspected, the governor may be assembled. As the various moving parts are assembled, dip in clean gasoline (if cloth is used, beware of lint) and lubricate with engine oil to insure free movement. Furthermore, after the governor has been completely assembled, apply a liberal amount of good clean engine oil over all the moving parts of the governor, thus insuring initial lubrication. Refer to Figs. 29 and 41, and assemble the governor in the following manner:

1. Replace the two oil pump gears (66) and (67) in the governor base (either side up); wipe the adjoining surfaces of base and governor body clean; see that gasket is in place between base and governor case and not damaged; then, holding base and gears face up, set body onto base with dowels in base registering with holes in body. Temporarily, slide ballhead shaft (25) down through body and base, to align the two pieces, then replace the three fillister head screws through base and draw up evenly. Revolve the ballhead shaft during the tightening process to make sure shaft revolves freely.
2. With ballhead assembly (25) down in governor body, support piece of ½" rod in bench vise, as shown in Fig. 43. With upper end of shaft resting on rod install collar (57) over end of shaft and

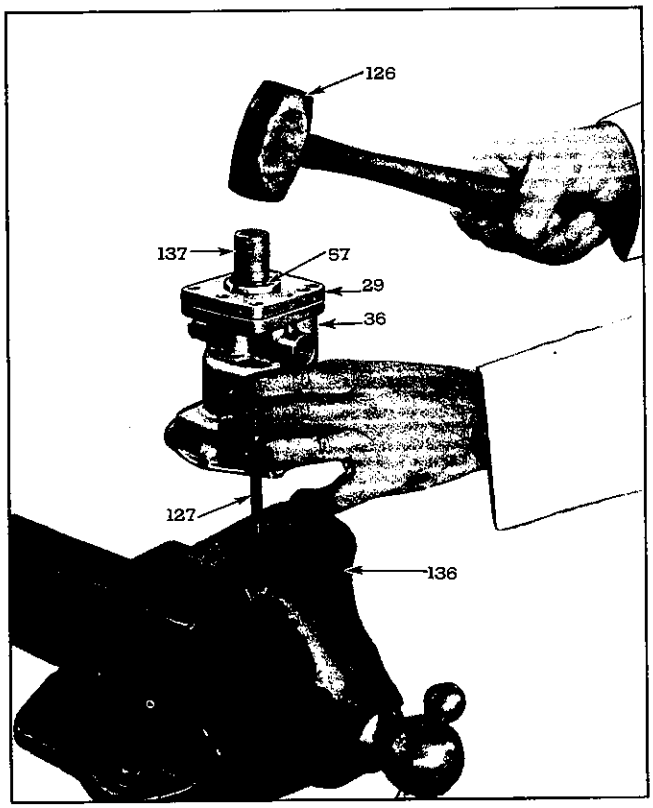


Fig. 43—Replacing Drive Shaft Collar on Drive Shaft of Ballhead.

29. Governor Base.
36. Governor Case.
57. Collar—Drive Shaft.
126. Soft Hammer.
127. Rod—½" Brass.
136. Vise.
137. Driving Tool (Hollow Sleeve).

tap into position with convenient hollow sleeve and hammer. The collar must not be driven too far onto shaft, neither should end play exist. The shaft should turn freely.

3. Moisten surface with oil and drop servo piston (30) into place, cone end down.

4. **Replace Terminal Lever** as follows:

   (a) Place the terminal lever (31) in the governor case with convex bearing surface for servo piston next to piston and holes for terminal shafts in alignment with holes in case.

   (b) Place the short terminal shaft (50) in left-hand opening and long terminal shaft (71) in right-hand opening—as viewed from front side of case where serial number plate is attached—with holes of cotter pins in shafts in alignment with holes in terminal lever, as shown in Fig. 44.

   (c) Slide the serrated ends of the two terminal shafts into the terminal lever (31) and install the two cotter pins (41). Spread cotter pins.

   (d) Drive a welch plug (73) into outer end of each terminal sleeve (35).

   (e) Place the governor case on bed of arbor press as shown in Fig. 45 and press terminal sleeve (35) and welch plug (73) assembly into case and over outer end of shaft. Install terminal sleeve and welch plug assembly in opposite side of case and over shaft in the same manner and tight against case.

NOTE: When pressing terminal sleeve into case, be sure case is flat on bed of press. Line up with shim as shown in Fig. 45.

5. If disassembled, the speed adjusting lever (120), floating lever (121) and spring fork (49) may be reassembled as follows:

   (a) Place tines of spring fork (49) over floating lever (121) with holes for fork pin in line. Install pin (42).

   (b) Place tines of speed adjusting lever (120) over non-slotted end of floating lever (121) and install the second pin (42).

   (c) Turn pins (42), if necessary, and lock pins in adjusting lever and floating lever with

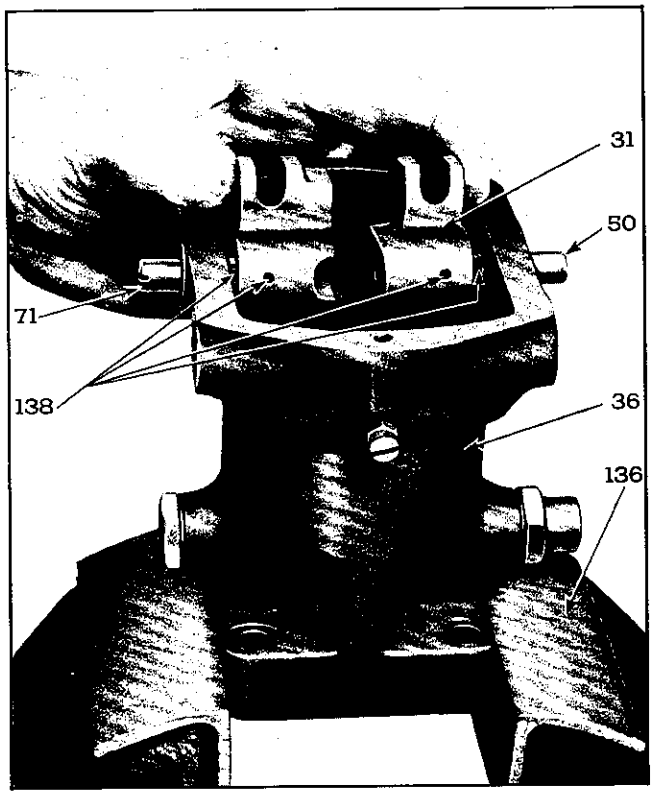


Fig. 44—Correct Relation of Holes in Terminal Shafts to Holes in Terminal Lever.

31. Terminal Lever.
36. Governor Case.
50. Shaft—Short Terminal.
71. Shaft—Long Terminal.
136. Vise.
138. Pin Holes.

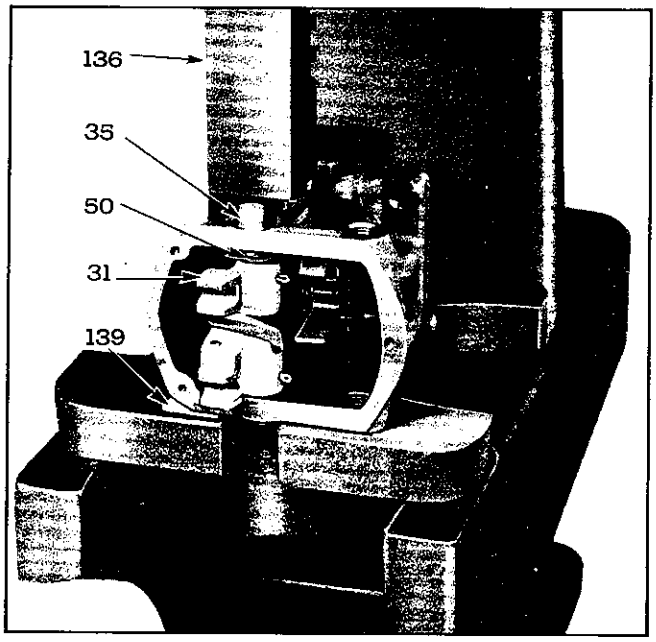


Fig. 45—Replacing Terminal Sleeve in Governor Case.

31. Terminal Lever.
35. Terminal Sleeve.
50. Shaft—Short Terminal.
136. Arbor Press.
137. Shim.

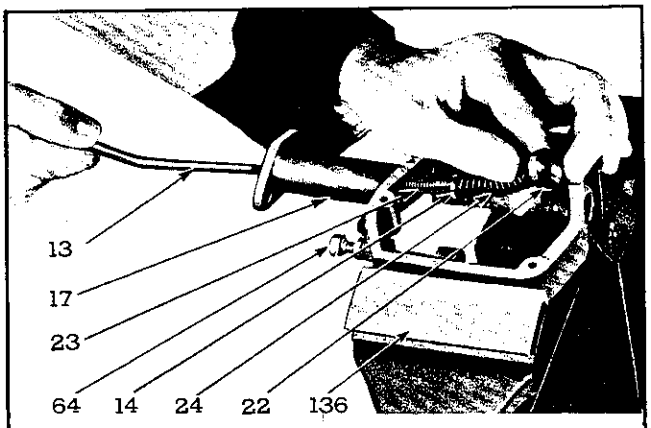
lock wire (48). Bend over lower end of lock wire.

6. Screw small end of speeder spring (64) onto lower end of spring fork (49) and spring seat (44) onto large end of spring.
7. Place thrust bearing assembly (125, 53, and 56) over lower end of pilot valve plunger (33) with small washer next to spring seat.
8. Holding governor case assembly horizontally, lubricate pilot valve plunger and set plunger and bearing assembly down into case with plunger entering opening in ball head (25).

NOTE: When entering pilot valve plunger into ball head, keep the ball bearing assembly next to spring seat and have flyweights at outer position and then plunger assembly will slip readily into place.

9. With undercut in non-serrated end of speed adjusting shaft (37) towards bottom of governor case and hole in serrated end of shaft in alignment with hole in speed adjusting lever (120), install shaft through left side of case—as viewed from serial number side of case—and into lever. Install and spread cotter pin (43) holding shaft in place.
10. With flat face of droop adjusting bracket assembly (32) next to bolting surface of terminal lever (31) and with pin on opposite face in slot of floating lever (121), attach bracket to terminal lever with bolt (39) and plain washer (70) through slot in bracket.
11. Install a copper washer (68) next to head, then place speed adjusting sleeve (34) over shaft (37) and screw into governor case tight against washer.
12. Install two neoprene seals (54) over shaft and into counter bore of speed adjusting sleeve (34).
13. With copper washer (68) next to head, install spacer cap (46) into governor case at hole in line with and at opposite side of the case to the speed adjusting shaft.
14. Place limit pin (1) in speed adjusting lever (120) with head of pin toward cover.
15. With copper gasket (68) next to head, install plug (45) into right side of governor case—as viewed from serial number side of governor—opposite to the by-pass valve assembly.
16. With a copper gasket (68) over body, install the by-pass valve assembly (122) into left side of governor case opposite plug (45).
17. Screw a lock nut (72) well down on the high speed limit adjusting screw (63), then install screw in back face of governor case just back of the speed adjusting lever (120). See "Throttle Adjustment," Page 37, Sec. 16, to adjust this screw. Adjustment takes place after the governor is installed on the engine.
18. **Assemble Sub-Cap** as follows:
    (a) If removed, replace sub-cap plug (19) into counter bore of governor sub-cap at bolting flange of sub-cap to cylinder head. Start plug straight in casting, then force into position with an arbor press.
    (b) If removed, replace bushing (21) into counter bore for fuel rod of sub-cap.

    Start bushing straight in bore of casting, then force into position with an arbor press until outer end of bushing is flush with bottom of counter bore.
    (c) Place the long fuel rod spring (23) inside the neck of the sub-cap—flared end first.
    (d) Holding the sub-cap between soft jaws of bench vise as shown in Fig. 46, insert threaded end of fuel rod (13) through spring (23) until about ½" extends beyond spring.
    (e) Place fuel rod collar (14) over threaded end of fuel rod with flat face next to spring.
    (f) Insert large fuel rod collar (22) inside of short spring (24) (emergency shut-down) and pilot this assembly over the fuel rod, thus compressing the long spring until the



13. Fuel Rod.
14. Collar—Fuel Rod—Small.
17. Sub Cap.
22. Collar—Fuel Rod—Large.
23. Long Spring.
24. Short Spring.
64. Screw—Maximum Fuel Adjusting.
136. Vise.

Fig. 46—Placing Fuel Rod, Springs and Collars in Governor Sub-Cap.

flat face of the large collar (22) rests against the boss on the inside of the sub-cap, as shown in Fig. 47. Push fuel rod through both springs, collars and the outer bushing of the sub-cap.

(g) Install fuel rod seal (59) over thread end of fuel rod and into sub-cap.

(h) Place fuel rod spacer (20) over threaded end of fuel rod, followed by lock nut (16) and shut-down knob (15). Knob need not be locked as it will be properly positioned when the governor is installed on the engine.

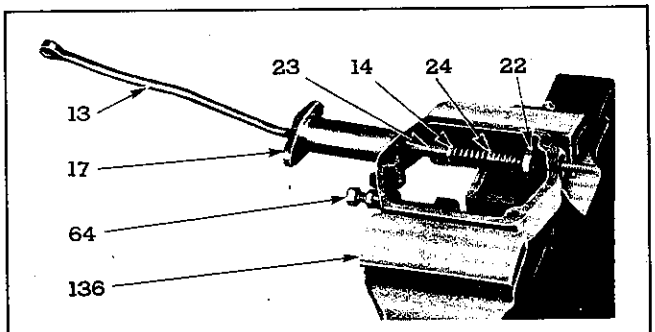
(i) Screw nut (38) on maximum fuel screw (64) and install screw into back face of sub-cap. This screw will be adjusted after governor is installed on the engine. (See "Throttle Control Adjustments," Page 37.)

NOTE: Sub-cap assembly need not be replaced at this time unless governor is to be completely assembled and placed in stock as it has to be removed from governor when governor is installed on the engine.

19. **If sub-cap is to be attached—**

(a) Affix a gasket (52) to top of governor case, then place sub-cap assembly down on case by pressing in on fuel rod knob so that collar (22) on fuel rod will rest against front working face of terminal lever (31), as shown in Fig. 48.

(b) Attach starting solenoid adaptor (79) to governor cover (40) using two bolts (80) and lock washers (81) with bolts up through cover bottom and bolting pad on adaptor for link (76) at front face of governor case.

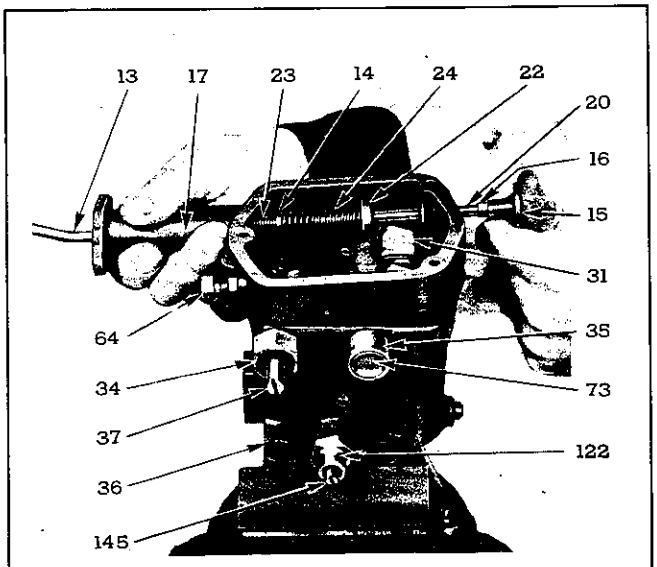


13. Fuel Rod.
14. Collar—Fuel Rod—Small.
17. Sub Cap.
22. Collar—Fuel Rod—Large.
23. Long Spring.
24. Short Spring.
64. Screw—Maximum Fuel Adjusting.
136. Vise.

Fig. 47—Position of Fuel Rod Springs and Allied Parts in Governor Sub-Cap.

(c) With the two wire terminal screws of solenoid toward back face of governor, attach solenoid (74) to adaptor on top of cover with four bolts (80), lockwashers (81) and nuts (82).

(d) Affix a new gasket (52), if necessary, on upper surface of sub-cap and set cover (40) down on sub-cap. Using a lockwasher (71) on the two forward screws (60), place the three screws through the cover and sub-cap, then screw into case. Tighten screws.



13. Fuel Rod.
14. Fuel Rod Collar—Small.
15. Knob—Shut-Down.
16. Lock Nut—Shut-Down Knob.
17. Sub Cap.
20. Spacer—Fuel Rod.
22. Fuel Rod Collar—Large.
23. Long Spring.
24. Short Spring.
31. Terminal Lever.
34. Speed Adjusting Sleeve.
35. Terminal Sleeves.
36. Governor Case.
37. Shaft—Speed Adjusting.
64. Screw—Maximum Fuel Adjusting.
73. Welch Plugs.
122. Relief Valve Assembly.
145. Plug—Shipping and Storage.

Fig. 48—Installing Sub-Cap on Governor Case.

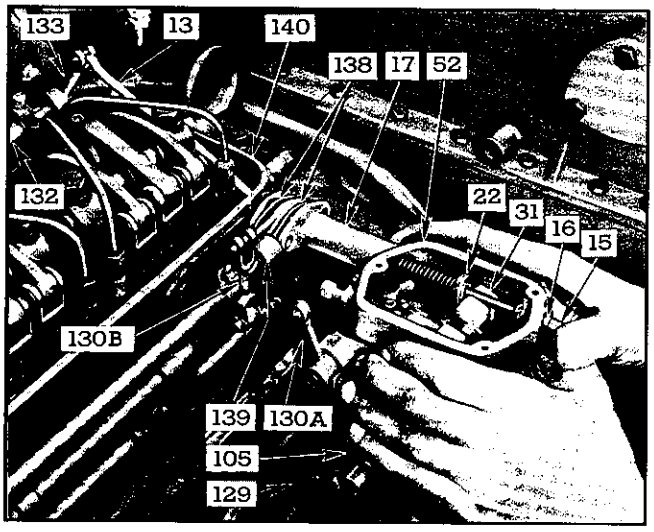


Fig. 49—Installing Governor Sub-Cap and Governor on Engine—Cover Removed from Sub-Cap.

13. Fuel Rod.
15. Knob—Shut-Down.
16. Lock Nut—Shut-Down Knob.
17. Governor Sub Cap.
22. Collar—Fuel Rod—Large.
31. Terminal Lever.
52. Gasket—Sub Cap-to-Cover.
105. Gasket — Drive Mechanism-to-Governor Base.
129. Oil Line.
130A. Lever—Governor Control.
130B. Link—Throttle Control.
132. Tube—Injector Control.
133. Lever Injector Control Tube.
138. Gaskets—Sub Cap-to-Cylinder Head.
139. Bracket—Throttle Control.
140. Cylinder Head.

(e) Place bolt (83) through hole in up-turned flange of adaptor (79), then spring (84), nut (85), lock washers (86) in turn on bolt (83).

(f) Place pilot of link (76) over stud (75) of the solenoid and lower hole in link over bolt (83). Secure link with nut (78) at solenoid stud, also, lock washer (86) and nut (85) at bolt (83).

(g) Attach one end of ground wire (142) to rear terminal of solenoid (74) and the other end under one of the solenoid hold-down bolts.

Replace Governor on Engine—If a governor assembly less the governor drive is to be installed on the engine and the drive is attached to the blower, remove the drive then attach governor to drive before installing the governor. ***The governor must be attached to the drive before the governor is attached to the engine*** to make sure the splined drive shaft of the governor ballhead is in exact alignment with the coupling sleeve of the drive.

1. When attaching governor to drive, place a gasket (105), Fig. 41, down over studs (88) of the drive housing flange, then set governor assembly down onto drive flange with opening for oil line into governor pointing in the same direction as the drive shaft of the drive housing.
2. Secure governor assembly to drive housing using a lock washer and nut (106) at each of the four studs. Draw nuts down uniformally and after tightening, revolve drive shaft of the governor drive, also the ballhead of the governor, for any bind. ***Parts must move freely without bind.***
3. If installed, remove governor cover and sub-cap.
4. If governor and drive assembly revolve freely, affix a gasket (107) to the governor drive housing flange, then set the assembly against end of blower with splines on drive shaft registering with those inside blower shaft. Install governor drive housing to blower bolts (108)—finger tight only—with lock washer (109) on each bolt.
5. Affix a gasket (52) to top bolting flange of governor case.
6. Holding throttle control bracket (139) in place with throttle shaft in bearing of bracket and a gasket (138) each side of the bracket as shown in Fig. 49, insert the long projecting end of the fuel rod (13) through the bracket, gaskets and cylinder head flange.
7. Line up bolt holes for sub-cap-to-cylinder head bolts and then, using lock washers, turn bolts into place ***finger tight only.***
8. Pour about ½ pint of lubricating oil over the governor mechanism for initial lubrication.
9. Place a gasket (52)—in good condition, or new—in position on top of the governor case.
10. With solenoid adaptor (79) bolted in place on governor cover and attaching bolts (80) for solenoid also in position, set governor cover (40) down onto sub-cap. Start three attaching screws (60) through cover and sub-cap and into governor case. (Use lock washers (71) on the two rear screws only.) Tighten screws holding cover and sub-cap to case. Also, tighten bolts holding sub-cap to cylinder head and bolts holding governor drive to blower.
11. With bolt completely removed from governor control lever (130A), slip lever onto speed adjusting shaft in a position as shown in Fig. 49. Put bolt in place and fasten lever securely to shaft with lock washer and nut. Slip the clevis link (130B) of the throttle control linkage over end of governor control lever (130A) and push clevis pin into place. Stretch out throttle retriever spring and insert spring end through hole in clevis pin.
12. If solenoid link guide bolt (83) and spring (84) were removed from solenoid adapter, insert bolt through hole in adapter, slip spring over bolt, and turn one nut (85) onto bolt. Place one lock washer (86) in position on bolt. Set starting solenoid and link assembly onto the four attaching bolts in the adapter, at the same time guiding

link (76) over a guide bolt and against lock washer already positioned on bolt. (See Fig. 29 for details of assembly.) Slip ground conductor over nearest solenoid-to-adapter bolt, push solenoid well back toward engine, and secure to adapter with four nuts (82) and lock washers (81). (See Page 22, Sec. 18 for service operations on the Starting Solenoid Assembly.) Attach conductor from starting motor to open terminal of solenoid.

13. Start oil line fitting into tee at pressure relief valve and draw up tight enough to be leak proof.
14. After installing governor on engine and before making governor adjustments, the fuel injectors must be properly timed (see "Timing Injectors," Page 12, Sec. 15) and the exhaust valve lash must be carefully checked at .011" "GO" and .013" "NO GO." (See "Adjust Valve Lash," Page 2, Sec. 11.)

    If these operations were carried out just before removal of the governor, it should not be necessary to repeat them at this time.

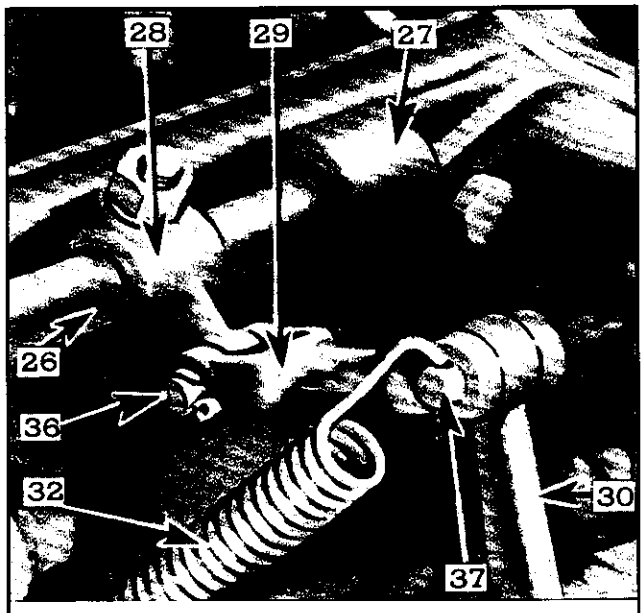
Throttle Control Adjustments—Before starting the engine, the throttle control mechanism must be adjusted to insure proper action of the engine when the throttle is placed in the "NO FUEL" and "FULL FUEL" positions.

While the shafts and levers of the throttle control mechanism on most installations are flatted to assure assembly in only one position, the mechanic should check the system as follows:

1. Set throttle on instrument panel or control board in the STOP or NO FUEL position. Check at governor and make sure the control lever at the governor has turned the speed adjusting shaft to its maximum NO FUEL (counter clockwise on "C" and "D" engine models when looking at exposed end of shaft) position. Make necessary changes in linkage until this condition is established.
2. Set throttle in the RUN or FULL FUEL position, thus moving the speed adjusting shaft in the ***opposite*** direction. With the throttle in this position, make sure that the lever (28) and clevis link (29) between governor and cylinder head have not moved into or over a ***dead center position.*** (Fig. 50)

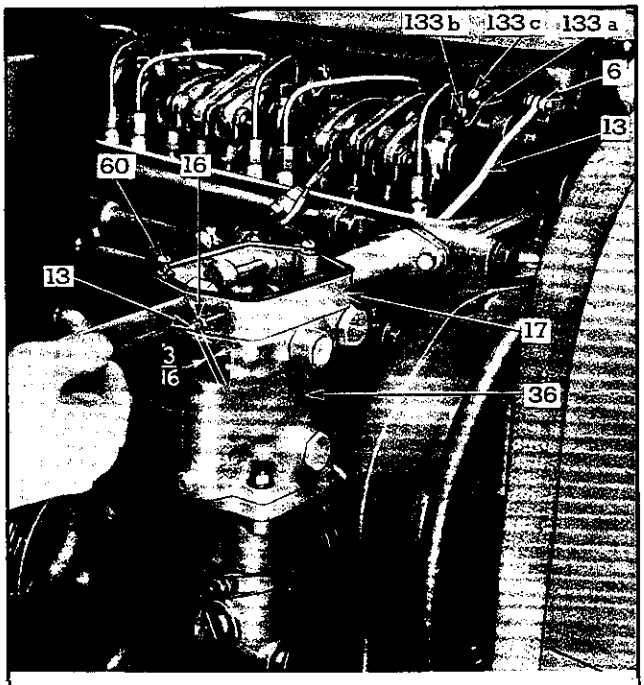
Governor Adjustments—After installing a governor, the adjustments enumerated below should be carried out in the order shown. All adjustments are made with the engine stopped.

I. Fuel Rod Adjustment.
II. Maximum Fuel Adjustment.
III. Position Injector Control Racks.
IV. Speed Droop Adjustment.
V. Maximum Speed Adjustment.



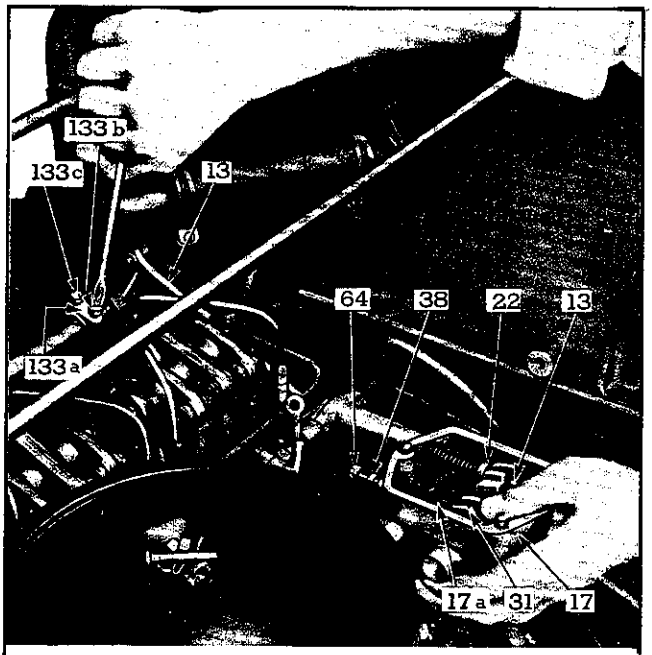
26. Throttle Control Shaft at Side of Cylinder Head.
27. Shaft Attaching Bracket.
28. Lever—Shaft-to-Clevis Link.
29. Clevis Link.
30. Governor Operating Lever.
32. Return Spring.
36. Clevis Pin.
37. Clevis Pin.

Fig. 50—Correct Position of Throttle Linkage at Full Open Throttle Setting.



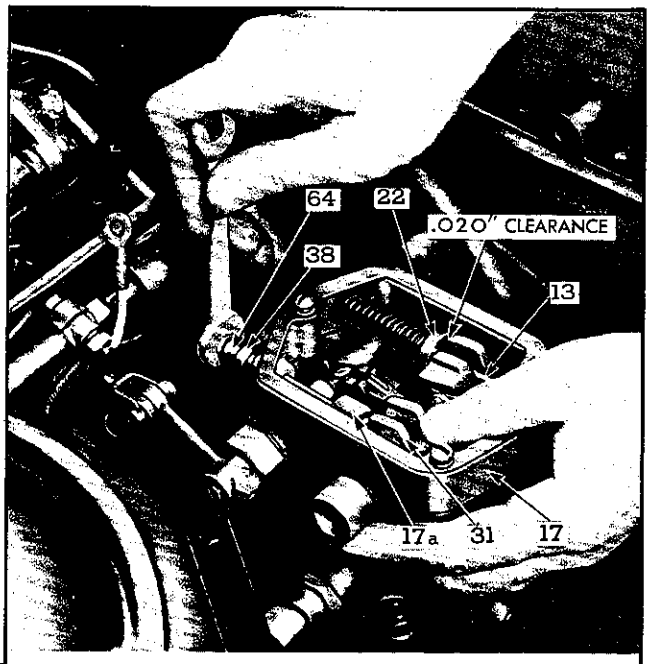
6. Lever—Injector Control Tube.
13. Fuel Rod.
16. Lock Nut—Shut Down Knob.
17. Subcap.
36. Governor Case.
60. Screw—Cover and Subcap-to-Case.
133a. Lever—Injector Rack Control.
133b. Adjusting Screw—Rack Control Lever—Inner.
133c. Adjusting Screw—Rack Control Lever—Outer.

Fig. 51—Adjusting Fuel Rod—Hydraulic Governor.



13. Fuel Rod.
17. Subcap.
17a. Boss—Governor Subcap.
22. Collar—Fuel Rod.
31. Terminal Lever.
38. Lock Nut—Maximum Fuel Adjusting Screw.
64. Screw—Maximum Fuel Adjusting (Load Limit).
133a. Lever—Injector Rack Control.
133b. Adjusting Screw—Rack Control Lever—Inner.
133c. Adjusting Screw—Rack Control Lever—Outer.

Fig. 52—Positioning Governor Terminal Lever for Wide Open Throttle.



13. Fuel Rod.
17. Subcap.
17a. Boss—Governor Subcap
22. Collar—Fuel Rod.
31. Terminal Lever.
38. Lock Nut—Maximum Fuel Adjusting Screw.
64. Screw—Maximum Fuel Adjusting (Load Limit).

Fig. 53—Setting Maximum Fuel Adjusting Screw.

I. **Fuel Rod Adjustment—**

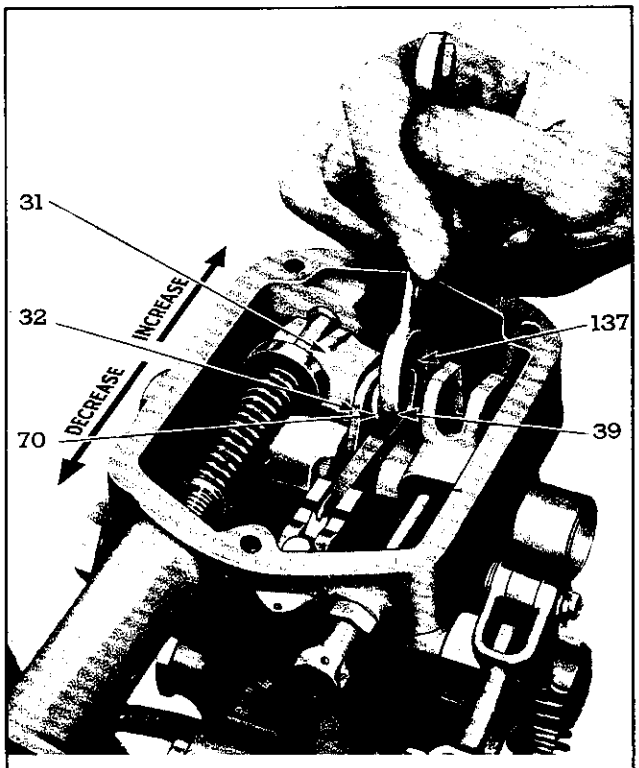
1. Remove governor cover and replace two screws (60) through subcap (17) and into governor case (36) to hold subcap in position, as shown in Fig. 51.
2. Remove valve rocker cover, then with throttle at control cabinet in "Stop" position, loosen adjusting screws (133b) and (133c) in all six injector rack control levers (133a) four turns.
3. Loosen fuel rod lock nut (16) and remove shut-down knob.
4. Turn lock nut (16) to such a position that 3/16" of the fuel rod (13) extends beyond nut.
5. Replace fuel rod knob against nut and tighten lock nut (16).
6. Refer to Figs. 52 and 53 and loosen lock nut (38) on maximum fuel adjusting (load limit) screw (64) and back screw out flush with outer face of boss (17a). While holding the fuel rod (13) way in and the terminal lever (31) tight against the boss, as shown in Fig. 52, turn inner rack control adjusting screw (133b) down until fuel rod collar (22) contacts terminal lever (31) and the terminal lever *just starts* to leave the boss (17a) in the subcap. Tighten outer rack control adjusting screw (133c).

II. **Maximum Fuel Adjustment (Load Limit).** Again, while holding fuel rod way in (*Full Fuel* position of injector racks) with terminal lever (31) up against fuel rod collar (22), as shown in Fig. 53, turn fuel adjusting screw (64) in until .020" space exists between terminal lever (31) and collar (22). Tighten lock nut (38).

CAUTION: The purpose of turning the fuel screw (load limit) (64) in to contact the terminal lever is to move the injector rack out slightly from the Full Fuel position so the gear tooth does not strike the end tooth of the injector rack. To move the screw in too far will prevent full open position of the injector racks. THIS MUST BE AVOIDED. The screw is in the proper distance when a .020" feeler gauge fits snugly between the fuel rod collar (22), Fig. 53, and the terminal lever (31) with the fuel rod (13) way in and the terminal lever tight against fuel adjusting screw (64).

III. **Position Remaining Injector Control Racks**

1. Disconnect fuel rod (13) from control tube lever (6), Fig. 51, by removing clevis pin. Push control tube lever (6), thus holding No. 1 injector rack all the way IN and adjust each of the remaining rack control levers (133a) in turn to the full IN position by: turning down on inner adjusting screw (133b) until the injector rack can be felt striking "bottom" and No. 1 rack can be seen to *just begin* movement *outward.* Then tighten outer screw (133c) and lock inner screw (133b). After positioning each rack lever, check to see that No. 1 rack



31. Terminal Lever.
32. Bracket—Droop Adjusting.
39. Screw—Droop Adjusting.
70 Washer—Droop Adjusting Screw
137. Wrench.

Fig. 54—Adjusting Speed Droop.

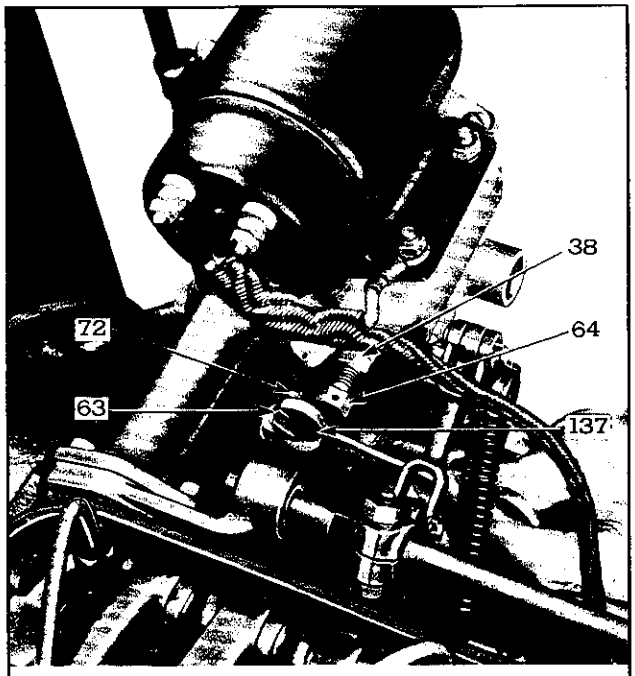
has not moved out. If No. 1 rack has moved out, the lever just positioned has been moved in too far and should be readjusted by loosening the inner adjusting screw (133b) and tightening outer adjusting screw (133c).

2. Release control tube lever (6), permitting control tube spring to return racks to no-fuel position. Injector racks being in no-fuel position, check the distance between the body of the injector and the edge of the rack coupling. This distance should be approximately 7/8". Be sure that no-fuel position can be reached, otherwise engine cannot be stopped when throttle is closed.

IV. **Speed Droop Adjustment**—Speed droop is that governor characteristic which allows engine speed to increase with decrease in load.

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

Governor droop is checked and set at the factory before engines are shipped and no further adjustment should be necessary for satisfactory engine operation. However, if a governor has had major repairs or been overhauled, the speed droop should be adjusted after the governor has been installed on the engine. The purpose of adjusting



38. Lock Nut—Maximum Fuel Adjusting Screw.
63. Screw—High Speed Limit Adjusting.
64. Screw—Maximum Fuel Adjusting.
72. Lock Nut—High Speed Limit Adjusting Screw.
137. Wrench.

Fig. 55—Setting Maximum Speed and Maximum Fuel Limit Screws.

is to establish a definite engine speed at no load with a known speed at full load.

The full load and speed for a generator set will be found on the generator name plate. With this as a basis, adjust the droop to obtain approximately 40 RPM greater speed at no load than at full load with the same throttle setting. Check no load and full load speed with an approved hand tachometer. To adjust droop:

1. With engine stopped, remove the governor cover.
2. Loosen droop bracket adjusting screw (39), shown in Fig. 54, and move bracket (32) ***toward*** engine to ***decrease*** and ***away*** from the engine to ***increase*** the amount of droop.

V. **Maximum Speed Adjustment**—The high speed limit adjusting screw (63), shown in Fig. 55, limits the travel of the governor speed adjusting shaft, which is in turn connected, through linkage, to the throttle at the control panel. linkage, to the throttle at the control cabinet. Moving the screw IN will decrease—and OUT will increase—the maximum engine speed. Loosen lock nut (72) on screw (63) and with engine warm and throttle set to run at the desired maximum speed under ***no load*** turn screw IN until tachometer shows a slight speed decrease then back off on screw until desired speed is again obtained. Tighten lock nut.

HYDRAULIC GOVERNOR DRIVE

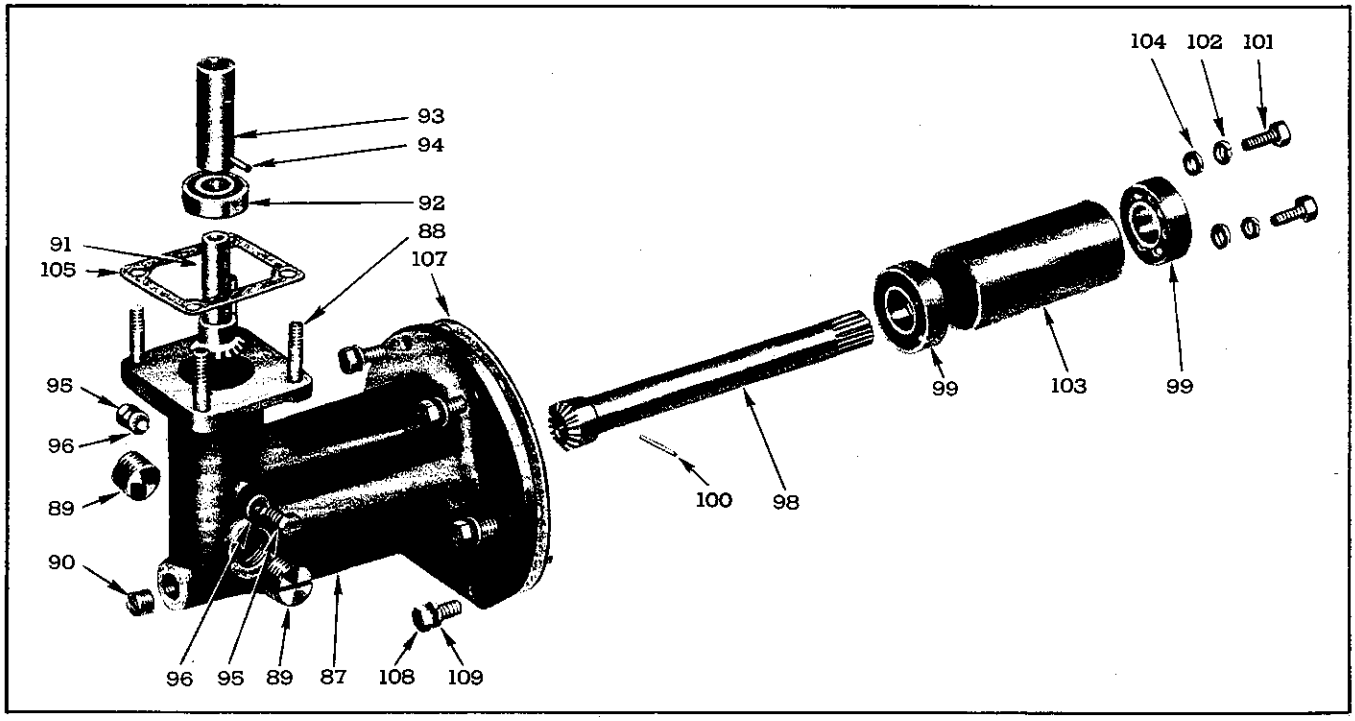


Fig. 56—Governor Drive Details and Relative Location of Parts.

87. Housing—Governor Drive.
88. Stud—Governor-to-Drive Housing.
89. Pipe Plugs—⅞".
90. Pipe Plug—½".
91. Gear—Driven.
92. Bearing—Driven Gear.
93. Sleeve—Driven Gear.
94. Groove Pin—Driven Gear.
95. Bolts—Conical Point.
96. Washer—Leather
98. Gear—Drive.
99. Bearings—Drive Gear.
100. Pin—Drive Bearing Thrust.
101. Bolts—Bearing Retaining.
102. Lock Washers—Retainer Bolts.
103. Spacer—Drive Gear Bearing.
104. Plain Washers—Bearing Retaining.
105. Gasket—Governor Assembly-to-Drive Assembly.
107. Gasket—Governor Drive-to-Blower.
108. Bolts—Drive Assembly-to-Blower.
109. Lock Washers—Drive Assembly-to-Blower and Governor-to-Drive Assembly.

Description—As will be seen from Fig. 29, the hydraulic governor drive consists of a combined horizontal drive shaft and bevel gear and a combined vertical driven shaft and bevel gear; both mounted on ball bearings and retained inside a cast iron housing.

Drive to the horizontal shaft is by means of serrations on inner end of the shaft to mating serrations inside the upper rotor shaft of the blower. By the same method the governor ballhead shaft is driven off the vertical shaft by means of splines inside a sleeve pressed on and pinned to the vertical shaft.

The bearings on the horizontal shaft are positioned by removable retainer bolts, and on the vertical shaft by two lock screws. The housing flange at the drive shaft is gasketed and bolted to the front blower end plate, while the governor proper is gasketed and bolted to the flange at opening for the driven shaft.

Lubrication—Gears and bearings of the governor drive assembly are lubricated by drain back from the governor proper which spills over the moving parts and then drains into the blower end-cover compartment.

Service—If the governor and drive have had considerable use and the governor fails to control the engine speed properly, the fault may lie in either the governor or the drive. To function properly the back lash in the bevel gear drive should not exceed .003", and .002" is more desirable. On the other hand, the gear teeth must not bottom so ***no*** lash exists. This feature may be checked by removing the screw plugs at bottom and side of housing and by means of a screw driver or similar tool, check for shaft end play as well as gear lash. In case parts need replacing in the governor drive, the governor proper should be removed from the drive assembly, as directed under "Remove Governor from Engine," Page 27, and then the drive assembly removed from the blower.

Remove Governor Drive Assembly—After the governor has been removed, the drive assembly may be removed from the blower by backing out the six housing-to-blower retaining bolts and pulling the assembly straight forward until drive shaft is free of the blower shaft.

Special wrench, Tool KMO-326A, may be used to advantage for removing the rear attaching bolts between drive assembly and cylinder head. (See Fig. 37, Sec. 15, for illustration of Tool KMO-326A.) The gasket between the drive and blower can usually be preserved if care is exercised in removal.

Disassemble Governor Drive—Should disassembly of the governor drive mechanism be necessary, refer to Figs. 29 and 56 and proceed as follows:

1. Remove two drive shaft and bearing retaining bolts (101) with lock washers (102) and plain washers (104). As bearings are slip fitted into the housing, the drive gear (98) and two bearings (99), along with spacer (103) may now be lifted from the housing. If bearings stick, jar housing on bench to loosen.
2. Remove bearings from drive gear.
   (a) Lift bearing (99) near serrated end of shaft off shaft and remove spacer (103).
   (b) Drive pin (100) out of place behind second bearing (99). This bearing may now be pulled or tapped off shaft. In some cases, this bearing may be too tight to tap from position and it may be necessary to use a bearing puller or arbor press to remove it.
3. Clip lock wire (97) and remove two conical-pointed bolts (95) with leather washers (96) from drive housing. Lift or jar the following pieces from the housing as an assembly: Driven gear (91), bearing (92), sleeve (93), and groove pin (94).
4. Disassemble driven gear assembly.
   (a) Drive groove pin (94) from place in sleeve (93) and gear (91).
   (b) Separate sleeve and bearing from driven gear. If necessary, bearing may be supported in a vise and the driven gear tapped out of bearing and sleeve, using a brass rod and hammer.
5. Two plugs (89) and one plug (90) may be removed from housing to facilitate cleaning and inspection.

Inspection—After disassembly wash parts in clean gasoline before inspecting.

Examine gear teeth for rough marks, chipping, or scoring. Any one of these conditions will render the gears useless for further use.

After washing and blowing out with dry air, revolve the bearings slowly by hand for rough spots. Bearing should roll freely and smoothly. Slight end play is not objectionable in single row annular ball bearings, in fact, they are built with that characteristic.

If inspection shows bearings to be satisfactory, lubricate each one with engine oil preparatory to assembly. If bearings are found to be unsatisfactory for further use, as is rarely the case, new bearings must be substituted.

Assemble Governor Drive—After inspection and substitution of the necessary parts, if substitutions were necessary the governor drive may be assembled by reversing the sequence of operations for disassembly, as follows:

1. Press bearing (92) onto driven gear (91), and slip sleeve (93) into position over gear shaft and against bearing. Line up pin holes in sleeve and shaft and tap groove pin (94) into place.
2. Slip driven gear assembly into position in housing and lock in place with two conical-pointed bolts (95). Be sure leather washers (96) are in place under each bolt head; then draw bolts up just tight enough to strike on outer race of bearing. ***Thread lock wire through bolt heads to secure.***
3. Slip one bearing (99) over drive end of drive gear (98) and tap or press into position against shoulder on gear. Start thrust pin (100) into gear shaft and drive up tight. Insert gear, bearing and pin assembly into position in housing. Set bearing spacer (103) into place in housing and position other bearing (99) over shaft end into housing. Screw two retainer bolts (101) into housing using plain washers (104) and lock washers (102).
4. After assembly, support drive shaft between copper jaws of bench vise, and check end movement of shaft assemblies, also back lash of gears. There should be ***no*** end movement of shafts, and desired back lash is .002″ with a maximum of .003″. Make sure that assembly operates freely by spinning drive gear shaft by hand. Replace inspection plugs (89) and (90). In case one new gear has been installed and bind is evidenced due to insufficient back lash, the lash may be increased by placing a .001″ or .002″ shim between bearing (92) or (99) and housing.

Attach Governor Drive Assembly to Engine—

1. Set governor drive-to-blower gasket (107) in place on drive housing and start shaft of drive gear (98) into place in upper blower rotor shaft. Rotate shaft slightly to make serrations match. Set housing in position against blower end plate cover and attach with six bolts (108) and lock washers (109). Tighten bolts finger tight only, until after governor assembly has been attached to cylinder head.

   Special wrench KMO-326-A may be used to advantage for tightening inside bolts. (See Fig. 37, Sec. 15, for Tool KMO-326-A.)
2. Install governor assembly as outlined on Page 36, and check governor adjustments as discussed on Page 37.

INSTRUMENT PANEL

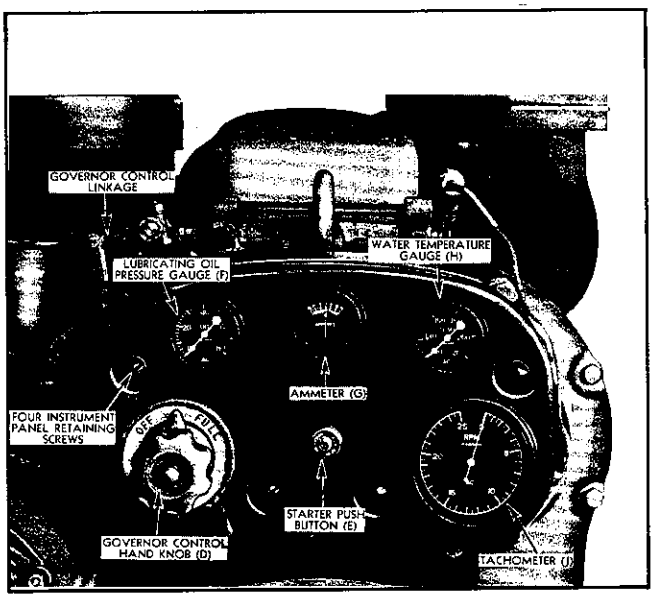


Fig. 1—Instrument Panel Assembly.

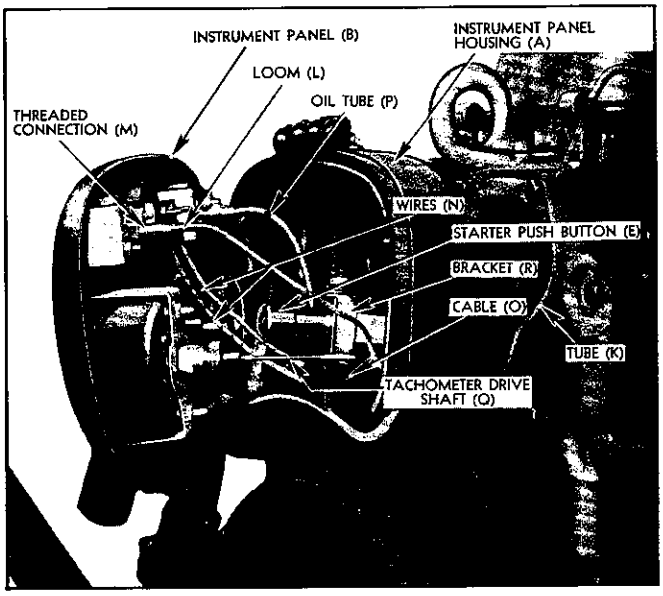


Fig. 2—Instrument Panel Released from Housing Showing Various Connections.

Description—A readily accessible and conveniently arranged instrument panel is attached to all Packaged Power units in plain view of the operator, Fig. 1 illustrates a typical instrument panel used on an industrial Packaged Power unit equipped with a power take-off. The governor control hand knob furnished with this panel is suitable for power take-off units; but where very close engine regulation is required the hand knob may be replaced by a vernier control. Only the instrument panel provided with hand knob as used on power take-off units is described in this text.

The complete unit consists of the instrument panel proper, to which the various instruments are attached, and the instrument panel housing, as shown in Fig. 2. The instrument panel housing "A" is fastened to the gear train cover by two cap screws and the panel "B" is fastened to the housing by four cap screws with rubber grommets between the two members.

The group of instruments consists of: a hand knob "D" for governor control; starting push button "E"; lubricating oil pressure gauge "F"; ammeter "G," showing the generator charging rate; water temperature gauge "H," showing the cooling water temperature; and tachometer "J," showing the engine R. P. M.

Fig. 2 shows the instrument panel separated from its housing and the connections to the various instruments from the engine.

The flexible tube "K," protected at each end by the loom "L," leads from the water temperature gauge "H" to the engine water manifold through a threaded connection "M." The wires "N" lead from the ammeter "G" through the cable "O" to the battery charging generator. The copper tube "P" leads from the lubricating oil pressure gauge "F" to the engine oil gallery. The tachometer drive shaft "Q" leads from the tachometer "J" to an adapter secured either to the camshaft gear or balancer shaft gear. The starting push button "E" is mounted on a bracket "R" secured to the rear of the cast iron housing "A." The wires from this starting push button lead through the cable "O" to the electric starter and the battery. When pushed in, this button completes the electric circuit between the battery and the solenoid starter switch. The hand knob "D" for governor control is secured to the cast iron housing "A" by the stud "S" and is connected through suitable linkage to the governor.

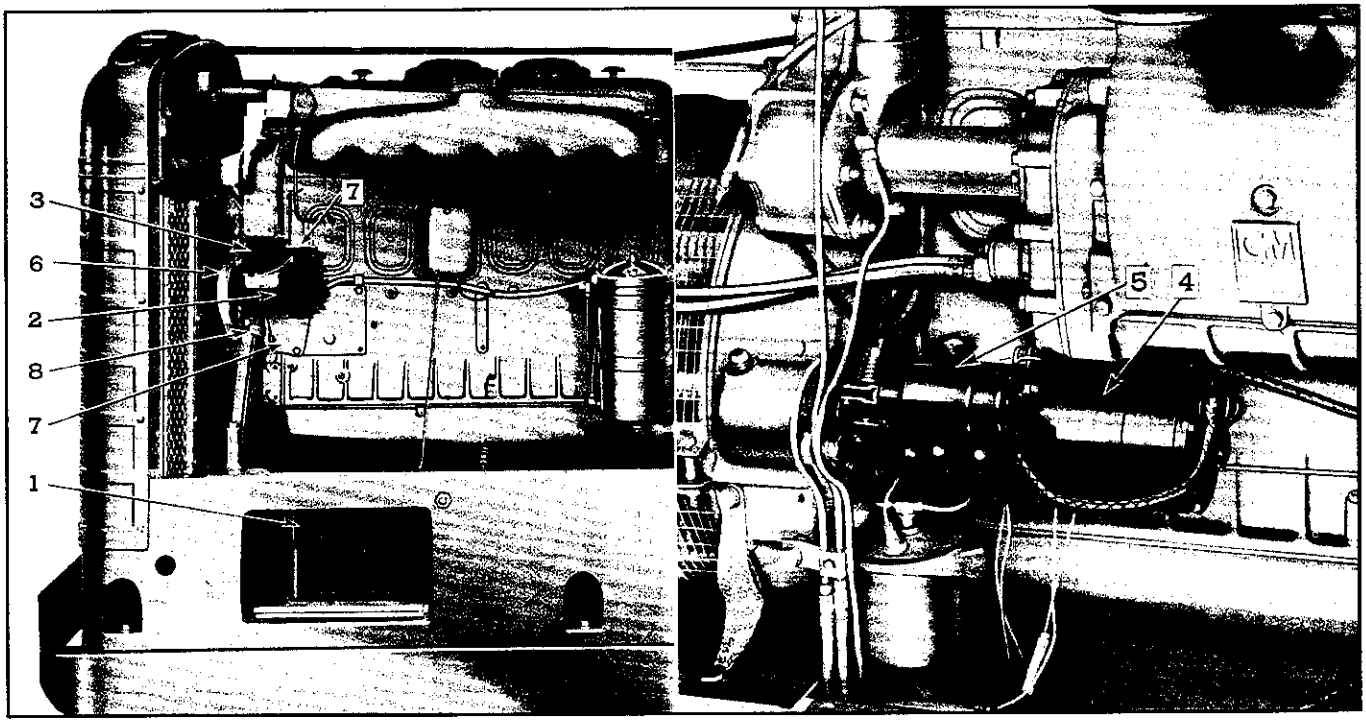
Service—As will be seen from Fig. 2 the attaching method for the various instruments is shown when the four cap screws are removed and the panel pulled away from housing. Any one of the various instruments is simply removed from either the instrument panel or the housing by loosening the attachments at the instruments.

To remove the throttle knob, unscrew the acorn nut at the center of the outer face and pull the knob from

the shaft. The knob shaft may be removed by loosening the instrument housing from the gear train cover and pulling the shaft out from the back.

Service on any of the instruments in this group is available at any United Motors Service Station and all parts are available at the Parts Department of the Detroit Diesel Engine Division, Detroit 23, Michigan.

ENGINE STARTING SYSTEM



1. Storage Battery.
2. Generator—Battery Charging.
3. Step-Voltage Control Assembly.
4. Starting Motor Assembly.
5. Solenoid Starting Shift and Switch.
6. Belt—Generator Drive.
7. Bracket—Generator Mounting.
8. Adjusting Strap—Generator Belt Tension.

Fig. 1—Location and Mounting of Units in a Typical Electrical Starting System.

Description—The 12 volt electrical starting system shown in Fig. 1 consists of a battery charging generator, complete with cut-out relay and step voltage control, a solenoid operated starting motor, and a governor actuating solenoid, all mounted on the engine proper.

A 12 volt storage battery is housed in the steel base (Fig. 1) while a starting motor switch and charging current ammeter are mounted on the unit control panel. These units are all connected together to form a circuit as shown in the wiring diagram on Page 23.

BATTERY

Battery Service—Authorized service on batteries is available at branches or service stations of the United Motors Service, Inc.

Battery Registration—The battery manufacturer is represented by Authorized Service Stations, which are prepared to carry out the terms of the maker's warranty. In order that engine owners shall have the benefit of this warranty, it is necessary for the Dealer to register the battery with the local service station on all new engine deliveries.

Battery Care—The storage battery is a rugged, trouble-free source of electrical energy ***only*** when it is properly cared for. Batteries should be checked with hydrometer at least once a week and the electrolyte must be maintained at the proper level —$\frac{3}{8}$" above the plates.

Battery terminals and connections should be prevented from corroding by cleaning the cable clamp and terminal post separately, using medium steel wool. After cleaning, clamp together firmly; then, coat with vaseline. These connections should be kept free of water and dirt.

Filler plugs should be kept tight at all times, and the top of the battery kept dry. The electrolyte should always be maintained at the proper level, and pure distilled water added to each cell until the solution is about $\frac{3}{8}$" above the top of the plates. This should be done each week—summer and winter.

Adding water to the battery in freezing weather should be done only before the engine is run for a period long enough to bring up the battery charge. Unmixed water in the battery may freeze and burst the cells, causing severe damage, necessitating major repairs or even replacement. Periodical hydrometer check is advisable, and should show a reading of not less than 1.270 for a battery in good condition. If the reading falls below 1.225, the battery should be charged from an outside source. Batteries not used for long periods should be checked

for electrolyte level, and specific gravity, at least once a month. In addition, such batteries should be given a booster charge of one ampere per positive plate per cell every 30 days in order to compensate for the self-discharge which is characteristic of all lead-acid storage batteries.

BATTERY CHARGING GENERATOR AND STEP-VOLTAGE CONTROL UNIT

Description—The Delco Remy generator, commonly used on Series 71 Diesel power units, is a 12-volt bi-polar unit controlled internally by an adjustable third brush and externally by a step-voltage control. The armature shaft is supported at the drive end by a ball bearing and at the commutator end by a bronze bearing. The drive end of the armature shaft carries a pulley for a V-belt drive. (See Figs. 2 and 3.) The brushes are held in reaction type holders and bear on the commutator with a pressure of 25 ounces. The third brush bears on the commutator with a pressure of 17 ounces.

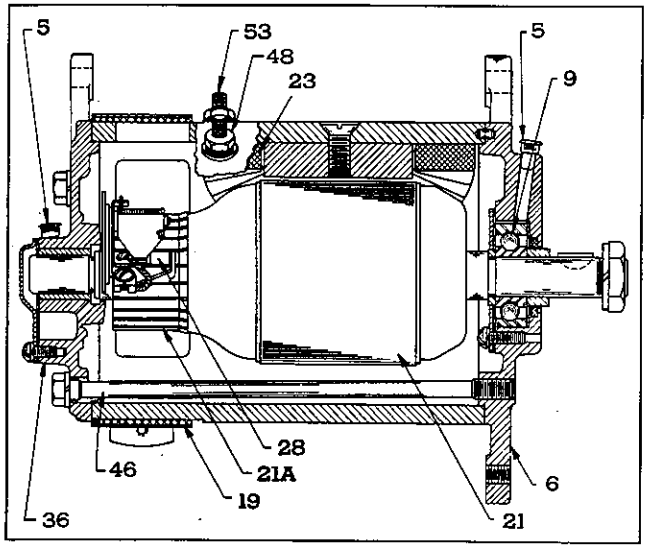


Fig. 2—Generator Assembly.

5. Oilers—Hinge Cap.
6. Drive End Frame.
9. Ball Bearing.
19. Cover Band Assembly.
21. Armature.
21A. Commutator.
23. Field Coil.
28. Brush.
36. End Frame—Commutator.
46. Through Bolts.
48. Stud—Field Terminal.
53. Stud—Armature Terminal.

The generator is mounted on a bracket attached to the side of the cylinder block, and driven by a V-belt from a pulley mounted on the front end of the crankshaft. The generator, which revolves at approximately 1.75 times engine crankshaft speed, is mounted on the side of the engine opposite to the blower.

To provide a simple drive belt adjustment, the generator is hinged from the front and rear generator end plates to the top of a supporting bracket, and is held in any desired position (within the limitations of the belt) by a clamp screw which slides in a second slotted bracket.

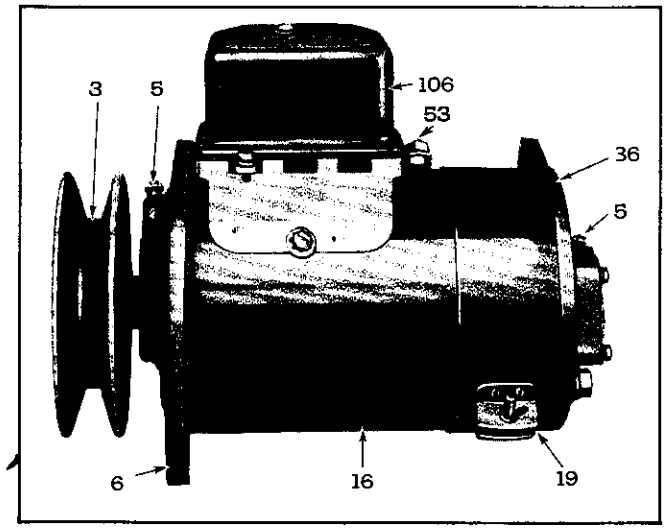


Fig. 3—Battery Charging Generator with Drive Pulley and Step Voltage Control Unit Attached

3. Drive Pulley.
5. Oiler—Hinge Cap.
6. Drive End Frame.
16. Field Frame.
19. Cover Band.
36. Commutator End Frame.
53. "ARM" Terminal Stud.
106. Step-Voltage Control Unit.

As shown in Fig. 4, the output of the generator is 8-10 Amps. when cold and 6-8 Amps. when hot at 2400 armature RPM. As a steady charging rate of 6-8 Amps. would soon destroy the storage battery, an output controlling device becomes necessary. To accomplish this, a step-voltage control together with a cut-out relay is wired into the generator circuit.

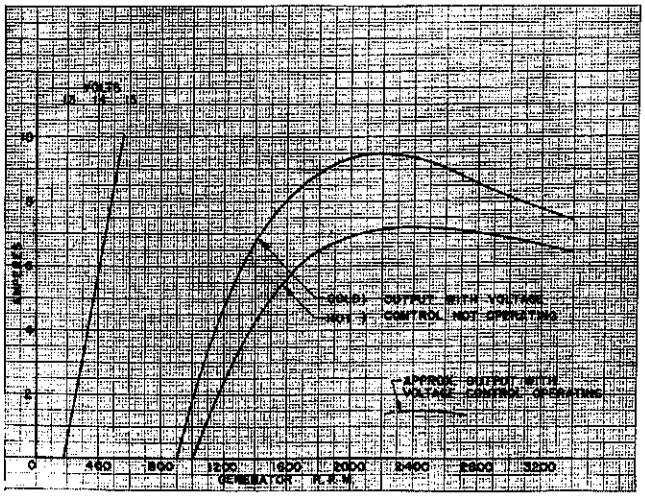


Fig. 4—Generator Output Curve.

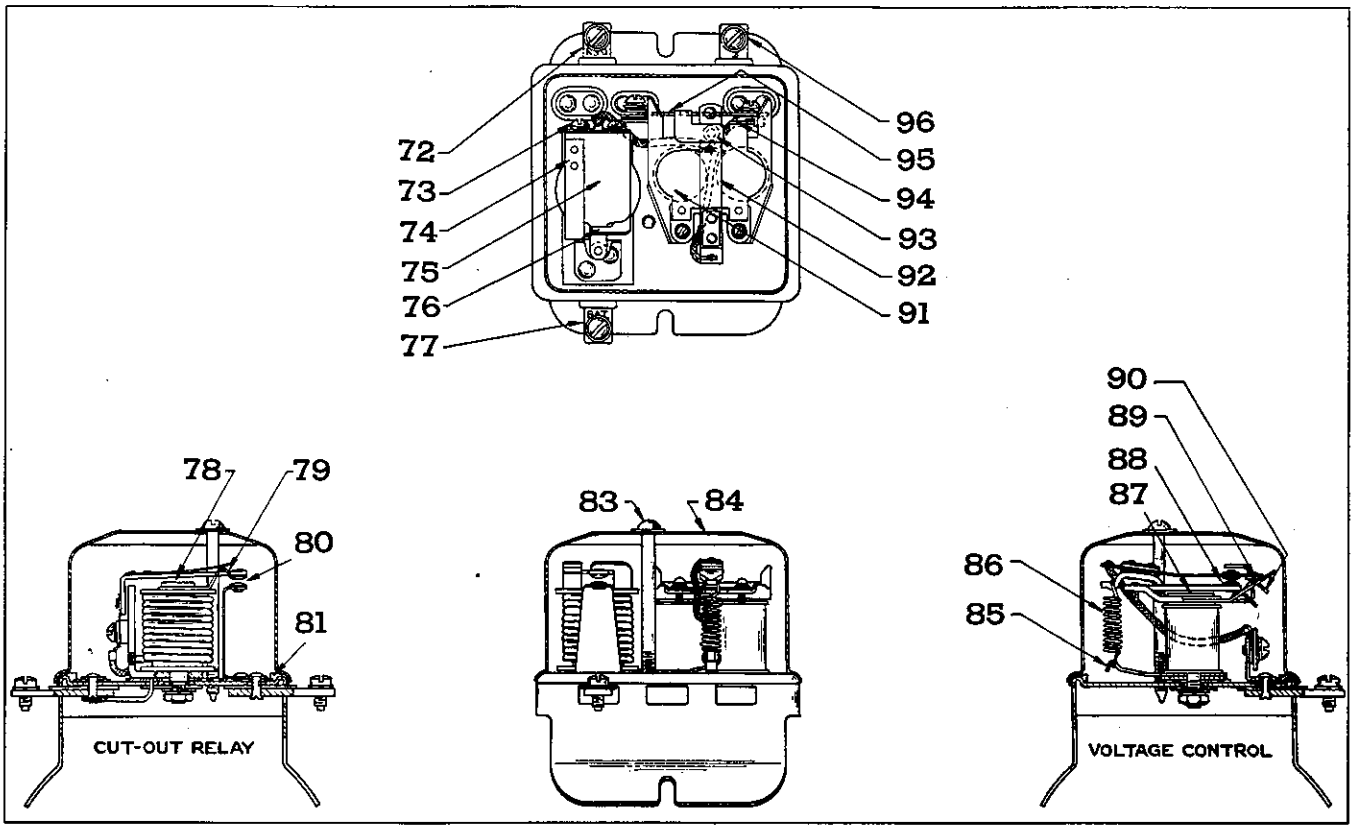


Fig. 5—Step-Voltage Control Unit and Cut-Out Relay.

72. "GEN" Terminal.
73. Screws—Cut-Out Relay Armature Mounting.
74. Spring—Cut-Out Relay Armature.
75. Armature—Cut-Out Relay.
76. Armature Stop—Upper Cut-Out Relay.
77. "BAT" Terminal.
78. Air Gap—Cut-Out Relay.
79. Spring Post—Cut-Out Relay.
80. Contact Points—Cut-Out Relay.
81. Gasket—Rubber.
83. Screw—Cover-to-Base.
84. Cover.
85. Spring Hanger—Lower—Step-Voltage Control.
86. Armature Spring—Step-Voltage Control.
87. Air Gap—Step-Voltage Control.
88. Contact Points—Step-Voltage Control.
89. Fibre Bumper.
90. Bumper Stop.
91. Armature—Step-Voltage Control.
92. Contact Spring—Step-Voltage Control.
93. Armature Stop—Upper—Step-Voltage Control.
94. Armature Stop—Lower—Step-Voltage Control.
95. Resistance.
96. "F" Terminal.

The **step-voltage control** unit is mounted on the generator field frame as shown in Fig. 3, and connected into the circuit as shown in the wiring diagram on Page 23.

The purpose of the step-voltage control is to increase or decrease the generator output in accordance with the requirements of the battery and the connected electrical load. When the battery becomes properly charged, a set of contact points in the control open and shunt the generator field circuit through a resistance unit to ground.

With the resistance unit in the field circuit, the generator maximum output is reduced approximately 5 to 7 amperes. If the battery should become partially discharged, the contact points in the control close, removing the resistance from the field circuit, and the generator output increases to its maximum, depending upon the setting of the third brush.

The voltage control does not increase the maximum output of the generator, as this is dependent entirely upon the design of the generator and the position of the third brush. Should the generator output be too high, the output should be reduced by adjusting the third brush to just meet the requirements. The voltage control unit will then reduce the output to a safe value when the battery becomes fully charged, and prevent high voltages within the electrical system.

The **cut-out relay,** a component part of the voltage control unit, closes the circuit between the generator and the battery only when the generator voltage has built up to a value sufficient to charge the battery. The cut-out relay opens the circuit when the generator slows or stops and current begins to flow back from the battery into the generator.

When the generator is at rest, the cut-out relay contact points are open. As the engine is started, and the generator speed increases, there is but one path, external to the generator, through which the current

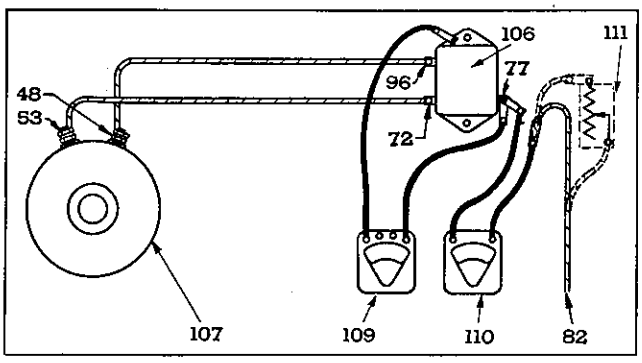


Fig. 6—Ammeter and Voltmeter Connections to Step-Voltage Control for Checking and Adjusting Generator Output.

48. Field Terminal (F)—Generator.
53. Armature Terminal (A)—Generator.
72. "GEN" Terminal on Control.
77. "BAT" Terminal on Control.
82. Cable to Control Cabinet.
96. "F" Terminal on Control.
106. Step-Voltage Control Assembly.
107. Generator—Battery Charging.
109. Voltmeter.
110. Ammeter.
111. Variable Resistance.

can flow. This is through the current winding of the relay, then the voltage winding, to ground. The generator voltage increases with increased speed. which causes more current to flow through the cut-out relay windings. When the voltage reaches the value for which the relay has been set, it is forcing enough current through the windings to create in the core sufficient magnetism to overcome the armature spring tension. The armature is pulled down toward the core, the contact points are closed, and current flows through the points to the battery. This current flows through the current winding in the right direction to add to the magnetic force holding the armature down and the points closed.

Should the generator slow to below generating speed, or stop, current will begin to flow from the battery to the generator. The direction of current flow in the voltage winding is always the same, to ground; therefore, its magnetic field is always in the same direction. But with the direction of current flow in the current winding reversed, its magnetic field is reversed.

The magnetic fields of the two windings now buck each other and the resultant magnetic field is no longer strong enough to hold down the armature. The armature is pulled up by its spring tension; the circuit is broken. Thus, a cut-out relay may be thought of as an electrical check valve which permits current to flow in only one direction—from generator to battery.

Generator Lubrication—The generator bearings are lubricated through hinged cap oilers. The application of 5 drops of engine oil every 200 hours of operation provides sufficient lubrication to keep the bearings in good condition.

Service—Testing and Adjusting Generator Circuit—No attempt should be made to test or adjust any part of the generator circuit without dependable instruments. If such instruments are not available, the tests may be made at any United Motors Service Station, who are authorized to carry out any service operation in connection with the electrical starting system. To check the generator, an accurate 0-10 or 0-20 ampere ammeter, an accurate 0-20 volt voltmeter, and a 2-ohm variable resistance of sufficient capacity to carry 10 amperes continuously, are needed.

DO NOT RUN OR TEST GENERATOR ON OPEN CIRCUIT. TO DO SO MAY DESTROY CONTROL OR GENERATOR.

Quick Generator Step-Voltage Control Checks.

1. A low charging rate with a fully charged battery indicates proper operation.

2. Excessive gassing of the battery indicates overcharge. The voltage control is designed to reduce the generator charging rate to approximately 2 amperes at 2000 generator RPM (approximately 1200 engine RPM) when the battery has approached a fully charged condition. Check the voltage control action by stopping the engine and connecting ammeter into the charging circuit, as shown in Fig. 6. Disconnect load from "BAT." terminal of voltage control and connect negative ammeter lead to this terminal. Connect positive ammeter lead to disconnected lead. With the ammeter connected and the engine restarted, there should be 6 to 8 amperes charge for a short time (up to 30 minutes with a charged battery). As the current used in starting is replaced in the battery, it will come up in voltage until the voltage control operates. This should reduce the charging rate to about two amperes. Failure of the units to operate in this manner will necessitate their being taken off the engine for further check and adjustment as described on Page 5.

3. A low battery, and a low or no charging rate, indicate either the third brush of the generator or the voltage control is out of adjustment. Loose connections in the charging circuit, particularly at the battery terminals, may also cause a low charging rate with a low battery. Connect ammeter in the charging circuit as described above. With the generator operating at about 2000 RPM (approximately 1200 engine RPM) and a low battery, the output should be 6 to 8 amperes. If less than 5 amperes is obtained, connect a jumper lead from the "F" terminal of the voltage control to ground (base of voltage control is satisfactory). If the output increases to 6 or 8 amperes, the trouble is in the voltage control. If the output does not increase to 6 to 8 amperes with the jumper lead connected from the "F" terminal of the voltage control to ground, the generator is at fault, and it must be checked further, as discussed under "Checking Generator Output."

Checking Generator Output.

1. Refer to Fig. 6 and disconnect lead from "BAT." terminal of voltage control and connect to one terminal of the variable resistance. Connect positive ammeter lead to "BAT." voltage control terminal. Connect negative ammeter lead to other terminal of the variable resistance. Connect negative voltmeter lead to "BAT." voltage control terminal and positive lead to ground (base of voltage control or generator frame).
2. Connect a jumper lead (not shown in diagram) between the "F" terminal of the voltage control unit and the ground to eliminate the voltage-control resistance.
3. Set engine speed for maximum generator output (approximately 2100 generator RPM or 1200 engine RPM).
4. Adjust variable resistance until voltmeter reads 14.1 to 14.5 volts. The output should be approximately 6 to 8 amperes with the generator at operating temperature. Adjust the generator output by shifting the third brush in the direction of rotation to increase the output, and in the opposite direction to decrease the output. Adjust the variable resistance after shifting third brush to maintain 14.1 to 14.5 volts before taking ampere reading.

   Before moving the third brush, it is necessary to loosen the clamp screw on the face of the commutator end frame. Do not loosen this screw more than one or two turns. Considerable force may be required to move the third brush due to the construction of its mounting. (See Fig. 10 for details.)

   CAUTION: Never under any circumstances, set the generator output above 8 amperes at 14.1 to 14.5 volts.
5. If unable to obtain 6 to 8 amperes by shifting the third brush, remove the generator and voltage control and service them in the manner described in the following pages of this section.

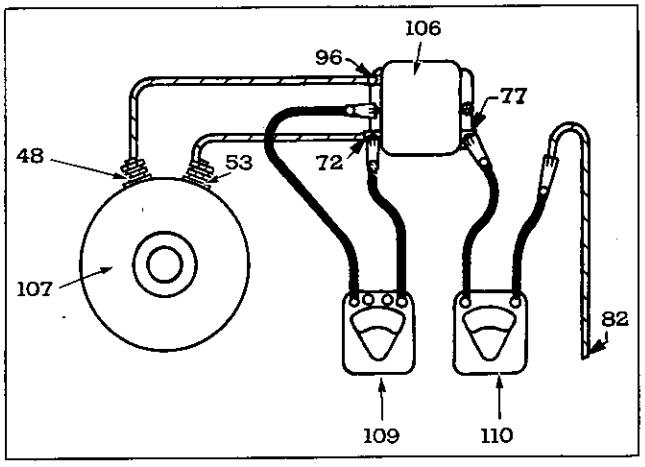


Fig. 7—Ammeter and Voltmeter Connections for Checking and Adjusting Cut-Out Relay.

48. Field Terminal (F)—Generator.
53. Armature Terminal (A)—Generator.
72. "GEN" Terminal on Control.
77. "BAT" Terminal on Control.
82. Cable to Control Cabinet.
96. "F" Terminal on Control.
106. Voltage Control Unit.
107. Generator—Battery Charging.
109. Voltmeter.
110. Ammeter.

Checking Cut-Out Relay—Connect the test leads of an ammeter and voltmeter into electrical system as shown in Fig. 7. Start engine, gradually increase speed, and note the relay closing voltage. The reading should be 12.9 volts to 13.9 volts.

Decrease the engine speed and note on ammeter the reverse current necessary to open the points. This reading should be from 0 to 4.0 amperes. If adjustments are necessary, disconnect the regulator, remove the cover and make adjustments as described under "Adjustments—Cut-Out Relay," Page 10.

Remove Generator from Engine—With hood side panel on exhaust side of engine removed, the generator and step-voltage control assembly may be taken off the engine as follows:

1. Disconnect from "BAT." terminal of voltage regulator the lead wire to the control cabinet.
2. Remove the belt-tension-adjusting bolt from the drive end frame at front of generator and drop adjusting arm out of way against cylinder block.
3. With generator suitably supported, remove the two bolts, nuts, and washers holding generator to mounting bracket, free generator from drive belt and remove to work bench.

Disassemble Generator—After testing has proved it necessary, the generator may be torn down for repair and rebuilding by referring to Fig. 10 and proceeding as follows:

1. Remove nut (52) and lockwasher (51) from each generator terminal stud (48) and (53) and disconnect leads (63) to regulator assembly. Remove two regulator mounting screws (60) with toothed lockwasher (61) and plain washer (62) and remove regulator assembly from generator.
2. Remove cover band assembly (19) by taking out retaining screw (20). Disconnect field terminal lead (24) from movable brush and armature terminal lead (18) from one stationary brush by removing brush lead screws (64) and lock washers (65). The two loose brushes (27) and (28) may be removed at this time.
3. Remove two through bolts (46) and gently tap commutator end frame away from field frame and armature.

4. **Disassemble Commutator End Frame—**

(a) Remove three screws (30) and lockwashers (31) holding stationary brush holder assembly (33) to end frame and remove entire holder assembly along with tension spring (32). Remove third brush locking screw (39), and clamp (35), then with a screwdriver, lift third brush mounting ring (34) off hub of end frame.

(b) Remove three screws (44) and lockwashers (45) holding cover (43) to commutator end frame. Remove gasket (42). Oil wick (41) may now be pulled from place.

(c) If necessary, bushing (38) may be removed from the frame by pressing out in an arbor press or a suitable bench vise. Hollow sleeves of the proper diameter are necessary for this operation.

(d) The remaining stationary brush may now be removed by taking out the brush lead screw (64). Brush tension arms and tension springs can be removed if necessary by releasing the tension on the spring with a pair of needle-nose pliers and then sliding the two pieces off the hinge pin along with the small spacing washer (29).

5. Separate field frame and coil assembly from drive end frame and armature by tapping lightly with a soft hammer. Then, with armature supported in soft jaws of a bench vise, loosen and remove lock nut (1) and lockwasher (2) and with a suitable gear puller, remove pulley (3) and key (66) from armature shaft. The drive end frame assembly may now be separated from the armature and the two loose spacers (4) and (14) removed from the end frame.

6. **Disassemble Drive End Frame—**

(a) Remove three screws (12) and lockwashers (13) holding bearing retainer and gasket to end frame and remove retainer and gasket.

(b) Ball bearing (9), which is a slip fit in the end frame, may be lifted from place along with felt oil-distributing washer (7) and its retainer (8).

7. **Disassemble Field Frame—**

(a) With a dab of paint, mark the location of pole pieces (22) and field windings (23) within the field frame.

(b) From the field terminal stud (48) on outside of frame remove nut (52), lockwasher (51), plain washer (50), and insulating washer (49); then press the terminal stud down and into field frame. If necessary, the armature stud (53) with lead (18) attached may be removed through inside of frame by taking off nut (52), lockwasher (51), plain washer (50) and insulating washer (49).

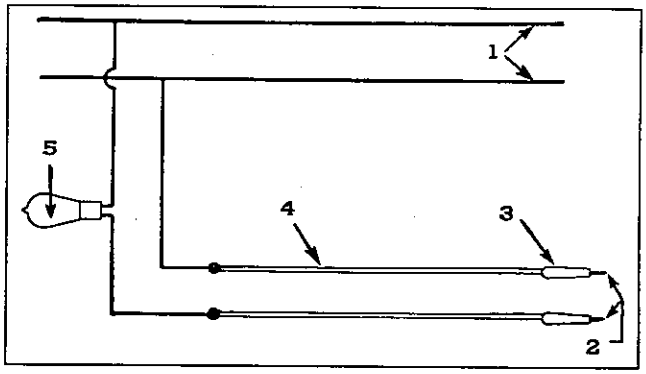


Fig. 8—Wiring Diagram for Checking Grounded Armature.

1. 110 or 220 Volt Line.
2. Test Points.
3. Insulated Handles.
4. Flexible Leads.
5. Light Bulb.

(c) Using a heavy socket screwdriver, or if necessary, a drift punch, loosen the two pole piece screws and remove. Pole pieces and field coils may now be removed from the frame.

NOTE: Care should be taken not to break or damage the insulated connection between the two field coils.

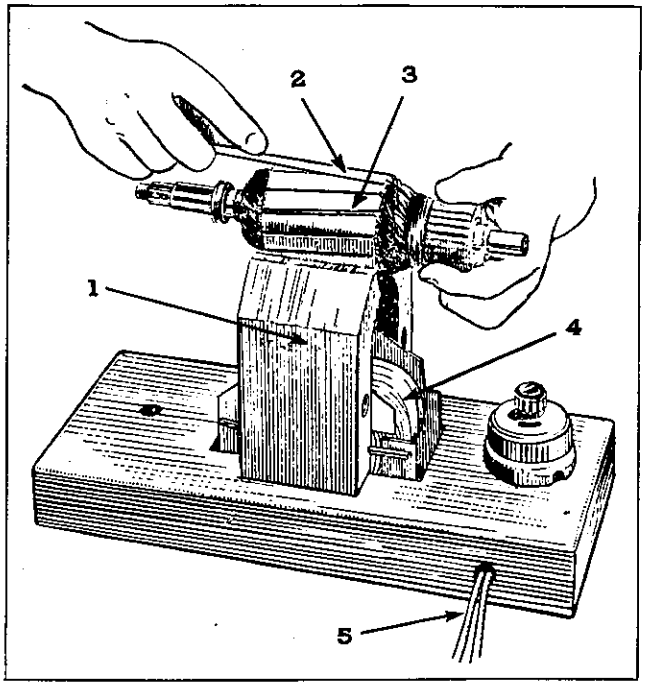


Fig. 9—Checking Generator Armature with "Growler"

1. Laminated Iron Core.
2. Steel Strip Held Over Slot in Armature.
3. Armature.
4. Winding.
5. Wires Connected to 110 Volt A.C. Line.

Cleaning and Inspection of Parts—

After disassembly, all parts should be cleaned, examined, and defective parts replaced. The procedure of cleaning and inspecting parts is as follows:

1. **Armature**—Do not clean the armature by any degreasing method, since this would damage the insulation and might ruin the armature. Wipe with a clean cloth *slightly* dampened with carbon tetrachloride or similar solvent. If commutator is rough, out of round, worn, has high mica, filled slots, or is burned, it must be turned down in a lathe and the mica undercut. Armature may be checked for ground, open or short circuit, as follows:

(a) **Ground**—Check with test lamp and test points from the commutator to the armature shaft or lamination. If the lamp lights, indicating ground, and if the ground is not readily apparent and repairable, the armature must be replaced.

(b) **Open Circuit**—An open circuited armature is easily detectable, since this condition produces badly burned commutator bars. The bars connected to the open coils in the armature soon burn since every time they pass under the brushes they interrupt a flow of current so that heavy arcing occurs. If the bars are not too badly burned,

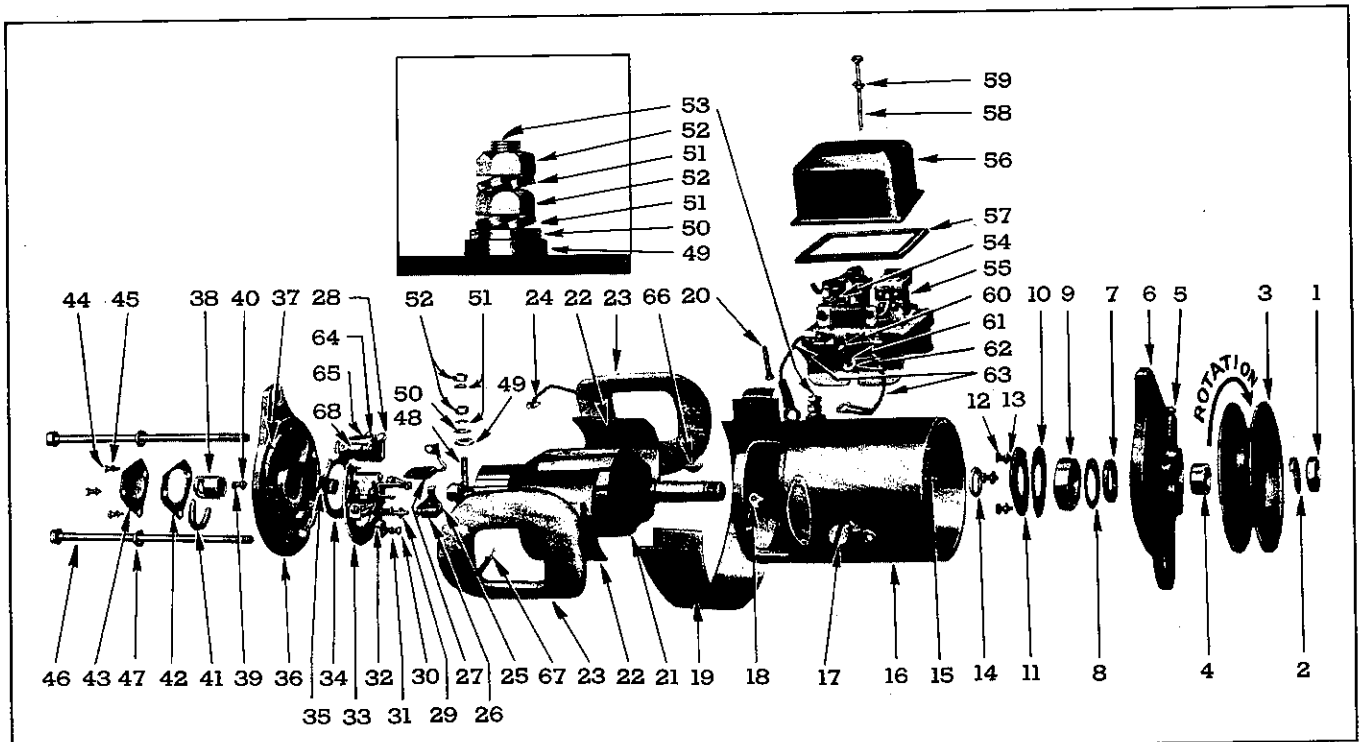


Fig. 10—Battery Charging Generator Details and Relative Location of Parts.

1. Lock Nut.
2. Lock Washer.
3. Drive Pulley.
4. Spacer—Thick.
5. Oiler.
6. End Frame—Drive.
7. Washer—Felt Oil Distributing.
8. Retainer—Felt Oil Washer.
9. Ball Bearing.
10. Gasket—Bearing Retainer.
11. Bearing Retainer.
12. Screw—Bearing Retaining.
13. Lock Washer—Bearing Retaining Screw.
14. Spacer—Thin.
15. Dowel—Field Frame to Drive End Frame.
16. Field Frame.
17. Screw—Pole Shoe.
18. Lead—Armature Terminal.
19. Cover Band Assembly.
20. Screw—Cover Band.
21. Armature.
22. Pole Piece.
23. Field Coils.
24. Lead—Field Coil to Brush.
25. Brush Tension Arm.
26. Spring—Main Brush Tension.
27. Brush—Stationary.
28. Brush—Movable.
29. Spacer—Brush Retainer.
30. Screw—Brush Holder Assembly-to-Commutator End Frame.
31. Lock Washer.
32. Tension Spring—Movable Brush Ring.
33. Brush Holder Assembly.
34. Mounting Ring—Movable Brush.
35. Clamp—Movable Brush Locking.
36. End Frame—Commutator.
37. Dowel—Commutator End Frame-to-Field Frame.
38. Bushing—Commutator End Frame.
39. Screw—Movable Brush Locking Clamp.
40. Lock Washer.
41. Oil Wick—Commutator End.
42. Gasket—Commutator End Cover to Frame.
43. Cover—Commutator End Frame.
44. Screw—Cover Retaining.
45. Lock Washer.
46. Through Bolts.
47. Lock Washers.
48. Terminal Stud—FIELD.
49. Washer—Insulating.
50. Flat Washer.
51. Lock Washer.
52. Nut—Terminal Stud.
53. Terminal Stud—ARMATURE.
54. Step-Voltage Control.
55. Cut-Out Relay.
56. Cover—Regulator Assembly.
57. Gasket—Regulator Assembly Cover-to-Base.
58. Screw—Regulator Assembly Cover Hold-Down.
59. Lock Washer.
60. Screw—Regulator Assembly Mounting.
61. Lock Washer—Toothed.
62. Washer—Plain.
63. Leads—Regulator-to-Generator Terminals.
64. Screws—Brush Retaining.
65. Lock Washers.
66. Woodruff Key—Shaft-to-Pulley.
67. Connecting Lead Between Field Coils.
68. Spring—Third Brush Tension.

the armature may often be saved. (See Armature Repair, below.)

(c) **Short Circuit**—A shorted armature may be detected on a growler. The growler is a strong electromagnet connected to a source of alternating current. When shorted armature is placed on the growler, and a hacksaw blade held above the shorted coils in the armature, the blade will be alternately attracted to and repelled from the armature, causing the blade to buzz against the armature. Before discarding an armature testing shorted, inspect the commutator slots carefully, since copper or brush dust sometimes collects in the slots and shorts adjacent bars.

2. **Fields**—The fields should not be cleaned by any degreasing method, since this would damage the insulation and might ruin the windings. Clean by wiping with a clean, dry cloth. Be careful in handling the winding assembly to avoid breaking or weakening the connecting lead between the two windings. Test the field current draw by connecting a 12-volt battery and an ammeter in series with the two field leads. The current draw should be 1.5 to 1.67 amperes at 12 volts. Replace windings if they do not meet specifications. The field insulation should be in good condition. If it is charred or worn away so that the wire is exposed, it is sometimes possible to re-wrap the windings with insulating tape and paint them with insulating compound. All soldered connections should be made with rosin flux solder. If the terminal stud or clip is damaged, replace.

3. **Brushes**—If the brushes are worn down to 7/16" (original length 3/4"), replace. New brushes may be seated with a brush seating stone. The brush seating stone is an abrasive material which, held against a revolving commutator, disintegrates, carries under the brushes and seats them in a second or two. After seating brushes, blow out with air.

4. **Brush Springs**—The brush springs should have sufficient tension to provide the proper pressure between the brushes and commutator after the unit is assembled. This may be checked by assembling the brushes, brush springs, and arms to the commutator end frame placing the commutator in position in the end frame and then checking with a spring gauge the amount of pull required to raise the brush arms from the brushes. Replace springs if tension is not 25 ozs. on the main brushes and 17 ozs. on the movable third brush.

5. **Bearing**—If the bearing appears to roll roughly, or sloppily, replace it. Otherwise, the bearing may be cleaned by rotating it in carbon tetrachloride, drying it with air, and immediately relubricating with ball bearing grease.

6. **Brush Ring**—If the brush ring, brush arm pins, brush holders, spring stop pins are damaged (bent, warped, cracked, insulation burned, etc.), replace. The ring is of a riveted construction so that it must be serviced as a unit.

7. **Miscellaneous**—Any defective insulator, screw, washer, lead, stud, retainer, plate, etc., should be replaced. Cracked, bent, battered, worn, burned insulators and washers are defective. Screws or studs which are bent, battered, broken, or which have crossed or damaged threads, are defective. Leads which have broken strands, badly frayed insulation, are defective.

Generator Repair Operations—

1. **Armature**—Conditions in the armature requiring repair are:

(a) **Commutator worn, dirty, etc.**—If the commutator is rough, worn, out of round, has high mica, filled slots, burned spots, place the armature in a lathe and turn down the commutator. Make cut no deeper than necessary. Minimum diameter of commutator should be 1.675 ". If it is necessary to turn the commutator below this diameter, discard the armature. Undercut mica 1/32".

(b) **Armature Open**—Some bars badly burned, with other bars fairly clean, indicates an open-circuited armature. The open circuit will usually be found at the commutator riser bars and is often a result of generator overload—the consequence of an excessively high generator output resulting from a too advanced third brush adjustment. If the bars are not too badly burned, the armature may sometimes be saved by resoldering the leads in the riser bars with rosin flux, turning the commutator down and undercutting the mica. Make sure the third brush is adjusted according to specifications.

2. **Fields**—Conditions in the field windings requiring repair are:

(a) **Field Insulation Defective**—If the field insulation is defective, charred or worn away, so the field circuit is, or could become, grounded, it may sometimes be repaired by re-wrapping the field windings with insulating paint. This operation must be executed with care and neatness, since excessive bulkiness of the tape will prevent reassembling the windings under the pole shoes in the proper manner. ***All soldered connections should be made with rosin flux solder.***

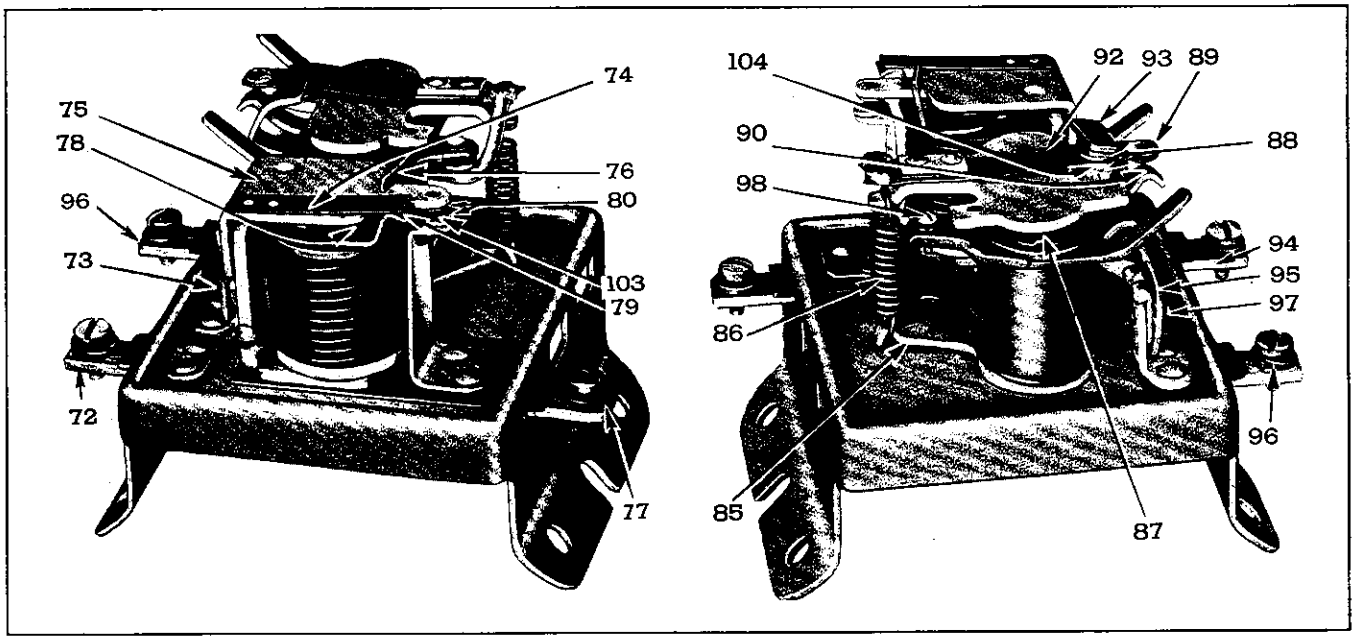


Fig. 11—Step-Voltage Control Assembly Showing Details of Cut-Out Relay (LEFT) and Step-Voltage Control (RIGHT).

72. "GEN" Terminal.
73. Screw—Cut-Out Relay Armature Mounting.
74. Spring—Cut-Out Relay Armature.
75. Armature—Cut-Out Relay.
76. Armature Stop—Upper Cut-Out Relay.
77. "BAT" Terminal.
78. Air Gap—Cut-Out Relay (.015 Inch).
79. Spring Post—Cut-Out Relay.
80. Contact Points—Cut-Out Relay.
85. Spring Hanger—Lower—Step-Voltage Control.
86. Armature Spring—Step-Voltage Control.
87. Air Gap—Step-Voltage Control.
88. Contact Points—Step-Voltage Control.
89. Fibre Bumper.
90. Bumper Stop.
91. Armature—Step-Voltage Control.
92. Contact Spring—Step-Voltage Control.
93. Armature Stop—Upper—Step-Voltage Control.
94. Armature Stop—Lower—Step-Voltage Control.
95. Resistance.
96. "F" Terminal.
97. Screws—Resistance Mounting.
98. Screws—Armature Mounting—Step-Voltage Control.
103. Contact Point Opening Cut-Out Relay (.020 inch).
104. Contact Point Opening Step-Voltage Control (.015 inch).

Service—Step-Voltage Control Assembly—As a rule, the voltage regulator should ***not*** be disassembled. The only exception is where some part such as the cut-out relay or step-voltage control armature requires replacement. The adjustments of the unit are delicate and must be made with great precision in order to obtain normal operation of the unit. Actually, only a few parts can be removed from the unit, since the windings, terminals, etc., are assembled by riveting.

Disassemble Step-Voltage Control—

1. Remove cover by removing screw (83) and washer. (See Figs. 5 and 10.)
2. Remove resistance by unscrewing two screws (97) and lockwashers. This also disconnects lead soldered to voltage control armature.
3. Detach voltage control armature (91) by removing spring (86), two screws (98), lockwashers and washers. Lead may be unsoldered from armature.
4. Remove two screws (73) and lockwashers and remove cut-out relay armature (75) and flat two hole washers. It is not necessary to unsolder lead from the two hole clip washer.

Inspection of Parts—General—All parts should be examined, with particular emphasis on the contact points in both the cut-out relay and the voltage control unit. Points which are dirty, burned, or oxidized should be cleaned. The point and fibre bumper on the flat spring on the voltage control armature, and the point on the cut-out relay armature should be assembled tightly. Leads, windings, insulators, screws, washers, must all be in good condition. If the windings, stationary cut-out relay contact point, insulators, are burned or otherwise defective, replace the complete step-voltage control. The step-voltage control is mostly of riveted construction and only the parts now disassembled are serviceable items.

Repair—Step-Voltage Control Assembly—Contact Points—which are pitted, rough, dirty, or burned may be cleaned with a stroke or two of a clean, fine-cut contact file. Blow out all dust. Be careful in cleaning the voltage control unit contact points to avoid bending or distorting the flat armature spring. The spring should hold the two points in contact with the proper spring tension. Never use emery cloth or sandpaper to clean the points, since small particles of emery or sand might embed in the points

surfaces and prevent good contact. Do not touch the points surfaces after cleaning them, since any trace of oil or grease may cause the points to burn.

Assemble Step-Voltage Control—

1. Attach cut-out relay armature (75) with two screws (73) and lockwashers. Thick two hole washer goes under relay armature, while thin two hole clip washer goes over armature.
2. Attach voltage control armature (91) with two screws (98), lockwashers and washers. Solder lead to armature if it has been unsoldered and hook spiral spring (86) between armature and lower spring support. ***Use only rosin flux solder where required.***
3. Attach resistance (95) with two screws (97) and lockwashers. This also attaches other end of lead from voltage control armature. Lead should be attached under screw and lockwasher nearest voltage control unit.
4. **Attach cover with screw and washer.**

Cut-Out Relay Adjustments—

1. **Air gap** (.015 inch)—With the contact points held closed, check the air gap between the armature and the center of the core. To adjust, loosen the two screws at the back of the relay and raise or lower the armature as required. Tighten screws securely after adjustment.
2. **Point Opening** (.020 inch)—Measure point opening with points open. Adjust by bending the upper armature stop.
3. **Closing Voltage** (12.9 to 13.9 volts)—Connect voltage control to generator and battery in normal manner to check relay closing voltage. Connect voltmeter from "GEN" terminal to voltage control base. It is not necessary to connect ammeter into circuit unless it is desired to measure generator output. Gradually increase generator speed and note voltage at which relay points close. Adjust by bending up on the spring post to increase the spring tension and raise the closing voltage. Bend down to lower closing voltage.

Step-Voltage Control Adjustments—

1. **Contact spring tension** (0.7-1.4 oz.)—The flat contact spring (92) tension is measured at the contacts (88) with the armature and spring just separated from the upper stop (93). The pull required to separate the points should be carefully measured with a spring gauge. Adjust by slightly bending the flat spring.
2. **Air Gap** (.045 in.)—The air gap is measured between the center of the core and the armature with the armature (91) held down against the lower armature stop (94). Bend the lower armature stop to adjust.
3. **Armature Travel** (.045 in.)—Release the armature and gauge the distance between the armature and the lower armature stop. Adjust by bending the upper armature stop.
4. **Point Opening** (.015 in.)—With the armature held down against the lower armature stop, measure the contact point opening (104). Adjust by bending bumper stop (90).
5. **Voltage Setting**—The ***opening voltage*** (14.1-14.7 with unit hot—180° F.) of the contact points is checked by connecting the meters and ¼ ohm variable resistance, as illustrated in Fig. 6, to the voltage control, generator and battery. Increase generator speed slowly and note the voltage at which the contact points of the voltage control unit open. The moment at which the contact points open will be indicated by the sudden drop in charging rate as shown by the ammeter. STEP-VOLTAGE CONTROL MUST BE AT OPERATING TEMPERATURE AND COVER MUST BE IN PLACE. If the battery is low, the voltage control may not operate. To obtain sufficient voltage to cause the voltage control points to open, operate the generator at medium speed and slowly cut in resistance until the voltage control points open. Note voltage. To adjust, bend the spiral spring hanger down to increase the opening voltage setting. Bend up to lower the setting.

   The ***closing voltage*** (12.0 max. volts) is checked by reducing the generator speed or cutting out resistance so the voltage drops to the value at which the points close. Adjust by adjusting the ***air gap,*** as described above. Increase the air gap to raise the closing voltage, or decrease the air gap to lower the closing voltage. After readjusting the air gap, readjustment of the contact point opening may be required.

Assemble Generator—Having made all necessary repairs and using new parts where required, refer to Fig. 10 and assemble the generator as follows:

1. **Assemble Field Frame—**
   (a) Set field coils (23) and pole pieces (22) in position inside of frame (16) as indicated by the paint dabs placed on pieces at disassembly and secure in place with two heavy screws (17). After assembly, field coils must be far enough away from ends of frame to allow proper positioning of the two end frame assemblies. The field terminal stud (48), brush lead (18), and coil connecting lead (67) must be at commutator end of field frame.

(b) Place terminal stud (48) of field coil through opening in frame marked "F" and then place over the stud an insulating washer (49), a plain washer (50), and a lock washer (51). Secure in place with nut (52). The armature terminal stud (53), with brush lead (18) attached, may be inserted from inside frame through the remaining hole, marked "A" and secured in place using parts identical to those on the field terminal stud.

2. **Assemble Drive End Frame—**

(a) Place felt oil-distributing washer (7) into bore of end frame followed by the metal felt retainer (8). Concave side of retainer must be toward felt. Lower ball bearing assembly (9) into place in frame.

(b) Set bearing retainer gasket (10) and retainer (11) in place over bearing and fasten with three screws (12) and lock washers (13).

(c) Spacers (4) and (14) may be set in place, awaiting assembly of drive end frame to armature shaft and field frame.

3. **Assemble Commutator End Frame—**

(a) If bushing (38) was removed from end frame (36), it may now be pressed into place with an arbor press or bench vise. ***Do not attempt to drive bushing into end frame.*** When installing bushing ***be sure oil cut in bushing lines up with bore in frame for oil wick.***

(b) Oil wick (41) may be pushed into the oil wick bore with some sharp tool that can be hooked into the felt. If a new wick is used, it should be soaked in oil before installing.

(c) Replace gasket (42) and cover (43) and secure with three screws and lock washers (44) and (45).

(d) If removed, tension arms (25), space washers (29) and brush springs (26) and (68) must now be assembled onto the hinge pins of the brush holder assembly. Note that the tension spring for the movable third brush is different from the two springs for the main brushes and may be recognized by its cadmium finish contrasting with the copper finish of the main brush springs.

Slip a washer (29) over each hinge pin and then with a spring and tension arm held properly together (straight end of spring through hole in arm) slide the two pieces over the hinge pin. With pliers or a hooked tool, compress spring and snap spring arm over catch on holder assembly to lock in place.

(e) Place movable brush mounting ring (34) in place over hub of end frame with brush box near mounting extension. Fasten clamp (35) in place over ring with clamp screw and lock washer (39) and (40).

Locate main brush holder assembly (33) on end frame and fasten with three screws and lock washers (30) and (31). Be sure flat tension spring (32) is in position under center screw and bearing against movable brush mounting ring as shown in Fig. 10.

(f) Two carbon brushes (27) and one carbon brush (28) may now be inserted in the holders. Note that the movable brush differs from the main brush and may be distinguished by a notch on the top surface into which the tension arm fits. Brushes must be put in holders so that the bottom surface properly fits the commutator as it rotates. To assure this contact, pigtail leads must be on side of brush away from end frame. Connect brush leads to holders temporarily with retaining screws and lockwashers (64) and (65) and tip brushes in box holders so that commutator may easily be inserted between them. To tip brushes, raise brush out of box until tension arm rests on side of brush rather than the top.

4. Support armature—commutator down—in soft jaws of vise with shaft end resting on vise frame. Slip narrow spacer (14) over shaft followed by the drive end frame assembly. Set large spacer (4) in position over shaft and against inner bearing race and tap end frame into position against shoulder on armature shaft.

Place Woodruff key (66) in keyway and start pulley (3) onto shaft. Using a short sleeve, tap pulley into position on shaft leaving .015" to .020" clearance between pulley and spacer (4). Secure pulley with nut and lock washer (1) and (2).

5. Stand assembled armature and drive end frame on outer pulley face and slip field frame assembly over armature and into place against drive end frame. Be sure dowel (15) is in place in field frame.

6. Place commutator end frame assembly over shaft and commutator and up against field frame matching dowel of end frame to dowel hole in field frame.

Release the three tipped brushes and set them in place against the commutator making sure they are in proper position for clockwise rotation looking at drive pulley end of generator.

Connect lead wire (24) from field coil to brush lead screw on movable third brush and connect lead (18) from "A" terminal (53) to insulated main brush. If necessary, commutator end frame may be backed out of dowel hole and rotated to make these connections.

7. Tighten all brush lead or retaining screws (64) securely, making sure lock washer (65) is in place on each screw. Then replace the two through bolts (46) and lock washers (47) to hold entire generator assembly together and tighten bolts firmly. Brush pigtails must be positioned so they will not interfere with rotating parts.
8. A new or rebuilt voltage control unit assembly (see Pages 9 and 10) may now be attached to the field frame, using screws (60), lock washers (61) and flat washers (62).

NOTE: One hole in the field frame is plugged with an extra set of control unit mounting washers and screw. Control unit must be positioned so as to set in a horizontal position when installed on engine.

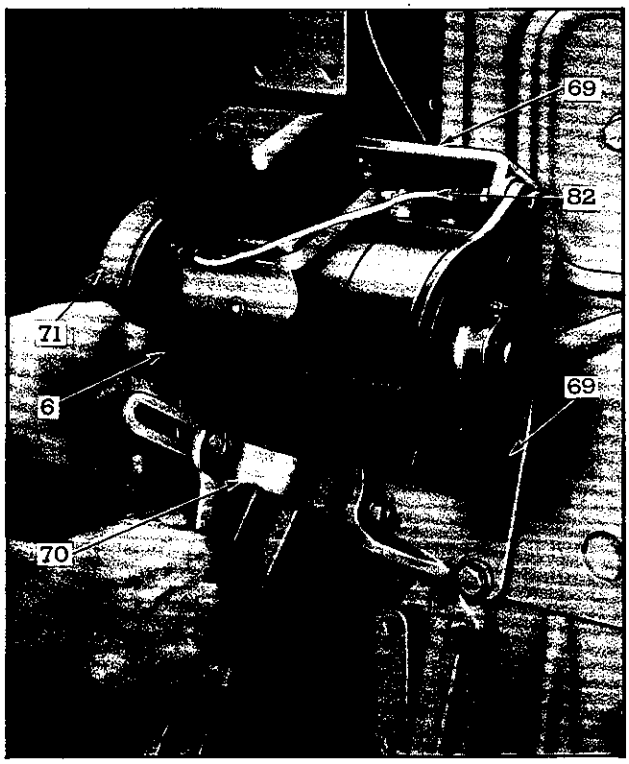


Fig. 12—Battery Charging Generator Mounting and and Belt Tension Adjustment.

6. Drive End Frame.
69. Bracket—Generator Mounting.
70. Strap—Generator Adjusting.
71. Belt—Generator Drive.
82. Cable—Voltage Control Unit-to-Control Cabinet.

Using the two leads (63), connect "F" terminal of generator to "F" terminal of control unit and "A" terminal to "GEN" terminal.

Rotate generator by hand to check for free movement of armature in bearings. Brushes may be lifted for double check if generator seems to turn too hard.

9. If a test stand is available, make tests and adjustments as outlined on Pages 4 and 5 before installing generator on engine.

   With no test stand, the generator must be installed on the engine and then tested and adjusted before continuous operation is attempted.

Replace Generator on Engine—

1. Hang generator assembly to mounting bracket with two bolts, lock washers, and nuts as shown in Fig. 12.
2. Fasten adjusting strap (70) to bottom extension of drive end frame (6), and adjust drive belt tension as outlined on Page 7, Sec. 13.
3. Attach cable (82) from control cabinet to "BAT" terminal on voltage control unit.

INSTALLATION CAUTION—

After the generator is re-installed on the engine, or at any time after leads have been disconnected and then reconnected to the generator, a jumper lead should be connected momentarily between the battery "BAT" and armature "GEN." terminals of the voltage control unit before starting the engine.

This allows a momentary surge of current from the battery to the generator which correctly polarizes the generator with respect to the battery it is to charge.

Never operate the generator on open circuit. To do so will allow it to build up a dangerously high voltage which will probably result in complete generator failure.

4. Run tests and make adjustments on generator and voltage control unit as outlined on Pages 4 and 5 before putting generator into continuous operation.

STARTING MOTOR

The starting motor, furnished with the Series 71 Diesel power unit, is a 4-pole, 8-brush, 12-volt, series wound, heavy-duty unit. A solenoid starting shift and switch is mounted on the motor and is operated by remote control from the instrument panel. The armature shaft is supported on three plain bearings provided with wick oilers. The Dyer Drive, at the rear end of the shaft, is used to transmit the power of the starting motor to the engine flywheel. (See Fig. 13.)

Operating Characteristics—Starting Motor on Six Cylinder Models—The starting motor, running free (no load test), draws 100 amperes maximum at 11.6 volts at a speed of 5000 RPM; and with the

armature locked, the motor draws a maximum of 570 amperes at 2.2 volts and develops 20 lbs. ft. torque.

Solenoid Starting Shift and Switch—The solenoid starting shift and switch is mounted on the starting motor and connected to the batteries and starting motor, as shown in Figs. 13 and 25. Remote control starting is accomplished by means of a starter switch on the instrument panel, which, upon being closed, energizes the starter solenoid. Inside the solenoid is a heavy plunger, which is connected by linkage to the pinion shift lever, which operates the Dyer Drive. When the starter switch is closed, the battery energizes both the PULL-IN and HOLD-IN coils. (See Fig. 14.) The PULL-IN coil, which draws a comparatively heavy current for a short interval, moves the plunger which pulls the pinion into mesh with the flywheel ring gear. The HOLD-IN coil also assists in this operation. Continuation of the plunger movement closes the solenoid switch contacts permitting the starting motor to crank the engine. During the cranking operation, only the HOLD-IN coil, drawing but a few amperes, is energized.

Starting Motor and Dyer Drive—The Dyer drive, which transmits the power of the starting motor to the engine flywheel, consists of the splined portion of the armature shaft, the shift sleeve, the pinion guide, the pinion, the pinion stop, washers, and springs. The thrust washers furnish a thrust bearing for the shift sleeve when it is in the returned position; the springs aid in the lock operation and in the engagement action. The entire drive is contained in the starting motor drive housing, and is operated by a remotely controlled solenoid. The movement of the pinion is controlled by means of a shift lever which is

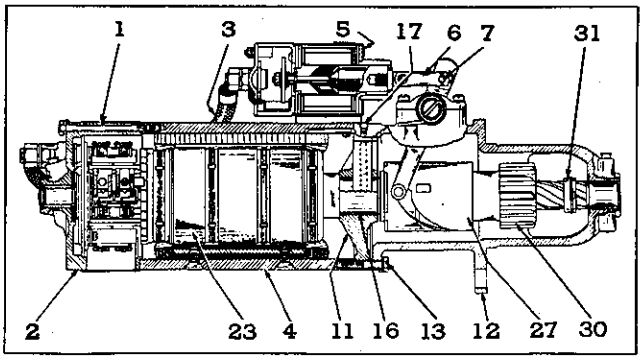


Fig. 13—Starting Motor Assembly.

1. Cover Band.
2. Frame Assembly—Commutator End.
3. Cable—Solenoid-to-Starting Motor.
4. Frame Assembly—Field.
5. Solenoid Switch.
6. Link Assembly.
7. Pin—Shift Lever.
11. Plate Assembly—Center Bearing.
12. Housing Assembly—Dyer Drive.
13. Bolts—Drive Housing.
16. Bushing—Center Bearing Plate.
17. Oiler—Center Plate Bearing.
23. Armature.
27. Shift Sleeve.
30. Pinion—Motor Drive.
31. Collar—Motor Drive Pinion Stop.

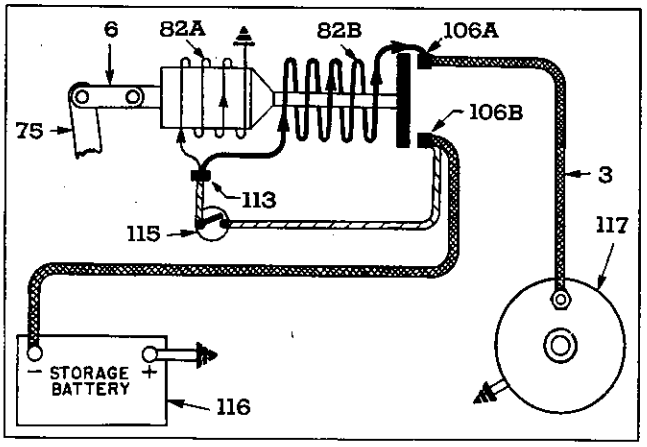


Fig. 14—Solenoid Switch Electrical Circuit.

3. Solenoid Cable.
6. Shifter Link.
75. Shifter Lever.
82A. Hold-In Coil.
82B. Pull-In Coil.
106A. "MOTOR" Terminal.
106B. "BAT" Terminal.
113. Switch Terminal.
115. Starter Button.
116. Battery.
117. Starting Motor.

connected directly to the shift sleeve. (See Figs. 13 and 15.) The Dyer Drive provides for positive engagement of the starting motor pinion with the engine flywheel before the starting motor switch contacts are closed or the armature is rotated. The pinion is thrown out of mesh with the flywheel by the reversal of torque as the engine starts.

Starting Motor Lubrication—The starting motor bearings are lubricated through hinged-cap oilers. Application of five drops of engine oil every 500 hours of operation provides sufficient lubrication to keep the bearings in good condition.

Oil is applied to three oilers located along the length of the starting motor, as follows:

1. Front, or commutator, end of motor.
2. Center, just beneath link end of solenoid.
3. Rear end of motor drive housing. Available through plugged hole in outer surface of flywheel housing.

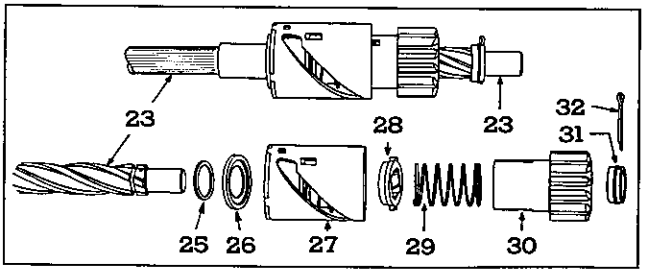


Fig. 15—Complete Dyer Drive and Its Component Parts.

23. Armature Shaft.
25. Space Washer—Plain.
26. Space Washer—Cupped.
27. Shift Sleeve.
28. Pinion Guide.
29. Pinion Spring.
30. Pinion.
31. Pinion Stop.
32. Cotter Pin.

Starting Motor Service—The starting motor cover band should be removed, when the engine is overhauled, for inspection of the commutator and brush connections. If the commutator is dirty, it should be cleaned with No. 00 sandpaper. ***Never use emery paper to clean the commutator.*** A glazed or blued commutator does not indicate a condition requiring service, as this is a normal and satisfactory condition on a used unit. The brushes should be examined and replaced if unduly worn. All the electrical connections should be kept clean and tight, and the brush spring tension maintained at 34 to 40 ounces. When the engine is operating in very dusty surroundings, the starting motor should be periodically removed and thoroughly blown out with dry compressed air. If dust and dirt accumulations are allowed to collect inside the motor, such accumulations will interfere with the operation of both the motor and the Dyer Drive.

CAUTION 1: Never put oil on the commutator or brushes.

CAUTION 2: Never crank an engine with the batteries over 80 seconds at any one time. If the engine does not start in this length of time, locate the trouble and make corrections.

Solenoid Service—If the starting motor solenoid fails to operate when the starter switch is closed and the external wiring is in order, the PULL-IN coil is defective. If the plunger pulls in and immediately releases, repeatedly, the HOLD-IN coil is defective. In either case, replace the coil and shell assembly.

Starting Motor Disassembly:

For purposes of simplicity in disassembly, inspection, repair, and re-assembly of the starting motor assembly, the following procedure may be followed. First the starting motor will be torn down into six sub-assemblies and then each sub-assembly in turn will be disassembled, repaired, and reassembled.

I. **Disassembly into Main Sub-Assemblies**—

1. Unscrew terminal nuts (33) (See Fig. 16 and 17)

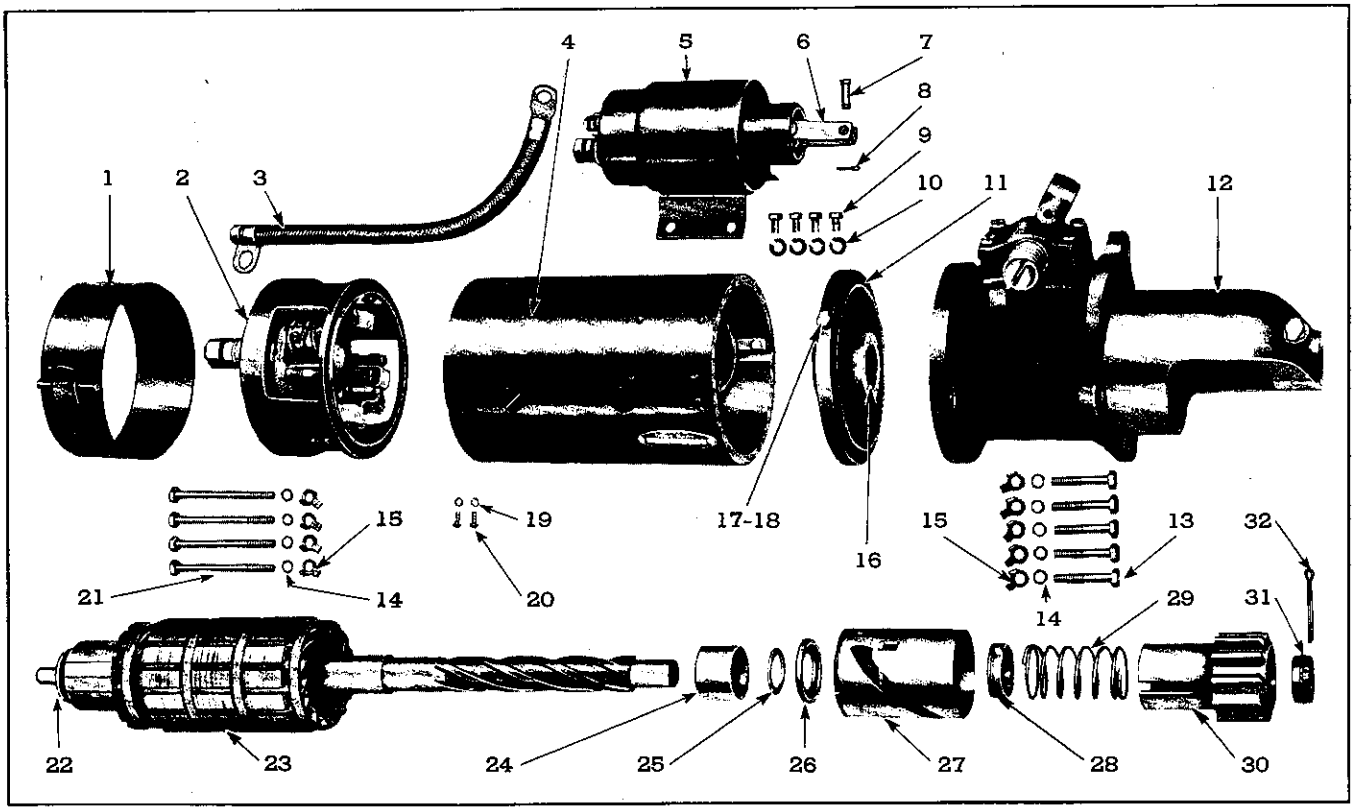


Fig. 16—Starting Motor Disassembled into Main Sub-Assemblies.

1. Cover Band.
2. Frame Assembly—Commutator End.
3. Cable—Solenoid Connector.
4. Field Frame Assembly.
5. Solenoid Switch.
6. Link Assembly.
7. Pin—Shift Lever.
8. Cotter Pin.
9. Screws—Solenoid Switch Mounting.
10. Lock Washers.
11. Plate Assembly—Center Bearing.
12. Housing Assembly—Dyer Drive.
13. Bolts—Drive Housing.
14. Plain Washers.
15. Lock Washers.
16. Bushing—Center Bearing Plate.
17. Oiler—Center Plate Bearing.
19. Lock Washer — Brush Lead Screw.
20. Screw—Brush Lead.
21. Bolts—Commutator End Frame Attaching.
22. Washer—Armature Brake Shoe.
23. Armature.
24. Space Collar.
25. Space Washer.
26. Space Washer.
27. Shift Sleeve.
28. Guide—Motor Drive Pinion.
29. Spring—Motor Drive Pinion Meshing.
30. Pinion—Motor Drive.
31. Collar—Motor Drive Pinion Stop.
32. Cotter Pin—Motor Drive Pinion Stop Collar.

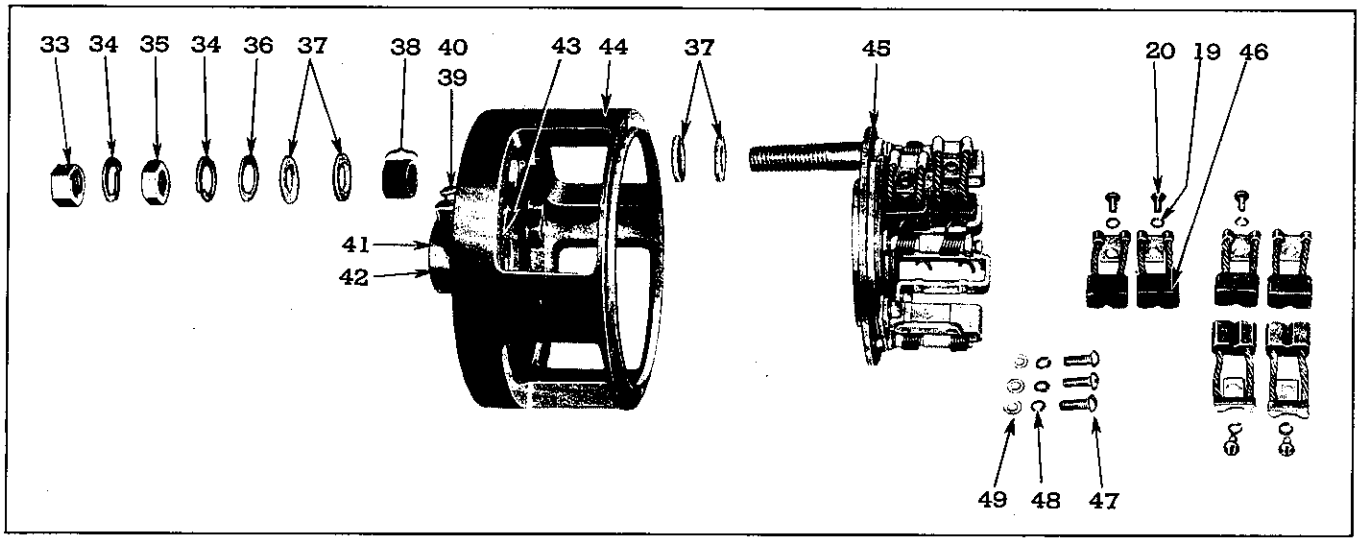


Fig. 17—Commutator End Frame Sub-Assembly.

33. Nut—Terminal Stud.
34. Lock Washer—Terminal Stud Nut.
35. Nut—Terminal Stud.
36. Washer—Plain—Terminal Stud.
37. Washer—Insulating—Terminal Stud.
38. Washer—Insulating—Terminal Stud.
39. Oiler—Commutator End Frame.
40. Oil Wick—Commutator End Frame.
41. End Plug.
42. Bushing—Commutator End Frame.
43. Brake Washer.
44. Frame—Commutator End.
45. Brush Plate Assembly.
46. Brush.
47. Screws—Brush Plate Insulating Plate Attaching.
48. Lock Washers—Brush Plate Insulating Plate Attaching Screw.
49. Washer—Plain—Brush Plate Insulating Plate Attaching Screw.

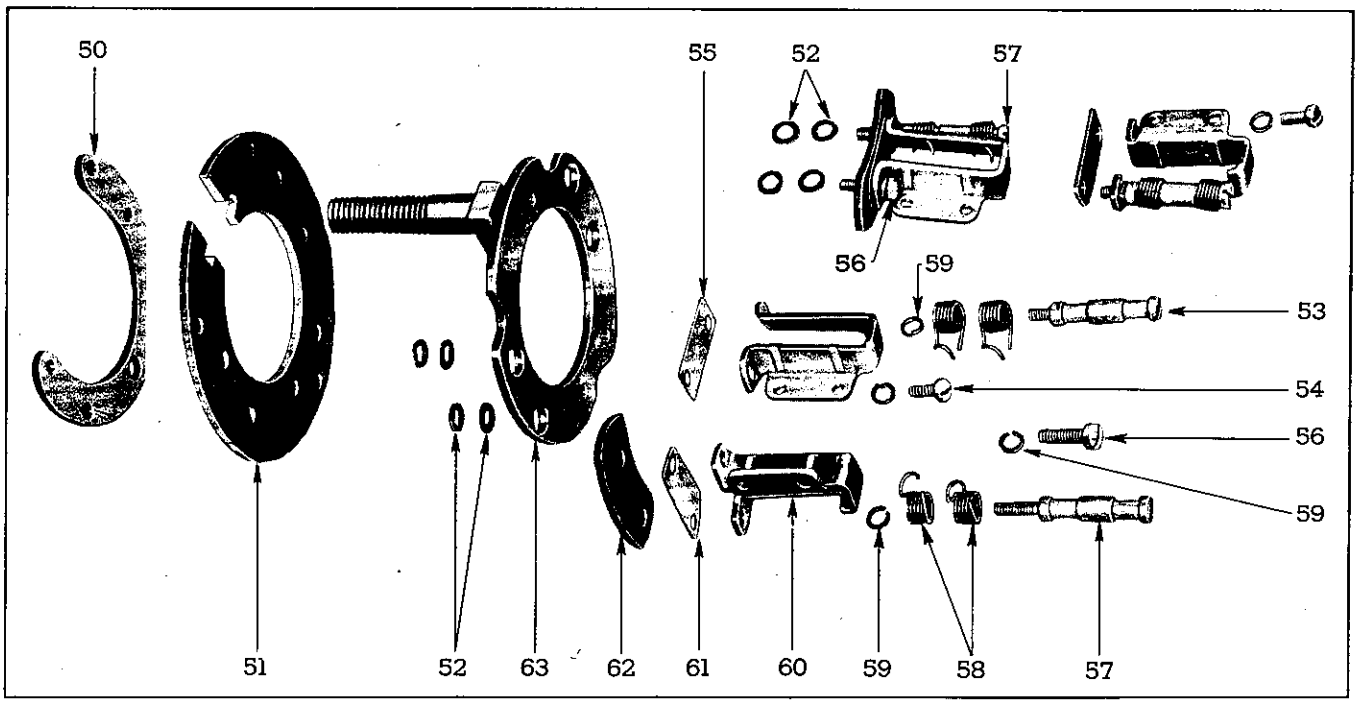


Fig. 18—Brush Plate Details and Relative Location of Parts.

50. Plate—Brush Holder Screw Support.
51. Plate—Brush Plate Insulating.
52. Washer—Brush Plate Screw Insulating.
53. Screw—Brush Holder—(Long-Grounded Brush).
54. Screw—Brush Holder—(Short-Grounded Brush).
55. Plate—Brush Holder Space—(2 Hole—Grounded Brush).
56. Screw—Brush Holder—(Short—Insulated Brush).
57. Screw—Brush Holder—(Long—Insulated Brush).
58. Brush Spring.
59. Lock Washer — Brush Holder Screw.
60. Brush Holder.
61. Plate—Brush Holder Space—(2 Hole—Insulated Brush).
62. Plate—Brush Holder Insulating —(2 Hole).
63. Brush Plate and Terminal Stud Assembly.

and (97), Fig. 22, remove lock washers (34) and (98). Cable assembly (3) may now be removed.

2. Remove cotter key (8) and pull pin (7).

3. Unscrew four solenoid mounting screws (9) and remove four lock washers (10). Solenoid assembly (5) may now be removed from field frame assembly (4).

4. Unscrew five motor drive housing screws (13) and remove five plain washers (14) and five lock washers (15). Lock washers (15) should be discarded. Grasp drive end housing (12) and pull away from field frame assembly (4). When armature shaft (23) is free of bushing (80) (See Fig. 20) manipulation of the drive end housing (12) will free the stud on the Dyer shift lever (75) from the slot in the shift sleeve (27). Drive end housing (12) with shift lever attached, can then be removed.

5. Remove motor drive pinion stop collar cotter pin (32). Pinion stop collar (31) may now be removed from armature shaft.

6. Grasp shift sleeve (27) and pull shift sleeve away from armature core. Motor drive pinion (30), motor drive pinion meshing spring (29), and motor drive pinion guide (28) will turn off the armature shaft along with the shift sleeve (27). Cupped space washer (26) can now be slipped from armature shaft along with space washer (25).

7. Grasp center bearing (11) and pull away from armature core. Space collar (24) can now be pulled from armature shaft. Press bushing (16) from center bearing. Oiler (17) and oil wick (18) can be removed.

8. Remove cover band (1) by prying under snap with a screw driver. Unscrew two brush lead screws (20) which connect ends of two field coils to brush lead clips. Remove two lock washers (19). Unscrew four commutator end frame attaching screws (21), remove four plain washers (14) and four lock washers (15). (Discard lock washers (15). Commutator end frame assembly (2) may be removed from field frame assembly (4).

II. Disassemble Commutator End Frame—

1. Refer to Fig. 17 and unscrew terminal stud nut (35) and remove lock washer (34), plain washer (36), two insulation washers (37) and eight insulation washers (38). Unscrew six brush lead attaching screws (20), remove six lock washers (19). This allows brushes (46) to be removed from brush holders (60). Refer to (8) under "Disassembly Into Main Sub-Assemblies," for removal of other two brush lead screws (20) and lock washers (19). Unscrew three brush plate attaching screws (47), remove three lock washers (48) and plain washers (49). Brush plate (45) may now be lifted from commutator end frame (44) and two insulating washers (37) removed from terminal stud.

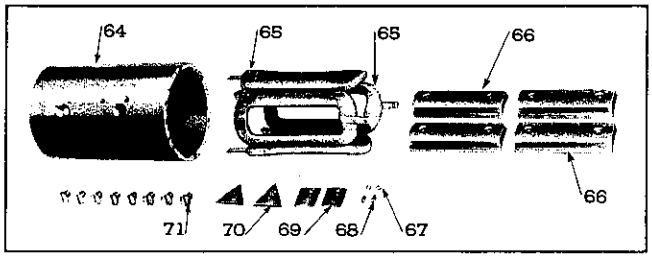


Fig. 19—Field Frame Details and Relative Location of Parts.

64. Field Frame.
65. Field Coil Assembly.
66. Pole Shoes.
67. Lock Washer—Field Coil Ground Screw.
68. Screw—Field Coil Ground.
69. Insulation Strip—Field Coil.
70. Insulation Strip (Triangular)—Field Coil.
71. Screw—Pole Shoe.

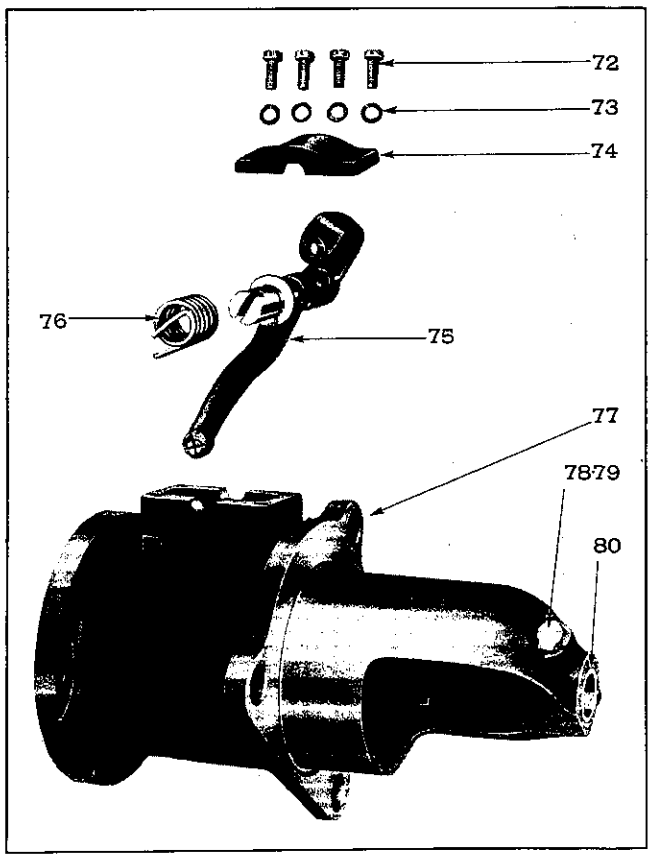


Fig. 20—Motor Drive Housing Details and Relative Location of Parts.

72. Screw—Motor Drive Housing Cover Plate.
73. Lock Washer—Motor Drive Housing Cover Plate Screw.
74. Cap.
75. Shift Lever.
76. Spring—Shift Lever.
77. Housing—Motor Drive.
78. Oiler.
79. Oil Wick.
80. Bushing.

III. **Disassemble Brush Plate Assembly**—

1. For two insulated brushes unscrew two brush holder screws (56) and (57), (two long and two short). Remove two brush springs (58) from the two long screws (57) also four lock washers (59), two brush holders (60), two brush plates (61), and two insulating plates (62) can also be removed. (See Fig. 18.)
2. For two ground brushes unscrew four brush holder screws (53) and (54) (two long and two short). Remove four brush springs (58) from the two long screws (57), also four lock washers (59). Two brush holders (60), two brush plates (55) may now be removed.
3. Remove brush plate and terminal stud (63) and pull out eight brush holder screw insulating bushing washers (52). These washers are for the four insulated brush holder screws (56) and (57).
4. Separate brush holder screw support plate (50) from brush plate insulating plate (51).

IV. **Disassemble Field Frame Assembly**—

1. Unscrew two field coil ground screws (68) (See Fig. 19) and remove two lockwashers (67). Using screwbit and brace unscrew eight pole shoe screws (71). The four pole shoes (66), two field coil assemblies (65), two triangular insulation strips (70), and two square insulation strips (69) may now be lifted out of frame (64).

V. **Disassemble Motor Drive Housing**—

1. Remove end of shift lever spring (76) from slot in shift lever (75). (See Fig. 20.)
2. Unscrew four cap attaching screws (72) and remove four lock washers (73). Cap (74) and shift lever (75) may be removed.
3. Remove oiler (78) and oil wick (79). Bushing (80) may be pressed from housing (77).

VI. **Disassemble Solenoid Switch**—(Refer to Figs. 21 and 22.)

1. Unscrew link assembly (6) from solenoid plunger. (See Fig. 16.)
2. Tilt solenoid case assembly (82) (Fig. 21) and plunger (81) will fall out.
3. Remove terminal end cover (92) by removing bolts (93) and lock washers (94).
4. Remove terminal nut (97) (Fig. 22), lock washer (98), lock nut (99), lock washer (98), plain washer (100), and insulating washer (101) from both copper terminal studs (106).
5. Remove stud nut (107), lock washer (108), nut (107), lock washer (108), plain washer (109) and two insulating washers (110) from insulating stud (113). Remove insulating plate (102) from bracket (103). Remove insulating washer (111) from terminal stud (113).

   Remove terminal stud (113) and motor terminal stud "M" from the two wire terminals attached to the end of the solenoid case assembly.

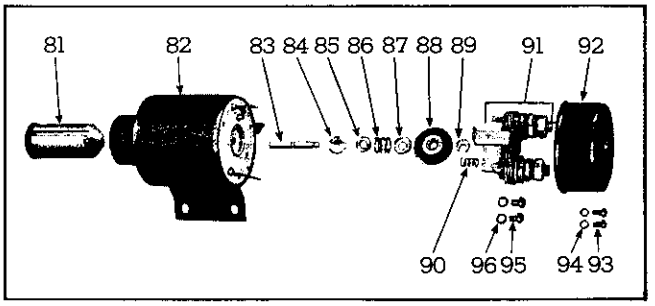


Fig. 21—Solenoid Switch Details and Relative Location of Parts.

81. Plunger.
82. Case and Coil Assembly.
83. Push Rod.
84. Washer—Contact Spring Retaining—Cupped and Slotted.
85. Washer—Contact Spring Retaining—Plain.
86. Spring—Contact Cushion.
87. Washer—Contact Spring Retaining—Cupped.
88. Contact Disc.
89. Washer—Contact Push Rod Retaining—Cupped and Slotted.
90. Spring—Plunger Return.
91. Terminal Bracket Assembly.
92. Cover—Terminal End.
93. Screw—Terminal and Cover.
94. Lock Washer—Terminal and Cover Screw.
95. Screw—Terminal Bracket Attaching.
96. Lock Washer—Terminal Bracket Attaching Screw.

6. Remove two screws (95) (Fig. 21) and lock washer (96) and withdraw bracket (103) (Fig. 22) and insulating plate (104), together with battery terminal (106) and plain washer (114) away from end of solenoid case assembly (82).

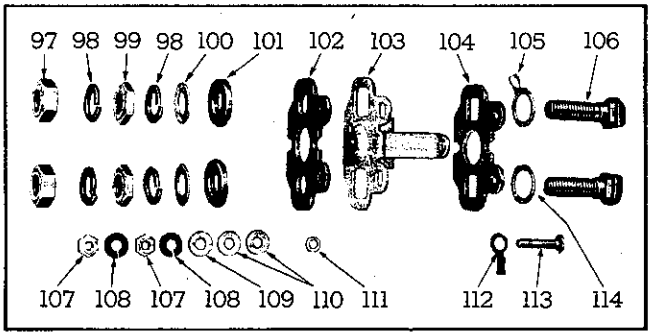


Fig. 22—Solenoid Switch Terminal Bracket Details and Relative Location of Parts.

97. Nut—Terminal Stud.
98. Lock washer—Terminal Stud.
99. Nut—Terminal Stud.
100. Washer—Plain—Terminal Stud (Outside).
101. Washer—Terminal Stud Bushing.
102. Plate—Terminal Stud Insulating (Outside).
103. Terminal Bracket.
104. Plate—Terminal Stud Insulating (Inside).
105. Terminal Clip.
106. Terminal Stud.
107. Nut—Terminal Stud.
108. Lock washer—Terminal Stud.
109. Washer—Plain—Terminal Stud.
110. Washer—Terminal Stud Insulating Bushing.
111. Bushing—Terminal Stud Insulating.
112. Terminal Clip—Small.
113. Terminal Stud.
114. Washer—Plain—Terminal Stud.

7. Remove spring (90) from end of push rod (83); also retainer washer (89).
8. Remove contact disc (88), retainer washer (87), spring (86), flat washer (85) and retainer washer (84) from push rod (83).

VII. **Disassemble Solenoid Switch Terminal Bracket**—

1. Unscrew two terminal stud nuts (99) and remove two lock washers (98). Slide two plain washers (100) from two terminal studs (106). Next remove two insulating washers (101). (See Fig. 22.)
2. Unscrew terminal stud nut (107) and remove lock washer (108). Unscrew next terminal stud nut (107) and lock washer (108). Slide plain washer (109) and two insulating washers (110) from terminal stud (113).
3. Remove two terminal studs (106) and stud (113). Clips (105) and (112) may be removed along with plain washer (114). Pull insulating plates (102) and (104) from bracket (103). Remove insulating washer (111) from metal terminal bracket (103).

Inspection—Commutator End Frame.

1. If bushing is badly worn or damaged, install new bushing.
2. Inspect brake washer. If badly worn or damaged, cement new washer in place.
3. See that all insulating plates and washers are clean, dry and unbroken. Replace all insulation that is not serviceable.
4. Brush holders should permit free action of brushes and be perpendicular to brush plate. Replace if damaged. Screws, short and long, should be straight and have good threads.
5. Brush plate (stud attached) should be smooth and flat. See that stud is securely welded in place. Clean threaded holes with tap if necessary.
6. Springs should be full length, and of proper tension. Use new springs if in doubt.
7. Brush pigtails should be firmly anchored in brushes and in connecting plate. New brush length is ½". If brushes are worn shorter than ¼", replace with new Delco-Remy part.

Inspection—Field Frame.

1. Inspect field coil insulation for breaks. If coil windings are found exposed where they should be covered, replace with new coils.
2. Tapped holes in pole shoes should have full, clean threads. Great torque reaction demands that pole shoes be securely held to frame.
3. See that all tapped holes (at commutator end, at drive housing end, and at solenoid) are clean and have good threads.
4. Make sure that oil cup is clean and cap is firmly seated.

Inspection—Motor Drive Housing.

1. If drive housing bushing is badly worn or damaged, install new bushing.
2. Center bearing plate bushing should be treated as above. Normally, the clearance of the shaft in this bushing is .010" (.005" on a side). Replace only if bushing wall thickness is reduced to an extremely low figure. (.020"-.030".)
3. If necessary, clean threaded holes with tap. Registering surfaces (machined faces—flywheel housing side—field frame side) should be smooth and clean.
4. Shift lever return spring should be inspected for cracks. Coil should be 5½ turns, with shaft locking end parallel to and pointing in same direction as long end that seats on housing. If spring appears to be weak, replace with new part.

Inspection—Solenoid.

1. Examine all insulating strips and washers for charring, oil, grease, dirt, or moisture. Replace parts if necessary.
2. Clean contacts of studs with stiff wire brush. DO NOT GRIND. This insert is tungsten—a valuable metal, and no advantage will be gained by creating a flat surface. Remove scale and dirt only! If pit holes extend down through insert, replace with new terminal studs.
3. Treat contactor disc in like manner. Generally, parts excessively worn, or cracked or broken, should be replaced by new service parts.
4. If wires in terminal housing are damaged beyond repair (broken off short) it will be necessary to use a new solenoid case and coil assembly.
5. Felt seal on end of plunger should make firm contact with passageway in coil. Felt seal prevents dirt and foreign matter from entering plunger tube, and is necessary for continued operation. Felt seal is anchored in place by spunover plunger end, and is a factory process. If felt is badly worn, use a new plunger-seal assembly.

Inspection—Armature.

1. Inspect armature shaft journal for wear. If badly worn or scratched, use new armature assembly.
2. Brake shoe surface should be clean and smooth.
3. Commutator should be trued up in a lathe, and mica under-cut.
4. Make certain that soldered joints are clean and tight.

5. Check coil windings for ground, with one test point on any commutator segment, and the other test point on field laminations. Test armature on growler for continuity.

Inspection—Dyer Drive.

1. Replace thrust washers if badly worn.
2. Shift sleeve, as an assembly, if badly worn, should be replaced with a new unit.
3. Pinion guide should slip freely on shaft. Lugs should not be bent or grooved. Replace with new part if badly worn.
4. If pinion has damaged splines or broken teeth, replace with new part.
5. Pinion spring should have seven full turns and a free length of 2 5/32".
6. If splines on shaft are worn excessively, replace with new armature assembly.

Starting Motor Assembly — All parts having been inspected the starting motor may be as assembled by reversing the sequence of operations for disassembly and referring to Figs. 16, 17, 18, 19, 20, 21, and 22 which are referred to in connection with the build-up of the various sub-assemblies. Illustrations referred to also show the relative positions of the various sub-assemblies.

With these references assemble the starting motor as follows:

VII-A and VI-A. **Assemble Solenoid Switch**—Refer to Figs. 21 and 22 and assemble solenoid switch as follows:

1. Place following parts on push rod (83) in the sequence given: Retaining washer (84) over center slot in push rod (83), plain washer (85) against retaining washer, spring (86) against washer (85), retainer washer (87) with cup side next to spring, contact disc (88) and retainer washer (89).
2. Install push rod assembly into front face of solenoid (82).
3. Place spring (90) over outer end of push rod (83).
4. With flat face of head on motor terminal stud (106) away from contact disc (88) on push rod, place stud on large terminal of wire on face of solenoid. Place terminal stud (113) in other wire terminal.
5. Lay insulating plate (104) down on inside of terminal bracket (103) with holes in plate and bracket in alignment. Put battery terminal stud (106) down through plate and bracket with flattened portion of head on stud away from center of plate.
6. Holding "B" terminal to prevent plate from leaving bracket, set bracket and plate assembly onto end of solenoid with motor terminal stud entering hole in bracket.
7. Attach bracket assembly to end of solenoid using lock washers (96) and screws (95).
8. Set solenoid on bench resting solenoid on supports and once more check terminal (106) to see that flattened portion of head is away from disc on solenoid push rod.
9. Install insulating washer (111) over stud (113) and down into counter-bore of bracket (103).
10. Place insulating plate (102) over studs and next to bracket (103).
11. Assemble the following pieces in turn over stud (113):

    Two insulating washers (110), one flat steel washer (109), one lock washer (108), one nut (107), one lock washer (108) and another nut (107).

12. Install the following pieces in turn over each terminal stud (106):

    One insulating washer (101), one flat washer (100), one lock washer (98), one nut (99), one lock washer (98) and one nut (97).

13. Place cover (92) over terminals and next to end of solenoid (82) and attach with two lock washers (94) and screws (93).
14. Screw link assembly (6) (Fig. 16) into solenoid plunger (81) (Fig. 21) and install plunger into solenoid.
15. ***CAUTION: Any time that the link assembly is removed from the solenoid plunger, or the original adjustment of the link changed in the plunger, the Dyer drive must be readjusted before operating the solenoid switch. (See "Dyer Drive Adjustment", page 21.)***

V-A. **Assemble Motor Drive Housing**—Refer to Fig. 20 and assemble drive housing as follows:

1. Place oil wick (79) into oil wick channel of housing (77) and install oiler (78) over top of wick. Tap oiler into place lightly with wood block to prevent damage to oiler cap.
2. Locate shift lever assembly (75) with long end of lever inside housing (77).
3. Using a lock washer (73) on each bolt (72), install cap (74) and tighten bolts.
4. Replace spring (76) on shaft of lever (75) so that bent end of spring will enter slot in end of shaft and straight end of spring will rest on boss of housing (77). When spring is properly installed, tension of spring will hold lower end of lever toward field frame of starting motor.

IV-A. **Assemble Field Frame**—Refer to Fig. 19 and assemble field frame as follows:

1. Place a pole shoe (66) into each field coil (65) from the inside.
2. Replace two triangular insulating strips (70) and two square insulating strips (69) in the end of the field frame opposite to which the field coils attach to the field frame. The triangular strips are used between field frame and coil at the junction of the coil connections. The square strips are used beneath the terminals of the coils which attach to the brush holders.
3. Heeding marks placed on pole shoes, coils and field frame at disassembly, place the coil and shoe assembly inside field frame (64) and attach the two terminals of field coil to field frame with screw (68) and lock washer (67).
4. Thread pole shoe screws (71) through field frame and into pole shoes. Draw screws tight.

III-A. **Assemble Brush Plate Assembly**—Refer to Fig. 18 and assemble brush plate assembly as follows:

1. Align support plate (50) brush plate insulating plate (51), and brush plate and terminal stud (63) so stud passes through stud opening in (51).
2. Place eight brush holder screw insulating washers (52) in four large holes of brush plate (63).
3. Place small brush plate (61) and small insulating plate (62) against brush holder (60) with holes in alignment on the three pieces. Place this assembly up against brush plate (63) so as to align holes with insulating washers (52).
4. Place lock washer (59) on holder screw (56), and thread screw through brush holder (60), small brush plate (61), small insulating plate (62), brush plate (63), insulating washers (52), insulating plate (51) and into support plate (50). Attach other grounded brush holder in the same manner.
5. Place lock washer (59) over threaded end of long screw (57) and place two springs (58) over body of screw. Position springs on screw so straight ends of spring are up against flat face of brush holder (60); then thread screw into position in holder plate (50) in the same manner as screw (56).
6. Follow above procedure on the other insulated brush holder.
7. Locate two non-insulated brush holders the same as the two insulated brush holders mentioned in Item 5, except, that small insulator plate (62) and insulator washers (52) are omitted and the screws (53 and (54) thread into the large brush plate (63). Install the second non-insulated brush holder in the same manner.
8. Pull the brush terminals up through the brush holders from the inside with the groove in the brushes in line with the track in the holder. Do not position brushes in holders as yet. Fasten brush terminals (46) to brush holders with lockwasher (19) (Fig. 17) and screw (20) at each brush. Repeat this operation on all eight brushes.

II-A. **Assemble Commutator End Frame**—Refer to Fig. 17 and assemble commutator end frame as follows:

1. Place two insulating washers (37), then eight insulating washers (38), over threaded terminal on brush holder plate (45).
2. Locate brush holder assembly (45) into end frame (44) with terminal stud of (45) passing through rear face of (44).
3. Place two insulating washers (37), one flat washer (36) and one lock washer (34) over terminal stud (45) and replace nut (35) finger tight only.
4. Place lock washer (48) and one plain washer (39) over each of the brush plate attaching screws (47) and thread screws through brush plate into rear face of commutator end frame. Tighten nut (35) on terminal stud.
5. While holding curled end of brush spring (58), Fig. 18 up and back, slide each brush up into holder so bottom face of brush is approximately half way up into holder. When spring is released contact will be made at side of brush and spring tension will keep brush suspended in this manner.

1-A. **Assemble Starting Motor Assembly to Field Frame**—Refer to Fig. 16 and assemble starting motor as follows:

1. Heeding the marks originally scribed on the field frame and commutator end frame to establish relationship between parts, assemble commutator end frame (2) to field frame (4) so that terminals of field coils may be attached to the two brush holders. Attach the two field coil terminals to brush holders using lock washers (19) and screws (20).
2. Being sure that brushes are held up in brush holders with springs, as previously mentioned, lubricate bearing and armature shaft and slide armature (23) through coils in field frame with journal entering bearing in commutator end frame (2).
3. Place spacing collar (24) over drive end of armature shaft and next to end of armature.
4. Lubricate shaft with clean engine oil before attaching center bearing. With ribs on center bearing plate assembly (11) facing armature, slide center bearing onto shaft and up against field frame.

5. Install plain washers (14), new lock washers (15), on the four bolts (21) and attach the commutator end frame (2) to field frame (4). After tightening bolts, bend ears of lockwashers to prevent bolts from turning.
6. Using small-nosed pliers to relieve tension on brush springs, push brushes into place against commutator with ends of springs resting on top faces of brushes.
7. **Assemble Dyer Drive as Follows**—(See Fig. 16).
   (a) Place the following parts, in sequence given on the drive end of the commutator shaft: Plain washer (25), cupped space washer (26), with cup side of washer away from field frame as shown in Fig. 16, and shift sleeve (27). Place spring (29) inside of hollow pinion (30) with drive pinion guide (28) next to spring with ears on outside diameter of guide facing pinion. Start ears into slots in pinion and hold guide approximately half the distance down slots, then start pinion guide and spring assembly onto splines of armature shaft. Pinion and guide assembly cannot be started onto shaft unless ears on guide are held down into slots in pinion.
   (b) Slip pinion stop (31) in place with cotter pin hole toward end of shaft. When lugs on stop enter groove on shaft, rotate stop until cotter pin holes align. Insert cotter pin (32) and secure in place.
8. Slip the drive end housing assembly (12) over end of armature shaft and against center bearing plate (11), guiding finger of shift lever (75) into slot of shift sleeve (27). (See Fig. 20.)
9. Put plain washer (14), then a new lock washer (15) over each bolt (13) and attach parts (12) and (11) to field frame (4).
10. Replace cover band (1) over openings in commutator end frame (2).
11. Attach solenoid assembly (5) to field frame (4).
12. Adjust Dyer Drive as outlined below:

Dyer Drive—Adjustments—The Dyer Drive is properly adjusted before leaving the factory.

When the shift lever is in the extreme forward position and the switch contacts in the solenoid are closed, there should be at least 1/8" to 3/16" travel of the pinion against the pinion spring pressure, as indicated in Fig. 23. This adjustment can be checked easily by disconnecting the lead from the solenoid to the starting motor and using the battery current through the solenoid to hold the shift lever in the forward position. Since disconnecting this lead opens the pull-in coil of the solenoid, it may be necessary to assist the movement of the plunger by hand, to assure that the plunger will reach its extreme travel position, closing the switch contacts. The starting motor armature will not revolve with this lead disconnected. The pinion travel can be checked by pushing the pinion back against the spring pressure. Since observing the pinion engagement with the flywheel is very difficult with starting motor in place, the motor assembly may be removed and supported in a bench vise to conduct this test. A storage battery may be connected as described above to conduct the test. ***The adjustment can be changed by temporarily disconnecting the shift lever from the plunger linkage and turning stud IN or OUT of the solenoid plunger as necessary.***

A test can be made to determine if the engagement action is being completed before the switch contacts

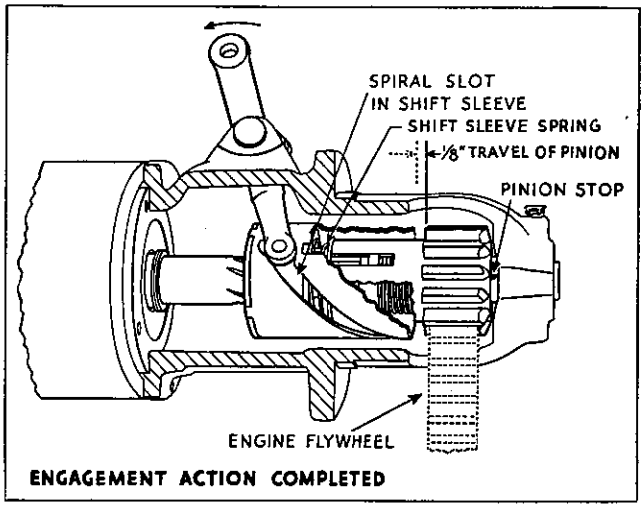


Fig. 23—Adjustment for Dyer Drive Pinion Travel.

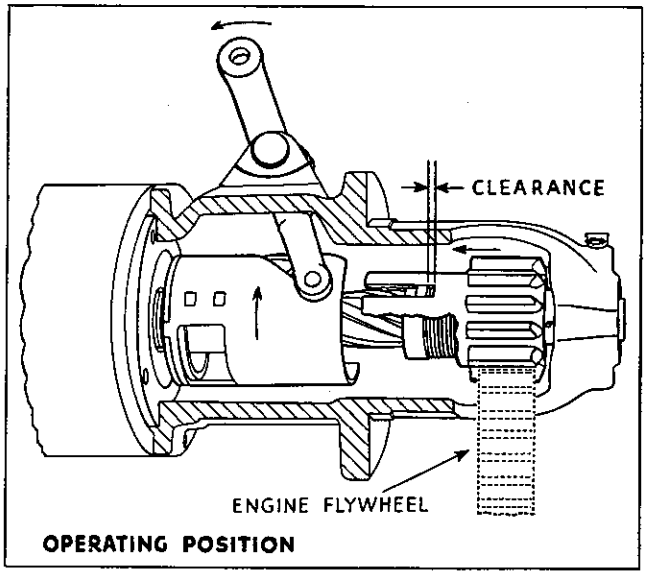


Fig. 24—Clearance Between Pinion Guide and Slot for Proper Pinion Engagement.

are closed. This can be done by placing a ¾" spacer between the pinion and the pinion stop. The shift lever can then be moved forward, forcing the pinion against the spacer. It should not be possible to close the switch contacts with the spacer inserted. For this check, reconnect the lead from the solenoid to the starting motor so armature will turn if switch contacts are made before pinion strikes the ¾" spacer. This adjustment can be changed by screwing the solenoid plunger in or out as mentioned above.

When the pinion is in the driving position, as shown in Fig. 24, there should be clearance between the pinion guide and the bottom of the slot, as indicated. If there is no clearance at this point, the drive will be taken directly from the lugs on the pinion guide rather than from the heavy spline in the pinion itself. If it is found that there is no clearance at this point, the pinion and the pinion guide should be replaced. The pinion with its lock and lock spring is released by moving the pinion shift sleeve forward and along the splines of the shaft. In reassembling the parts, the pinion lock lugs should be in the slots in the pinion hub with the lugs toward the pinion, or it will not be in the proper position to lock on the shaft.

STARTING SOLENOID

(Hydraulic Governor Actuating)

Description—The solenoid assembly shown in Fig. 25 is mounted on top of the hydraulic governor and wired into the electrical starting system as shown in the wiring diagram on Page 23. The action of the solenoid plunger when energized is transmitted through the stud (7) and link (9) to the fuel rod of the governor and serves to move the rod from NO FUEL to FULL FUEL position and thus effect rapid starting. The solenoid remains energized until the engine has started and the governor has picked up control of the throttle mechanism. (See Sec. 16 for details of solenoid operation.)

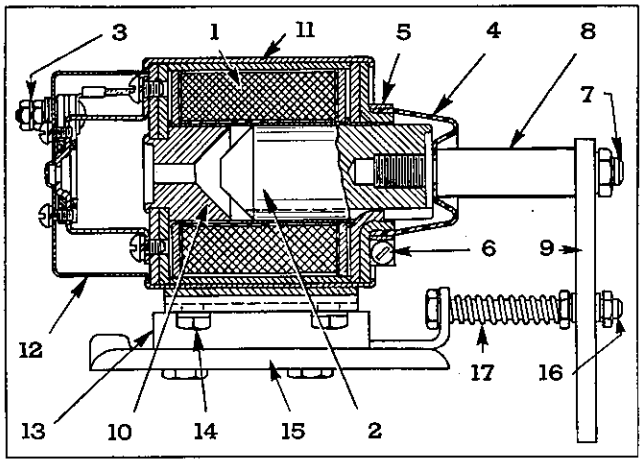


Fig. 25—Starting Solenoid Assembly.

1. Winding.
2. Plunger.
3. Terminal.
4. Rubber Shield.
5. Retainer—Rubber Shield.
6. Retainer Screw.
7. Stud.
8. Spacer.
9. Link.
10. Solenoid Core.
11. Solenoid Case.
12. Cover—Terminal Stud.
13. Adaptor—Solenoid-to-Governor Cap.
14. Bolts—Solenoid-to-Adaptor Attaching.
15. Governor Cap.
16. Guide Bolt.
17. Spring—Plunger Return.

The solenoid is a rugged, heavy duty unit, consisting principally of a core (10) and windings (1) which, when energized, act to move the plunger (2) from its extended at-rest position in and against the cone of the core. The three major parts are suitably housed and supported in a sheet metal case to which is welded a mounting bracket. Leads from the sealed-in windings are attached to the terminal studs (3) which are fully insulated from the solenoid case. A removable metal cover (12) is provided at the terminal end of the case to protect leads, studs, and insulators from possible damage, while a rubber shield (4), opposite the terminal end, serves to keep dirt and foreign matter away from the plunger.

Lubrication—While no lubrication is required on the solenoid, it may be advisable to occasionally place a drop or two of engine oil on the guide bolt (16) at the hole in the adaptor. Oil at this point will help prevent occurrence of any bind.

Service—Because of the heavy construction of the starting solenoid, and its mechanical simplicity, service operations on this part are unnecessary. However, should difficulty be encountered, or the solenoid damaged through accident, it will be necessary to replace the entire assembly as a unit.

The solenoid may be removed from the governor by removing the nuts and lock washers from the four solenoid-to-adapter bolts (14), disconnecting the cable leading to the starting motor, removing the nut and lock washer from the guide bolt (16) and then lifting the assembly off the governor and adaptor.

The remaining attached parts—stud (7), spacer (8), and link (9)—may be removed from the inoperative solenoid, attached to the new service part, and the entire assembly then replaced on the governor by reversing the procedure for removal.

WIRING

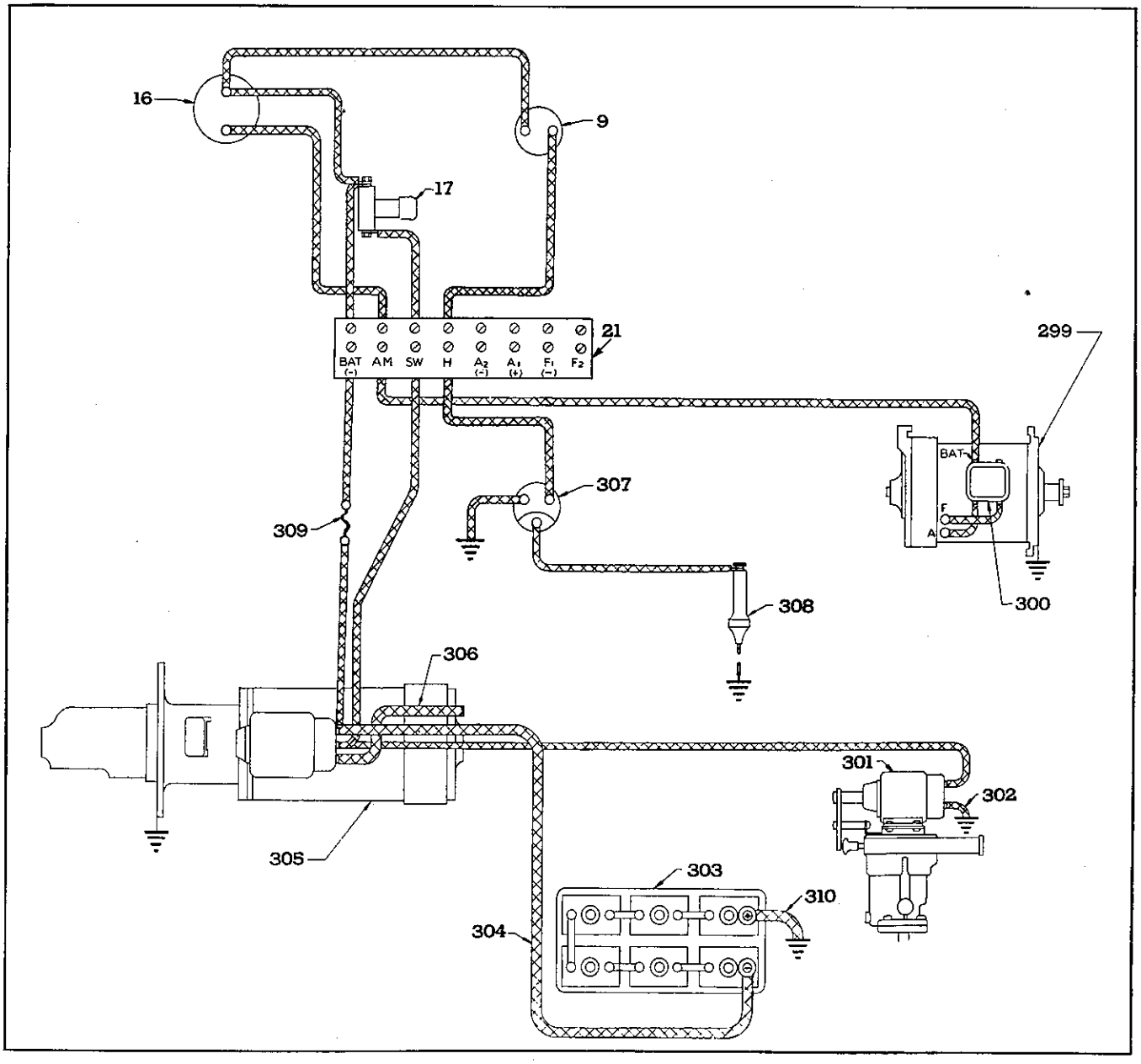


Fig. 26—Typical Electrical Starting System Wiring Diagram (12 Volt)

9. Switch—Air Heater.
16. Ammeter—Battery Charging.
17. Switch—Starting Motor.
21. Terminal Block (Used on Generator Sets With Control Cabinets Only).
299. Generator—Battery Charging.
300. Voltage Control Unit.
301. Starting Solenoid Assembly
302. Ground Lead—Starting Solenoid.
303. Storage Battery.
304. Cable—Storage Battery-to-Starting Motor.
305. Starting Motor Assembly.
306. Cable—Starting Motor to Solenoid Starting Switch.
307. Coil—Air Heater.
308. Electrode—Air Heater.
309. Fuse.
310. Cable—Storage Battery to Ground.

Series 71 Power Units are equipped with 12 volt or 24 volt starting systems depending upon the starting motor or charging generator requirements.

Due to the high voltage of the starting circuit and the amount of power available from the storage battery, it is imperative that every precaution be

observed in guarding against the possibility of a short circuilt or a ground in the system.

All wires should be of sufficient size to carry the electrical load to which they are subjected without overheating. Use stranded wire and cable throughout the installation to guard against breakage due to vibration. Keep all joints clean and tight and solder all terminal clips and other electrical connections. Use only a rosin flux in soldering electrical connections; an acid flux induces corrosion and may cause a high resistance.

Extra heavy insulation must be used on all wires and the wires must be supported at enough points to keep them from moving about and chafing through their insulation. A precaution that should be observed in all high voltage systems is that of insulating all terminals and clips that are ordinarily left exposed. The use of rubber boots, rubber tape, or friction tape and shellac, to cover all unprotected portions of the circuit, will be a big factor in assuring safety in the electrical system. All terminal clips should be large enough and strong enough to take care of both the electrical and mechanical loads to which they are subjected.

NOTE: Necessity for replacing burned fuses will be relieved if the proper measures are taken in protecting the system against short circuits or grounds. TAPE AND SHELLAC ALL EXPOSED TERMINALS. Fuses of the proper capacity should be used in accessory or lighting circuits wherever indicated, and should be of capacity required to give ample protection.

ENGINE MOUNTINGS

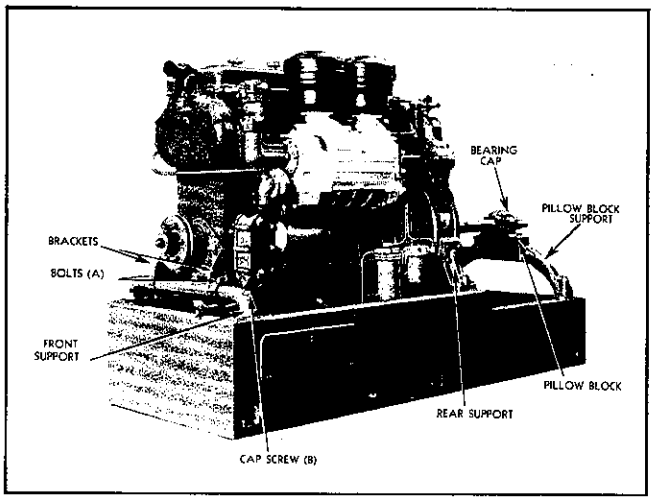


Fig. 1—Rigid Engine Mountings—Used with Power Take-off Units.

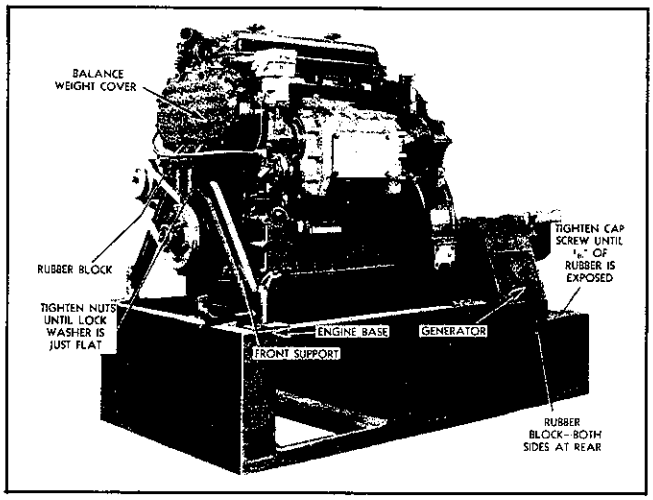


Fig. 2—Rubber Engine Mounting—Used with Generator Sets.

Description—Rigid engine mountings are used on units equipped with power take-off and rubber mountings on units equipped with industrial generators.

The front support for the rigid mounting is bolted either to the crankshaft front cover near each end of the cover, as shown in Fig. 1, or to a flange in connection with the balance weight cover. When the rigid mounting is bolted to the balance weight cover, the wishbone support is used, as shown in Fig. 2, and a solid block is substituted for the rubber block. Both outer ends of the front support are bolted to the engine base.

The two rear supporting brackets for the rigid mounting attach to a pad at each side of the flywheel housing at the upper ends, and rest on the engine base at the lower ends.

When a long power take-off shaft is used requiring an outboard bearing, a pillow block mounted to a support on the engine base carries a ball bearing to absorb the load on the outer end of the shaft.

When rubber engine mountings are used, they are located as illustrated in Fig. 2.

Service—Changing Engine Mountings—Rigid. The front support for rigid engine mounting may be loosened by removing the two through bolts (A) that attach the mounting brackets to the support, and the two cap screws "B" that attach the support to the engine base. After loosening the attaching bolts "A" and "B," and before attempting to remove the support, raise and block up the front end of the engine. (See Fig. 1.)

NOTE: If the front engine support is removed by loosening the bolts which attach the brackets to the engine crankshaft front cover, then the engine should be blocked up before the attaching bolts are removed.

The rear mounting brackets may be changed by supporting the engine at the rear, and then removing the cap screws that retain the brackets.

Replacing Engine Front Rubber Mounting. To replace the engine front rubber mounting:

1. Relieve load of engine on front rubber mounting by means of a chain hoist attached to front lifting bracket of cylinder head.
2. Back off nuts at balance weight cover holding rubber block between cover and front engine support and remove rubber block.
3. Replace front rubber block by slipping block between balance weight cover and support—exposed rubber face on support—and let weight of engine rest on rubber.
4. Install the two supporting bolts from the top. Draw nuts of bolts up until the spring is just removed from the lockwasher under each nut.

Replace Engine Rear Rubber Mountings. To replace the engine rear rubber mountings:

1. Loosen nuts and remove the two hold-down bolts at generator frame to engine base at each side of generator.
2. Attach chain hoist at generator lifting hook and raise generator *just enough* to remove rubber blocks.

3. **Replace:** The rear rubber blocks are retained inside and bonded to a rectangular steel housing open on one face. When installed, the exposed face of the rubber rests on the engine base.

With generator raised just enough so that rubber blocks may be slid into position, locate both blocks. Using one of the special rubber grommets—bonded to a steel washer at both faces—under each cap screw head, put cap screws down through generator frame, rubber block, and tighten into engine base.

The rubber block will be under the proper tension when the edges of the steel retainers for the rubbers are 1/16" from engine base.

POWER TAKE-OFF

Description—The power take-off consists of a clutch mounted to the flywheel. A shaft, driven by the clutch, is mounted at each end on a ball bearing and near the center (rear of the clutch) on two taper roller bearings. The clutch housing, supports the shaft taper roller bearings and the clutch operating mechanism. A support, mounted on the engine base at the bottom, with a pillow block at the top, contains a ball bearing for the power take-off shaft. (See Fig. 1.)

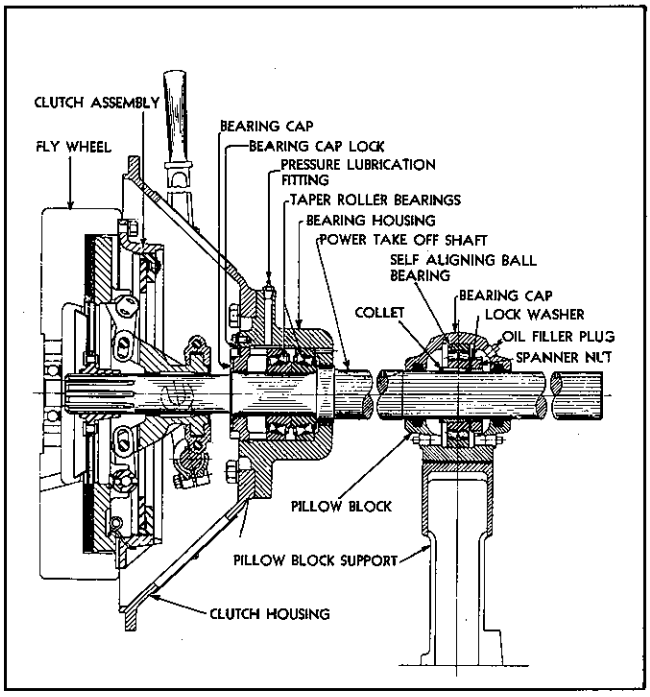


Fig. 1—Power Take-off Assembly.

CLUTCH

Description—The clutch is a single-plate, dry-disc, Over-Center cam-engaging type, with screw-thread adjustment between an adjusting ring and backing plate.

The construction of the clutch is the same for all models, the details differ only to accommodate the three sizes of driven plates. (See Fig. 2.)

A 14-inch clutch (11-inch drive plate), type PTA-111, is used on the 3-71 engine; a 15½-inch (12-inch drive plate), type PTA-112, is used on the 4-71 engine; and a 17-inch (13-inch drive plate), type PTA-113, is used on the 6-71 engine.

The clutch back plate "A" is bolted to the rear face of the flywheel and carries most of the clutch weight (adds to the flywheel effect). A pressure plate "K" with flat ground surfaces is driven by lugs engaging in slots in back plate "A."

Two camshafts "D," carrying hardened rollers "C," operate between a steel ring "G," attached to an adjusting ring "H," and hardened steel plates inserted in the pressure plate "K." A driven plate "B," faced on both sides, and splined to the power take-off shaft, is engaged between the flywheel rear face and the clutch drive plate when the operating sleeve "E" is forced inward by the operating collar "F." The adjusting ring "H" is locked in position with a lug "J," carried on the adjusting ring "H" and locked in slots in the backing plate "A." A series of springs "L" maintains complete clearance between the driving and driven members when the clutch is disengaged.

Operation—Threaded into the back plate is an adjusting ring "H," with which is used the adjusting ring plate "G." Turning the adjusting ring clockwise or counter-clockwise, decreases or increases respectively, the distance from the pressure plate to the adjusting ring plate, between which the double-end roller bearing camshafts "D" must operate.

The roller bearing camshafts "D" are operated by means of the operating or release sleeve "E." Fig. 2, shows what takes place when the camshafts are in the "released," "on-center," and "over-center," positions. The hardened rollers in the ends of each camshaft contact the hardened steel inserts in the pressure plate, and the adjusting ring plate, and in the engaged position exert a pressure from the adjusting ring plate to the pressure plate, which pressure in turn is applied to the faced clutch plate "B" and flywheel face.

The bronze-bushed operating or release sleeve "E" is moved forward to engage, or backward to release, by the release bearing "F," through means of trunnion connections to a fork which, in turn, is connected through a cross-shaft to the operating handle. The release bearing "F" remains stationary, and is clamped around a collar on the rotating operating or release sleeve.

The faced clutch plate "B" is driven by the friction created by the pressure plate "K" and the flywheel face when the clutch is engaged, transmitting power to the splined clutch shaft. The front end of the clutch shaft is supported in a pilot bearing mounted in the flywheel, the outer end in turn being connected to the equipment driven by the engine or power unit. With the clutch disengaged, friction between the pressure plate, faced clutch plate, and flywheel, is relieved, and the faced clutch plate comes to a

standstill, as does the clutch shaft. Then, with the engine idling, the clutch back plate or cover assembly continues to rotate with the flywheel, and the bronze-bushed clutch operating or release sleeve rotates around the stationary clutch shaft.

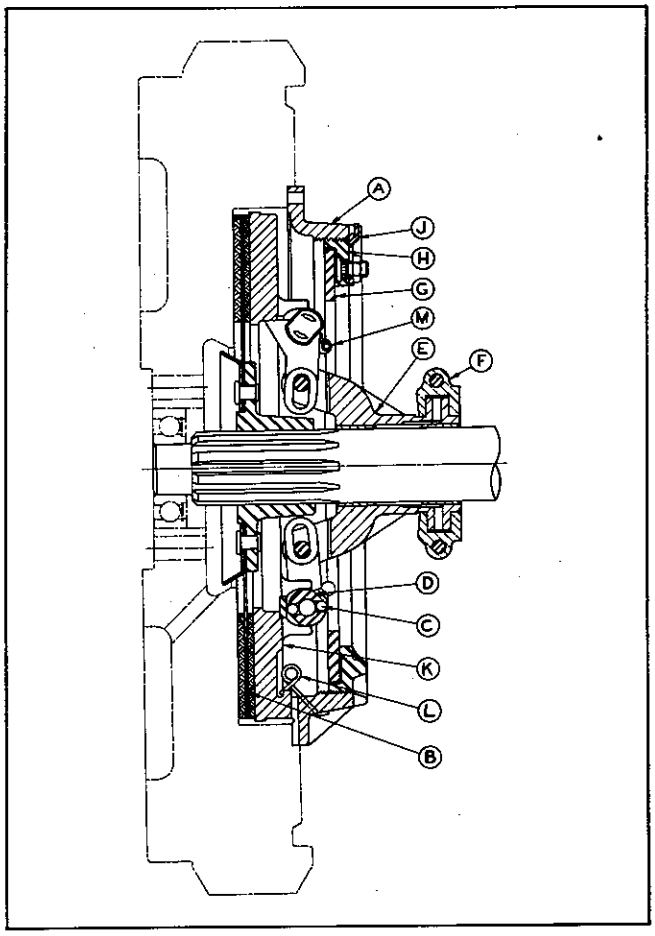


Fig. 2—Clutch Assembly.

Power Take-off—Shaft and Bearings—The power take-off shaft on some installations is mounted on a pilot ball bearing in the flywheel at the inner end and two taper roller bearings in the clutch housing at the rear end. An additional outboard self-aligning ball bearing is used on the outer end of the take-off shaft. The belt pulley is located between the taper roller bearings and the outboard bearing.

The two taper roller bearings are assembled into a housing, which is in turn bolted to the clutch housing. The two bearings are placed back to back, to take thrust in both directions, as shown in Fig. 1. The outer bearing inner race abuts against a shoulder on the shaft, the front bearing shoulders against the outer bearing, and the assembly is held in place with a bearing cap screwed into the housing and locked with a retainer. Lubricant is retained in the bearing housing by reverse threads in the bearing housing end cap.

The outboard ball bearing is mounted in a pillow block, which in turn is mounted to a support bolted to the engine base. The bearing assembly may be shifted endwise in the pillow block, but is restrained radially by the bearing cap. The inside diameter of

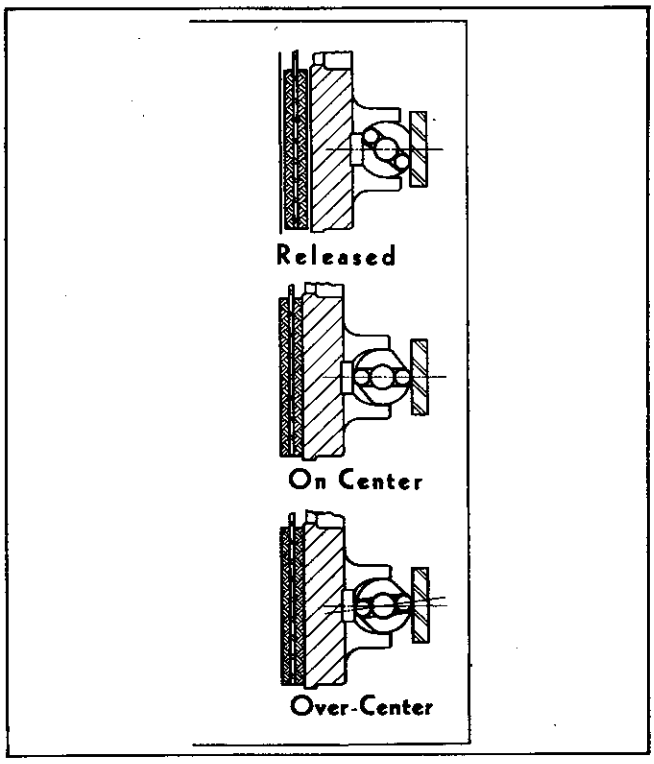


Fig. 3—Clutch Cam Positions for Full Clutch Release, On Center, and Over Center (Full Engagement).

the inner race of the bearing is tapered and rides on a corresponding taper on the outside diameter of a split sleeve (collet), which may be shifted on the shaft and locked in any desired position. When the collet lock nut is tightened, the bearing is locked to the collet and the collet to the shaft. This construction permits sliding the bearing assembly on the shaft and within the pillow block, to allow for any endwise variation in pillow block support mounting.

Power Take-off—Lubrication—There are four points for lubrication on the power take-off: One for the clutch release bearing, located on the side of the clutch cover; one for the taper roller bearing in the rear of the clutch cover; one for the cams in the clutch assembly; and one for the ball bearing at the rear end of the power take-off shaft. The first three points mentioned are lubricated by means of pressure fittings; and the ball bearing at the rear end of the power take-off shaft is lubricated through a removable filler plug.

A good grade of chassis lubricant should be used through the pressure fittings, and regular transmission lubricant (S. A. E. 90 for winter, S. A. E. 160 for summer) should be used in the cavity for the ball bearing at the rear end of the power take-off shaft.

The clutch release bearing should be lubricated after each 5 hours of operation if clutch is engaged and disengaged frequently. The taper bearing in the rear of the clutch cover should be supplied with grease (three or four strokes of gun) after each 150 hours of operation. The cams should be lubricated (three or four strokes of gun) after each six months of operation. The cavity for the ball bearing at the rear end of the power take-off shaft should be examined after 500 hours of operation, and THE LOWER HALF OF THE TRUNNION BLOCK SHOULD NEVER BE CARRIED MORE THAN TWO-THIRDS FULL OF LUBRICANT, OTHERWISE THE BEARING MAY OVERHEAT. To determine the level of the lubricant in the bearing, it may be necessary to remove the trunnion cap.

Clutch and Power Take-off Service—Because of such features as anti-friction roller camshafts, hardened steel inserts in pressure plate, hardened steel adjusting ring plate, and the use of high grade woven clutch plate facings, an unusually small amount of service is required on Over-Center Clutches. The frequency of required adjustments has also been greatly reduced as a result.

Of considerable importance is the proper lubrication of the operating collar or release bearing "F," as well as the release sleeve "E."

Clutch Adjustment—At the first indication that the clutch is slipping after being fully engaged, an adjustment should be made immediately. This is accomplished by removing the hand-hole cover plates on the clutch housing, releasing the adjustment lock "J" and then turning the adjusting ring "H" clockwise, two or three notches at a time or until a very firm but not excessive pressure on the clutch control lever is required to engage the clutch fully. Then be sure to turn back the adjustment lock into a notch in crown of back plate "A."

Turning of the adjusting ring "H" can best be accomplished with a ⅜" diameter steel rod having a blunt end, inserted through the hand-hole in clutch housing and engaging the end with one of the holes in the adjusting ring, then forcing the adjusting ring around to the required position.

Change Clutch Facings—Eventually the facings on the clutch plate will wear to a point where they will have to be replaced. the frequency with which facings will have to be replaced, as well as the frequency of adjustments, depends to a great extent on the type of service for which the clutch is used. Service calling for frequent engaging and disengaging will cause more facing wear than service where engagements and disengagements are infrequent Then too, if the conditions are such that engaging is accomplished slowly, permitting the clutch to slip considerably before final full engagement, the facings will wear much more rapidly than with quick engagements. Frequent engagement, or partial engagement of an extended duration, causes slippage and rapid wear of the clutch plate facings; excessive heating may also result, causing damage to other parts of the clutch. Therefore, this should be avoided as much as possible, and the clutch kept in proper adjustment at all times. Both facings should be replaced, using the facings and rivets specified by the parts list applying to the engine model being used, or use a new driven plate with facings attached. It will be necessary to remove the clutch housing and power take-off assembly and the clutch assembly from the engine to change a clutch driven plate.

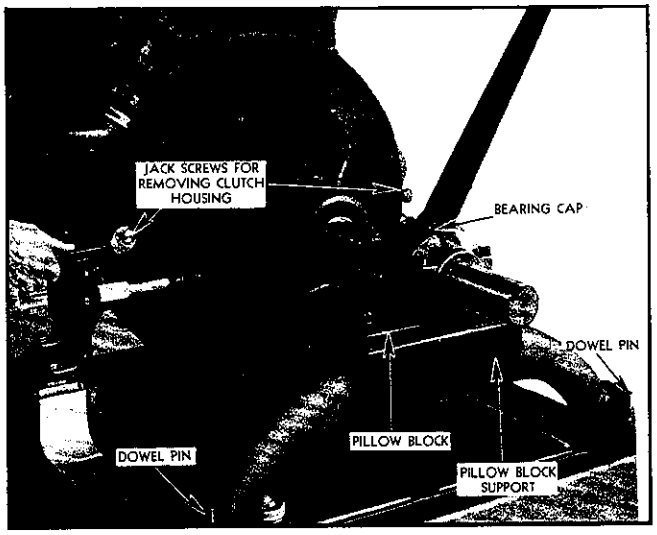


Fig. 4—Removing Clutch Housing from Flywheel Housing.

Remove Clutch Driven Plate—The following operations are necessary to remove the clutch driven plate.

1. Loosen the pillow block support for the rear power take-off bearing at the engine base by removing two cap screws and backing out the two dowel pins as far as possible.
2. Remove the cap screws which attach the clutch housing to the flywheel housing. Since the clutch housing pilots into the flywheel housing, considerable force may be necessary to separate the former from the latter. To facilitate separation of the two housings, two ½"-13 cap screws may be screwed into holes provided in opposite sides of the clutch housing flange. Turning the screws down evenly to bottom on the flywheel housing, as shown in Fig. 4, will separate the two pieces.

3. Pull the clutch housing and pillow block support back sufficiently to free the power take-off shaft from the clutch.
4. Remove the cap screws which attach the clutch assembly to the flywheel, and remove clutch and driven plate.
5. With driven plate removed, the old facings may be loosened from the plate and new facings installed, using the specified facings and rivets.

Disassemble Clutch—When removing a driven plate, advantage should be taken of the opportunity to disassemble the clutch and inspect and replace any worn or damaged parts. The disassembly operations may be performed as follows:

1. Loosen the cap screw and remove the lock "J" from the adjusting ring "H." (See Fig. 2.)
2. Before disassembling the clutch, mark the pressure plate and back plate, so these parts may be replaced in the original relative positions. This will avoid an out-of-balance condition.
3. Remove the adjusting ring by revolving counter-clockwise. This will permit removal of the operating sleeve "E" and camshaft assemblies as a unit.

Inspection of Clutch Parts—Special attention should be given to the return springs "L," as excessive heat may cause these parts to lose their tension. The camshafts "D" should always be replaced in complete sets, as should the hardened steel inserts in the pressure plate "K." If the pressure plate is heat-checked, due to excessive slippage, replacement is advisable. Check the bronze bushing in the release sleeve "E" for excessive wear, as well as the release bearing "F."

Assemble Clutch—After all clutch parts have been inspected and necessary worn parts replaced, the clutch may be assembled by reversing the sequence of operations for disassembly. The important feature to remember when assembling the clutch is to have the positioning marks previously placed on the pressure plate and back plate in line, so not to throw the clutch out of balance. The positioning of the various parts should be as shown in Fig. 2.

Install Clutch to Flywheel—The clutch assembly may be attached to the flywheel as follows:

1. Locate the clutch driven plate next to flywheel face with chamfered side of spline at hub of plate to the rear of the motor.
2. Place the clutch assembly in position at the rear of the flywheel and start the six retaining cap screws into flywheel, then pull cap screws down evenly. Before tightening the cap screws, be sure that the release sleeve is in the release position, which will leave the driven plate free.

NOTE: For attaching the clutch housing and shaft assembly to the engine, see "Install Clutch Housing and Drive Shaft Assembly to Engine," page 4.

Remove Ball Bearing from Rear End of the Power Take-off Shaft—If it becomes necessary to remove the ball bearing from the rear end of the power take-off shaft, the operations may be performed in the following manner:

1. Remove the bearing cap from the pillow block. (See Fig. 4.)
2. Loosen the pillow block support at the engine base by removing two cap screws and backing out the two dowel pins as far as possible.
3. Loosen the lock nut on the bearing sleeve (collet) inside the bearing inner race so that the collet and bearing assembly will slide endwise on the shaft.
4. Pull the pillow block, bearing assembly, and pillow block support, endwise off the end of the shaft.

Remove Taper Roller Bearings—

1. Remove ball bearing from rear end of shaft. (See Fig. 1.)
2. Loosen and remove the clutch housing and shaft assembly from the flywheel housing.
3. Remove the cap screws inside of the clutch housing that retain the roller bearing housing to clutch housing, and slide the shaft and bearing assembly back away from clutch housing.
4. Remove the lock for the roller bearing cap and remove cap by turning counter-clockwise.
5. Support the roller bearing housing in an arbor press and push the shaft back off of bearing inner races.

Bearing Inspection—Thoroughly wash the bearings in clean gasoline and blow out with air, and then repeat the process before inspection. Some light engine oil should be applied to the balls or rollers after cleaning with air and before revolving by hand. The taper roller bearings as well as the ball bearings should run smooth when cleaned and revolved by hand. If the rollers or balls or bearing races show any indication of pitting, the bearing assembly should be discarded.

The bearings should not be revolved by directing air pressure into either the ball or roller assemblies.

Remove Power Take-off Shaft—The power take-off shaft may be removed from its bearings by carrying out the instructions above for removing the shaft rear bearing and the taper roller bearings at the back of the clutch housing.

Replace Bearings and Power Take-off Shaft—Before attempting to install the bearings into their housings or on the shaft, careful observation should be made of the bearing mountings shown in Fig. 1. Note that the taper roller bearings are placed back to back to take thrust in both directions and that the outboard bearing (when used) is locked in position on the shaft with a taper collet and nut. The following order of operations should be observed when installing the bearings and the shaft:

1. Press the two taper roller bearings over the inner end of the shaft and tight against the shoulder with the bearings back to back.

2. Slide the roller bearing housing over the bearings from the rear; then screw cap in place tight against bearing outer race and lock with retainer and cap screw.

3. Bolt roller bearing housing and shaft assembly to the rear face of the clutch housing.

4. **Install Clutch Housing and Drive Shaft Assembly to Engine.** Lubricate pilot bearing with viscous chassis lubricant and slide the inner end of the shaft through the clutch release sleeve with the trunnion started on the clutch yoke. Shift the driven plate with the fingers and push the shaft through the splines of the plate, and continue to slide the assembly into position so that the inner end of the shaft pilots into the bearing in the flywheel. The pilot at the flange of the flywheel housing will, at this time, be started into the flywheel housing. Start the cap screws through the clutch housing and into the flywheel housing finger-tight, then tighten cap screws evenly. The clutch should be released during this entire operation.

5. **Replace Rear Outboard-Bearing and Support:**

   (a) Start the collet and bearing assembly over the outer end of the shaft with threaded end of collet toward rear end of shaft.

   (b) Set the trunnion (bearing lower support) up against the bearing, with bearing cap removed and trunnion bolted to its support.

   (c) Slide the entire assembly along on the shaft so the bearing support bolts can be started in place in the engine base.

   (d) Install the bearing cap temporarily to hold the bearing tight in the trunnion.

   (e) Slide equal thickness of shims under each leg of trunnion support. Use only enough shims so they can be slid in place with the fingers.

   (f) Determine the proper thickness of shims to use under the pillow block support to align the three bearings on the shaft. This is done by mounting a dial indicator as shown in Fig. 5, with indicator button resting on top side of shaft to the rear of the bearing. With engine bolted down tight, note how much the outer end of the shaft springs down when the trunnion support is bolted down tight to the engine base. The required thickness of shims to add under each leg of support will be shown by the indicator. Add this amount of shims and again take indicator readings with support bolted down. The shaft should align within .002" with engine and trunnion support bolted tight to engine base.

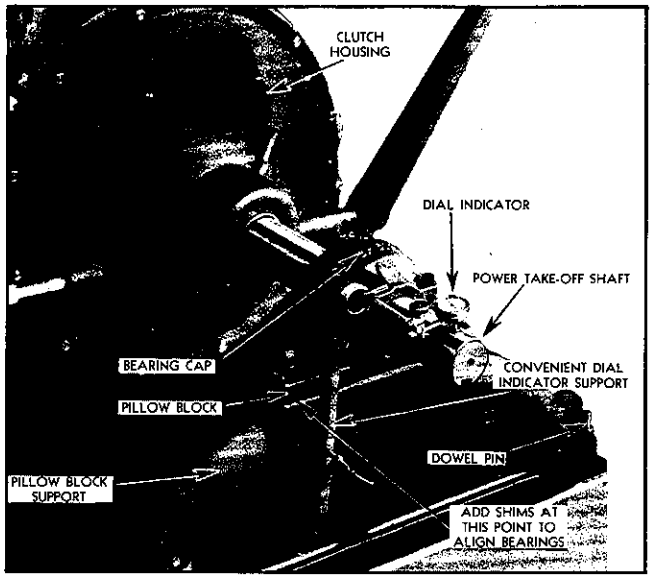


Fig. 5—Indicating Outer End of Power Take-off Shaft for Bearing Alignment.

   (g) Remove the trunnion bearing cap, shift the bearing assembly endwise, if necessary, to locate bearing centrally in the trunnion block, and screw the collet nut tight and lock with tongued washer.

   (h) Fill bearing cavity in lower pillow block two-thirds full with good quality transmission lubricant (S. A. E. 90 for winter or S. A. E. 160 for summer) and bolt trunnion cap into place.

ENGINE INSTALLATION

Whenever possible, the power plant should be mounted to prevent dirt blowing onto the engine. This is particularly true in connection with stone crushers, gravel machinery, etc. In certain installations where the air is laden with lint or chaff, it may be necessary to surround the air cleaner with a large area of fine mesh screen to keep the lint particles from plugging the air cleaner.

If the unit is to be set up inside a building, provision should be made for ample air circulation for the radiator and blower. If the room is small, the temperature high, and the circulation poor, the radiator should be exposed to an outside air supply.

Consult manufacturers representative for recommendations when radiator is to be set up remote from the engine

If the exhaust pipe loops to form a trap or rises in a vertical direction, a drain should be provided at the lowest point to expel the water from the exhaust. Open the drain when stopping the engine and leave open until the engine is again started. A horizontally inclined exhaust pipe should slope away from the engine for drainage. Long exhaust pipes or air intake pipes should be enlarged by one pipe size for each ten feet in length.

On those units which are not supplied with a muffler as standard equipment, and where a silencing device is desirable or demanded without the use of a muffler, a pit suitably constructed makes a very satisfactory silencing chamber. Such a pit may be excavated from a bank and filled with large, loose stones with one side, at the bottom, open for drainage. The exhaust pipe should run down near to the bottom of the pit where it is surrounded with stones.

If the pit is excavated from solid ground and surrounded with earth on the four sides, the inner walls should be concreted and a drain provided at the

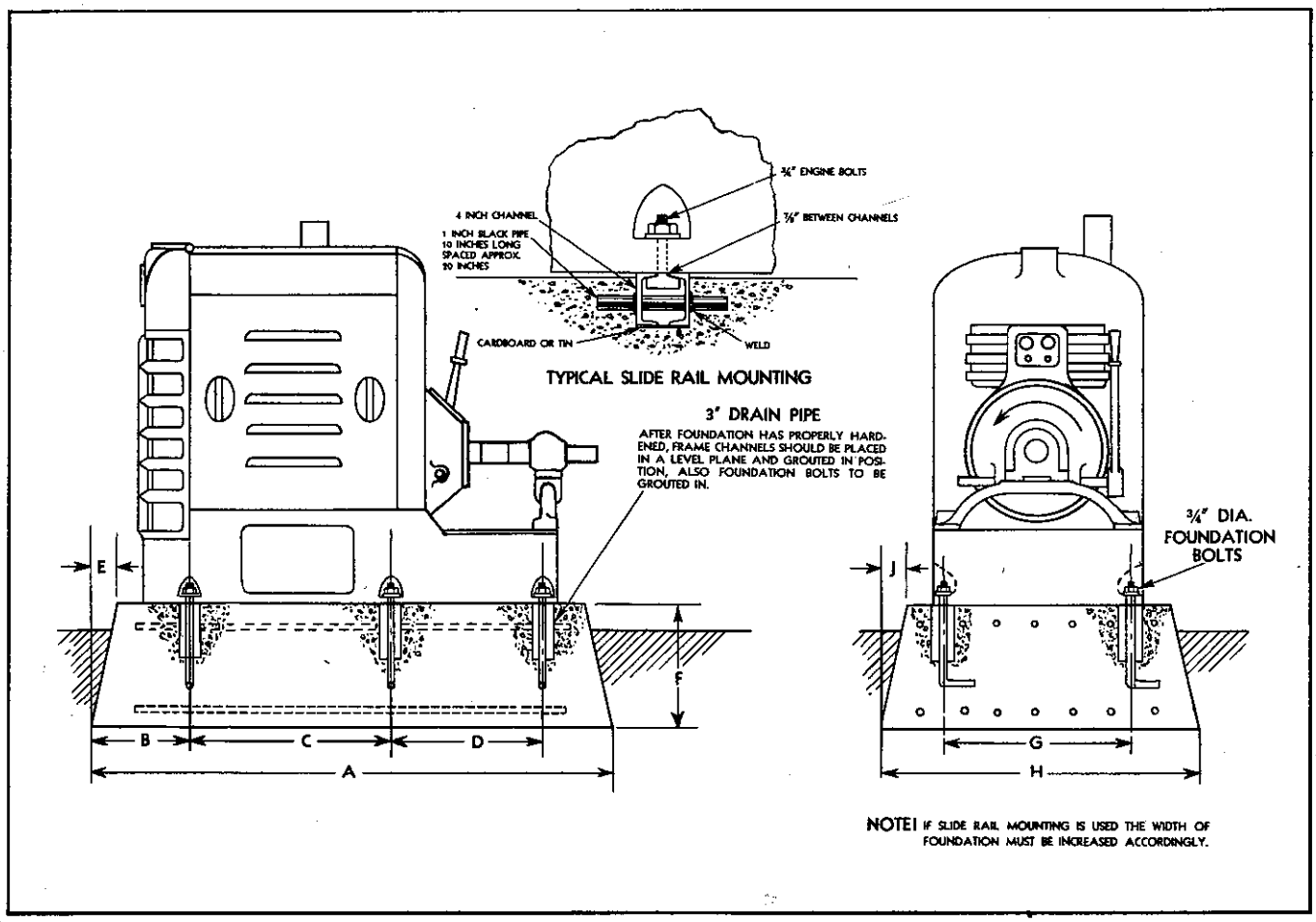
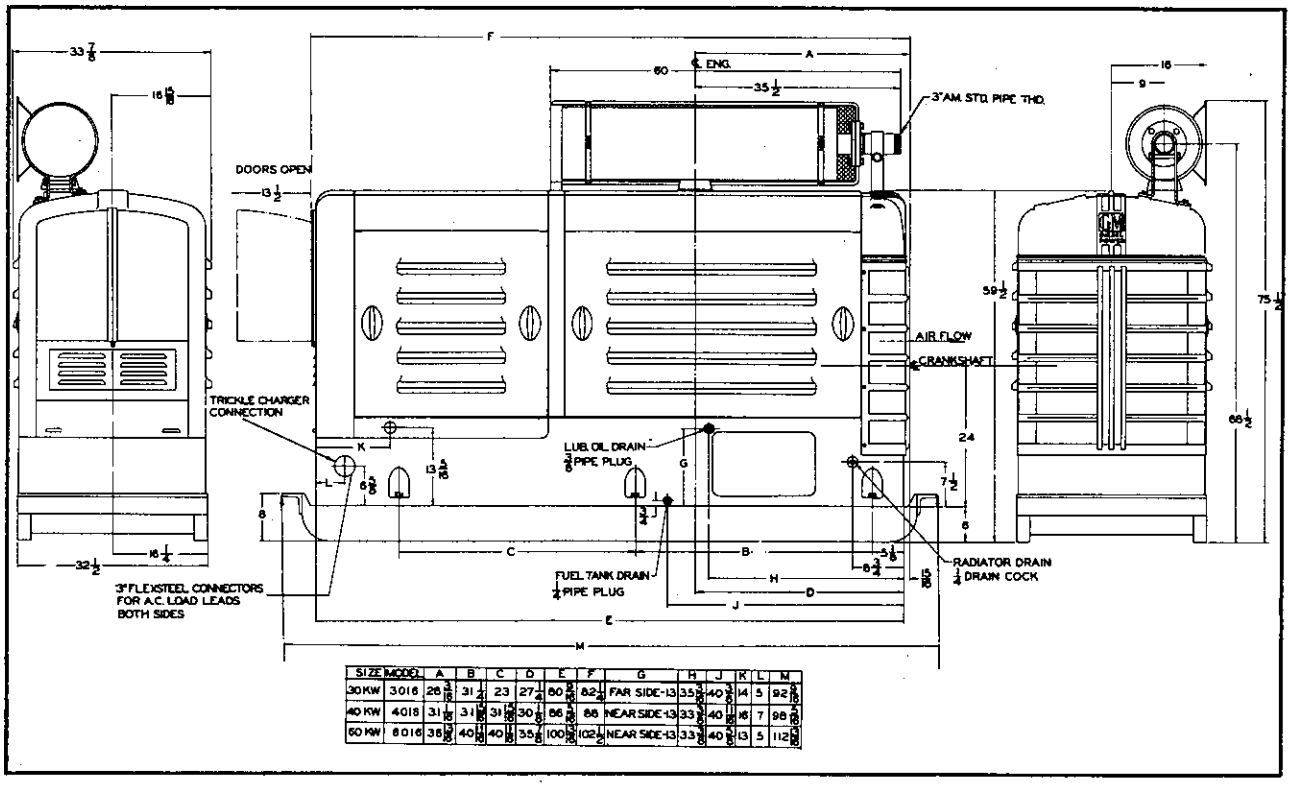
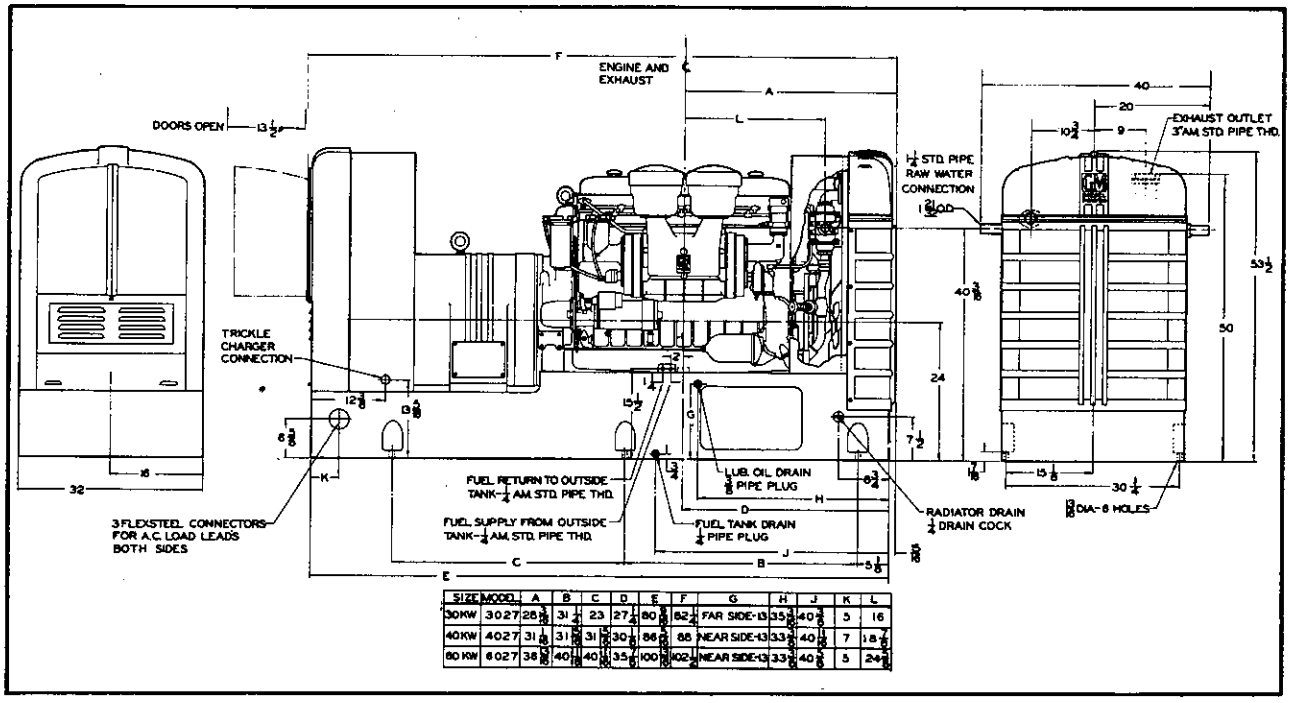


Fig. 1—Suggested Engine Foundations—Models 3-71, 4-71, and 6-71 Engines.



SIZE	MODEL	A	B	C	D	E	F	G	H	J	K	L	M
30 KW	3016	26 3/16	31 1/4	23	27 1/4	80 3/16	82 1/4	FAR SIDE-13	35 3/16	40 3/16	14	5	92 3/16
40 KW	4018	31 1/16	31 1/16	31 1/16	30 1/16	86 1/16	88	NEAR SIDE-13	33 3/16	40 1/16	18	7	98 1/16
60 KW	6016	36 3/16	40 1/16	40 1/16	35 3/16	100 1/16	102 1/2	NEAR SIDE-13	33 3/16	40 1/16	13	5	112 1/16



SIZE	MODEL	A	B	C	D	E	F	G	H	J	K	L
30 KW	3027	28 3/16	31 1/4	23	27 1/4	80 3/16	82 1/4	FAR SIDE-13	35 3/16	40 3/16	5	16
40 KW	4027	31 1/16	31 1/16	31 1/16	30 1/16	86 1/16	88	NEAR SIDE-13	33 3/16	40 1/16	7	18 7/16
60 KW	6027	36 3/16	40 1/16	40 1/16	35 3/16	100 1/16	102 1/2	NEAR SIDE-13	33 3/16	40 1/16	5	24 3/16

Fig. 2—Outline Dimensions—Models 3-71, 4-71, and 6-71 Engines.

bottom for drainage. Water must not be allowed to accumulate in the pit and cover the end of the exhaust pipe. Such construction will cause undesirable back pressure in the engine.

A neat and satisfactory cover may be constructed for an enclosed pit either from 2" hard wood planks or concrete. When the closed pit construction is resorted to, a vent pipe six inches in diameter should extend through the cover for escape of the exhaust gases.

Fig. 1, shows a typical concrete foundation to which the engine base may be bolted and Fig. 2, gives the necessary dimensions for locating and installing the power unit. The engine foundation shown will be satisfactory for all average conditions. When the soil is sandy or extremely wet, the concrete foundation should be proportionately larger. Necessary reinforcing bars should be used in the concrete foundation.

LUBRICATION AND PREVENTIVE MAINTENANCE

NOTE: Open chart on page 3 for ready reference to location of parts mentioned.

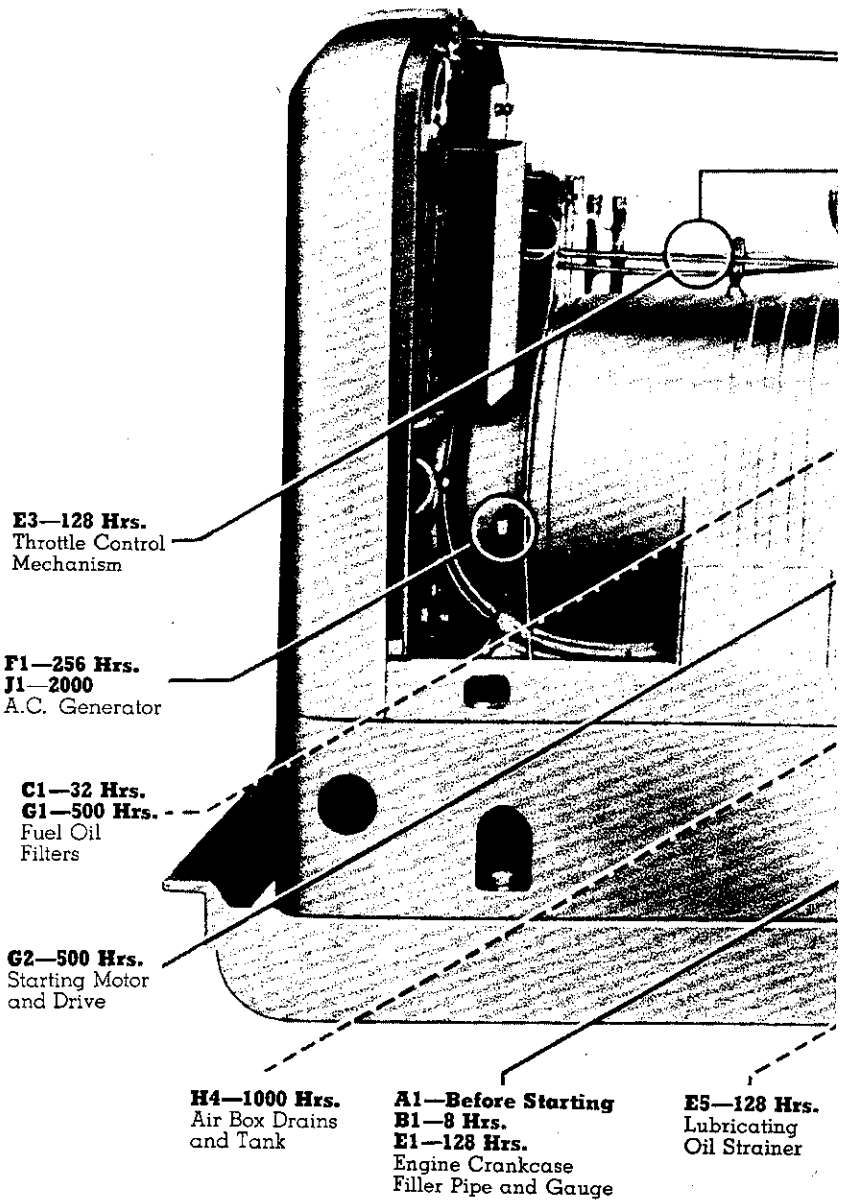
INTERVAL	PART—OPERATION	SPECIFICATIONS	REMARKS
A BEFORE EACH START	**A1—CRANKCASE**—Check lubricating oil level on dip stick of engine.	Recognized **heavy duty** lubricating oil only. SAE-30 viscosity above 20° F. See page 22, Sec. 12, for lower temperatures.	Check oil level with engine stopped. Oil level should be to "FULL" mark on gauge stick. Never let oil fall below "LOW" mark on gauge.
	A2—COOLING SYSTEM—Check water in cooling system.	Soft water or permanent antifreeze.	Remove radiator cap and add soft water to within 2 inches of overflow pipe. Open air vent when draining or completely filling the cooling system.
	A3—FUEL OIL GAUGE—Read gauge to determine quantity of fuel in tank.	High Speed Diesel engine fuel only. Do not use common burner fuels. See Spec., page 31, Sec. 15.	Fill fuel tank before starting engine.
	A4—ENGINE—Check for readiness.		For the first start or after any lay-up period, see "Preparations for Starting" page 5.
B EVERY 8 HOURS	**B1 — CRANKCASE** — Check lubricating oil level on dip stick of engine.	Recognized **heavy duty** lubricating oil only. SAE-30 viscosity above 20° F. See page 22, Sec. 12, for lower temperatures.	Check oil level with engine stopped. Oil level should be to "FULL" mark on gauge stick. Never let oil fall below "LOW" mark on gauge.
	B2 — COOLING SYSTEM — Check water in cooling system of engine.	Soft water or permanent antifreeze.	Remove radiator cap and add soft water to within 2 inches of overflow pipe. Open air vent when draining or completely filling the cooling system.
	B3 — FUEL TANK — Check fuel supply by reading gauge.	High speed Diesel engine fuel only. Do not use common burner fuels. See Spec., page 31, Sec. 15.	Do not permit fuel tank to become EMPTY. Fuel pump will lose its prime and may be seriously damaged.
	B4—CLUTCH RELEASE BEARING—Lubricate.	Chassis lubricant.	The clutch release bearing should be lubricated after every 8 hours of operation if clutch is engaged and disengaged frequently. Give one or two strokes of pressure gun. Lubricate sparingly to avoid grease on clutch facings.
	B5—OUTBOARD BEARING—Check for overheating.	Transmission lubricant SAE-90 for winter and SAE-160 for summer.	Place hand on bearing cap to check for signs of overheating. If bearing is hot, remove cap and lubricate as outlined in item F6.
C EVERY 32 HOURS	**C1—FUEL FILTERS**—Drain ¼ U. S. pint of fuel from each fuel filter.		Open drain at bottom of both Primary and Secondary filter and catch waste in receptacle.
D EVERY 64 HOURS	**D1—BATTERY CHARGING GENERATOR**—Check belt tension.		If erratic charging rate indicates a loose belt, loosen lock bolt on generator bracket. Move generator away from engine enough to obtain proper belt tension, and tighten lock bolt. **Do not over tighten belt.**

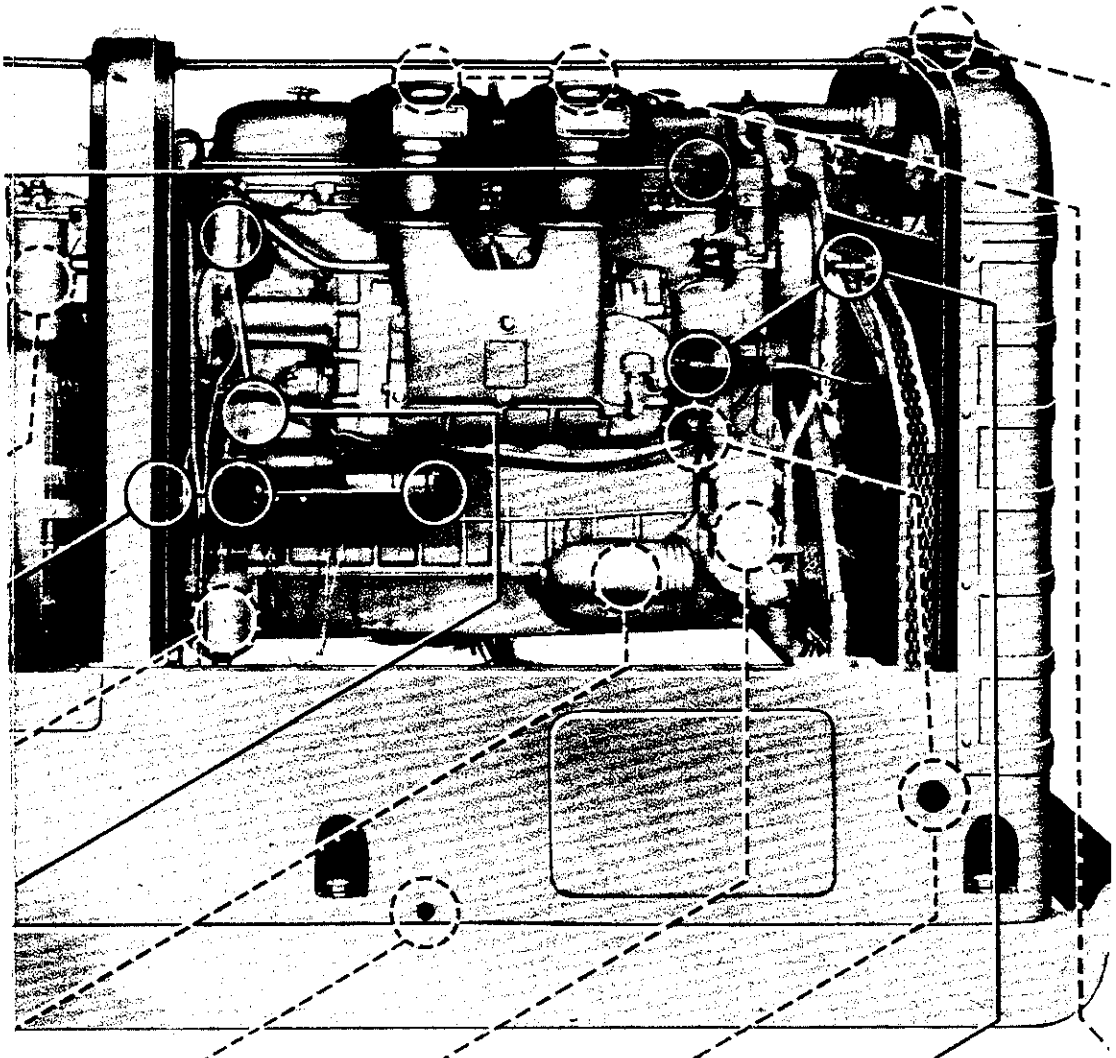
NOTE: For further information, refer to the section of this manual which treats in detail the operation in question; or see the specific manual for the engine model in question.

INTERVAL	PART—OPERATION	SPECIFICATIONS	REMARKS
E EVERY 128 HOURS	**E1—CRANKCASE**—Change oil in engine crankcase.	Recognized **heavy duty** lubricating oil only. SAE-30 viscosity above 20° F. See page 22 Sec. 12, for lower temperatures.	Remove plug at end of drain hose and drain crankcase. Refill to "FULL" mark on gauge.
	E2—LUBRICATING OIL FILTER—Clean or renew element.		If cleanable type, remove and clean packs. See instructions for cleaning, page 16, Sec. 12. If replaceable type, change element. See instructions for changing element, page 18, Sec. 12.
	E3—THROTTLE CONTROL MECHANISM—Lubricate throttle control mechanism—clevis pins, and levers.	Engine oil.	Use oil can and lubricate as necessary. Wipe surplus oil from engine.
	E4—AIR CLEANER AND SILENCER—Remove and clean filtering element.	SAE-50 oil.	Remove wing nut and cover. Wash filtering element and bowl in clean fuel oil. Dip element in engine oil and reassemble **after element has thoroughly drained.** Add oil to "oil level" **shown on bowl.** Under severe working conditions, servicing the air cleaner may be required more frequently.
	E5—LUBRICATING OIL STRAINER—Clean strainer.		With engine shut down, remove plugs in strainer adapter and drain the strainer shell. Unscrew retainer bolt and remove shell and strainer assembly. Withdraw strainer from shell and wash thoroughly in clean fuel oil. **Do not use scraper or hard bristle brush on strainer.** With parts reassembled and new gaskets in place, where necessary, reattach shell and strainer to adapter. Replace drain plug, start engine, and check for leaks.
	E6—BATTERY CHARGING GENERATOR—Lubricate at two oil cups.	Engine Oil.	Use oil can and lubricate as necessary.
	***E7—ENGINE TUNE-UP**		Lash valves—Time injectors—Adjust governor—Position injector control racks—etc., as outlined on page 15.
F EVERY 256 HOURS	**F1—POWER GENERATOR**—Check for oil level in bearing housing.	Same oil as used in engine at the prevailing temperature.	When generator is not running, remove plug at filler hole and cap from oil cup and add oil at filler hole to top of cup. Allow excess oil to drain from cup before replacing cap.
	F2—STORAGE BATTERIES—Check water level in storage batteries.	Soft water—Distilled.	Do not let water level fall below top of plates. Add water to within ⅛" to ⅜" below filler plug. Maximum specific gravity differs for various battery models. Check manufacturer's recommendation for Specific gravity.
	F3—OVER-SPEED TRIP DRIVE ADAPTER—Lubricate two fittings with grease gun.	Chassis lubricant.	One stroke of pressure grease gun at each fitting.
	F4—OVER-SPEED TRIP GOVERNOR—Remove from engine, clean and lubricate.	SAE-10 oil.	Disassemble governor. Clean with gasoline and add 4 U. S. fluid ounces of clean light oil. DO NOT TAMPER WITH MECHANISM.
	F5—POWER TAKE-OFF FORWARD BEARING.	Chassis lubricant.	Attach pressure gun to fitting in rear of clutch cover and lubricate with two or three strokes of gun.
	F6—OUTBOARD BEARING—Lubricate.	Transmission lubricant—SAE-90 for winter—SAE-160 for summer.	Remove upper half of bearing housing. Fill lower half of housing two-thirds full. **Housing must not be more than one-third full or bearing will overheat.** If bearing has been overheated, remove all of old lubricant before adding new.

*Items marked with an asterisk to be performed after first 128 hours and each 512 hours thereafter.

INTERVAL	PART—OPERATION	SPECIFICATIONS	REMARKS
G EVERY **500 HOURS**	**G1—FUEL OIL FILTERS**—Renew element in primary and secondary fuel oil filters.		To renew element (engine stopped), drain and remove bowl and element from cover. Discard the old element and, using a new element and cover gasket, re-assemble the bowl to the cover. After starting engine, check for leaks.
	G2—STARTING MOTOR—Lubricate starting motor.	Engine oil.	Use oil can and lubricate as necessary at three (3) places. To reach the rear oiler, it is necessary to remove a pipe plug from the flywheel housing.
	G3 — FUEL TANKS — Drain sediment and water from fuel tank when necessary.		Drain sufficiently to remove all water and sediment. Catch waste in suitable container.
H EVERY **1000 HOURS**	**H1 — CYLINDER LINER** — Inspect and clean air inlet ports (not shown on chart).		Remove hand hole cover plates on cylinder block to inspect ports. See page 2, Sec. 3, if cleaning is necessary.
	H2—BLOWER—Examine blower lobes for contact. (not shown on chart).		Remove air inlet housing and screen to expose rotor lobes. **Be sure engine is stopped and starting battery disconnected when inspecting blower.** If blower needs reconditioning, See Sec. 14. Clean screen before replacing.
	H3—PISTONS—Examine piston rings through ports (not shown on chart).		Remove hand hole cover plates on cylinder block, crank engine and examine rings through ports. If rings are stuck, scored or grooves worn badly, replace parts as directed in Sec. 6. If ports are more than ⅓ choked, clean as directed in Sec.3.
	H4—AIR BOX DRAINS—Inspect and clean.		Remove drain pipes and fittings from block. Open passages in pipes and elbows with compressed air. Inspect floor of air box and wipe clean and dry with rags or blow out with compressed air.
	H5—OIL COOLER—Remove and clean.		Remove and examine core and clean with live steam or its equivalent, if necessary. See page 21, Sec. 12.
J EVERY **2000 HOURS**	**J1 — POWER GENERATOR** —Drain and refill bearing housing.	Same oil as used in engine at the prevailing temperature.	When generator is shut down, remove drain plug at bottom of bearing housing, or oil cup from fitting. Remove plug from filler hole and flush bearing cavity with fuel oil. Allow surplus to drain from housing, and if necessary remove remainder with suction pump inserted in oil cup opening. DO NOT ALLOW OIL TO DRAIN INTO EXCITER FRAME. Replace oil cup and add oil at filler hole to top of cup. Allow excess oil to drain from cup before replacing cap.
	J2 — COOLING SYSTEM — Drain and flush system.		Remove vent plug and drain system. Flush with a reputable flushing compound. Open air vent and refill cooling system with soft water or permanent anti-freeze to within 2" of overflow pipe.
K EVERY **6 MONTHS**	**K1—CLUTCH CAMS AND TOGGLES**—Lubricate.	Chassis lubricant.	Remove clutch inspection cover. Stop engine and release clutch. Attach pressure grease gun to fittings on cam shaft and lubricate with two or three strokes of gun. Lubricate toggles in clutch at cam shafts with engine oil.


E3—128 Hrs.
Throttle Control
Mechanism
F1—256 Hrs.
J1—2000
A.C. Generator
C1—32 Hrs.
G1—500 Hrs.
Fuel Oil
Filters
G2—500 Hrs.
Starting Motor
and Drive
H4—1000 Hrs.
Air Box Drains
and Tank
A1—Before Starting
B1—8 Hrs.
E1—128 Hrs.
Engine Crankcase
Filler Pipe and Gauge
E5—128 Hrs.
Lubricating
Oil Strainer



G3—500 Hrs.
Fuel Tank
Drain

H5—1000 Hrs.
Oil Cooler

J2—2000 Hrs.
Cooling
System Drain

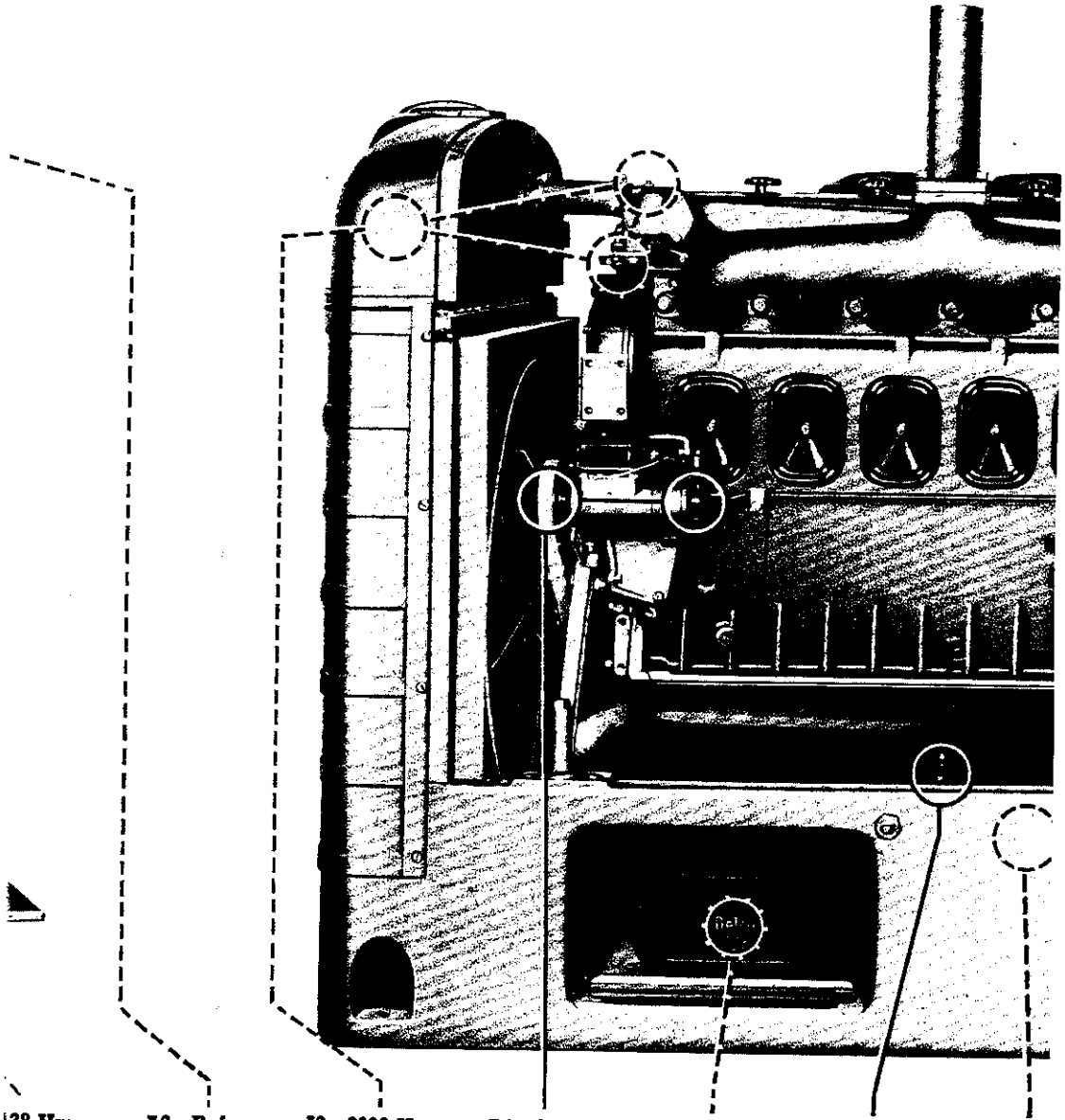
F3—256 Hrs.
F4—256 Hrs.
Overspeed
Trip
Mechanism

E4—
Air (
and

NOTE: Solid circles and lines d
Broken circles and lines c

Fig. 1—Referenc

ND PREVENTIVE MAINTENANCE



128 Hrs.
leaner
Silencers

A2—Before Starting
B2—8 Hrs.
Water Tank
Filler Cap

J2—2000 Hrs.
Cooling System
Radiator Vent
and Drains

D1—64 Hrs.
E6—128 Hrs.
Battery
Charging
Generator

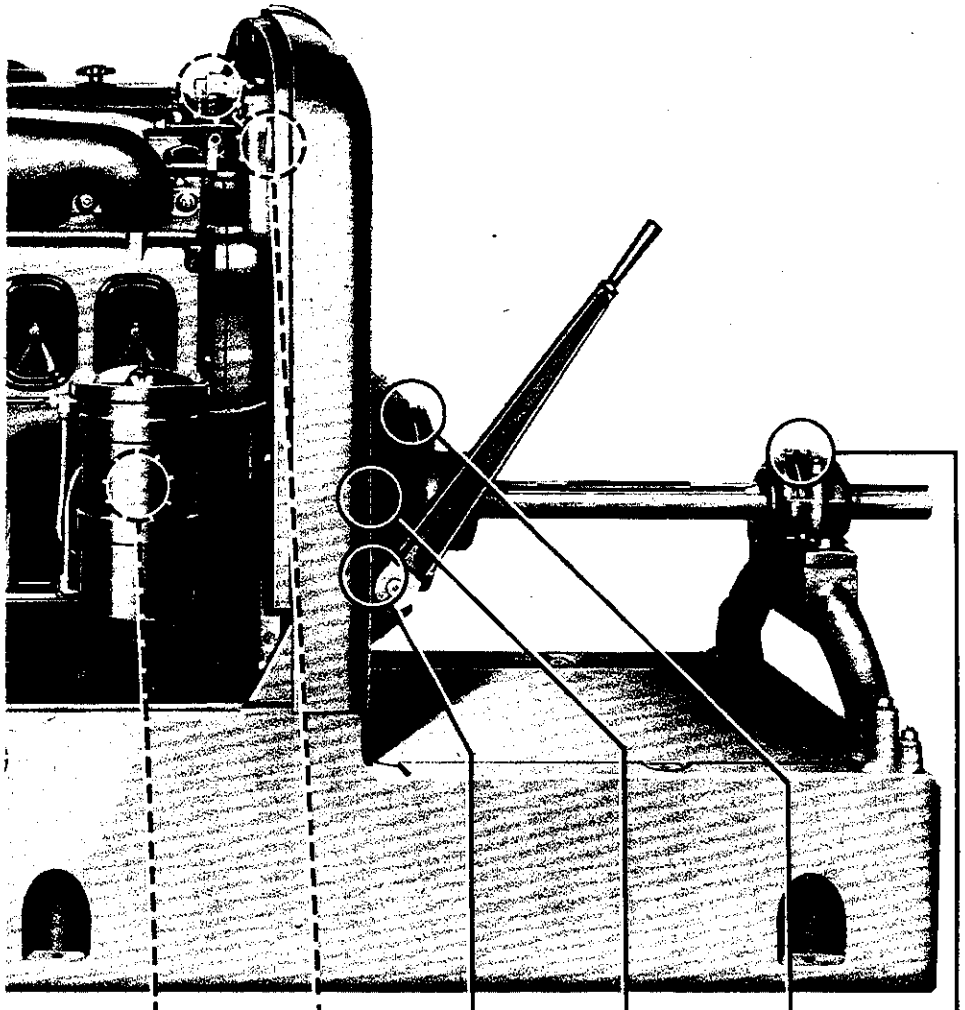
F2—256 Hrs.
Storage
Battery

E1—128 Hrs.
Lube Oil
Drain

A3—Bef Sta
B3—8 H
Fuel Oil
and Gas

signate the lubrication necessary for successful engine operation.
esignate the maintenance necessary for successful engine operation.

e ***Chart for Lubrication and Maintenance Points.***



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E2—128 Hrs.
Lubricating
Oil Filter

C1—32 Hrs.
G1—500 Hrs.
Fuel Oil
Filters

B4—8 Hrs.
Clutch
Release
Bearings

K1—6 Mo.
Clutch Cams
and Toggles

F5—256 Hrs.
Power
Take-off
Forward
Bearing

B5—8 Hrs.
F6—256 Hrs.
Outboard
Bearing

OPERATING INSTRUCTIONS

A—PREPARATION FOR STARTING

NOTE: Adhere to item A1 to A9, inclusive, below, when preparing to start a new unit and only those items marked with an asterisk for routine starting.

A1 Replace all drain plugs in the cooling system which were removed for shipping, and fill cooling system with clean soft water. In weather colder than 32 degrees F. use a permanent anti-freeze solution.

A2 See that storage batteries are well charged (1.275 gravity) and that water level is at least 3/8" above plates. Check all electrical connections for tightness.

A3* Check oil level in crankcase by means of the bayonet gauge at side of crankcase. Keep oil level up to "Full" mark on gauge. (See lubricating oil specifications, Sec. 12.)

A4* Fill the fuel tank with clean, filtered fuel oil and open valves in the fuel lines. (See Fuel Oil Specifications, Sec. 15.)

A5* Lubricate all parts of the power unit shown in lubrication and preventive maintenance chart.

A6* If manually controlled emergency shut-down is used, consisting of flap valve at blower air intake and Bowden wire control at instrument panel, see that button at instrument panel is way in to hold valve open. If automatic overspeed trip is used, see that reset lever on flap valve shaft is in contact with governor plunger collar to hold valve open.

A7 In electrical generator sets, check electrical connections against instructions furnished with each unit.

A8* Generator set—open main power switch and switch on field energizing circuit. Power take-off set —disengage clutch.

A9* Clear power unit of all tools or other obstructions that might interfere with engine operation.

B—STARTING

B1 First observe instructions under "Preparation for Starting."

B2 Open the throttle to idling position. If Woodward governor is used and starting solenoid not furnished, push fuel rod way in at front of governor sub-cap and start engine by engaging the starter button.

CAUTION: Avoid overheating starting motor. Do not operate over 30 seconds at a time.

B3 If air heater is used for starting:

(a) Turn on heater ignition switch.

(b) Open engine throttle wide.

(c) Operate plunger of heater fuel pump as necessary and, an instant later, engage starter.

(d) When engine is running, regulate throttle and lock heater pump plunger.

(e) Turn off heater ignition switch. (See "Cold Weather Engine Starting," page 9.)

B4 Immediately after starting, observe the oil pressure on gauge. If no pressure shows on gauge after 10 to 15 seconds, stop engine and check lubrication system.

B5 If electrically controlled automatic engine shutdown is used, move toggle switch on instrument panel to ON position after engine starts.

B6 Run engine at part throttle and no load for four or five minutes, giving engine chance to warm up. In case of emergency, omit warm-up period and apply load as soon as oil pressure reaches normal.

B7 Move throttle to wide open position on generator set, adjust throttle control to obtain approximately 1236 r.p.m. This will give 1200 r.p.m. full load speed.

B8 When using generator set, close main switch, With power take-off unit, engage clutch.

B9 Start the room ventilating fan, if one is provided, or open windows as much as weather conditions permit.

C—RUNNING

C1 See that the oil pressure, as indicated by the pressure gauge, does not fall below 20 lbs. (4 lbs. is satisfactory at idle).

C2 LUBRICATING OIL FILTERS.

(a) STRAINERS. (Primary Filter.) Remove strainer body and wash strainer in clean fuel oil or carbon tetrachloride at each engine oil change. Be sure strainers are well washed so no sludge remains between or in back of the wires. (See Page 19, Sec. 12.)

(b) FILTERS. (Secondary.) Remove filter pack assembly and clean pack at each engine oil change. Install clean element on replaceable element type filters.

C3 LUBRICATING OIL COOLER. Remove and clean oil cooler unit each 1000 hours, or 20,000 miles of engine operation. Element may be cleaned

by passing live steam, mixed with soapy compound, through the element for a few minutes.

C4 FUEL OIL FILTERS. The filter between the fuel tank and fuel transfer pump, as well as the filter between the fuel transfer pump and the injectors, should have the elements renewed after each 500 hours or 10,000 miles of engine operation, or more often if necessary, depending upon the cleanliness of the fuel oil. ***Filter elements cannot be cleaned.*** One quarter pint of fuel and sediment should be drained from both filters daily. For satisfactory engine operation, the fuel flow at return manifold should be approximately ½ gallon per minute at 1200 r.p.m. and the pressure on a gauge placed in the fuel return manifold (upper) at the end opposite to the fuel return line should read not less than ten pounds. Gauge pressure and fuel flow will be reduced as filter elements choke up with dirt.

C5 AIR CLEANERS. Remove and service air cleaner every 100 hours or less, depending on the severity of working conditions. Wash dirt accumulations from screen filtering element in clean kerosene. Let element drain thoroughly before replacing in container. Replenish oil reservoir with engine oil up to indicated level.

C6 FUEL TANK. Keep fuel in tank clean by supplying filtered fuel from a storage tank with suitable settling chambers. Never pump fuel oil directly from tank wagon into the engine tank. Do not use galvanized tanks or containers for fuel, use Black Iron or Terneplate tanks.

C7 FUEL LINES. All fuel line points, especially on suction side of fuel transfer pump, must be kept tight so air will not be drawn into the fuel system. Engine operation will be erratic if air is introduced into the fuel system even though other parts of the engine are in normal working condition.

C8 Check storage battery gravity (1.275) each week and maintain water level ⅜" above plates.

C9 OVERSPEED TRIP AND SHUT-DOWN. If engine is equipped with overspeed trip, the flap valve in the blower air intake will close with excess engine speeds. Should valve close, determine cause of excess engine speed and open valve by indexing reset lever with governor plunger.

C10 ELECTRICALLY CONTROLLED AUTOMATIC ENGINE SHUTDOWN—If engine is equipped with automatic engine shutdown it will stop if: (a) cooling solution temperature exceeds approximately 200° F; (b) oil pressure drops below 10 lbs. On early type units equipped with toggle switch, throw switch to the "OFF" position immediately after the engine stops. Later units are provided with a fuel oil switch, which automatically disconnects the electrical circuit when the engine stops.

D—STOPPING

D1 If automatic engine shut-down is used, throw toggle switch on instrument panel to OFF position.

D2 Open main switch on control panel or disengage clutch.

D3 If working conditions permit, partly close throttle and allow engine to run at half speed or lower without load for five minutes before stopping.

D4 Move throttle to OFF position.

D5 Close valves in fuel lines.

D6 Stop the room ventilating fan, if one is provided, or close the windows, as weather conditions indicate.

D7 If used, open drain or valve in exhaust line or silencer to drain the exhaust line of condensation.

D8 If there is any danger of water freezing in the water jackets or other parts of the cooling system, and an anti-freeze is not used, drain cooling system and leave drains open.

D9 Check and replenish oil in the engine crankcase as necessary.

D10 Check the amount of fuel in tank and replenish as required so there will be an ample supply of fuel for the next run.

D11 Clean the engine thoroughly and be sure it is in proper shape for the next run.

D12 Carry out all maintenance and lubrication instructions as indicated under "Lubrication and Preventive Maintenance," Page 2. Also perform any repairs or adjustments as indicated by operation during last run.

When the engine is to be stored or removed from operation for an extended period, special precautions should be taken to protect the engine against run accumulations, corrosion on the wearing surfaces, and gumming in the fuel system.

E—STORING

E1 INJECTORS. Experience has proved that there is no advantage in storing the engine with the injectors removed and stored separately. However, the practice of checking (popping) the injectors before storing is recommended. Such practice will insure the units being in first class working order when the engine is put in operation again. If "popping" check shows that any of the spray tip holes are plugged, remove tip and replace any defective parts as instructed under "Recondition Injector Spray Tips," Page 7, Sec. 15. After injectors have been checked and replaced in the engine, they should be timed and the racks positioned, as described on Page 12, Sec. 15.

Leaving the regular fuel oil in the injectors without their being operated for any great length of time

has proved to be unsatisfactory, as oxidization of the fuel is apt to leave gummy deposits on the close fitting parts that will interfere with satisfactory operation. ***Before storing, therefore, the fuel system should be purged with a special oil,*** a quantity of which will remain in the fuel system when the engine is shut down for storage.

Two mixtures found to be satisfactory for this purpose are:

1. A mixture of 20% medium steam turbine oil and 80% pure white kerosene.
2. A mixture of 20% rust-proofing oil and 80% pure white kerosene. The rust-proofing oil should be of a quality marketed by reputable oil companies.

Purging the Fuel System—The recommended procedure for purging the fuel system is:

1. Remove injectors and check (pop) each unit for any plugged holes in the spray tips. (See "Remove Injectors," Page 5, Sec. 15, and "Testing Injectors," Page 11, Sec. 15.)
2. Replace and time injectors, and position injector racks. (See "Time Injectors," and "Position Injector Racks," Page 12, Sec. 15.)
3. Drain the fuel oil from the fuel tank and the fuel filters.
4. Substitute approximately two gallons of special purging oil in the fuel tank and run the engine at normal speed until the fuel supply in the tank is nearly exhausted. Leave the fuel system filled with the purging oil.

NOTE: Neglect the smoky exhaust when starting the engine after using the purging oil, as this condition is normal.

E2 PROTECT CYLINDER WALLS. If the power unit is to be stored or out of operation for a considerable period, the cylinder walls should be coated with a film of heavy engine oil—either SAE 50 or 60 viscosity. To coat the cylinder walls, remove the injectors and crank the engines until the various pistons are at bottom center. Be sure throttle is in "NO FUEL" position. By means of an atomizing spray gun, coat the cylinder walls in turn by inserting nozzle of spray gun through injector openings.

Do not use enough oil inside cylinder bores to form a puddle on top of pistons.

E3 CRANKCASE. Drain crankcase and flush clean with light engine oil. Replace drain plug and fill to high mark on dip stick with the same light engine oil.

E4 LUBE OIL FILTERS. Thoroughly clean lube oil filters.

E5 AIR CLEANERS. Service air cleaners as directed under Item C5 above.

E6 COOLING SYSTEM. Drain and flush the complete cooling system. Foreign deposits may be removed from heat exchanger core by circulating a reputable make of scale solvent through the core until deposit is removed.

E7 STORAGE BATTERY. Replenish water to bring level 3/8" above plates. Fully charge battery to 1.275 gravity. Store in dry place and keep charged. Consult authentic battery service station for battery storage and care.

E8 Protect engine with water-proof cover if exposed to the elements.

COLD WEATHER STARTING

When starting an internal combustion engine in cold weather, a large part of the energy of combustion is absorbed by the pistons, cylinder walls, cooling water, and in overcoming friction.

Under extremely low outside temperatures, the cold oil in the bearings and between the pistons and cylinder walls creates very high friction and the effort to crank the engine is much greater than when the engine is warm. In the Diesel engine, the only means of igniting the fuel sprayed into the combustion chamber is the increased temperature due to compressing the air. This temperature becomes high enough under ordinary operating conditions, but may not be sufficiently high at extremely low outside temperatures to ignite the charge.

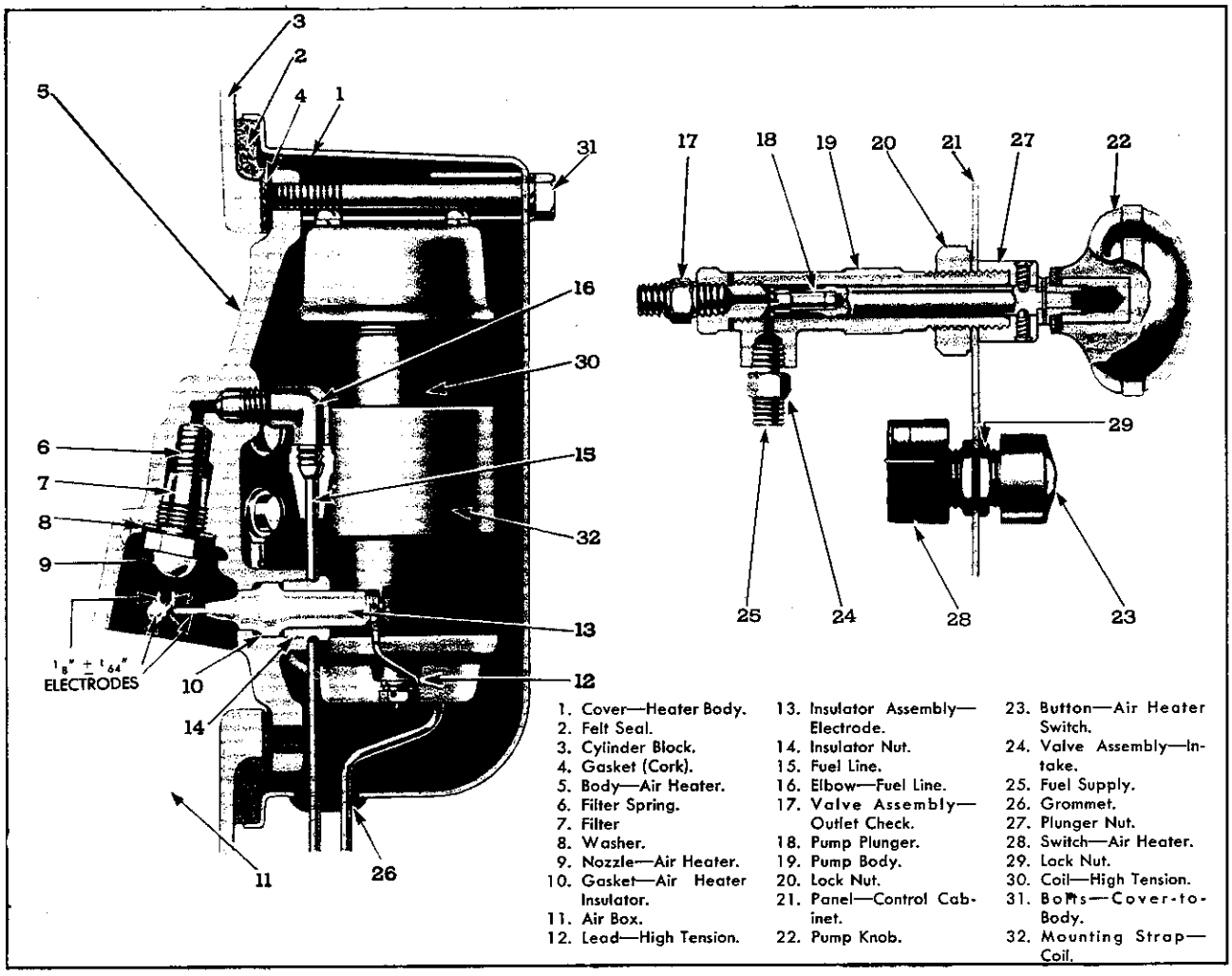
Under these unusually cold conditions, therefore, some external means of warming the ingoing air may be necessary.

The instructions for engine starting on page 5, include use of the air heater at temperatures below 40° F. A knowledge of the air heater assembly, as explained in the following pages, should assist the mechanic in its proper use.

AIR HEATER FOR COLD WEATHER ENGINE STARTING

Description—The air heater is essentially a small pressure oil burner with electric ignition. The burner proper is mounted in the engine air box, obtaining the necessary air for combustion from the charging blower and discharging the products of combustion and the directly flame-heated air into the engine cylinders with practically no heat loss. This results in an immediate response of the engine.

The device consists of two assemblies. One unit



1. Cover—Heater Body.
2. Felt Seal.
3. Cylinder Block.
4. Gasket (Cork).
5. Body—Air Heater.
6. Filter Spring.
7. Filter
8. Washer.
9. Nozzle—Air Heater.
10. Gasket—Air Heater Insulator.
11. Air Box.
12. Lead—High Tension.
13. Insulator Assembly—Electrode.
14. Insulator Nut.
15. Fuel Line.
16. Elbow—Fuel Line.
17. Valve Assembly—Outlet Check.
18. Pump Plunger.
19. Pump Body.
20. Lock Nut.
21. Panel—Control Cabinet.
22. Pump Knob.
23. Button—Air Heater Switch.
24. Valve Assembly—Intake.
25. Fuel Supply.
26. Grommet.
27. Plunger Nut.
28. Switch—Air Heater.
29. Lock Nut.
30. Coil—High Tension.
31. Bolts—Cover-to-Body.
32. Mounting Strap—Coil.

Fig. 2—Air Heater Assembly.

comprises the pressure pump and ignition switch and may be mounted convenient to the engine controls. The other unit contains the burner nozzle, filter, ignition coil and ignition points, and is designed to mount on cylinder block in place of air box cover.

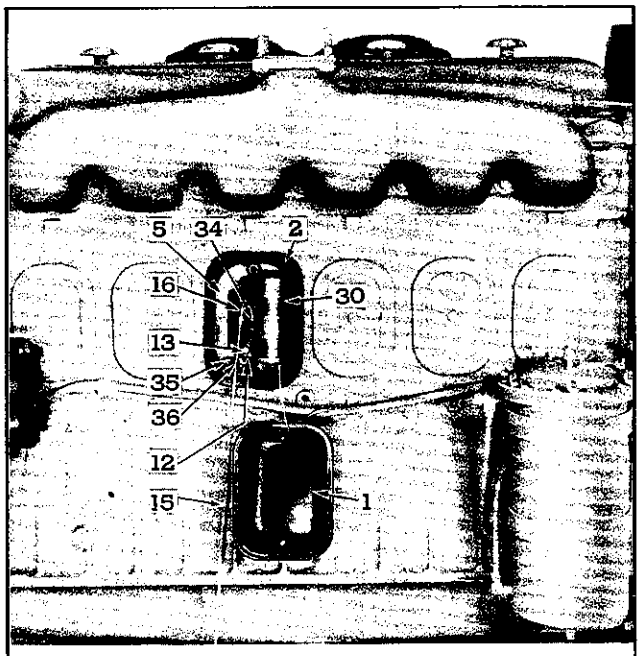
The pump is intended to supply fuel under pressure to the burner unit where the charge is filtered before reaching the discharge nozzle. The suction side of the pump is connected to the outlet of the primary filter, as shown in Fig. 2. The switch is connected in the line between twelve (12) volts of the starting battery and one terminal of the ignition coil on the burner, the other terminal of the coil (primary) being grounded to the engine. (See Fig. 2.)

The pump plunger, when not in use, is held in the "IN" position by a simple spring and ball mechanism.

The pump plunger is so propotioned that a firm pressure (10 lbs. or over) on the knob will deliver finely atomized fuel from the nozzle. This fuel can be readily ignited by the spark at the electrodes on the burner. The rate of travel of the plunger on the pumping stroke is determined by the flow of oil from the discharge nozzle and normally takes 3 to 4 seconds per stroke.

Operation—When starting a cold engine with the air heater, the sequence of operations is as follows:

1. Turn on the heater ignition switch.
2. Open engine throttle wide.
3. Engage starter.
4. Operate primer pump with smooth, even strokes, using a firm pressure of 10 pounds or more on the pumping stroke.
5. With engine running, regulate throttle, push plunger all the way in.
6. Turn off ignition switch.



1. Cover—Heater Body.
2. Felt Seal.
5. Heater Body.
12. Lead—High Tension.
13. Insulator and Electrode Assembly.
15. Fuel Line.
16. Elbow—Fuel Line.
30. Coil—High Tension.
34. Bolt—Heater Body-to-Cylinder Block.
35. Bolt — Tubing Clip-to-Heater Body.
36. Tubing Clip.

Fig. 3—Air Heater Mounting.

Engine usually starts firing during the first or second pumping stroke. At low temperatures, with heavy lubricating oil, the engine may fire for a time with the combined help of the starter and heater before developing sufficient power to run unassisted. Under these conditions, it is advisable to pause briefly at the end of each pumping stroke to allow the engine time to absorb the heat generated. ***Since the primer acts as a second source of fuel, the engine throttle should be regulated accordingly during this operation.***

CAUTION: Dependable starting of a Diesel engine by any means can only be obtained with adequate cranking speed. The lubricating oil used in cold weather must meet the specifications shown on page 22, Sec. 12. Batteries must be in good condition.

Installation—The general details of the installation of "Air Heater" are shown in Fig. 2. The units, comprising the burner nozzle, filter, ignition coil and ignition points are mounted on the cylinder block in place of the hand hole cover plates at a central cylinder. The unit comprising the pressure pump and ignition switch is mounted on the instrument panel convenient to the engine controls.

Any good primary wire can be used for the electrical connections, though in some installations it will be advisable to use oil-proof wire. Connections should be made to 12 volts of the battery. The current used

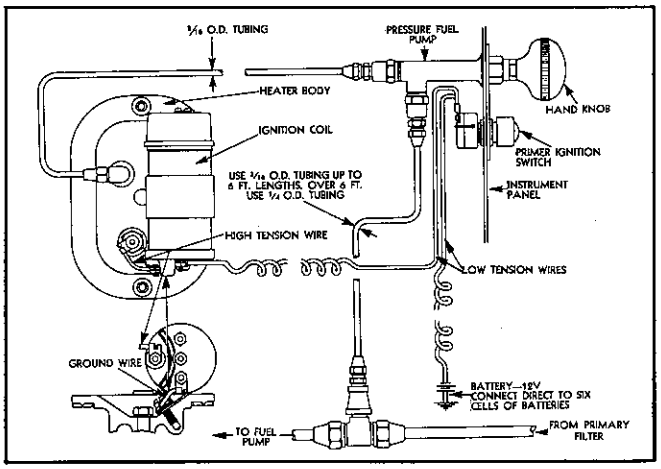


Fig. 4—Air Heater Wiring Diagram and Fuel Connections.

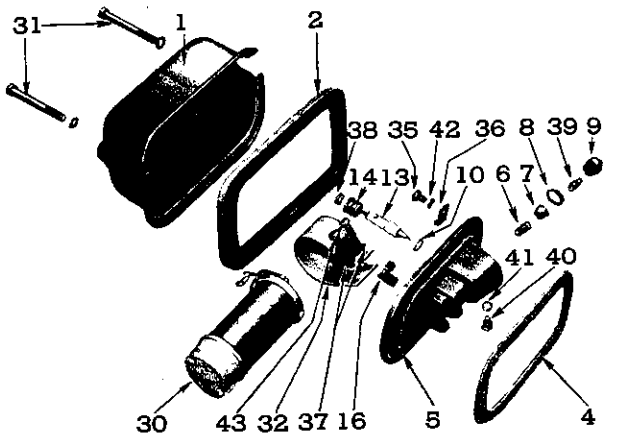
is very small so connections can be direct to six cells of the battery where series parallel switches are not used.

Copper tubing can be used for piping, but where considerable vibration is encountered, it is advisable to use either steel or flexible tubing. Pump and burner are equipped with ⅛" female pipe threads so that any suitable type of fittings may be used. Tubing on pressure side of pump must be able to withstand 200 pounds per square inch pressure. If more than six feet of tubing is required between the engine fuel line and the primer pump, it is advisable to use ¼" size, as the resistance to flow in the smaller 3/16" size may prevent proper filling of the pump. Again, if the vertical lift from the fuel level to the pump is over four feet, the insertion of a check valve at the junction of the pump suction tube and the main engine fuel line will prevent the primer pump losing its "prime." This can be a simple ball check without spring load.

In general, the vertical lift and length of all connections should be as short as possible. All tubing and wiring should be clipped to stationary members to prevent failures due to vibration.

Air box drains must be open at all times.

Service—If engine does not start, with wide open throttle, after two or three pump strokes, it is advisable to stop cranking and check for possible causes of failure. Assuming that the engine is in running order and cranking speed is 80 R.P.M. or over, the heaters should be investigated for (a) ***Failure of Ignition,*** and (b) ***Poor Oil Spray.*** If it is possible to do so, the burner elements should be removed from engine air box and reconnected outside of engine in such a position that the burner operation can be readily observed. With dash switch turned on, the coil interrupters should vibrate rapidly and continuous hot sparks should occur between the ignition electrodes. With the ignition turned ***off,*** a



1. Cover—Heater Body.
2. Felt Seal.
4. Gasket (Cork).
5. Body—Air Heater.
6. Filter Spring.
7. Filter.
8. Washer.
9. Nozzle—Air Heater.
10 Gasket—Air Heater Insulator
13. Electrode.
14. Insulator Nut.
16. Elbow—Fuel Line.
30. Coil—High Tension.
31 Bolts—Cover-to-Heater Body
32. Mounting Strap — Air Heater Coil.
35. Bolt — Tubing Clip-to-Heater Body.
36. Tubing Clip.
37. Lock Washer—Mounting Strap.
38. Nut—Electrode Post.
39. Swirl Pin.
40. Screw—Air Heater Electrode.
41. Lock Washer—Electrode.
42. Lock Washer—Tubing Clip.
43. Screws — Mounting Strap-to-Body.

Fig. 5—Air Heater Details and Relative Location of Parts.

push on the dash pump should result in cone-shaped discharges of oil fog from the burners. NOTE THAT THESE TWO TESTS SHOULD NOT BE MADE AT THE SAME TIME, AS THE BURNERS THROW A CONSIDERABLE FLAME AND WILL IGNITE ANY SURROUNDING COMBUSTIBLE MATERIAL.

(a) **Coil Interrupter Does Not Vibrate When Switch Is Closed:**
Check points beneath cover on end of coil for dirt or carbon, and wiring for loose or broken connections. Points may be cleaned with fine sandpaper or a special point file, and should be reset after cleaning to give .018" gap with the armature or vibrator arm held against the coil body.

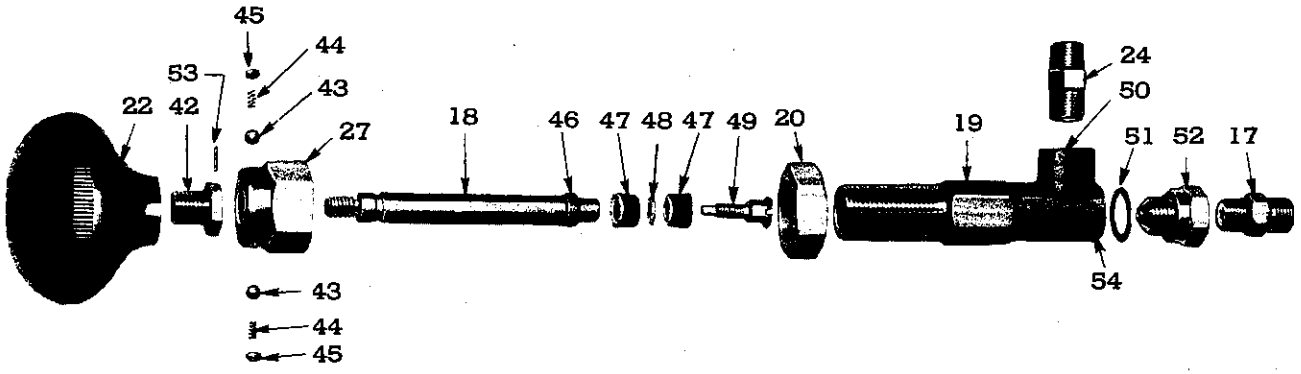
(b) **Spark Jumps Across Porcelain of Electrode:**
Check gap and, if necessary, reset wire electrode by loosening set screw and moving wire until gap is approximately 1/8". Retighten set screw. If gap is correct, then remove porcelain electrode by removing threaded gland and withdrawing electrode assembly. Care should be taken that small copper gasket under the electrode is not dropped out and lost. Porcelain may be cleaned by washing off in gasoline and scraping or sanding off any carbon accumulation. Reassemble as indicated by Fig. 2.

(c) **Spray Nozzle Plugged:**
Indicated by excess resistance on pressure pump or by failure of the nozzle to "fog" the fuel. Remove both ignition electrodes and unscrew nozzle assembly, using a 5/8" thin walled socket wrench. Remove the nozzle, filter, spring, and swirl pin in center of nozzle. Wash out, clean, and dry with compressed air, if possible. DO NOT USE STEEL WIRE OR DRILL TO CLEAN NOZZLE. THE SIZE AND SHAPE OF THE GROOVES AND ORIFICES ARE VERY IMPORTANT AND ANY DAMAGE WILL RENDER NOZZLE USELESS.

Reassemble swirl pin in nozzle. Assemble the spring, filter and nozzle in the casting, taking care to keep out all dirt during assembly and be sure nozzle gasket is leak-proof. Assemble and adjust the sparking electrodes.

Failure of the pressure pump can occur from two causes.

(a) **Check Valves, and** (b) **Plunger Piston Cups.**
(a) The Suction and Discharge Check Valves are threaded into the pump casting. An arrow indicating the direction of flow is



17. Valve Assembly—Outlet Check.
18. Pump Plunger.
19. Pump Body.
20. Lock Nut.
22. Pump Knob.
24. Valve Assembly—Intake.
27 Plunger Nut
42. Knob Adaptor.
43. Steel Ball.
44. Lock Spring.
45. Expansion Plug.
46. Stop Shoulder—Plunger
47 Piston Cups.
48. Washer—Piston Separator.
49. Screw—Piston Retaining.
50. Inlet Opening.
51. Gasket—Check Valve Adaptor.
52. Adaptor—Outlet Check Valve.
53. Groove Pin.
54. Outlet Opening.

Fig. 6—Air Heater Pump Details and Relative Location of Parts.

stamped on each valve and the suction check valve (½ lb. valve) is marked "½." The check valves are of the spring-loaded-ball type and the parts cannot be disassembled without being damaged. The valves can be cleaned, if necessary, by forcing gasoline through them with any suitable pump. See Fig. 6 for pump details.

(b) The Piston Cups on the Plunger are moulded from a special oil resistant composition, and if they should break or become worn, they should be replaced by duplicate parts. They may be replaced by removing the retainer screw on the inner end of the plunger. Assemble the new cups on the retainer screw with the spacer washer between as indicated and run the retainer screw up tight. A few drops of lubricating oil on the cups will facilitate entering them in the cylinder, and care should be taken that the edge of the entering cup is not turned back or torn in the operation.

Control Switch: The pilot light in the switch knob is a 12-volt globe. If light stays on regardless of switch position, the leads should be reversed.

TROUBLE SHOOTING AND ENGINE TUNE-UP

The satisfactory performance of a Diesel engine depends on two items of foremost importance:

1. The presence of sufficiently high compression pressure.
2. The injection of the proper amount of fuel at the right time.

The first one of these items depends almost entirely on pistons, piston rings, and valves with their operating mechanism; the second item depends on the injectors and their operating mechanism.

Lack of engine power, uneven running, excessive vibration, and a tendency to stall when idling may be caused either by a compression loss or faulty injector action.

I. **Engine Fails to Start at Temperature Above Freezing (32°F.).**

1. Throttle not in starting position.

   CORRECTION: See "Starting Engine", Page 5.

2. Fuel check valve stuck, at elbow (7) of supply line, at fuel tank. (See Fig. 51, Sec. 15.)
3. Fuel tank empty.
4. Air shut-off valve at blower closed.
5. Blower rotors not revolving.

   CORRECTION: Inspect for broken blower drive shaft, or any other damaged parts of blower drive mechanism.

6. Fuel supply insufficient.

   CORRECTION: See "Checking of Fuel Supply System," Page 20, Sec. 15.

7. Water in air box (possibly after a disassembly of the cylinder head).

   CORRECTION: Dry air box through handholes by means of compressed air or dry rags. Also check air box drains.

8. Improper engine timing.

   CORRECTION: See "Engine Timing," Page 1, Sec. 7.

II. **Uneven Running and Excessive Vibration.**

1. Faulty "Injector Timing" or "Rack Setting."

   CORRECTION: See "Timing Injector," and "Positioning Injector Control Racks," Pages 12 and 13, Sec. 15.

2. Fuel supply insufficient.

   CORRECTION: See "Checking of Fuel Supply System," Page 20, Sec. 15.

3. Hunting governor.

   CORRECTION: Remove all bind from injector control rack operating shaft mechanism. See "Governor Service", Sec. 16.

4. Cooling water temperature too low.

   CORRECTION: Inspect water thermostat in water manifold.

5. Valves in bad condition.

   CORRECTION: See "Checking Compression Pressure," below.

6. One or more cylinders cutting out.

   CORRECTION: **Tracing a Missing Cylinder.** If the cutting out of a cylinder is suspected, the following procedure will lead quickly to the discovery of the faulty cylinder.

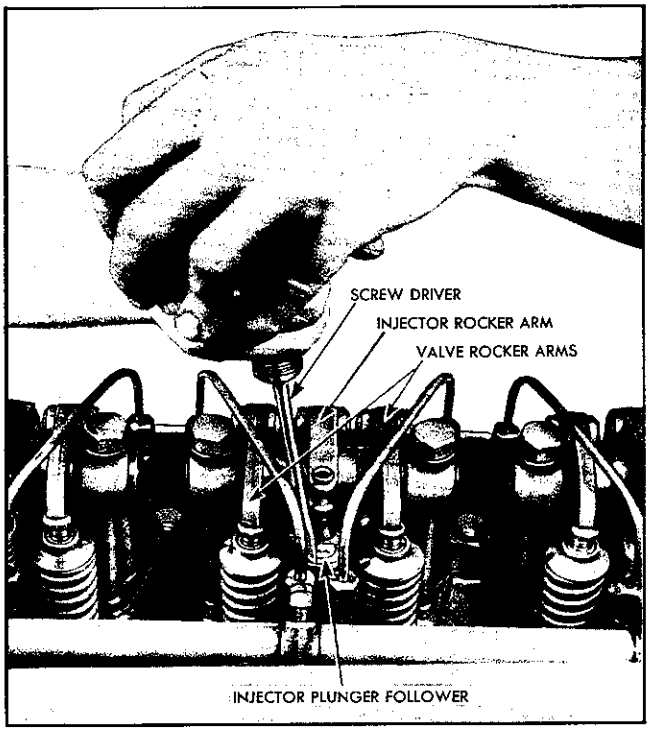


Fig. 7—Cutting Out an Injector by Depressing Injector Follower.

(a) Remove valve cover.

(b) Start engine and run at idle speed.

(c) Check exhaust valve lash on all cylinders with engine ***hot.*** Lash should be .011 GO and .013 NO GO.

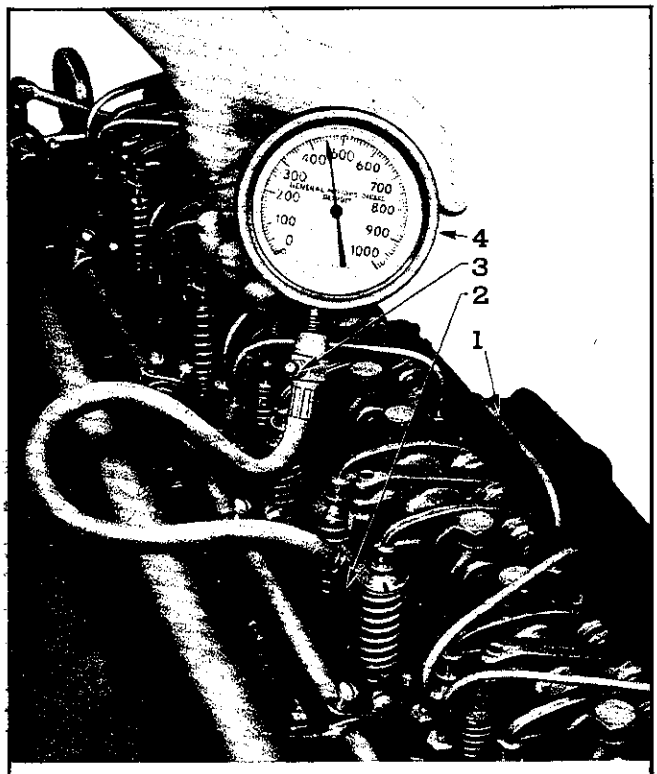
(d) Operate engine at 600 to 800 RPM. Cut out each injector in turn to determine faulty cylinder. Injector is cut out by holding follower down with screwdriver as shown in Fig. 7. If a decrease in speed is noted, this is an indication that the injector in question is working. If no decrease in speed is noted, this indicates that the injector is not functioning.

(e) Stop engine and remove fuel line from injector to return manifold.

(f) Hold finger over injector fuel outlet and crank engine with starter. Gush of fuel at injector while starter is turning engine indicates ample fuel supply.

(g) Remove injector as outlined on page 5, Sec. 15, and replace with a new one. If no spare injector is at hand, repair or clean injector and spray tip as outlined under Injector Service, Sec. 15.

(h) If the replacement of the injector has not eliminated the condition, the compression



1. Fuel Jumper.
2. Compression Adaptor Fitting.
3. Bleed Valve.
4. Gauge.

Fig. 8—Checking Compression Pressure with Tool J-1319-A

pressure of the cylinder in question should be checked: The compression pressure may be checked with Tool J-1319-A, as illustrated in Fig. 8.

Checking Compression Pressure

(a) Remove valve rocker cover.

(b) Start on No. 1 cylinder and remove fuel lines from both injector and fuel connectors.

(c) Remove the injector from No. 1 cylinder and install the pressure gauge in its place, the same as the injector was installed. See "Remove Injector," Page 5, Sec. 15, and Fig. 7 for installing pressure gauge and taking compression pressure.

(d) Use one of the two fuel lines as a "jumper" connection between the fuel inlet and return manifold connectors. This will permit fuel from the inlet manifold to flow directly to the return manifold.

(e) Start engine, run at approximately 500 RPM, and take readings on the gauge.

Do not take compression pressure by cranking engine with the starter.

(f) Perform this same operation on each cylinder in turn. The compression pressure on

any one cylinder should not drop below 385 pounds per square inch, nor should the pressure for any one cylinder be more than 25 pounds below the reading on the other cylinders, as for example.

Cylinder No.	Gauge Reading
1	370 lbs./sq. in.
2	400 lbs./sq. in.
3	395 lbs./sq. in.
4	405 lbs./sq. in.
5	410 lbs./sq. in.
6	400 lbs./sq. in.

Note that the compression pressure in No. 1 cylinder falls considerably below the pressures in the five other cylinders, indicating compression leak in No. 1 cylinder.

In such cases, the cylinder head must be removed see "Remove Cylinder Head," Page 0, Sec. 9, valve seats inspected for leaks, valve stems inspected for sticking, and cylinder head gasket for leaks.

If these parts are found to be in order, the leakage must take place past the piston and be due to insufficient sealing of the piston rings.

NOTE: To inspect the piston rings thoroughly, the piston must be removed from the engine. See "Removing Piston," Page 1, Sec. 6. Inspect the piston rings and ring grooves and replace the rings, as outlined on Page 3, Sec. 6. To replace the piston, see Page 6, Sec. 6.

7. **Air in Fuel System.**
   CORRECTION:
   (a) Disconnect the fuel return line and run engine, and observe if air bubbles are discharged with fuel. This can best be done by submerging the end of the pipe in an open can of fuel. (See Fig. 35, Sec. 15.)
   (b) Remove one fuel pipe to injector at end of engine which is highest, if standing on uneven ground, and install combination sight glass and pressure gauge fixture. Air bubbles will show up in the sight glass.
   (c) If air is present, inspect all fuel line connections from the suction side of fuel pump to the fuel tank. Inspect for cracked tubing flared ends. Inspect primary filter gasket. Inspect for holes chafed through fuel suction line. Inspect for cracks arising from screwing fittings in too tight at fuel pump and filter.

III. **Engine Stalls Frequently.**

1. Idling speed too low.
   CORRECTION: Check idling speed and adjust for a minimum of 400 R.P.M.
2. Cooling water temperature too low.
   CORRECTION: Inspect water thermostat in water manifold.
3. One or more cylinders cutting out.
   CORRECTION: See "Tracing Missing Cylinder", Page 11, Item 6, under "Uneven Running".
4. Hunting governor.
   CORRECTION: Remove all bind from injector control rack operating shaft mechanism. See "Governor Service", Sec. 16.
5. Choked fuel oil filters.
   CORRECTION: See "Fuel Oil Filter Service", Pages 26, and 28, Sec. 15.
6. Unsatisfactory injectors.
   CORRECTION: See "Remove Injectors", Page 5, Sec. 15, "Positioning Injector Control Racks", Page 13, Sec. 15, and "Reconditioning Injector Spray Tip," Page 7, Sec. 15.
7. Improper governor adjustment and governor linkage incorrectly set.
   CORRECTION: See "Governor Adjustment", Sec. 16, also "Injector Service", Page 5, Sec. 15.
8. Air in fuel system.
   CORRECTION: See "Checking of Fuel Supply System", Page 20, Sec. 15.
9. Engine overloaded.
   CORRECTION: If above corrections do not stop stalling condition, remove excess load.

IV. **Loss of Power.**

1. Injector racks not properly positioned.
   CORRECTION: See "Positioning Injector Control Racks", Page 13, Sec. 15.
2. Faulty injector timing.
   CORRECTION: See "Timing Injector", Page 12, Sec. 15.
3. One or more cylinders cutting out.
   CORRECTION: See "Tracing a Missing Cylinder", Page 11.
4. Air cleaners choked.
   CORRECTION: See "Air Cleaner Service", Sec. 14.
5. Insufficient fuel supply.
   CORRECTION: See "Checking of Fuel Supply System", Page 20, Sec. 15.
6. Choked fuel oil filter.
   CORRECTION: See "Fuel Oil Filter Service", Pages 26, and 28, Sec. 15.
7. Air in fuel system.
   CORRECTION: See "Air in Fuel System", Page 20, Sec. 15.
8. Unsatisfactory injectors.
   CORRECTION: See "Remove Injectors", Page

5, Sec. 15, "Positioning Injector Control Racks", Page 13, Sec. 15, and "Reconditioning Injector Spray Tip", Page 7, Sec. 15.

9. Improper governor adjustment.
   CORRECTION: See "Governor Adjustment", Sec. 16.
10. Loss of compression.
    CORRECTION: Check "Compression Pressure". See "Checking Compression Pressure", Page 12. Inspect for broken piston rings through air ports in liner.
11. Fuel tank air vent plugged.
12. Governor adjustments incorrect.
    (a) Governor low-speed spring gap improperly adjusted. (Mechanical Governor).
    CORRECTION: Adjust low-speed spring stop screw so gap is .0015" to .002". See Page 13, Sec. 15.
    (b) Engine speed drops too low when load is applied. (Hydraulic Governor).
    CORRECTION: Check speed droop adjusting lever. See "Speed Droop Adjustment" and "Speed Limit Adjustment" in Sec. 16.

V. **Smoky Exhaust:**

BLACK SMOKE:

1. Poor grade of fuel.
   CORRECTION: See "Fuel Oil Specifications", Page 32, Sec. 15.
2. Injector timing late.
   CORRECTION: See "Injector Timing", Page 12, Sec. 15.
3. Unsatisfactory injector.
   CORRECTION: See "Remove Injectors", Page 5, Sec. 15, "Positioning Injector Control Racks", Page 13, Sec. 15, and "Reconditioning Injector Spray Tip", Page 7, Sec. 15.
4. Air box cover plate gasket ruptured.
   CORRECTION: Replace gasket.
5. Air ports in cylinder liner choked.
   CORRECTION: Remove cylinder head; remove sludge from ports to air box with convenient tool; and remove sludge from air box.
6. Obstruction in blower air intake.
   CORRECTION: Remove air inlet housing and inspect and clean screen between housing and blower.

BLUE SMOKE:

1. Injector racks not properly positioned.
   CORRECTION: See "Position Injector Control Racks", Page 13, Sec. 15.
2. Cylinder cutting out.
   CORRECTION: See "Tracing a Missing Cylinder", Page 11.
3. Lubricating oil enters combustion chambers.
   (a) Piston rings worn or stuck. Oil rings assembled incorrectly.
   CORRECTION: See "Piston Ring Inspection", Page 2, Sec. 6.
   (b) Oil leaks into air box or blower housing because blower housing-to-block gasket is leaky or the blower rotor shaft seals leak.
   CORRECTION: Renew gaskets or seals.
   (c) Oil level too high in air cleaner.
   CORRECTION: See "Air Cleaner Service", Page 17, Sec. 14.
4. Engine temperature too low.
   CORRECTION: Neglect blue smoke before engine warms up to at least 140°F.

VI. **Engine Detonates.**

If a hard, metallic knock indicates detonation in one or more cylinders, the engine should be immediately stopped, to prevent serious damage due to the excessive pressures accompanying detonation.

Detonation is caused by the presence of fuel or lubricating oil in the air charge of the cylinders during the compression stroke.

CORRECTION: The engine should be checked for:

1. Leaky injectors. See "Recondition Spray Tip", Page 7, Sec. 15, or "Injector Disassembly and Inspection", Page 6, Sec. 15. Locate bad cylinder by cutting out injectors, one at a time, as in "Tracing Missing Cylinder", Page 11.
2. Leaking fuel connections in cylinder head.
3. Crankcase dilution due to fuel leaks.
   CORRECTION:
   (a) Drain and refill crankcase with specified oil.
   (b) Inspect air box and blower, and clean out with compressed air, also check to see if air box drains are open, See "7" below.
   (c) Tighten all fuel connections.
   (d) Inspect piston rings. See "Piston Ring Inspection", Page 2, Sec. 6.
4. Oil pull-over from air cleaners.
   CORRECTION: See that oil in air cleaners is not above indicated level and is of proper viscosity.
5. Leaky blower housing gasket.
   CORRECTION: Replace gasket.
6. Leaky blower oil seals.
   CORRECTION: See "Blower Inspection", Page

3, Sec. 14, and change seals according to instructions in "Blower Service".

7. Plugged air box drains.
   CORRECTION: Open drains—remove hand hole covers, and clean air box with dry rags.

VII. **Lack of Lubricating Oil Pressure.**

1. Oil supply in crankcase low allowing pump to suck air.
2. Crankcase oil diluted by fuel oil.
   CORRECTION: Observe odor of oil in crankcase for traces of fuel. Check for fuel leaks.
3. Use of improper lubricant.
   CORRECTION: See "Lubricating Oil Specifications", Page 22, Sec. 12.
4. Wear on crankshaft or connecting rod bearings.
   CORRECTION: See "Main Bearing Service", Page 2, Sec. 4, and "Connecting Rod Bearing Service", Page 4, Sec. 6.
5. Lubricating oil pump relief valve sticking.
   CORRECTION: Examine relief valve assembly. See Page 7, Sec. 12.
6. Oil cooler choked.
   CORRECTION: Clean cooler. See "Cleaning Oil Cooler", Page 21, Sec. 12.
7. Oil pump screen choked.
   CORRECTION: Remove oil pan and clean screen.
8. Oil pump drive inoperative.
   CORRECTION: Remove oil pan and inspect oil pump drive.
9. Oil lines choked, improperly tightened; or ruptured gaskets at pipes, resulting in oil leaks.
   CORRECTION: Remove oil pan, inspect gaskets, tighten connections.
   Choked oil lines are the results of very dirty and sludging oil. If this condition exists, the lubricating system should be thoroughly purged before resuming operation.

VIII. **Engine Runs Unevenly or Stops Frequently.**

1. Water in fuel.
   CORRECTION: Drain filter. Drain water from fuel tank. Fill filters with clean fuel. Disconnect fuel return line and allow engine to run and discharge fuel into a container until fuel system is purged of water.
2. Low fuel pressure.
   CORRECTION: See "Check Fuel Supply System," Page 20, Sec. 15.

IX. **Oil Does Not Stay in Air Cleaner.**

Gasket missing from flanged edge inside filter element.
CORRECTION: Install new gasket.

ENGINE TUNE-UP

Approximately 100 hours after the initial start or after overhaul, and otherwise, at 500 hour intervals, the variable adjustments of the engine should be checked and corrections made for any deviations from standard.

The checks necessary are listed below and procedure for them is outlined in the manual at the page and section indicated.

1. Adjust Valve Lash; Page 2, Sec. 11.
2. Time the Injectors; Page 12, Sec. 15.
3. Position Injector Control Racks; Page 13, Sec. 15, for mechanical governors and Page 38, Sec. 16, for hydraulic governors.
4. On mechanical governors, Adjust Idle Speed and buffer spring if necessary; Page 14, Sec. 16. On hydraulic governors, adjust speed droop and make other adjustments as required; Page 38, Sec. 16.
5. Inspect fuel oil filters and clean or renew filter elements; Page 25, Sec. 15.
   This item is especially important when considerable dirt has been found in the fuel.

RUN-IN SCHEDULES FOR 3, 4 AND 6 CYLINDERS SERIES 71 DIESEL ENGINES

Engines in which new pistons or piston rings, cylinder liners, main bearings, or connecting rod bearings have been installed, should be operated on a RUN-IN schedule prior to release for service. The purpose of the RUN-IN schedule is to assure proper alignment and seating of parts before the engine is subjected to FULL-LOAD operation.

When filling the lubricating system, remove valve cover and pour a gallon of oil over the valve gear. Check valve lash and injector timing before cranking the engine.

A minimum water jacket temperature of 160° F. should be maintained throughout the run.

The recommended oil pressures are 30 lbs. at 1200 RPM and 35 lbs. at 2000 RPM.

Change lubricating oil and clean oil strainer after completing the run-in to remove any metallic or foreign material accumulated during this period.

RUN-IN SCHEDULE FOR ENGINES OPERATING AT CONSTANT SPEED—GENERATOR SETS, ETC.

Hours	Per Cent of Rated Load	Nominal R. P. M.
¼*	0	1200
½	25	1200
½	50	1200
1**	75	1200
1	100	1200

*Warm-up and inspection period. This is a minimum run-in schedule and if time permits, the engine should be run for longer time increments than specified before applying full load.

**Check valve lash—.011" GO— .013" NO GO with engine hot.

Check injector timing. (See page 12, Sec. 15.)

Check injector balance and idle operation. See "Position Injector Control Racks", Page 13, Sec. 15 and "Governor Adjustments", Pages 14 and 38, Sec. 16.

Inspect for oil-leaks and tighten all external bolts.

Frictional losses in the engine will continue to decrease for 10 or 20 hours and consequently engine performance will improve. During this period it is desirable to avoid maximum power output except for short intervals.

RUN-IN SCHEDULE FOR ENGINES OPERATING AT VARYING SPEEDS — 400 TO 2000 R.P.M.

Time	Engine RPM	% Load
¼*	1000	0
½	1000	20
½	1300	30
½**	1500	50
½	1800	80
1	2000	100

*Warm up and inspection period. This is a minimum run-in schedule and if time permits, the engine should be run for longer time increments than specified before applying full load.

**Check valve lash—.011" GO—.013" NO GO with engine hot.

Check injector timing. (See page 12, Sec. 15.)

Check injector balance and idle operation. (See "Position Injector Control Racks," Page 13, Sec. 15 and "Governor Adjustments," Pages 14 and 38, Sec. 16.)

Inspect for oil leaks and tighten all external bolts.

Frictional losses in the engine will continue to decrease for 10 or 20 hours and consequently engine performance will improve. During this period it is desirable to avoid maximum power output except for short intervals.

TORQUE WRENCH PULLS

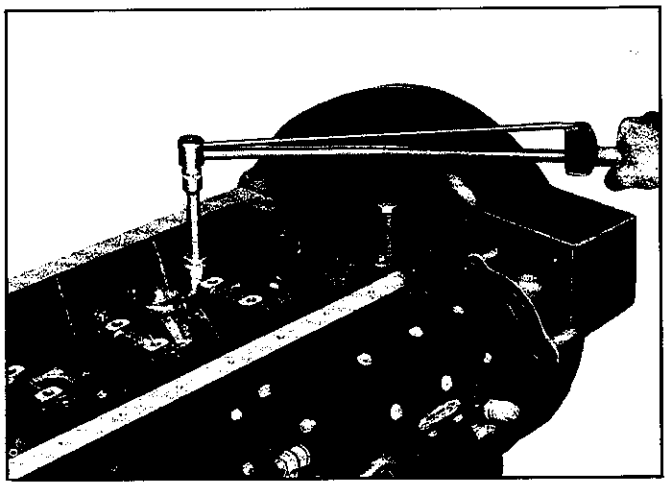


Fig. 9—Using Torque Wrench, Tool J-1264, on a Model 71 G. M. Diesel Engine.

When a torque wrench is available, the following values may be used when tightening nuts on the various studs and bolts. The Torque is given in lb. ft., and wrench J-1264, illustrated in Fig. 9, may be used.

Part	Torque Lb. Ft.
Injector clamp nuts	20-25
Cylinder head stud nuts	150-175
Connecting rod cap nuts	65-75
Main bearing cap nuts	155-185
Flywheel-to-crankshaft bolts	150-160
Flywheel housing-to-cylinder block bolts (½" dia. size)	90-100
Camshaft and balancer shaft lock nuts	300-325
Blower rotor gear retainer bolts: ½" dia. (new style)	55-65

DOUBLE-LAP TUBE FLARING TOOL
J-1885-A

Description—Should occasion require, tubes with 3/16", 1/4", 5/16" and 3/8" outside diameters may be flared at the ends to accommodate flared fittings with the tool illustrated in Figs. 10 and 11.

As seen from the illustrations, the tool consists of a die block for holding the tubing to be flared, a flare forming tool, a punch ram and a body in which may be clamped the die block and which guides the punch ram.

When flaring a tube, the tool may be either clamped in vise jaws to hold the die block in the tool body as shown in Fig. 10 or held by hand as shown in Fig. 11.

Operation—Refer to Figs. 12, 13 and 14 illustrating the various consecutive steps in flaring a tube, which is done as follows:

(a) Cut tubing end using tube cutter or hack saw. ***Be sure tubing is cut square***—this is important for tubing not cut square will result in an uneven flare. Remove all burrs around inside edge of tubing—failure to clean tubing ends prevents flare forming tool pilot from entering tubing freely.

(b) Be sure to place necessary compression fittings on the tubing before proceeding any further.

(c) Select proper die block. Die blocks are split in half with machined holes so arranged to accommodate 4 sizes of tubing in one block—3/16", 1/4", 5/16", and 3/8" O.D. tubing. Place tubing (1) in half of die block (2) in the space corresponding to size to be flared as shown in Fig. 12. Allow approximately 1/4" of tubing to project beyond countersunk end of die block. Use a lead or soft faced hammer, tap tubing in place removing any kinks or bends. Place other half of die block around tubing and tap firmly together. Avoid the use of an ordinary hard faced hammer when tapping tubing in place or die block together.

2. **Assembling Die Blocks in Tool Body.**

(a) Remove punch ram (4) from tool (5).

(b) Place die blocks (2) with tubing (1) into body of tool (5) and tap in place as shown in Fig. 12.

(c) Die blocks must be fully seated on bottom of body casting and firm against face of stop pin. Use block of wood to tap firmly in place. Die blocks not properly seated will produce imperfect flare.

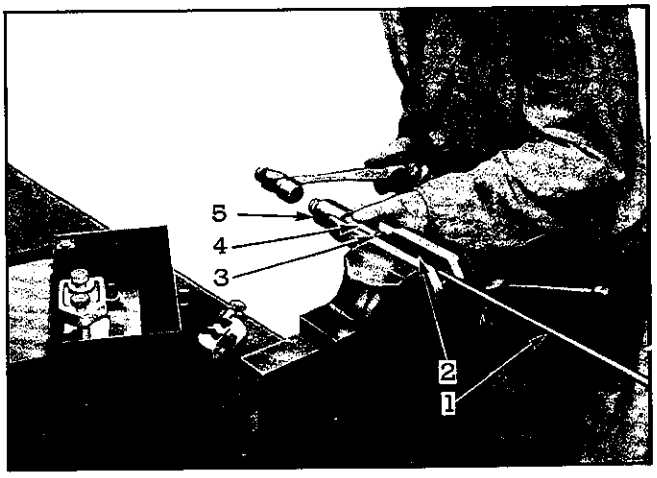


Fig. 10—Flaring Tubing with Tool Supported in Vise.

1. Tubing.
2. Die Block.
3. Flare Forming Tool.
4. Punch Ram.
5. Tool Body.

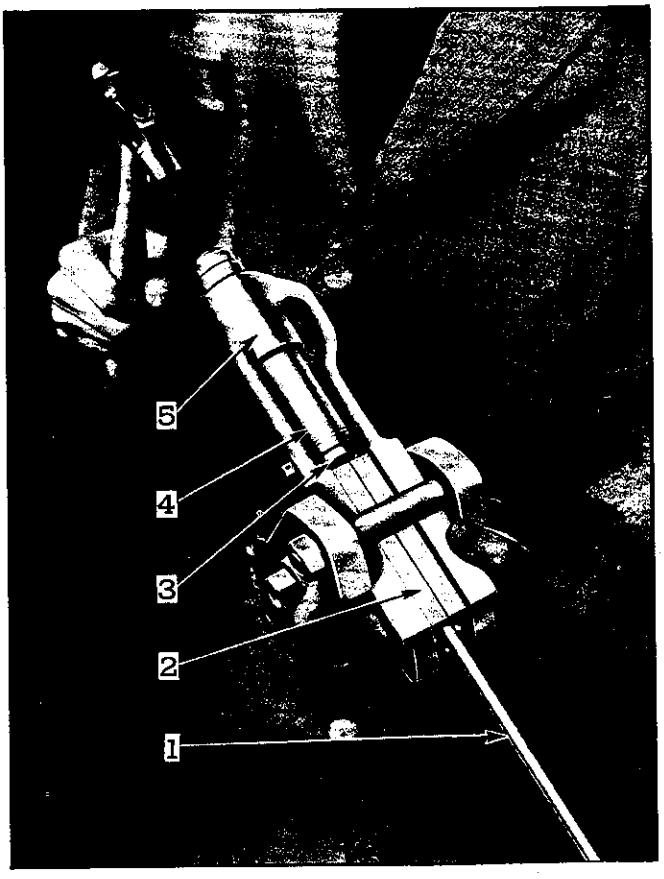


Fig. 11—Flaring Tubing with Tool Supported by Hand.

1. Tubing.
2. Die Block.
3. Flare Forming Tool.
4. Punch Ram.
5. Tool Body.

3. **Operation—Using Tool in Bench Vise—**

(a) Place tool in vise as shown in Fig. 10 so that the ledges on the sides of the tool ride on the top edge of the vise jaws and against small pin located at side of tool.

NOTE: A bench vise of at least 4½" capacity or larger is recommended to insure a firm grip and prevent tubing from slipping in die block.

(b) Draw vise jaws together with just enough pressure to hold in place.

(c) Insert punch ram (4) in tool. Then select proper size flare forming tool (3) and place in punch ram with the ***concave end*** facing toward the tubing.

(d) Move punch ram toward tubing until pilot end of flare forming tool enters tubing.

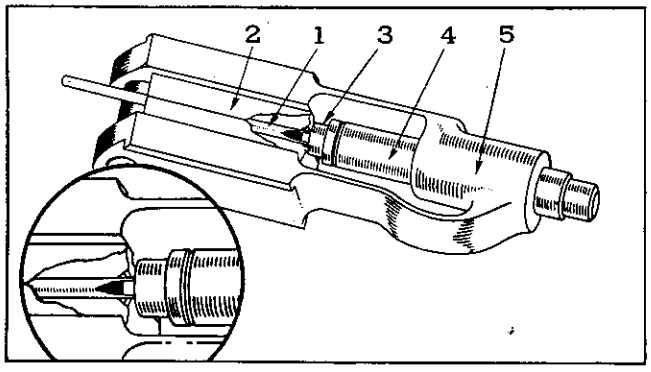


Fig. 12—Placing Tubing in Die Block Preparatory to Flaring.
(Operation 1)

1. Tubing.
2. Die Block.
3. Flare Forming Tool.
4. Punch Ram.
5. Tool Body.

(e) Tap end of punch ram with hammer until guide mark on upper end of ram is in line with the end of body of tool. This adjusts tubing to the proper distance in the die block.

(f) Draw vise jaws together ***as tight as possible.***

CAUTION: Failure to draw vise jaws tight will permit tubing to slip in die block when performing the flaring operations and a perfect flare cannot be obtained.

(g) Now strike end of punch ram several blows with hammer or until stop shoulder of flare forming tool touches die block. This upsets the end of tubing as shown in Fig. 13 and completes first flare forming operation.

(h) Pull punch ram back and reverse the flare forming tool (3) so that tapered end of tool is toward tubing. Move punch ram toward tubing until pilot end of flare forming tool enters tubing. Strike end of punch ram several blows with hammer. Move punch ram back enough to observe flare forming operation. Repeat striking punch ram with hammer until flare has been completely formed as shown in Fig. 14.

Using Tool Portably with Clamp Assembly—

The J-1885-SA-5 Clamp Assembly is provided so that the J-1885 Double-Lap Flaring Tool can be used on the job and where a bench vise is not available.

(a) Prepare tubing as previously outlined.

(b) Remove punch ram from tool.

(c) Place die blocks with tubing into body of tool and tap in place as shown in Fig. 12.

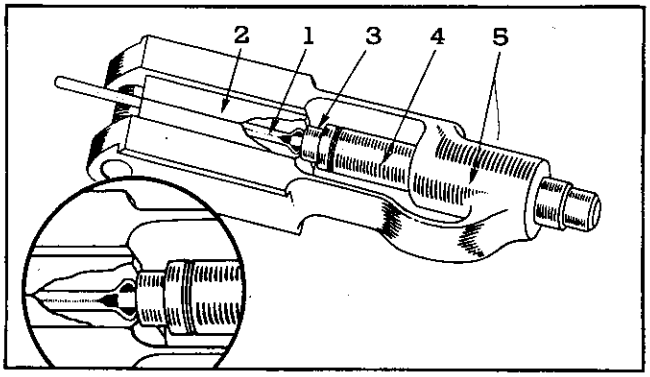


Fig. 13—Upsetting Tubing End.
(Operation 2)

1. Tubing.
2. Die Block.
3. Flare Forming Tool.
4. Punch Ram.
5. Tool Body.

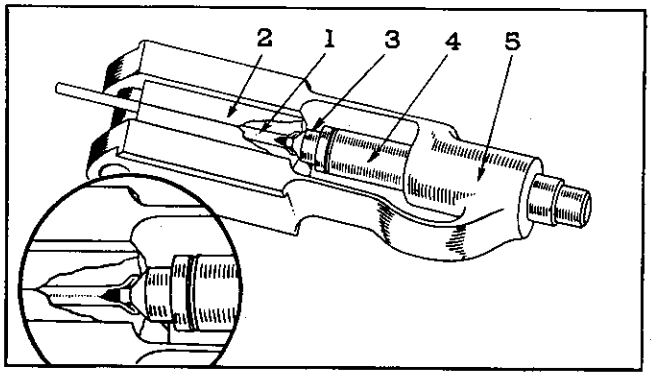


Fig. 14—Flaring Tubing End.
(Operation 3)

1. Tubing.
2. Die Block.
3. Flare Forming Tool.
4. Punch Ram.
5. Tool Body.

(d) Die blocks must seat firmly against stop pin at the bottom and back of body of the tool. Use block of wood to tap firmly in place. Die blocks not properly seated will produce imperfect flare.

(e) Slide J-1885-SA-5 Clamp Assembly over body of tool as shown in Fig. 11.

(f) Center clamp assembly and tighten clamp nuts just enough to hold die blocks in place.

(g) Insert punch ram in tool. Then select proper size flare forming tool and place in punch ram with the concave end facing toward the tubing.

(h) Move punch ram toward tubing until pilot end of flare forming tool enters tubing.

(i) Tap end of punch ram with hammer until guide mark on upper end of ram is in line with the end of body of tool. This adjusts tubing to the proper distance in the die block.

(j) Tighten clamp nuts securely—make sure that the top nut or nut nearest tubing is tightened first and then draw the lower nut tight.

(k) Proceed with instructions as previously outlined using clamp assembly as a vise to complete flaring operations.