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IMPLEMENT & TRACTOR

publication

OLIVER

SHOP MANUAL

MODELS

99 (6 Cyl.) 4 Speed

Super 99 (6 Cyl.) 6 Speed

Super 99GM (3 Cyl.) 6 Speed

MANUAL NO. O-7 PRICE, $3.25

IMPLEMENT & TRACTOR PUBLICATIONS, INCORPORATED

KANSAS CITY 5, MO.

Information and Instructions

This individual Shop Manual is one unit of the I&T SHOP SERVICE described elsewhere on this page. Contained in it are the necessary specifications and the brief but terse procedural data needed by a mechanic when repairing a tractor on which he has had no previous actual experience.

The material is arranged in a systematic order beginning with an index which is followed immediately by a Table of Condensed Service Specifications. These specifications include dimensions, fits, clearances and timing instructions, as well as liquid capacities of the transmission, final drive, crankcase and cooling system. Next in order of arrangement is the procedures section.

In the procedures section, the order of presentation starts with the front axle system and steering and proceeds toward the rear axle. The last portion of the procedures section is devoted to the belt pulley, power take-off and power lift systems. Interspersed where needed in this section are additional tabular specifications pertaining to wear limits, torquing, etc.

HOW TO USE THE INDEX

Suppose you want to know the procedure for R&R (remove and reinstall) of the engine camshaft. Your first step is to look in the index under the main heading of ENGINE until you find the entry "Camshaft". Now read to the right where under the column covering the tractor you are repairing, you will find a number which indicates the beginning paragraph pertaining to the camshaft. To locate this wanted paragraph in the manual, turn the pages until the running index appearing on the top outside corner of each page contains the number you are seeking. In this paragraph you will find the information concerning the removal of the camshaft.

DATA NOT INCLUDED IN THIS MANUAL

This manual covers the adjustment and removal of all the components contained in the tractor. It also covers the procedures and specifications for overhauling all of the components except carburetor, clutch, ignition unit, generator, regulator and starting motor. Bench overhaul data pertaining to these excepted units and embracing ALL of the tractors contained in the SHOP SERVICE is covered in two separate manuals. One of the separate manuals titled Standard Units Shop Manual contains repair and test procedures; the other, titled Standard Units Specifications Manual contains the tabulated test specifications. Both of these manuals are required for complete service information on any one model of tractor.

The complete SHOP SERVICE contains:

A. Heavy-duty, expandable binder.

B. Shop Manuals for each make of tractor.

C. Flat Rate manuals for each make of tractor.

D. Standard Units Shop manual and Standard Units Specifications manual applying to all the tractors.

E. Service Supplements.

Additional copies of this manual are available.

I&T SHOP SERVICE

PUBLISHED BY TECHNICAL SERVICES DIVISION

IMPLEMENT & TRACTOR PUBLICATIONS, INCORPORATED

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KANSAS CITY 5, MISSOURI, U. S. A.

Printed in U. S. A. (Second Printing)

SHOP MANUAL

OLIVER

MODELS 99 (6 Cyl.), SUPER 99 (D & HC), SUPER 99 GM

IDENTIFICATION

On 6 cylinder models tractor serial number is on plate aft of starting motor. Engine serial number stamped on right rear flange. On Super 99 GM tractor serial number is on plate at left side of clutch housing cover. Engine serial number is on plate right side of rocker arms cover and stamped on block upper right side.

The non Super models are equipped with a four speed transmission, all Super series have six speed transmissions.

BEGINNING SERIAL NUMBERS

Year	Number	Year	Number
1953	518314	1956	520456
1954	519300	1957	520868
1955	519700		

INDEX (By Starting Paragraph)

CONDENSED SERVICE DATA

GENERAL

	99	Super 99		
	HC & D	HC	D	GM
Engine Make	Own	Own	Own	G.M.
Engine Model	.....	.....	.....	3023
Cylinders, Number of	6	6	6	3
Cylinder Bore—Inches	4.0	4.0	4.0	4¼
Stroke—Inches	4.0	4.0	4.0	5.0
Displacement—Cubic Inches	302	302	302	213
Compression Ratio—Non-Diesel	6.2	6.2	.....	.....
Compression Ratio—Diesel	15.5	.....	15.5	17.0
Pistons Removed From	Above	Above	Above	Above
Main Bearings, Number of	4	4	4	4
Main & Rod bearings, Adjustable?	No	No	No	No
Cylinder Sleeves	Dry	Dry	Dry	Dry
Forward Speeds	4	6	6	6

TUNE-UP

Firing Order	1, 5, 3, 6, 2, 4	1, 5, 3, 6, 2, 4	1, 5, 3, 6, 2, 4	1, 3, 2
Valve Tappet Gap—Inlet	0.009 Cold	0.009 Cold	0.009 Cold	None
Valve Tappet Gap—Exhaust	0.016 Cold	0.016 Cold	0.016 Cold	0.009H
Valve Face and Seat Angle	45	45	45	30
Generator, Distributor and Starter, Make	Delco-Remy	Delco-Remy	Delco-Remy	Delco-Remy
Ignition Distributor Model	1111731	1111731	None	None
Ignition Magneto Make, Optional	Wico	Wico	Wico	None
Ignition Magneto Model, Wico	XVD2291	XVD2291	None	None
Distributor Breaker Gap	0.022	0.022	None	None
Magneto Breaker Gap	0.015	0.015	None	None
Injector Timing	Refer to paragraph 36			par. 90
Distributor Timing High Idle	28°B	28°B	None	None
Flywheel Mark Distributor High Idle Timing	IGN	IGN	None	None
Flywheel Mark Distributor Retard Timing	TC	TC	None	None
Flywheel Mark Magneto Running Timing	MAG	MAG	None	None
Distributor Governor Advance Curve	Refer to paragraph 52			None
Spark Plug Make	A-C, Champion or Auto-Lite			
Plug Model for Normal Duty	A-C 88S Comm. or equivalent			
Injection Pump, Make and Type	Bosch PSB	Bosch PSB	Bosch PSB	G.M. 70
Nozzle Opening Pressure	1750	No	1750	350-850
Plug Electrode Gap	0.025	0.025	None	None
Carburetor Make	Marvel-Schebler		None	None
Carburetor Model	TSX477 or	TSX581	None	None
Carburetor Calibration and Parts	Refer to paragraph 29A			
Engine Low Idle RPM—Battery Ignition	350	350	.....	.....
Engine Low Idle RPM—Diesels	600	.....	600	500
Engine High Idle RPM—Non-Diesels	1925	1925	.....	.....
Engine High Idle RPM—Diesels	1840	.....	1840	1840
Engine Governed RPM—Loaded	1675	1675	1675	1675
Belt Pulley RPM—Loaded	1000	980	980	980

SIZES—CAPACITIES—CLEARANCES

(Clearances in Thousandths)

Crankshaft Journal Diameter	2.625	2.625	2.625	3.500
Crankpin Diameter Prior Engine Serial 964432	2.250	2.250	2.625	.....
Crankpin Diameter Engine Serial 964432 and up	No	2.625	2.625	2.750
Connecting Rod Center to Center Length—Inches	6¾	6¾	6¾	10⅛
Camshaft Journal Diameter—Nominal	1¾	1¾	1¾	1½
Piston Pin Diameter	1.250	1.250	1.250	1.500
Valve Stem Diameter—Nominal	⅜	⅜	⅜	11/32
Compression Ring Width	⅛	⅛	⅛	⅛
Oil Ring Width	3/16	3/16	3/16	3/16
Main Bearings Clearance, New—Diesel	Refer to paragraph 24D			1.5-3
Main Bearings Clearance, New—Non-Diesel	Refer to paragraph 24D			.....
Main Bearings Clearance, Maximum	4.5	4.5	4.5	6
Rod Bearings, Clearance, New—Diesel	Refer to paragraph 23A			1.5-3
Rod Bearings Clearance, New—Non-Diesel	Refer to paragraph 23A			.....
Rod Bearings Clearance, Maximum	2.5	2.5	2.5	6
Piston Skirt Clearance	5-10 pounds checked with 0.003 feeler			4-9
Camshaft End Play	Spring Loaded			4-18
Crankshaft End Play	5-12	5-12	5-12	4-18
Camshaft Bearings Running Clearance	Refer to paragraphs 19A and 67B			
Cooling Systems—Gallons	5¼	5½	5½	5½
Crankcase Oil, Refill—Quarts	6	6	6	11
Crankcase Oil, if Filter is Changed	7 or 8	7	8	13
Transmission and Differential—Quarts	48	32	32	32
Hydraulic System, Maximum—Quarts	9	9	9	9
Add for Belt Pulley and PTO—Quarts	.....	4	4	4

TIGHTENING TORQUES

(In Foot-Pounds)

Oil Line Cylinder Head Bolts	96-100	No	96-100	.....
Cylinder Head, Non-Diesel—Foot-Pounds	91-100	91-100	No	No
Cylinder Head, Diesel—Foot-Pounds	112-117	No	112-117	165-175
Main Bearings, 6 Cylinder—Foot Pounds	108-112	108-112	108-112	No
Main Bearings, Bolts—Foot-Pounds	No	No	No	180-190
Connecting Rods—⅜ Bolts	44-46	44-46	44-46	No
Connecting Rods—7/16 Bolts on 6 Cylinder	87-92	87-92	87-92	65-75
Manifold Nuts and Rocker Shaft Brackets	25-27	25-27	25-27	.....
Flywheel	67-69	67-69	67-69	150-160

STEERING GEAR

1. All models are equipped with a Saginaw recirculating ball type gear basically similar to the unit used on the 4 cylinder, series 99 tractors as shown in Fig. 0450. As will be seen from the illustration, the teeth cut on the sector shaft (70) are tapered. The sector operating nut (71) rides on steel balls interposed between the nut and the wormshaft. Power steering of the linkage booster type is available. Construction of the gear unit and the method of adjusting the unit are the same with and without power steering.

1A. **ADJUST.** On tractors having 6 speed transmission, it is necessary to remove the steering gear or the transmission shifter tower when making a complete adjustment of the steering gear. On tractors having 4 speed transmission, it is not necessary to remove the gear or disturb the shifter tower.

2. WORM END PLAY. This adjustment is controlled by the threaded plug (B). To adjust worm end play, loosen the locknut (A) and rotate the adjuster nut (B) clockwise until there is no perceptible end play and no binding. Recheck the adjustment after tightening the lock nut.

2A. MESH (BACKLASH) ADJUSTMENT. This adjustment is controlled by the lash adjuster screw (C), shown in Fig. 0450 which, on 6 speed tractors, cannot be manipulated without first removing the gear housing from the transmission shifting tower or the tower from the gear housing. Gear unit can be removed from tower by removing the three attaching cap screws after disconnecting throttle rod and removing drop arm from gear. The mesh (backlash) adjustment should be made **after** the wormshaft end play has been adjusted. Place steering gear in mid-position (exactly half way between full left and full right turn position) and loosen the lock nut (D). Rotate lash adjuster (C) clockwise until a very slight drag is felt only when the steering wheel passes through the mid or central position. Wheel should revolve freely at all other points in its rotation. Gear is correctly adjusted when 16 to 20 inch pounds of torque at steering wheel rim is required to pass through the mid-position, wheels off floor, linkage disconnected.

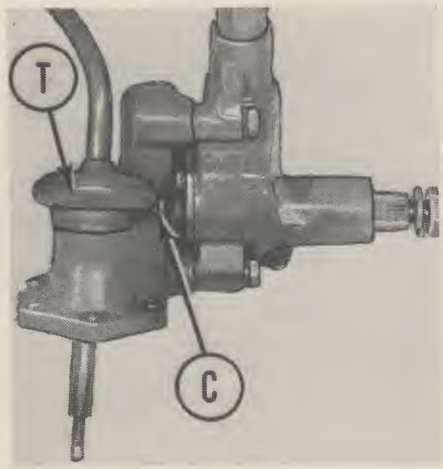


Fig. 0449 — Steering backlash adjustment screw (C) is not accessible until gear unit is separated from gear shifter tower (T).

Note: Backlash adjusting screw (C) should have from zero to 0.002 end play in sector shaft. If end play exceeds 0.002, it will prevent correct adjustment; in which case, the sector cover (76) should be removed and shim washers (S) added at head of adjuster screw to remove the excess backlash.

Caution: Do not turn steering wheel hard against stops when drag link is disconnected as ball guides may be damaged in doing so.

3. **R & R AND OVERHAUL.** To remove the steering gear unit, disconnect throttle rod at gear, remove drop arm from sector shaft and the three cap screws holding the unit to the shifter tower. Lift gear unit out from above.

Procedure for bench overhaul of the gear unit is as follows: Remove sector shaft arm and cap screws from sector cover (76) and withdraw sector and cover as a unit from housing.

Remove worm (screw) shaft cover (E) and withdraw worm shaft through

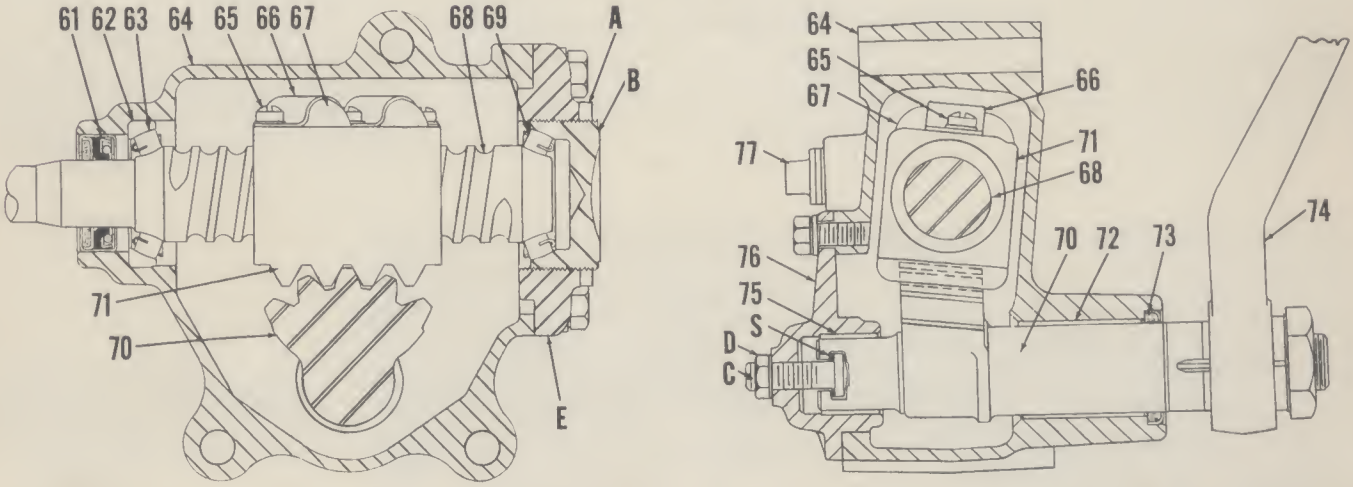


Fig. 0450—Saginaw steering gear (recirculating ball type) as used on later production series 90 and 99 tractors.

A. Lock nut
B. Worm shaft bearing adjuster nut
C. Lash adjuster
D. Lash adjuster lock nut
S. Shim washers
61. Seal
62. Bearing cup
63. Bearing cone
64. Gear housing
65. Clamp retaining screw
66. Retainer clamp
67. Retainer
68. Worm and shaft
69. Bearing cone
70. Sector and shaft
71. Ball nut
72. Bushing (large)
73. Seal
74. Sector shaft arm
75. Bushing (small)
76. Sector cover
77. Lubricant filler plug

this opening. Worm shaft bearing cup (62) and/or oil seal (61) can be renewed at this time.

Ball nut (71) should move along grooves in wormshaft smoothly without lumpiness and with minimum end play. If worm shows signs of wear, scoring or other derangement, it will be advisable to renew the worm and nut as a unit. The nut can be disassembled for inspection by removing the ball retainer clamp (66) and the retainers (67).

To reassemble ball nut, place nut over middle section of wormshaft as in Fig. 0452. Drop bearing balls into one retainer hole in nut and rotate worm shaft slowly to carry balls away from the hole. Continue inserting balls into hole until 40 balls are in each circuit and circuit is full to bottom of both holes. If end of worm is reached before 40 balls are in circuit, hold balls in position with a clean blunt rod as shown while shaft is turned in opposite direction, and then drop remaining balls in hole. Make certain that no balls are outside regular ball circuits. If balls remain in groove between two circuits or at ends, they cannot circulate and will cause gear failure.

Next, fill each ball retainer, Fig. 0451, with 13 balls and plug retainer ends with heavy grease; then, insert retainer units in worm nut and install retainer clamp. Exactly 106 balls are used in the circuit.

Sector shaft large bushing (72—Fig. 0450) has an inside diameter of 1.375 inches. Other sector shaft bushing (75) has an inside diameter of 1.0625 inches. I&T suggested clearance of shaft in bushings is 0.0015-0.003.

Select and insert shims (S) on sector mesh adjusting screw (C) to provide zero to 0.002 end play, before reinstalling sector and shaft in gear housing. Adjust worm (screw) shaft bearings and sector mesh as outlined in paragraphs 2 and 2A.

FRONT AXLE SYSTEM

SPINDLES

(Applies to tractors serial 5193000 and up. Refer to manual 0-2 for earlier tractors having conventional spindles.)

4. Front wheels are carried on "live" (rotating) spindles which revolve in tapered roller bearings mounted in the spindle carriers (16—Figs. 0454 and 0456A). The latter are supported by stationary pivots (23 and 24) anchored in the axle yokes and provided with needle type roller bearings (57) and separate thrust bearings.

5. Procedure for adjustment or renewal of front wheel bearings is conventional except that knuckle arms must be removed to obtain access to spindle nuts. Cups and cones may be renewed without removing the spindle carriers from the axle.

SPINDLE CARRIERS

(Applies to tractors serial 519300 and up.)

6. To remove or renew the spindle carrier pivot pins, proceed as follows: Remove front wheels and drive out the Rollpins (49—Fig. 0455) which retain the pivot pin in the axle yoke. Disconnect knuckle arm (17) from tie rod or remove from carrier. Remove grease fitting from pivot pins and extract same using a screw, nut and pipe as a puller as shown in Fig. 0456. Pivot pins may also be removed by using a slide hammer (inertia) type puller attached to a screw or rod on which has been cut a ⅛ inch pipe thread, threaded into the hole from which the grease fitting was removed. The roller type thrust bearing (58—Figs. 0456A and 0454) and pivot pins (23 & 24) can be renewed at this time. The longer pivot should be installed in the top of axle and should engage shorter pivot boss on the carrier. After carrier is installed, insert ½ pint of engine oil into same through pipe plug opening.

To remove the needle type pivot bearings, refer to paragraphs 6B and 6C.

6A. **SEALS, WEAR CUPS & WHEEL BEARINGS.** These parts can be renewed without removing spindle carriers from axle, after removing wheel spindles from carriers. Larger diameters of wheel bearing cups should all face in manner shown in Fig. 0454. Apply a thin coat of shellac or gasket cement to outer edge of metal portion of each grease seal. Do the same to the inner surface of the seal wearing cups (32). It is important that wearing surface of wearing cup be smooth and square with seal. Use

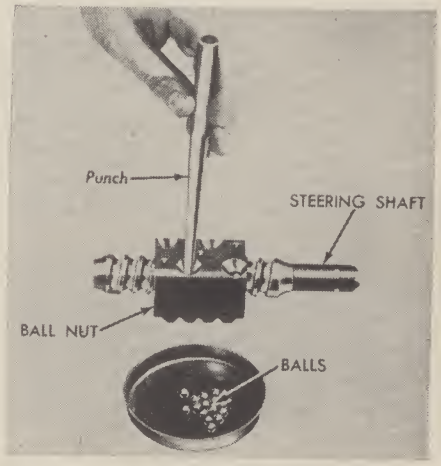


Fig. 0452—Aligning nut on worm shaft while inserting balls in ball circuit. Insert 40 balls in each circuit in nut. To complete each circuit, insert 13 balls in each ball retainer.

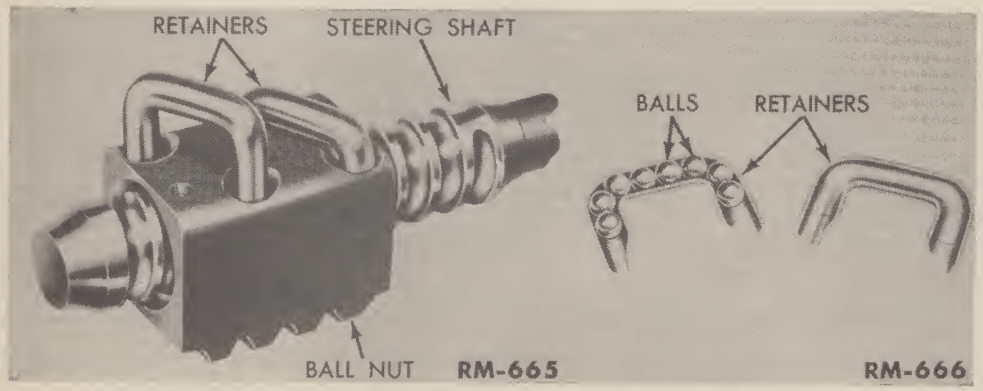


Fig. 0451—Saginaw gear (recirculating ball type) showing ball nut and ball circuit retainers. Insert 13 balls in each retainer. A total of 106 balls is needed.

crocus cloth or very fine sandpaper to remove slight nicks or foreign matter from wearing cup. The wearing cup and seal can be installed squarely without special tools if care is exercised, but Oliver Wear Cup Driver ST-124 and Seal Driver ST-123 are recommended.

6B. **PIVOT NEEDLE BEARINGS.** These bearings are of the closed end type and the Oliver Corporation states that a driver engaging only the top or the bottom of the bearing will damage it seriously. Recommended tool is the Owatonna Driving Mandrel No. 815 on which is placed the OTC No. 0-6 Driving Collar. The specified driver and collar combination applies pressure to upper edge of bearing to prevent distortion of same.

6C. To renew the needle roller type pivot bearings when spindle carrier is removed from axle, proceed as follows: Remove spindle (15) from carrier being careful not to damage the oil seal. Use one of the pivot pins (23) or a drift to drive the bearings out of the carrier. **Bearings will be damaged during removal, thus should not be removed unless new ones are available.** Using the OTC 815 driving mandrel with the 0-6 collar mounted on same, press or drift new bearings into carrier until top of each bearing is flush with carrier.

OTHER PARTS OF AXLE SYSTEM

7. Data in paragraphs 7A and 7B covers the important additional assemblies in the front axle steering system. Servicing of any other parts is conventional and self-evident after viewing exploded view, Fig. 0456A.

7A. **BOLSTER.** Front axle support (bolster) shown at (1) in Fig. 0456A, can be removed by unscrewing the retaining cap screw (7), bumping pivot (6) rearward and removing three bolts which attach bolster to front frame. Pivot is not bushed.

7B. **RADIUS ROD.** This item shown at (34) in Fig. 0456A can be removed without disturbing the front axle after removing two nuts from axle end of rod and unbolting stay rod ball socket (38) from lower side of front frame.

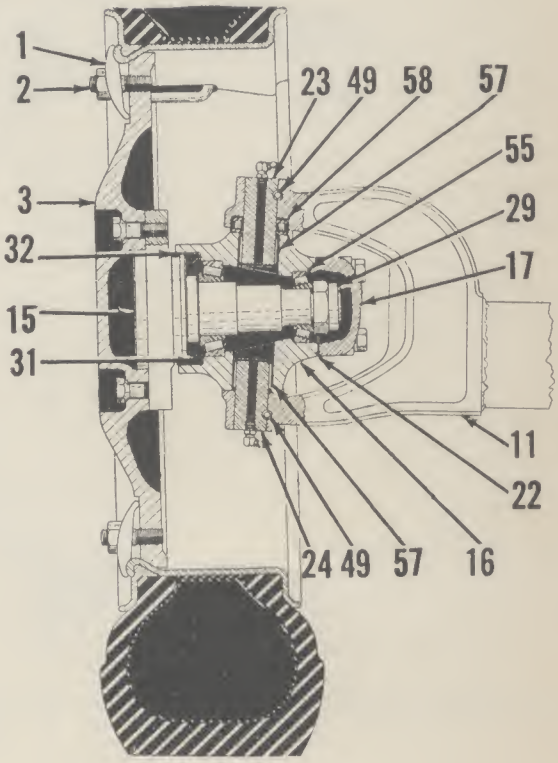


Fig. 0454 — Sectional view of "live" type front axle knuckle spindle.

1. Rim clamp
3. Front wheel
11. Front axle
15. Knuckle spindle
16. Spindle carrier
17. Knuckle arm
22. Gasket
23. Upper pivot
24. Lower pivot
29. Spindle nut
31. Seal
32. Seal wear cup
49. Roll pin
55. Wheel bearing inner
57. Needle bearing
58. Thrust bearing

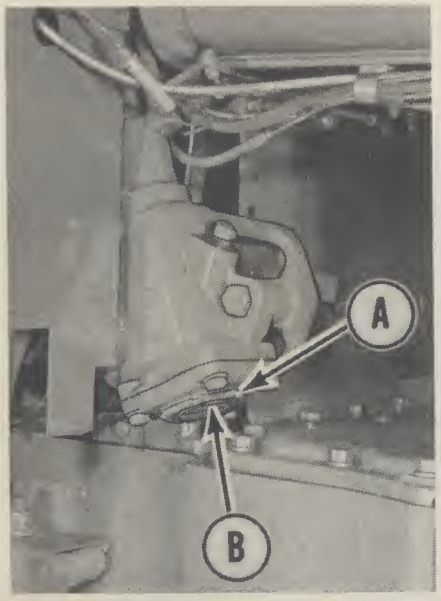


Fig. 0453—End play of steering gear worm-shaft is controlled by the threaded adjusting plug (B) and lock nut (A). Both of these parts are also shown in left view in Fig. 0450.

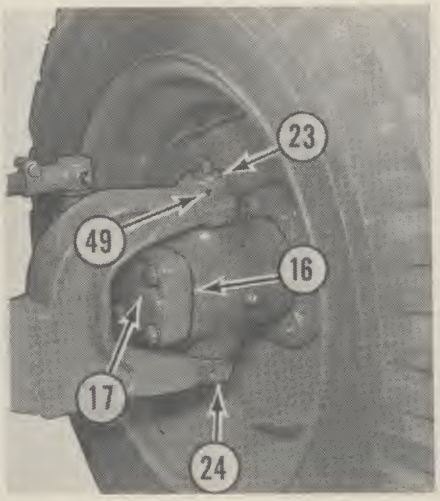


Fig. 0455—Center point easy steering is obtained by this "live" type wheel spindle and carrier. Refer to Fig. 0454 for details.

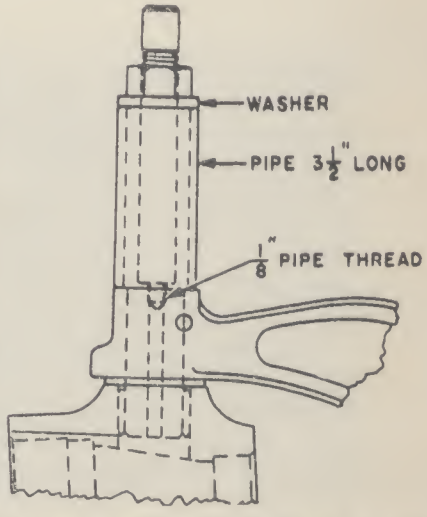
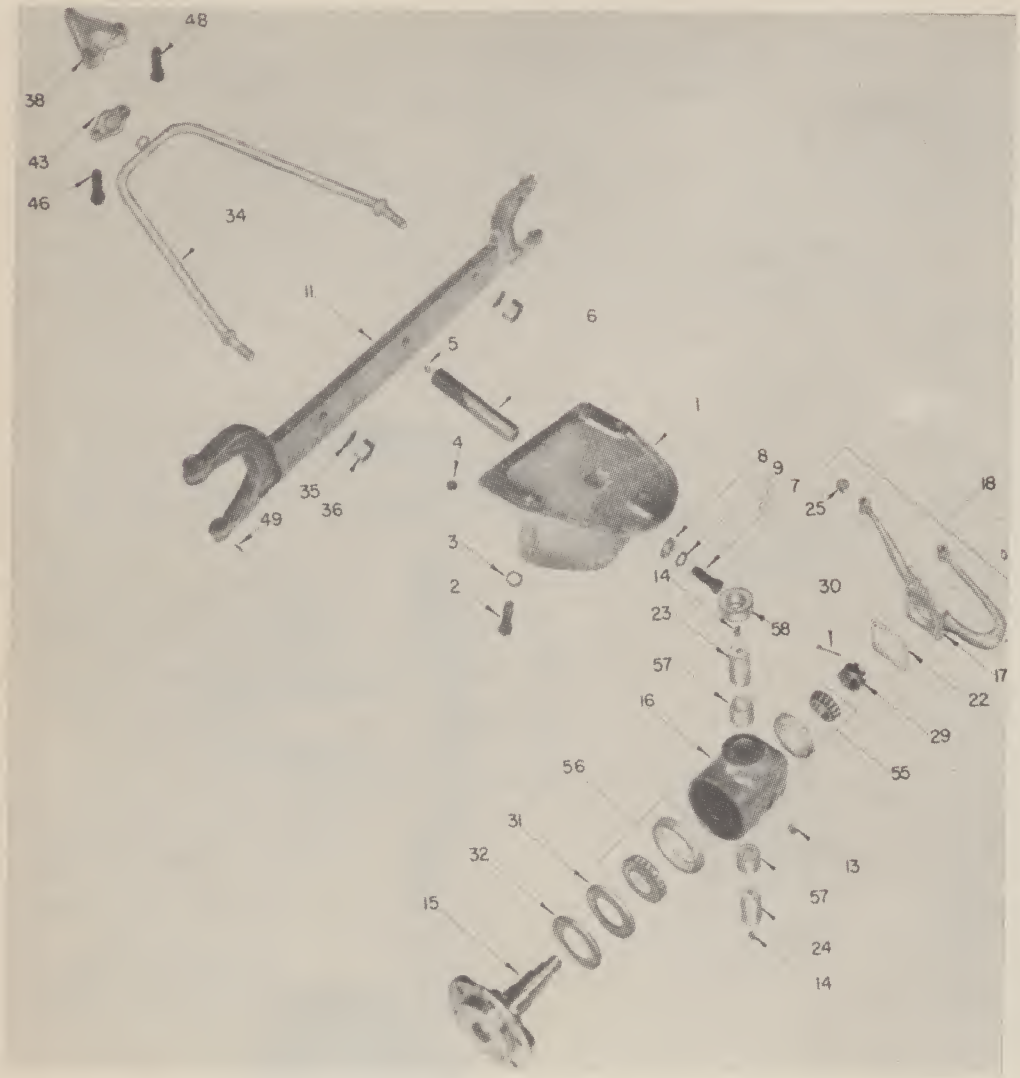


Fig. 0456—The ⅛ pipe thread in each knuckle pivot pin can be the attaching point for a pulling rig in removing pivot pins from axle.



1. Front bolster
6. Front axle pivot
11. Front axle
15. Steering spindle
16. Spindle carrier
18. Knuckle arm
22. Gasket
23. Upper pivot
24. Lower pivot
25. Knuckle arm ball
26. Tie rod
28. Front wheel
31. Seal
32. Wearing cup
34. Stay rod
38. Ball socket
43. Ball cap
45. Tie rod end
49. Roll pin
55. Wheel bearing
56. Wheel bearing
57. Needle bearing
58. Roller thrust bearing

Fig. 0456A—Components of front axle, bolster, stay rod and one wheel spindle assembly. Spindle (15) is "live" type and rotates in spindle carrier (16).

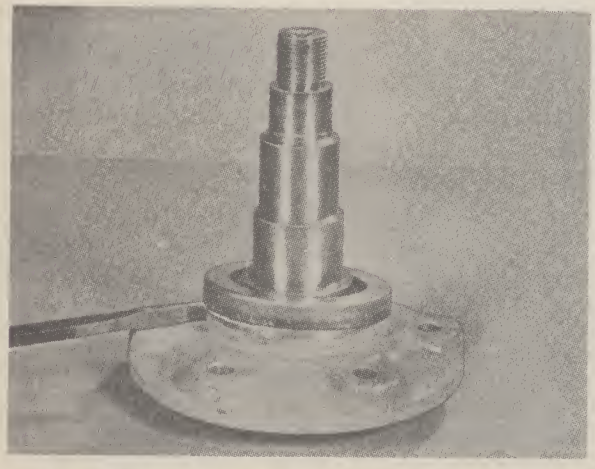


Fig. 0456B—Right view shows live front wheel spindle being removed from carrier. Spindle wearing cup shown at left must be square with grease seal and free of nicks or scoring

ENGINE ASSEMBLY (6 CYLINDER)

(Three cylinder type begins with paragraph 60.)

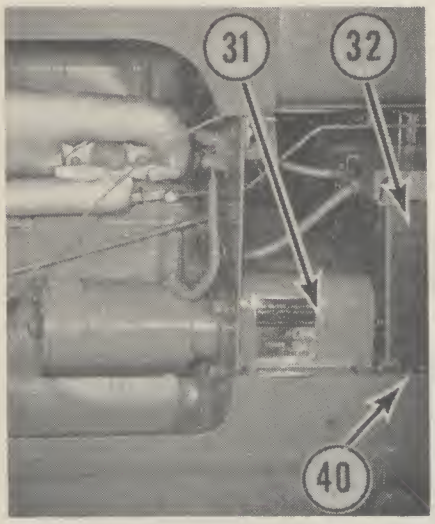


Fig. 0457—On tractors with 6 speed transmission access to clutch shaft coupling is by removal of battery, front cover (31) and flat dust cover (40).

REMOVE AND REINSTALL

10. To remove 6 cylinder engine assembly from tractor, proceed as outlined in paragraphs 10A through 10F.

10A. HOOD. Remove hood as follows: Loosen front grille center strap bolts, and remove two cap screws attaching front grilles to support and lift off grilles. Detach both headlights (each held by two screws) and disconnect wires. Remove hood straps, precleaner, muffler, and wiring harness clips from right side of hood. Lift off hood.

10B. PTO DRIVE SHAFT. If tractor is equipped with pto, remove the drive shaft of same as outlined for continuous type in paragraph 145J.

10C. FUEL TANK. Remove battery or batteries. Disconnect upper and lower radiator hoses and hour meter cable. Remove coolant temperature sending unit and air cleaner. On Diesel, remove leak-off line connecting the injectors to the tank. Disconnect fuel line at tank. Remove the four nuts attaching tank to bracket, three nuts attaching throttle and wiring harness to bottom of tank. Lift tank from tractor.

10D. Remove injection pump stop cable from fuel tank front bracket. Disconnect wiring harness at generator regulator and right headlight. Pull harness out of fuel tank front bracket. Remove throttle rod after disconnecting at rear of vertical rod crank and at injection pump.

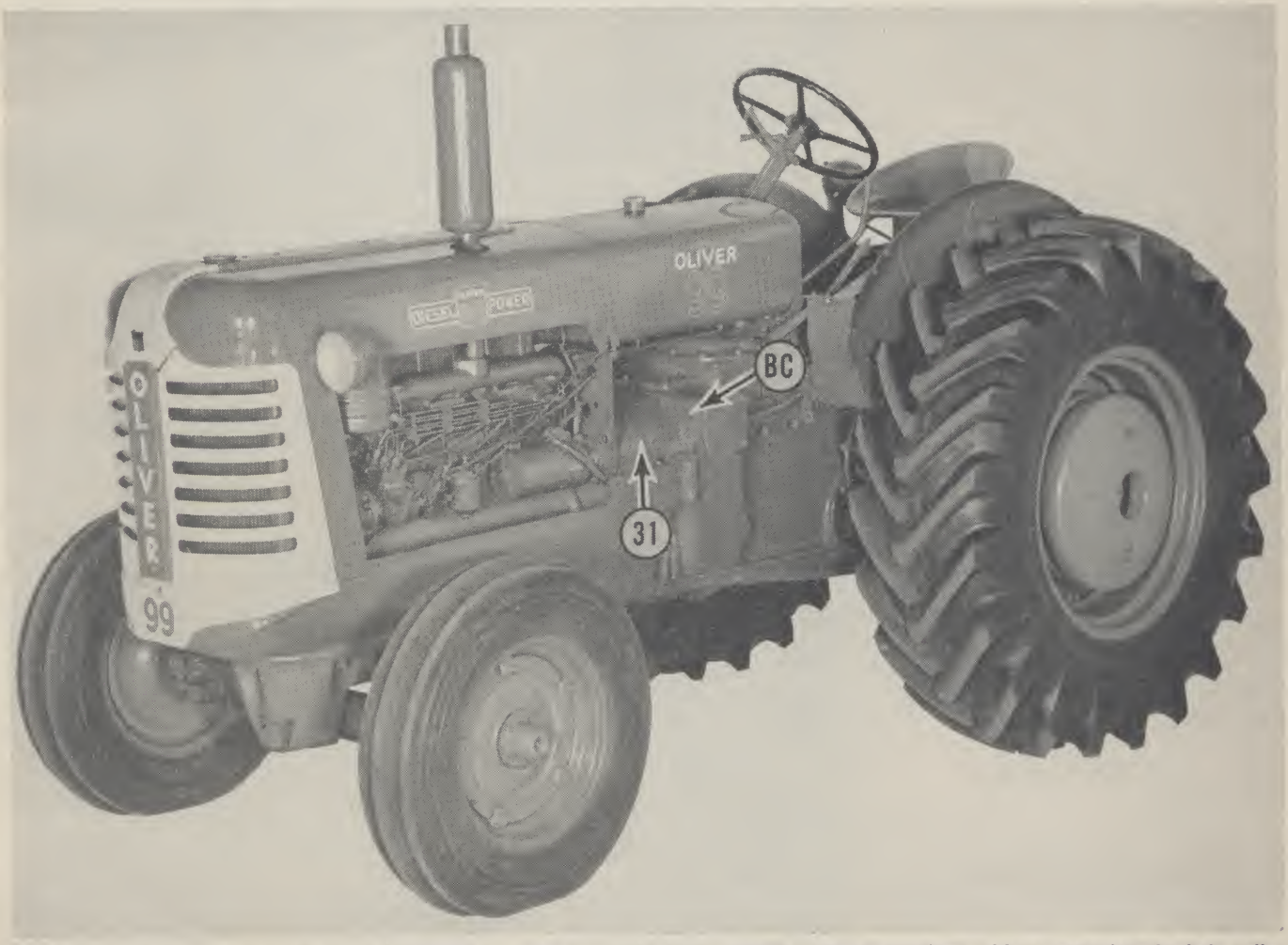


Fig. 0457A—On tractors with 4 speed transmission access to clutch shaft coupling can be obtained without removing the belt pulley carrier (BC).

Remove the clutch housing front cover (31—Fig. 0457 and 0457A) after removing the cap screws attaching it to front frame. If tractor has 6 speed transmission, remove the flat dust cover (40—Fig. 0457) by removing the screws attaching it to frame and to the clutch release bearing carrier. On 4 speed tractors, remove screws retaining release bearing carrier to the carrier support.

10E. CLUTCH SHAFT AND COUPLING. Refer to Fig. 0458. Remove chain (22) after extracting master link. Slide clutch shaft coupling (21) forward on shaft after loosening coupling clamping bolt. Disconnect outer end of the clutch shifter shaft, and loosen the set screw which retains shifter fork (26) to shifter shaft then bump shifter shaft out of fork toward left side of tractor. Withdraw clutch shaft (23) from clutch.

10F. LIFTING. Remove the two front and two rear engine mounting bolts which may be provided with aligning shims. Be careful not to mix these shims. Remove fan blades to prevent damaging the radiator core. Attach a lifting bracket to the two special hoisting studs located on top of engine cylinder head between exhaust manifold and rocker cover. Hoist engine out of front frame.

10G. **REINSTALL AND ALIGN.** Install felt strips at locations where engine rear adapter plate contacts main frame. Engine to transmission alignment should be checked whenever a new front frame or engine is installed or premature main clutch failures have occurred. Dial indicator rig shown in Fig. 0460 can be made up from rod and bar stock. Make first check with bottom of indicator in contact with bore wall of clutch pilot bushing. If total indicated runout exceeds 0.015, vary the shims at front and rear engine mounts to bring the reading within the 0.015 limit. Shims are available in thicknesses of 0.005 and 0.008.

After engine alignment has been corrected, check face runout of flywheel with gauge hooked up as shown in Fig. 0460. If total indicator reading exceeds 0.015, check for a bent crankshaft mounting flange.

CYLINDER HEAD

Six Cylinder

11. Herewith is procedure for R & R of head: Remove hood assembly as outlined in paragraph 10A. Remove air cleaner pipe, air cleaner and upper radiator hose. Remove two cap screws attaching pump by-pass to thermostat housing. Remove rocker arms cover, rocker oil feed line, rocker arms and shaft assembly and long pushrods. On Diesels, remove all pump to injectors pipes, leak-off pipe and the fuel return line connected to No. 6 injector. Disconnect the ether primer line at inlet manifold. On all models, disconnect temperature gauge sending unit and hour meter cable. Remove cap screws retaining head to block.

Retorque head screws after engine has operated a few hours. Screws can be retorqued without removing rocker shaft assembly by using ¾ inch crowfoot. Note that the drilled cap screw used for oil supply requires less tightening torque. Head screws on HC gasoline engines can be torqued to Diesel values if washers 1C-111 used on Diesel head retaining screws are installed.

Drilled (Oil Supply) Head Screw	95-100 Ft.-Lbs.
Other Head Screws— Non-Diesel	91-100
Other Head Screws— Diesel	112-117
Inlet Tappet Gap	0.009 Cold
Exhaust Tappet Gap	0.016 Cold

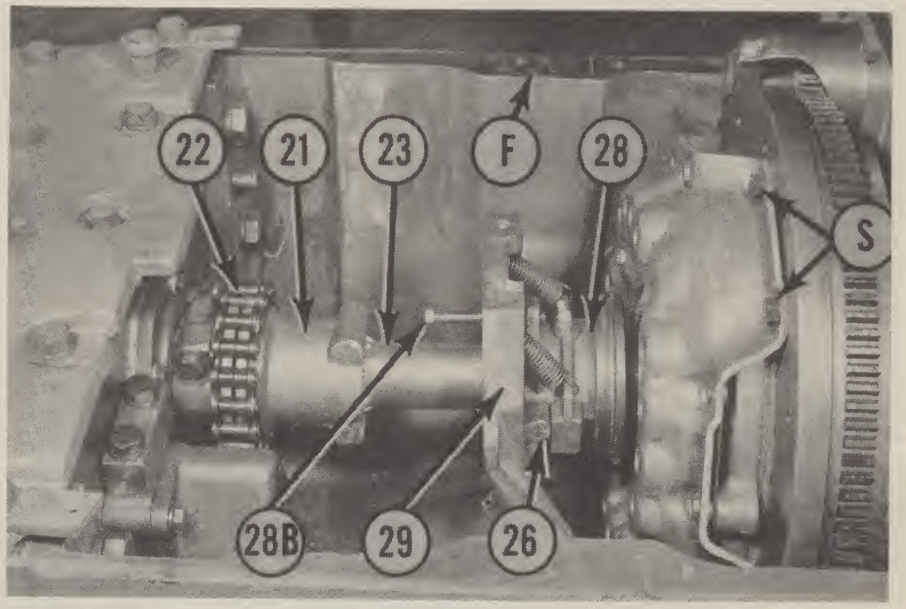


Fig. 0458—Clutch to transmission connections. Dust cover (40-Fig. 0457) is anchored to front frame (F) and to release bearing carrier support (29). The pto drive shaft on six cylinder models with continuous type pto passes through hollow clutch shaft (23) and is splined into flywheel. Bolt (28B) should be adjusted to provide ½" maximum release travel.

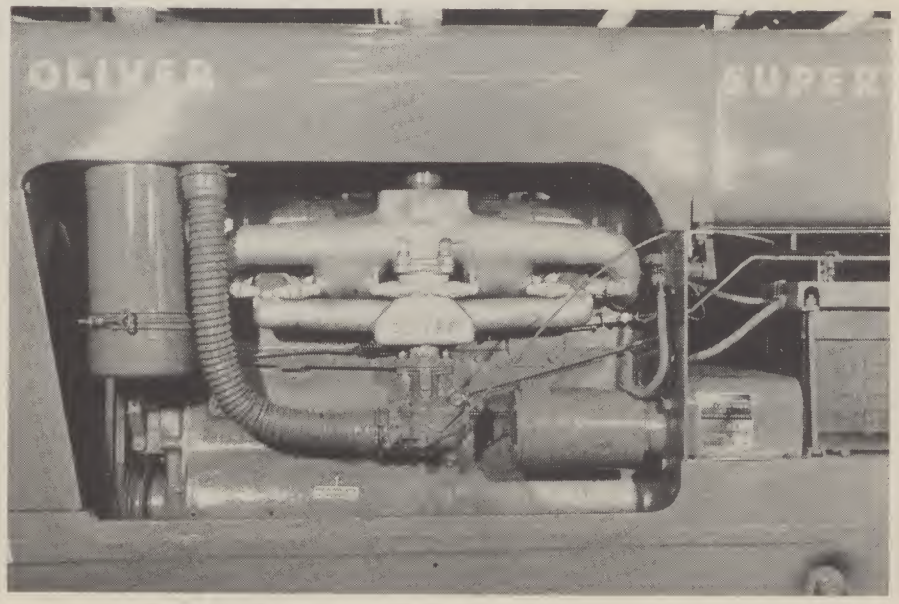


Fig. 0458A—Manifold side of 6 cylinder Super 99 gasoline engine.

VALVES, SEATS AND GUIDES

Six Cylinder

12. Intake valves are provided with seals to prevent oil flow into combustion chambers via the valve stems. Install new seals each time the valves are reseated. Exhaust valves seat on renewable inserts in the cylinder head and are provided with rotators on non-Diesel models only. Shoulder type valve guides should stand with respect to top machined face of cylinder head as indicated in table below. Guides may require one pass with reamer after installation to remove burrs or high spots. Inlet and exhaust guides are not interchangeable. Neither the valves nor the guides for non-Diesels are interchangeable with those used on Diesels. Refer also to information in table below.

Stem Diameter,
Nominal . . . . . $\frac{3}{8}$
Intake Clearance
in Guides 0.0015-0.0035
Exhaust Clearance
in Guides 0.0025-0.0045
Renew If Clearance Exceeds:
Inlet 0.0055
Exhaust 0.0075
Guide Height Above Machined
Top Surface Cylinder Head:
Non-Diesel, Inlet . . $\frac{3}{4}$ inch
Non-Diesel, Exhaust $\frac{27}{32}$ inch
Diesel (below top
surface) . . . . . 1/64 inch

VALVE ROTATORS

Six Cylinder Non-Diesel

13. Exhaust valves are fitted with Roto-cap positive rotators which require no maintenance. Observe when engine is running, to make certain that each exhaust valve rotates slightly. Renew the rotator of any exhaust valve which fails to rotate, as individual parts are not available for repairs. Exhaust valve springs used with rotators are of a different length than those used on inlet valves of same engine.

VALVE SPRINGS

Six Cylinder

14. On Diesel engines, the inlet and exhaust springs are the same, whereas on the non-Diesel, the exhaust springs are shorter, due to the use of the valve rotators. Renew any springs which are rusted or pitted or which do not conform with these specifications: On Diesel engines, exhaust and intake spring (part No. 1K-198, which supersedes and is interchangeable with part No. 1KA-198) should require 65-77 pounds to compress spring to length of $1\frac{19}{32}$ inches. On non-Diesel engines, equipped with valve rotators, intake springs (part No. 7AA-198) should show 114-134 pounds at $1\frac{15}{16}$ inches length; exhausts (part No. 7A-198B) 122-132 pounds at 1 53/64 inches. Free length of Diesel springs is $2\frac{25}{32}$ inches; of non-Diesel inlet springs, 2 49/64 inches; exhaust, $2\frac{11}{16}$ inches.

VALVE TAPPETS OR LIFTERS (Cam Followers)

Six Cylinder

15. Valve lifters are of the mushroom type operating directly in the unbushed bores in the cylinder block. It is necessary to remove the camshaft as per paragraph 19, before the lifters can be removed. Lifters are furnished in standard size only.

Lifter Diameter 0.6243
Running Clearance
in Bores 0.0005-0.002
Renew Block and/or
Lifter When Clearance Exceeds 0.007

ROCKET ARMS AND SHAFT

Six Cylinder

16. Rocker arms are provided with non-renewable, steel backed, babbitt lined bushings. Rockers are of the wickless type; those shown in Fig. 0463 were used on tractors serial 518300 through 519144 and the type shown in Fig. 0462 on tractors begin-

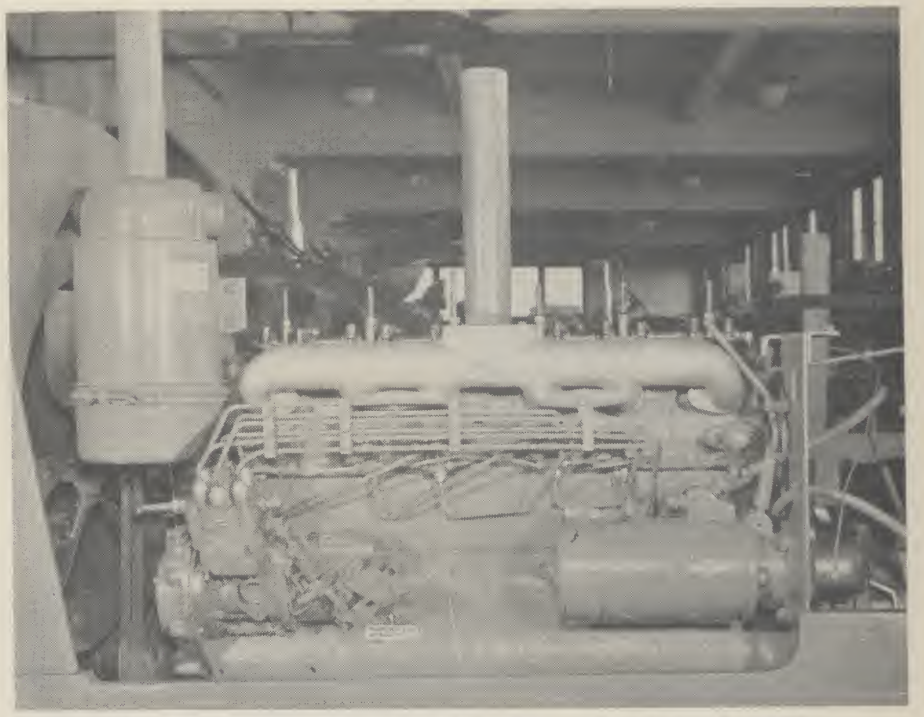


Fig. 0458B—Injector nozzle side of 6 cylinder Super 99 Diesel engine.

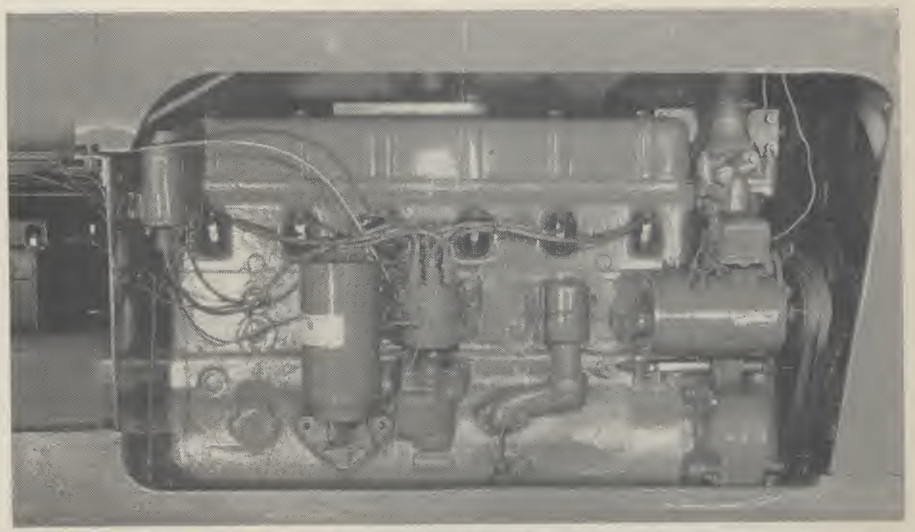


Fig. 0458C—Spark plug side of 6 cylinder Super 99 gasoline engine. Opposite side is shown in Fig. 0458A.

ning with serial 519145. The later design is most efficient in preventing over-oiling of valve stems and consequent excessive oil consumption. Later type is interchangeable on same rocker shaft as early type, but must be changed in complete sets, not individually. Parts numbers for late rockers are IKS206D left hand; IKS-206E right hand.

Rocker Shaft Diameter	0.742-0.743
Reject Shaft If Less Than	0.740
Running Clearance	0.0015-0.0035
Renew If Clearance Exceeds	0.005
Contact Button Radius	⅜ inch
Tappets Gap, Inlet Cold	0.009
Tappets Gap, Exhaust Cold	0.016
Brackets Tightening Torque	25-27 Ft.-Lbs.

TIMING GEAR COVER AND SEAL

Six Cylinder

17. To remove timing gear cover, it is necessary to first remove the hood and the radiator as follows: Loosen front grille center strip bolts and remove cap screws attaching grilles to support. Detach both headlights and disconnect wires from same. Remove hood straps, precleaner, muffler, and two wiring harness clips from right side of hood. Lift off hood.

17A. To remove radiator after hood is off, remove the two cap screws from each side which attach the radiator shell to the front frame. Also, remove the radiator to front frame screws and baffle to radiator shell screws.

17B. To remove timing gear cover when radiator is off, remove the hydraulic pump or blank plate from right side of gear cover. Remove generator, fan belts, crankshaft pulley and pulley felt seal. On Diesels, remove the bolts which attach the injection pump to the timing gear cover. The inner one of these bolts is provided with a copper sealing washer. Remove lubricating oil drain line from bottom of injection pump and from cylinder block. Disconnect the fuel line connecting the secondary filter to the pump.

Remove cap screws attaching timing gear cover to engine and the three which attach it to the front of oil pan. Remove water pump. A copper sealing washer is used under the head of the lower left pump attaching screw. Disconnect water by-pass from thermostat housing and lift off the timing gear cover.

17C. The treated cork oil seal (33—Fig. 0461) can be renewed at this time. Soak new seal in engine oil before installing.

While cover is off, check condition of thrust washer and the spring loaded camshaft thrust button in end of camshaft. On Diesel engines, an additional thrust button and washer set up is provided for the idler gear as shown at (49) in Fig. 0464.

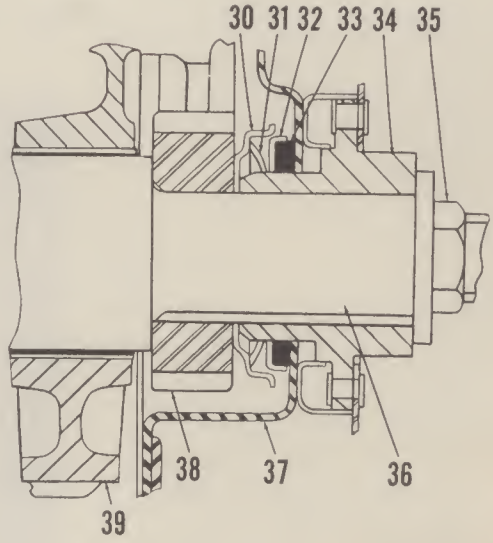


Fig. 0461—Crankshaft front oil seal of treated cork (33) can be renewed after removing the timing gear cover. Parts (30), (31), (32) and (33) are available only as an assembly.

30. Seal housing
31. Spring
32. Seal retainer
33. Cork seal
34. Crankshaft pulley hub
35. Pulley retaining nut
36. Crankshaft
37. Timing gear cover
38. Crankshaft gear
39. No. 1 main bearing cap

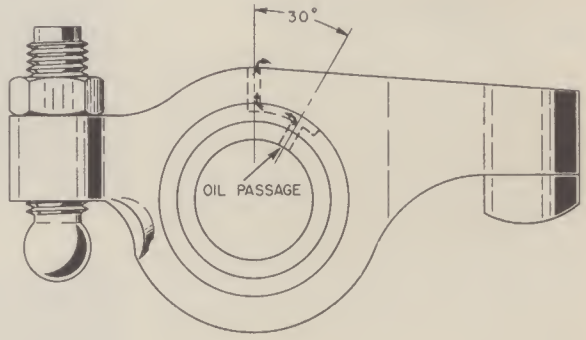


Fig. 0462—Latest rocker arm (IKS206E and F) has better oil control than type shown in Fig. 0463.

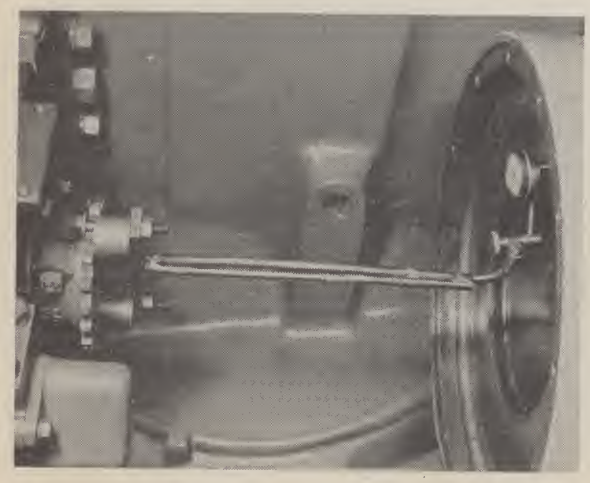


Fig. 0460—Checking alignment of flywheel face with transmission input shaft. Misalignment greater than .015 vertical, is corrected by varying the engine rear mounting shims.

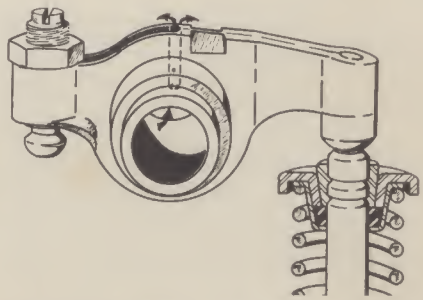


Fig. 0463—Beginning with engine 519145 this rocker arm is superseded by one shown in Fig. 0462.

TIMING GEARS

Six Cylinder

18. Timing drive on Diesel engines consists of three helical gears and the injection pump gear; on non-Diesels, two helical gears are used. The cylinder block for all models, however, is designed for the installation of an idler gear as shown in Fig. 0464. For all non-Diesel models, check to make certain that a plug (42—Fig. 0465) is installed in what would normally be the idler shaft bushing bore on the Diesel engines.

18A. Remove camshaft gear from shaft as shown in Fig. 0466, by using a puller attached to two 3/8-16 cap screws which can be threaded into gear. Crankshaft gear can be removed in a similar manner. Avoid pulling the gears with pullers which clamp or pull on the gear teeth.

The camshaft and crankshaft gears are stamped either "S" (standard), "O" (oversize), or "U" (undersize), and amount of oversize or undersize. Recommended backlash of camshaft to crankshaft gear is 0.001-0.003. Renew gears when backlash exceeds 0.007.

When reinstalling the cam gear, remove the oil pan and buck-up the camshaft at one of the lobes near the front end of the shaft with a heavy bar. The crankshaft gear should be heated in oil to facilitate installation.

Reinstall gears with the "C" mark on crankshaft gear meshed with a similar mark on camshaft gear as shown in Fig. 0465.

18B. The idler gear (48—Fig. 0464) is installed only on Diesel engines and can be removed after removing timing gear cover. Running clearance of gear spindle in bushings should not exceed 0.004. When gear is in contact with front face of sleeve, idler gear face should be flush with crank gear face.

If clearance is greater than 0.004, or if flush condition is not obtained, renew the sleeve and bushings assembly as neither part is available separately.

In rare cases, it may be necessary to reface the thrust face of a new sleeve assembly in order to obtain the flush setting. Bushings in new sleeve may require final sizing to provide the desired 0.0015-0.002 running clearance.

CAMSHAFT

Six Cylinder

The camshaft front journal on all models rotates in a steel-backed, babbitt lined bushing. The three remaining journals rotate in machined bores in the cylinder block.

19. To remove camshaft, first remove timing gear cover as outlined in paragraph 17. Remove ignition distributor from non-Diesel engines, rocker arms and shaft assembly, engine oil pan, and oil pump. On Diesel engines, remove primary fuel pump from right side of engine. Remove long push rods and block-up or support tappets (cam followers). Thread shaft and gear forward out of block bores.

19A. Camshaft lobe lift for all models is 0.247. Shaft journal sizes are: Front, 1.7495-1.750; others, 1.7485-1.7495. Recommended running clearance of number one journal is 0.0015-0.003 with a maximum of 0.005; all others, 0.0025-0.0045 with a maximum permissible clearance of 0.007.

When the running clearance in unbushed bores exceeds 0.007, correction can be made by renewing camshaft and/or cylinder block, or by reboring the bores in cylinder block to a diameter of 1.8745-1.8755 inches and installing bushings. Presized service

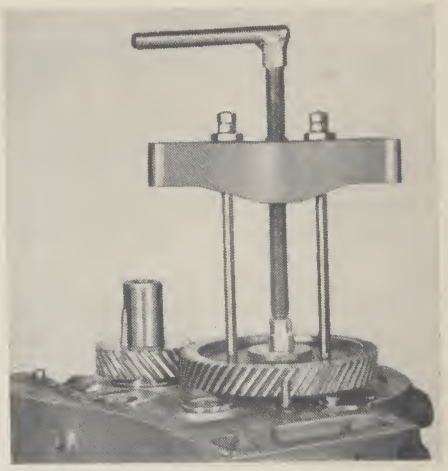


Fig. 0466—Removing camshaft gear on non-Diesel engines by using a puller attached to two 3/8-16 bolts which can be threaded into gear. Diesel engine camshaft gear removal is similar.

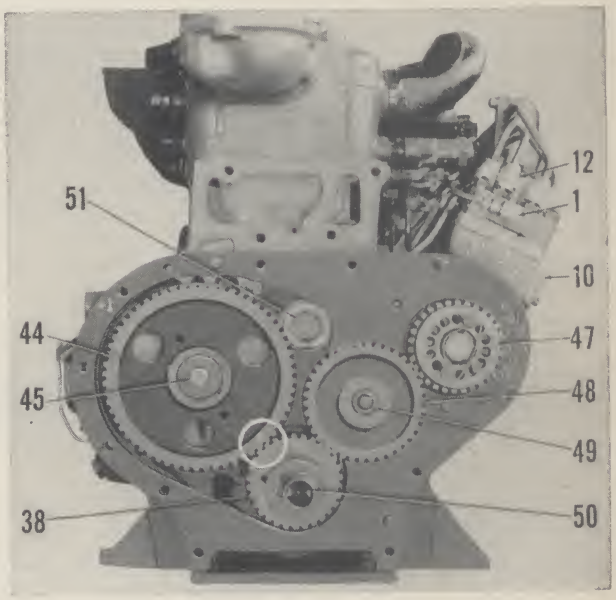


Fig. 0464—Timing gear installation on Diesel engines. Mesh camshaft gear mark "C" with an identical mark on crankshaft gear. Note call-out "12" indicates Diesel injection pump outlet for No. 1 cylinder. Shown is early PSB pump and Oliver 77 engine but 6 cylinder Super 99 is similar.

1. Nozzle return line
10. Timing port
38. Crankshaft gear
44. Camshaft gear
45. Thrust button
47. Injection pump drive gear
48. Idler gear
49. Thrust button
50. Crankshaft engaging ratchet
51. Location of non-Diesel engine governor drive gear bushing and sleeve

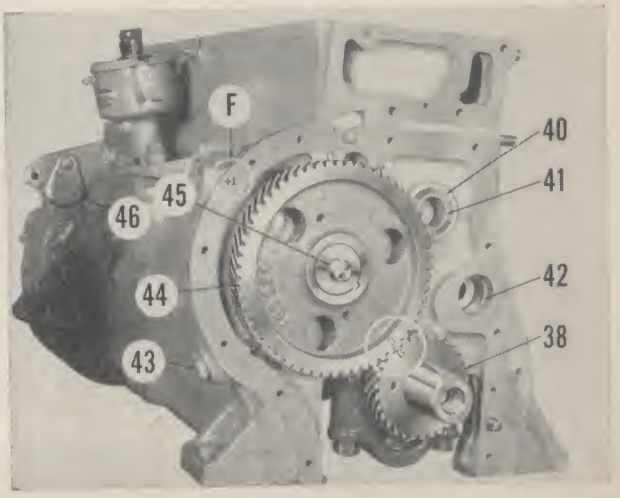


Fig. 0465—Crankshaft and camshaft gear installation on non-Diesel engines. Mesh camshaft gear mark "C" with an identical mark on crankshaft gear. Diesel engines are similar. Plug "42" is installed on all non-Diesel engines.

38. Crankshaft gear
40. Governor shaft sleeve
41. Governor shaft bushing
42. Plug (non-Diesel)
43. Oil pressure relief valve
44. Camshaft gear
45. Thrust button
46. Flywheel timing port (No cover on 99)

bushings as supplied for number one journal can be used and should be installed using a close fitting piloted driver.

Camshaft end play is controlled by a spring loaded thrust button. Thrust button spring has a free length of $1\frac{3}{16}$ inches and should have a pressure of 15.5-18.5 lbs. when compressed to a height of $\frac{25}{32}$ inch.

If for any reason, the cam gear was removed from the shaft, the gear should be pressed on the shaft before installing the shaft in the engine.

ROD AND PISTON UNITS
Six Cylinder

20. On early production non-Diesels, the connecting rod lower end bearing split line is at a right angle to length of rod; on all Diesels and later production non-Diesels, the lower end bearing split line is diagonal and the bearing inside diameter is larger than on early non-Diesels.

Piston and connecting rod units are removed from above after removing the cylinder head as per paragraph 11 and the oil pan as in paragraph 20A.

20A. Oil pan is removed in the conventional manner, but difficulty arises in removing the two attaching cap screws at rear end of pan. A vertically mounted, stamped steel, dust shield interferes with the removal of these two rear cap screws. Rather than cut or distort the dust shield which is held to the engine adapter plate by two cap screws, remove the shield. This is accomplished by removing the clutch housing front cover (31—Fig. 0457) and the two screws which attach the dust shield to the engine adapter plate. Remove nuts from rod bolts and push piston and rod assemblies upward out of the cylinder block.

Torque the $\frac{7}{16}$ inch bolts of diagonally split connecting rods to 87-92 foot pounds. Straight split type, with $\frac{3}{8}$ inch bolts, should be torqued to 44-46 foot pounds.

PISTONS, SLEEVES AND RINGS
Six Cylinder

21. **PISTONS & SLEEVES.** Cast iron pistons are supplied only in standard size and are available for repairs as a set for one or more cylinders. Each set contains a piston, sleeve, piston pin and pin retainers.

Sleeves should be renewed when either of the following conditions exist: Taper, 0.008; out-of-round, 0.002; wear, 0.010.

Desired piston skirt clearance is checked with a spring scale pull of 5-10 lbs., using a 0.003 x ½ inch feeler gage. Wear limit of pistons and sleeves is when a 0.006 x ½ inch feeler gage requires less than a 5-10 lb. pull on a spring scale to withdraw it.

Before installing the dry type cast iron (alloy No. 210) sleeves, clean cylinder block surfaces, and apply a coat of oil-mixed aluminum powder (Thermo-Lock) to outside surfaces of sleeves and bores in cylinder block.

21A. Effective with engine serial No. 952651, square flanged sleeves (7A-178A—Fig. 0467) instead of beveled flange type 7A178 are factory fitted in all cylinder blocks.

Both types will be available for service. The later square flange type can be installed in cylinder blocks originally fitted with the older beveled type, if the cylinder bores are counterbored at their upper ends to the dimensions shown in Fig. 0469.

21B. **RINGS.** There are three compression rings and one oil control ring per piston. The lower compression ring is a scraper type. Factory supplied service rings are stamped "Top" and should be installed in this manner.

Recommended end gap for all compression rings is 0.015-0.025 with a reject value of 0.045; oil control ring, 0.010-0.020 with a reject value of 0.045. Recommended side clearance, compression rings, 0.0015-0.002 with a reject value of 0.006; oil control ring, 0.0015-0.003 with a reject value of 0.006.

PISTON PINS AND BUSHINGS
Six Cylinder

22. The 1.2495-1.2498 diameter full floating type piston pins are retained in piston bosses by snap rings and are available in oversizes of 0.005 and 0.010.

The split type graphite bronze piston pin bushings should be installed in the rod so that bushing outer edge is flush with outer edge of rod bore and the split side is at the top of the rod. Two bushings are installed in each rod and those for Diesels are longer than non-Diesel bushings. Bushings should be sized after installation to provide a 0.0005-0.001 clearance on pin, and the piston bosses sized to provide a 0.0002-0.0004 clearance in piston.

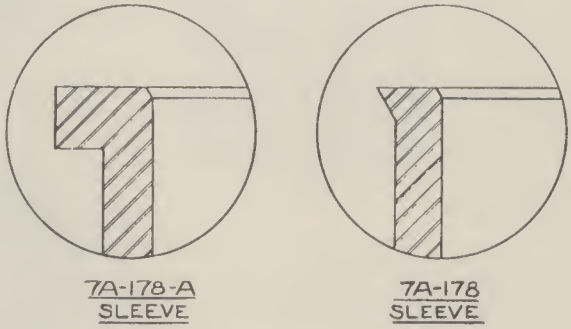


Fig. 0467—The latest type sleeves 7A-178-A are recommended for installation in all cylinder blocks. Old blocks can be counter-bored to receive new type sleeves as shown in Fig. 0469.

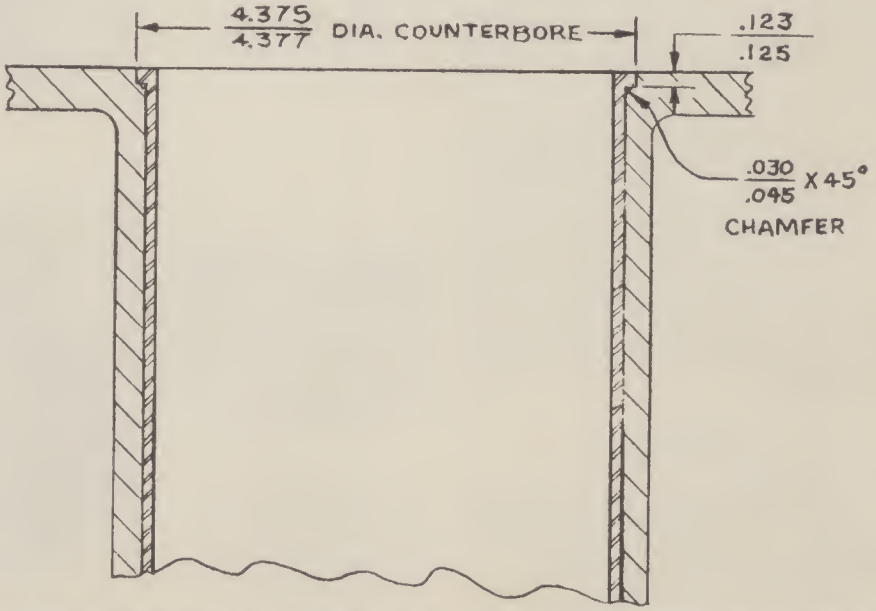


Fig. 0469—When older six cylinder blocks are counter-bored as shown, the new 7A-178-A sleeves can be installed.

CONNECTING RODS AND BEARINGS

Six Cylinder

23. Diesel connecting rods are split diagonally at the lower bearing parting line and are fitted with non-adjustable, copper-lead lined, precision bearing shells which ride on 2⅝ inch diameter crankshaft crankpins. Similar specifications apply to non-Diesel HC engines beginning with serial 964432.

Non-Diesel engines prior to serial 964432 have babbitt-lined precision type rod bearings which ride on 2¼ inch diameter crankpins and the lower bearing parting line is at a right angle to the length of the rod. The rod and bearing set up specified for later production non-Diesel engines can be installed in early production non-Diesel units if the later crankshaft, main bearings and pistons are also installed.

Refer to CRANKSHAFT AND BEARINGS for data on re-working older style Diesel connecting rods when they are to be used with new style Diesel crankshaft.

23A. Bearings are renewable from below without removing the rods from engine. Bearing shells for 2⅝ inch crankpins are furnished in one undersize of 0.003. For non-Diesels prior to engine serial number 964432 which have 2¼ inch crankpins, the available undersizes are 0.003, 0.030 and 0.033.

Crankpin Diameter HC prior 964432	2.250
Crankpin, Diesel & HC after 964431	2.625
Bearing Running Clearance, Prior 964432	0.001-0.0015
Bearing Running Clearance, HC after 964431	0.0005-0.0015
Renew If Clearance Exceeds	0.003
Rod Bolt Torque ⅜ Inch Bolt	44-46 Ft.-Lbs.
Rod Bolt Torque $\frac{7}{16}$ Inch Bolt	87-92 Ft.-Lbs.

CRANKSHAFT AND BEARINGS

Six Cylinder

24. Tocco hardened crankshafts part number 7A-119 having four main journals and 2⅝ inch diameter crankpins are used in early production Diesel engines. In Diesels beginning with engine serial number 952769, except engines 952840 through 952887, and in non-Diesels (HC) beginning with engine serial number 964432, crankshaft number 7A-119A having offset crankpins but otherwise the same as 7A-119 is used. In non-Diesel (HC) engines prior to engine serial 964432, the crankshaft part number IK-119B, is not Tocco hardened and the crankpins are of 2¼ inch diameter.

24A. Latest crankshaft, number 7A-119A can be installed in early production Diesels by using later pistons number 7A-228A shown in Fig. 0471 or, with the older 7A-228 pistons if the upper ends of the connecting rods are re-worked as shown in Fig. 0470. In HC non-Diesels, latest 7A-119A shaft can be used in early production engines if the later connecting rods, main bearings, and pistons are also installed.

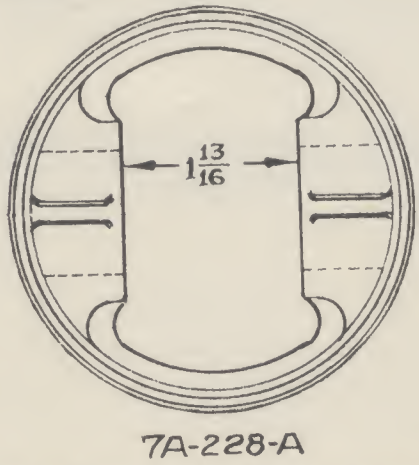


Fig. 0471—Latest piston for use with latest 7A-119-A crankshaft. Refer also to Fig. 0470.

24B. Rod and main bearings used with crankshafts having 2¼ inch crankpins are precision type renewable shell inserts lined with babbitt. Bearings used with shafts having 2⅝ inch diameter crankpins are of similar type but are lined with copper-lead. All bearings are of the non-adjustable type.

24C. All main bearings can be renewed from below without removing the crankshaft. Main bearings of 0.003, 0.030 and 0.033 undersize are supplied for shafts with 2¼ inch diameter crankpins. Bearings for the later Tocco hardened shafts with 2⅝ inch crankpins are available in only one undersize of 0.003.

24D. Check shaft and main bearings for wear, scoring and out-of-round.

Main Journal Dia.	2⅝
Crankpin Dia.-Early	2¼
Crankpin Dia.-Late	2⅝
End Play Control	No. 3 Brg.
Permissible Out-of-Round, Taper	0.0005
Running Clearance, Prior 964432	0.002-0.0035
Running Clearance, After 964431	0.0005-0.003
Renew If Clearance Exceeds	0.005
End Play	0.005-0.012
Mains, Tightening Torque—Ft.-Lbs.	108-112

CRANKSHAFT REAR OIL SEAL

Six Cylinder

25. Procedure for renewal of the one piece, treated cork oil seal shown in Figs. 0473 and 0476A is outlined in paragraphs 25A through 25D.

25A. On models with continuous (live) type pto the shaft is splined

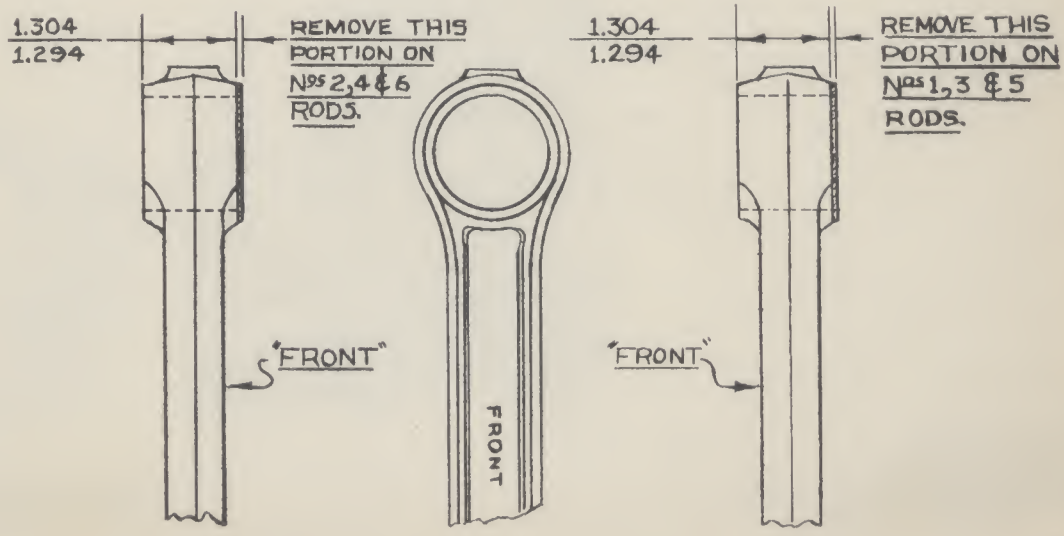


Fig. 0470—Old style Diesel connecting rods and pistons can be used with latest crankshaft if rods are reworked at upper ends as shown.

into the flywheel and should be removed as per paragraph 145J.

25B. Remove the clutch housing front cover (31—Fig. 0457) after removing 4 cap screws attaching it to front frame. Remove storage battery and the flat dust cover (40) which is attached to front frame by two screws and on models with spring loaded clutches, to clutch release bearing carrier by two additional screws. It is not necessary to remove belt pulley carrier on 4 speed tractors. Refering to Fig. 0458, remove master link from coupling chain (22). Remove chain and slide coupling (21) forward after loosening the coupling clamp bolt. Disconnect outer end of clutch shifter shaft and loosen the set screw which locates the shifter fork (26) on shaft. Bump shifter shaft out of shifter fork toward left side of tractor. Lift clutch shaft (23) rearward and out.

25C. Correlation mark clutch cover and flywheel then unbolt clutch from flywheel and flywheel from crankshaft and lift out.

25D. Remove the vertically mounted dust shield by removing two screws attaching it to the engine adapter plate. Unbolt seal retainer from adapter plate and from rear end of oil pan. The seal assembly, Fig. 0476A, can be renewed at this time. Soak new seal in oil before installing same.

FLYWHEEL AND RING GEAR
Six Cylinder

26. Remove flywheel as outlined in paragraphs 25B through 25C.

Flywheel run-out checked at rear outer face of wheel should not exceed 0.015. To install a new ring gear, heat same to 450 degrees F. and install with beveled end of teeth facing the engine.

OIL PUMP AND RELIEF VALVE
Six Cylinder

27. The vane type pump, Fig. 0476, which is driven by the camshaft, is mounted on underside of cylinder block. Pump removal requires removal of oil pan and one cap screw attaching the pump body to the lower side of the cylinder block. It will be necessary on non-Diesel engines to retime the ignition unit whenever the oil pump is removed, as its drive is supplied through the oil pump drive shaft.

Disassembly procedure is self-evident. Vanes should be installed to oil pump drive shaft so that flat sides of vanes will be facing the direction of normal rotation when viewed from the vane end, as shown in Fig. 0476. The pump body and cover are assembled without a gasket. If the pump becomes worn, do not attempt to repair it; renew the entire unit.

27A. Before installing the oil pump to non-Diesel engines, rotate the engine crankshaft until the number one piston is on compression stroke and the flywheel mark "TDC" is indexed at the inspection port. Install the oil pump so that the narrow side of the pump shaft, as divided by the slot (ignition unit drive slot) is on the crankshaft side and parallel to the crankshaft. Refer to Fig. 0474 which shows correct position of the ignition unit drive slot when viewed from above through the ignition unit shaft hole in the cylinder block. If the drive slot is not in the position as shown, remove the oil pump and remesh the pump drive gear. Reinstall the ignition unit and check the timing.

28. The non-adjustable piston type oil relief valve is located externally on the right side of the engine in the vicinity of timing gear cover gasket surface. Correct pressure is 26-34 psi at a crankshaft speed of 1675 rpm.

Relief valve spring (Oliver's part 7K-303) has a free length of 2 inches and should test 5-6 lbs. at a height of $1\frac{1}{16}$ inches.

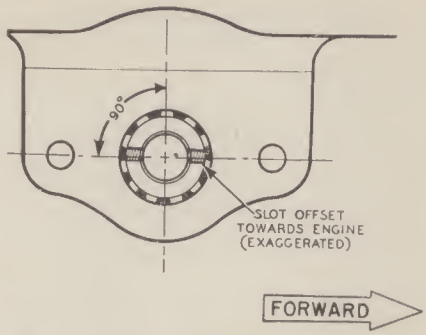


Fig. 0474—Correct position of the ignition unit drive slot when viewed from the ignition unit mounting pad surface.

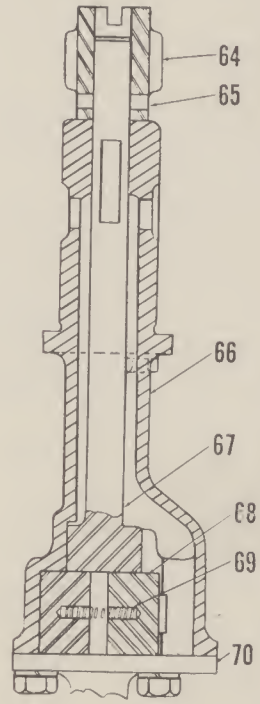


Fig. 0475—Cross-section through oil pump. Excessive wear is best corrected by renewal of pump assembly.

64. Drive gear
65. Retaining pin
66. Pump body
67. Drive shaft
68. Vanes
69. Spring
70. Cover

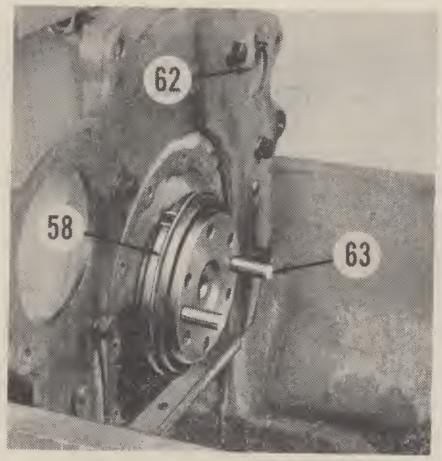


Fig. 0473—Crankshaft rear oil seal and retainer (58) can be renewed after removing the engine flywheel.

62. Welch plug 63. Dowel pin

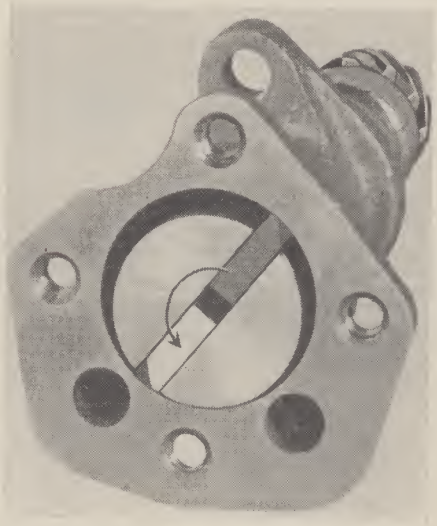


Fig. 0476—Oil pump vanes should be installed so that the flat sides will face in the direction of rotation.

CARBURETOR

29. Carburetor is a Marvel-Schebler TSX model. Early production engines used the TSX-477; latest production engines are fitted with TSX-581 units. Clockwise rotation of idle adjusting needle richens the idle mixture; whereas similar rotation of the high speed needle leans the high speed (power) mixture. Bowl fuel height is indicated on outside of carburetor body.

29A. Calibration and repair parts are as indicated herewith. Parts numbers shown are Marvel-Schebler, not Oliver.

	TSX 477	TSX 581
Idle Jet	49-165	49-285
High Speed Needle	43-631	
Idle Adjusting Needle	43-58	
Main Nozzle	47-221	47-365
Venturi $1\frac{1}{16}$"	46-490	
Economizer Jet	49-262	49-354
Float Needle & Seat	233-543	
Throttle Bushings	60-260	
Float	30-621	
Gasket Kit	16-594	
Repair Kit	286-1000	

DIESEL SYSTEM - 6 Cylinder

(System for Three Cylinder Begins with Paragraph 85)

Six Cylinder Only

The extreme pressure of the injector nozzle spray is dangerous and can cause the fuel to penetrate the human flesh. Avoid this source of danger when checking the nozzles by directing the spray away from your person.

GENERAL TROUBLE SHOOTING

Six Cylinder

32. The following data, supplied through the courtesy of American Bosch Company, should be helpful in shooting trouble on 4 cycle type Diesel tractor engines.

32A. **SYMPTOM.** Engine does not idle well; erratic fluctuations.

CAUSE. Could be caused by faulty nozzle or nozzles, also by pump overflow valve remaining in open position. The overflow valve if pump is so equipped, should be removed and washed in cleaning solvent.

32B. **SYMPTOM.** Intermittent or continuous puffs of black smoke from exhaust.

CAUSE. Faulty nozzle or nozzles, also improper engine operating temperature can be the cause of the trouble.

32C. **SYMPTOM.** Fuel oil builds up (dilution) in the engine crankcase.

CAUSE. The trouble could be caused by a leaking gasket under the delivery valve, or badly worn plunger. The remedy for any of these conditions would be renewal of the complete hydraulic head as a unit as outlined in paragraph 35.

32D. **SYMPTOM.** Sudden heavy black smoke under all loads.

CAUSE. This calls for removal of the entire injection pump assembly for handling by competent personnel. The difficulty possibly is caused by a stuck displacer piston. Other possible causes are improperly adjusted smoke cam or dilution of the fuel by engine oil being by-passed by a damaged hydraulic distributor head lubricating oil filter.

32E. **SYMPTOM.** Poor fuel economy.

CAUSE. Water temperature too low. Check thermostat for proper functional control. Check for fuel leakage.

32F. **SYMPTOM.** Engine low in power.

CAUSE. Filter between supply pump and injection pump may be clogged; or, a faulty supply pump. Due to type of fuel used, it may be necessary to advance the timing. Under no circumstances should the timing be advanced more than 4 degrees. Refer to paragraph 36.

32G. **SYMPTOM.** Engine rpm too low at full throttle position.

CAUSE. Could be caused by improper setting of the throttle linkage. Remove pump control lever cover and check if full travel is obtained at full load position of throttle control lever.

INJECTION PUMP

Six Cylinder

33. The injection pump as used on the Super 99 Diesel engine is an American Bosch PSB6A. The Oliver Super 77 and Super 88 Diesel engines use the same pump but with a different delivery calibration.

The single plunger, constant stroke, sleeve control type pump is driven at crankshaft speed by an idler gear which meshes with the crankshaft gear as shown in Fig. 0464.

Early production engines were equipped with PSB6A70Y 2920E; later production engines are equipped with PSB6A70Y 3826-A. Later pumps are fitted with Bosch HD9012-2A hydraulic head having rounded edges instead of the square type of early tractors.

A flyweight type governor, which is used to control the fuel delivery as a function of speed control, is an integral part of the injection pump.

The automotive, diaphragm type primary fuel supply pump, which furnishes fuel to the inlet side of the injection pump, is mounted on the right side of the engine and is driven by the engine camshaft. Refer to paragraph 43 for service data.

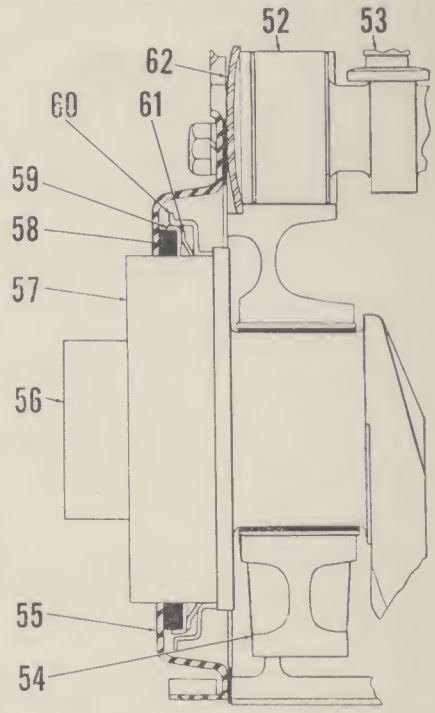


Fig. 0476A—Cross-sectional view showing the crankshaft rear oil seal which is made of specially treated cork.

52. Camshaft
53. Cam follower
54. Rear main bearing cap
55. Oil retainer
56. Crankshaft
58. Cork seal
59. Seal retainer
60. Seal assembly retainer
61. Spring
62. Expansion plug

33A. **PUMP TROUBLESHOOTING.** If the engine fails to accelerate or to respond to the throttle the trouble may be caused by excess friction in the control sleeve unit. With engine running, remove timing window from side of pump and observe action of control arm to which the governor rod is linked. If arm is sticking or moving erratically, stop the engine and disconnect governor rod. When arm is manually moved to either extreme of its movement, it should drop to neutral by its own weight. If movement is sticky, remove the control arm unit after unscrewing the two retaining screws. Wash unit in approved solvent and if this treatment does not give free movement, disassemble the unit and clean the bearing surfaces by lapping with mutton tallow.

If control arm swings freely when disconnected from governor rod, check governor rod for full travel and smooth operation. If binding in movement of governor rod is encountered, remove governor housing from end of pump and clean or renew parts as needed to remove wear or eliminate sticking. Refer to Fig. 0484A.

33B. HARD STARTING, POOR PERFORMANCE. Before condemning the pump assembly as the cause of these troubles, check condition of pump plunger as follows: Remove hydraulic head assembly as outlined in paragraph 35. Carefully unload the plunger spring (48—Fig. 0486) and extract the split cone keepers and pry off item (50). Lift out plunger and inspect same for scuff marks, scratches, rounded edges, rust and corrosion. Refer to Fig. 0479.

If any of these conditions exist, install a new hydraulic head assembly as per paragraph 35. If plunger checks O. K., reinstall plunger to control sleeve with slot facing out towards nameplate side of pump head. This can best be done with hydraulic head upside down by gentle maneuvering of sleeve and plunger. Don't forget the bronze thrust washer which seats on the drive gear.

34. **DELIVERY CALIBRATION.** For those shops equipped to test and calibrate Bosch pumps, the following data applies:

For early production 6A70Y 2920E and later production 6A70Y 3826-A versions, pump delivery for the Super 99 should be:

27.5-28.5 cc for 500 strokes @ 1674 pump rpm.

28.0-29.5 cc for 500 strokes @ 1100 pump rpm.

7.0-8.0 cc for 500 strokes @ 500 idle rpm.

It should be remembered, however, that for replacement purposes, one pump serves for the Super Series of the 77, 88 and 99. The universal replacement pump as received, is calibrated either for the 88 or the Super 88 engines, and must, therefore, be recalibrated when installed on the Super 99 engine. Recalibration is accomplished by turning the full load adjusting nut (99—Fig. 0477) located under the governor housing end plug (103) in or out as required. It is recommended that such recalibration be performed by the official Bosch station or some establishment equipped with the necessary test stand equipment. In an emergency where such facilities are not available, proceed as in paragraph 34A.

34A. Load the engine until the speed drops to 1000-1200 rpm when the throttle hand control is in the wide open position. Using a ⅜ inch deep socket, rotate the control rod nut (99) until the exhaust shows a slight indication of black smoke. Rotating the nut in a counter-clockwise direction lessens the smoke or leans the mixture by decreasing the amount of fuel delivered. Generally speaking, a pump calibrated for the 88 tractor engine will be approximately calibrated for the Super 99 by turning the nut inward (richer) 8 to 10 flats or 1⅓-1⅔ turns. Setting should be such that no exhaust smoke is present at light loads.

35. **HYDRAULIC HEAD UNIT.** Installation of a new or exchange hydraulic head unit is sometimes the indicated remedy when injection pump trouble is encountered. To R&R or renew the hydraulic head, refer to Figs. 0479 and 0482 then, remove the pump timing window cover and rotate the engine until the marked tooth of gear (51) is approximately in register with the "O" mark on early pumps or the arrow head on late pumps. Remove control arm unit from surface (CU) and engine oil small filter (38) from pump. The fuel lines and head nuts can now be removed and the head lifted off as shown in Fig. 0479. Do not attempt to lift off the head without first bringing the marks into register, as the sheet metal plate on top of the quill shaft gear prevents unmeshing of plunger drive gear (51) except in specified position. Use new "O" rings when reinstalling the hydraulic head.

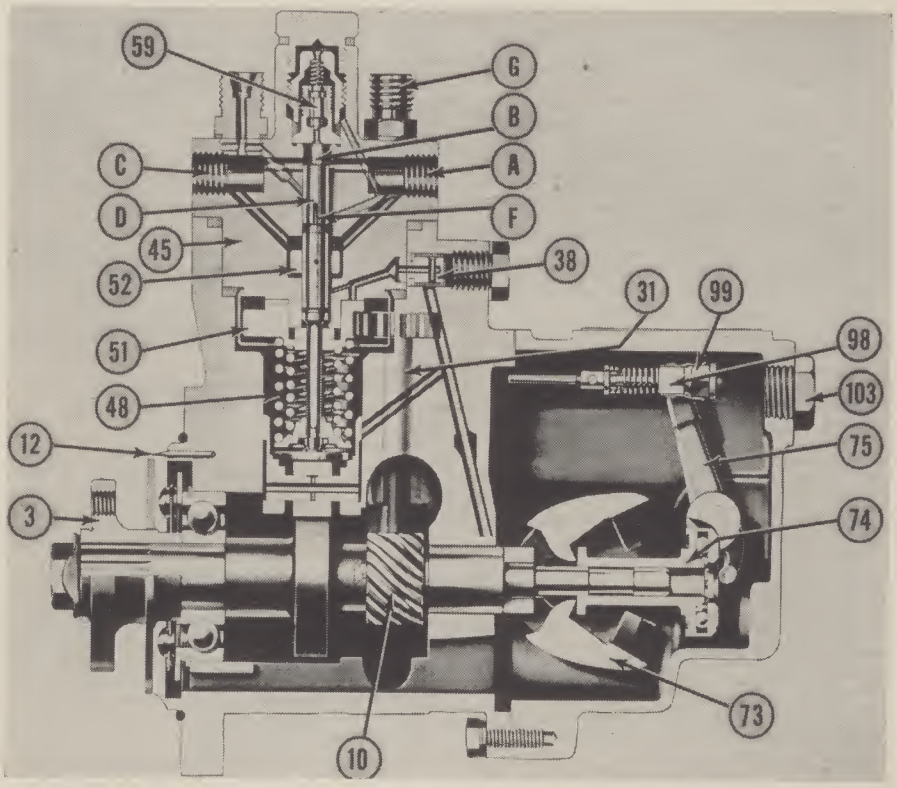


Fig. 0477—Phantom view of latest version Bosch PSB type injection pump is identified by the round cornered (instead of square) hydraulic head (45). Refer to Fig. 0486 for parts legend.

Courtesy—Diesel Publications, Inc.

36. **TIMING TO ENGINE.** Pump is correctly timed to the engine when the plunger port for No. 1 pump outlet closes either 28 degrees or 24½ degrees before TDC. These two settings are mentioned because the Oliver Corporation recommends the 28 degree setting for standard operation medium load conditions where the engine speed is not allowed to drop below the governed 1675 rpm. For severe load conditions where the engine is lugged down to 1400-1500 rpm, the recommended setting for maximum power is 24½ degrees.

36A. FLYWHEEL TIMING MARKS. Factory affixed timing mark on the flywheel is "FP". Beginning with engine serial 949518, all Super 99 Diesel tractors have the "FP" mark located 28 degrees before TDC; some earlier engines have the mark at 24½ degrees before TDC. Distance on flywheel from TDC to a 28 degree "FP" mark is $3\frac{9}{16}$ inches, to a 24½ "FP" mark 3⅛ inches.

When it is known that the pump internal timing is O. K., the pump can be timed to the engine as follows:

36B. Crank the engine until the flywheel mark "FP" is visible through the timing opening in the flywheel housing. Using a pair of dividers or other means, measure the distance on the flywheel from the "FP" mark to the "TDC" mark. If distance is $3\frac{9}{16}$ inches, the mark is at 28 degrees; if 3⅛ inches, the mark is at 24½ degrees. If actual mark is 3⅛ inches away from TDC, scribe a new "FP" mark at a point $3\frac{9}{16}$ distant from the "TDC" or $\frac{7}{16}$ distant from the other "FP" mark. You now have a 24½ degree and a 28 degree timing mark.

Remove inspection port plug (11—Fig. 0481) located in the timing gear cover directly above the pump drive gear. Remove the timing window cover (22) from side of pump.

Rotate engine crankshaft until air is felt escaping from the energy cell opening or until both valves of No. 1 cylinder are closed; then slowly, until the flywheel mark "FP" is aligned with the flywheel housing inspection port notch.

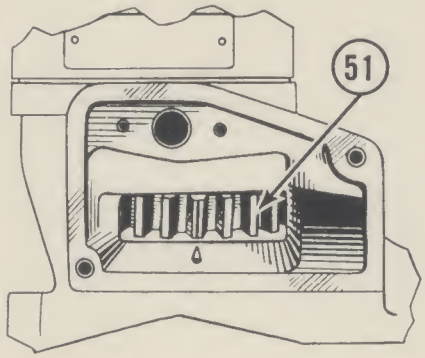


Fig. 0480—Pump is phased to fire number one cylinder when the marked tooth of plunger drive gear (51) is approximately in register with the "O" mark or arrow on timing window ledge as shown.

Note: Compression stroke of No. 1 cylinder can be determined either by removing the pipe plug and cap from the No. 1 energy cell or by removing valve rocker cover and observing the closing of No. 1 inlet valve.

At this time, the line mark on the injection pump coupling hub should be in register within $\frac{1}{32}$ inch with the pointer extending from the front face of the pump as shown in left circle in Fig. 0481. The mark and pointer are viewed through the inspection port plug opening (11). At the same time, the line marked tooth on plunger drive gear (51) will be in register within ¼ inch with the arrow or the "O" mark on window ledge. If the coupling mark is not in register with pointer, as stated, it will be necessary to remesh the pump gear as per paragraph 36C.

36C. Remove pump gear cover located on the front face of the engine timing gear cover.

Working through the pump gear cover opening, remove cap screws retaining the pump drive gear (PG—Fig.

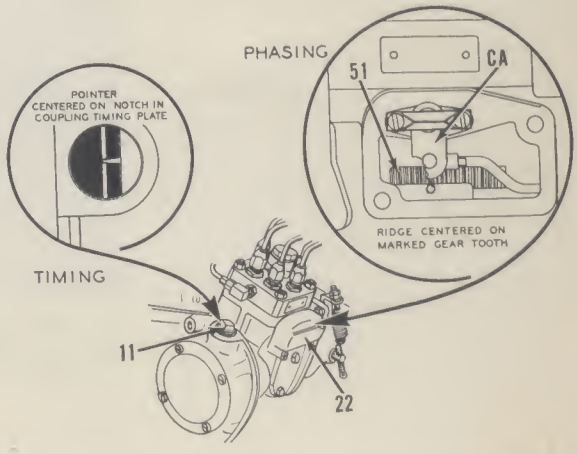


Fig. 0481 — Injection pump showing coupling hub timing marks in small circle and phasing position marks in large circle. Timing marks are visible through port when plug (11) is removed.

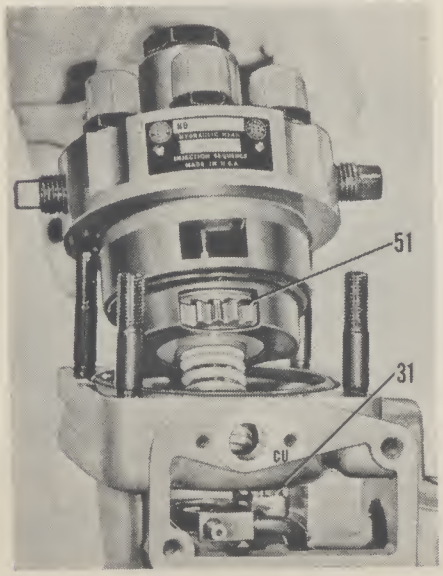


Fig. 0479 — To remove hydraulic head from injection pump, remove timing window and control arm unit from surface "CU" and oil filter (38—Fig. 0482) from pump body. Rotate engine crankshaft until marked tooth of plunger gear (51) is in register with "O" mark or arrow on window ledge then remove head nuts and lift off as shown.

Courtesy—Diesel Publications, Inc.

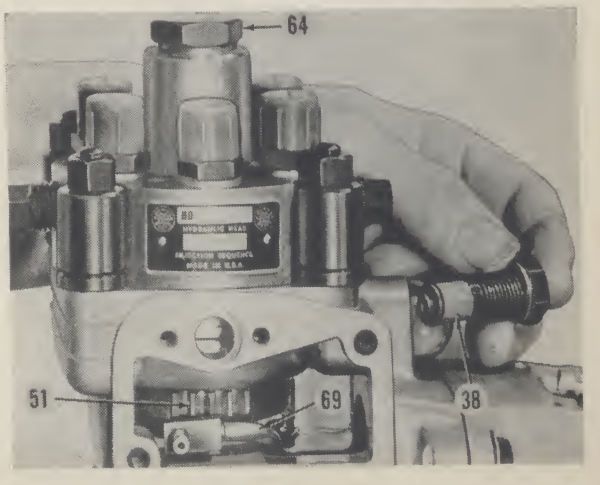


Fig. 0482 — Injection pump with control arm unit removed from rod (69) and from pump. Oil filter (38) is being removed preparatory to removing the hydraulic head unit.

0482A). Using a socket wrench, rotate the pump camshaft until the pump coupling hub line mark exactly registers with the pointer; then reinstall pump drive gear retaining cap screws. Several trials may be necessary before finding the holes which will admit the cap screws without throwing the marks out of register. Lock the cap screws with wire.

36D. **INTERNAL TIMING.** If pump has been disassembled, it should be internally timed at reassembly as follows:

Insert pump camshaft into body with the wide groove at splined end in register with the "CLW" mark on bearing retainer plate as shown in Fig. 0483. Install the quill gearshaft (31—Fig. 0486) through the bottom of the pump housing so that when the spiral gear (33) at bottom end is meshed with camshaft spiral gear, the open tooth of the spur upper gear on gearshaft (31) will be in register with the drill mark on the counterbore of the pump housing as shown in Fig. 0484. Now, install the hydraulic head assembly with the line marked tooth of its plunger gear in register with the arrow (an "O" on early production pumps) on the timing window recess as shown in Fig. 0480. Refer also to Fig. 0487.

36E. **INTERNAL PHASING.** Injection pump is correctly phased internally when the flow of fuel from the No. 1 outlet of the hydraulic head ceases at the instant when the line mark on coupling hub, shown in left circle in Fig. 0481, is in register with the pointer. Phasing is checked by using the flow method to determine port closing point as follows:

With pump mounted in a vise, connect a fuel oil line from a gravity supply tank to the inlet side of the hydraulic head. Remove constant bleed (overflow) line fitting from hydraulic head and replace with a ¼ inch pipe plug. Bleed pump of all air by loosening this pipe plug and rotating pump drive camshaft. Next, place operating lever in the full load position. Remove delivery valve cap screw (64) shown in Fig. 0482. With a $\frac{7}{16}$ inch socket wrench, unscrew the delivery valve holder and lift out the delivery valve spring and valve (Fig. 0485). The delivery valve body must remain in position. Reinstall delivery valve holder and cap screw.

With a wrench on the drive gear hub cap screw, rotate pump camshaft in a clockwise direction (viewed from drive end) until the marked bevel tooth of plunger drive gear approaches the arrow or "O" mark on the ledge of the pump inspection window. Continue rotating drive gear hub slowly until the flow of oil stops at No. 1 outlet in hydraulic head. At this time, the scribed line mark on drive coup-

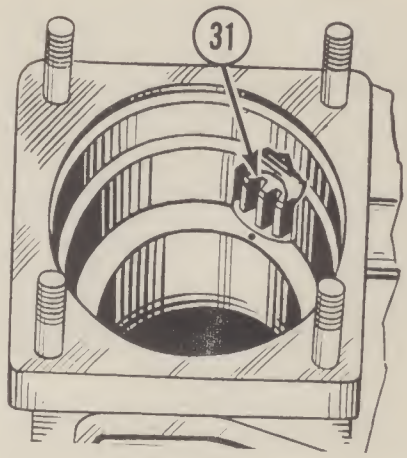


Fig. 0484—When assembling injection pump, the center open tooth of gear at top of quill shaft (31) should be registered with mark on body as shown, when pump camshaft is positioned as shown in Fig. 0483.

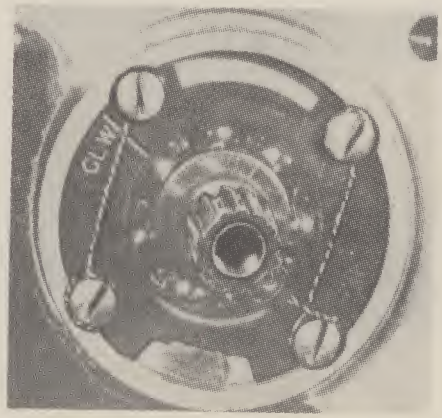


Fig. 0483—When reassembling the injection pump the wide spline at drive end of camshaft should be registered with mark "CLW" as shown.

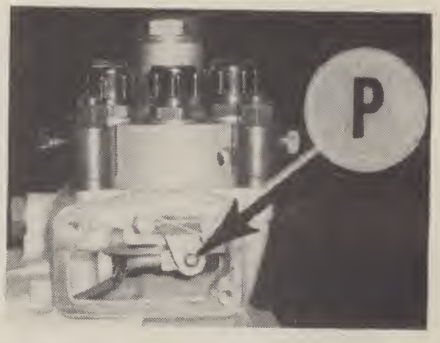


Fig. 0484A—When pin "P" is removed from control arm the control arm shaft should rotate freely in shaft bearings. This is important.

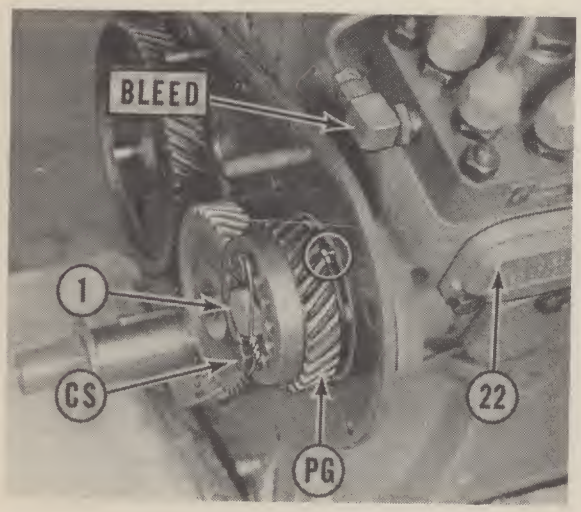
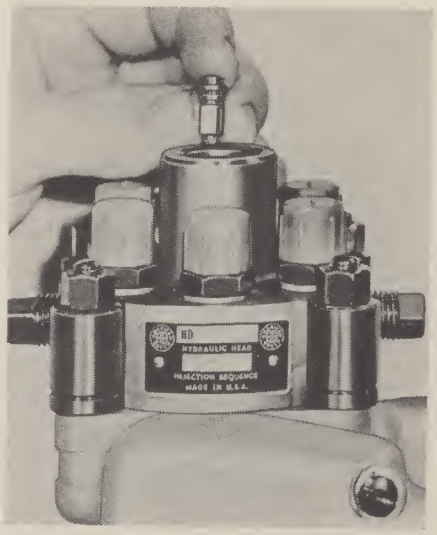


Fig. 0482A—View of injection pump and drive with timing gear cover removed. Pump timing pointer is shown in circle. Note bleed line.



Courtesy—Diesel Publications, Inc.

Fig. 0485—A stuck, scratched or corroded delivery valve may cause hard starting or non-starting of engine.

ling hub should be in register with body pointer within $\frac{1}{32}$ inch and marked plunger gear tooth in timing window will be about one tooth to the right of the arrow or "O" mark on inspection window ledge.

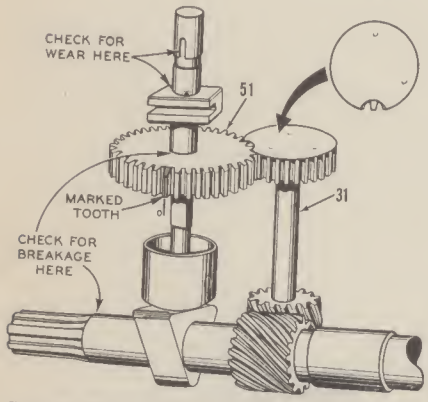
If pointer and mark on pump drive hub are out of register more than $\frac{3}{8}$ inch, the pump is incorrectly assembled. If out-of-register is $\frac{1}{8}$ or less, remove old timing mark and affix a new line mark on drive gear hub. Repeat this procedure until constant results are obtained. Reinstall delivery valve, spring, and overflow valve, which were previously removed.

Fig. 0486—Disassembled view of Bosch PSB pump 6A70Y3826-A used on Super series tractors. Note round cornered hydraulic head assembly (45). Refer also to Fig. 0477.

A. Fuel inlet
B. Space above plunger
D. Plunger
F. Plunger slot
G. To nozzles
3. Drive hub
8. Retainer for item 9
9. Camshaft bearing
10. Camshaft
11. Rubber ring
12. Timing pointer
13. Pump housing
14. Camshaft bushing
22. Window cover
26. Control assembly
31. Quill shaft and gear
32. Quill shaft bushing
33. Camshaft driven gear
36. Closing plug
38. Filter screen
41. Tappet roller
43. Tappet guide
45. Hydraulic head assembly
48. Spring, inner
51. Plunger drive gear
52. Plunger guide
55. Screw sealing ball
59. Delivery valve assembly
61. Spring for item 59
62. Holder for valve 59
69. Control rod assembly
72. Weight spider
73. Governor weight
74. Weight sleeve
75. Fulcrum lever
76. Governor housing
79. Bearing for 81
81. Fulcrum lever shaft
83. Seal for 81
88. Operating lever
91. Extension spring
94. Shut-off plate
96. Control rod spring
98. Control rod pin
99. Load adjusting nut
100. Stop plate
104. Shut-off spacer
106. Stud sleeve

36F. **REMOVE & INSTALL.** To remove injection pump from engine, proceed as follows: Shut off fuel supply at tank, disconnect all lines from hydraulic head, and disconnect hand controls Remove injection pump gear cover from front face of timing gear cover. Remove pump drive gear. Remove two cap screws, and one bolt and nut retaining pump to engine and remove pump.

Reinstall and time pump to engine as outlined in paragraphs 36A through 36C. After pump is installed, bleed the system as in paragraph 37. To adjust the governor speed, refer to paragraph 38A. The Super 77 and Super 88 engines use the same fuel injection pump as Super 99. This universal pump as received by the Oliver dealer is calibrated (fuel delivery adjusted) for the 88 engine, and should be recalibrated by an official station if installed on the Super 99.



Courtesy—Diesel Publications, Inc.

Fig. 0487 — Schematic view of internal drives in injection pump. Likely wear points are also indicated.

37. **FUEL SYSTEM BLEEDING.** The Diesel fuel supply system should be bled whenever the system has been disconnected or fuel tank emptied. To bleed low pressure side, loosen bleed screws located in the fuel filters. Operate priming lever on supply (primary) pump located on right side of engine, with full strokes, until clear fuel (free of air bubbles) flows past fuel filter bleed screw on first filter; then, close the bleed screw. Repeat this procedure on second, also on third, fuel filter if so equipped. To bleed the high pressure system, loosen the fuel line connections at the nozzles; then, using the starting motor, turn engine over until clear fuel (free of air bubbles) flows past the nozzle connections.

38. **GOVERNOR FREEDOM.** The necessity for free movement of the governor linkage extends to the delivery control unit located on the injection pump housing under the timing window. Refer to Fig. 0484A. To check freedom of unit, remove pin (P) from unit arm. If arm shaft is tight in bearing, remove the wired retaining cap screws and free up or renew control unit as outlined in paragraph 33A.

38A. **GOVERNOR ADJUSTMENT.** The Diesel engine governor (flyweight type) is an integral part of the injection pump. Engine low idle no-load speed of 600 crankshaft rpm is adjusted by means of screw (101—Fig. 0488). Rotating the adjusting screw in a clockwise direction decreases the engine idle speed.

The high idle engine speed of 1840 crankshaft rpm is adjusted by varying the tension of governor spring (91) with adjusting nuts (90).

38B. **GOVERNOR SPRING.** Governor spring (91—Fig. 0488) for Super 99 tractor engine is Bosch SP9013-1, (Oliver 7A5798A) having 8½ coils of 0.092 wire, overall diameter of 0.750, and free length of 2.0 inches.

39. **SMOKE STOP ADJUSTMENT.** Refer to Delivery Calibration, paragraphs 34 and 34A.

DIESEL NOZZLE UNITS

40. Unless the shop is equipped with the necessary nozzle tester, servicing of the nozzles should be limited to the minor work outlined in paragraph 40C.

American Bosch nozzles AKB6062618A are of the closed pintle type shown in Figs. 0491 and 0492.

40A. **LOCATING A FAULTY NOZZLE.** If one engine cylinder is misfiring, it is reasonable to suspect a faulty nozzle. Generally, a faulty nozzle can be located by loosening the high pressure line fitting on each nozzle in turn; thereby allowing the fuel to escape instead of entering the cylinder combustion chamber. As in checking spark plugs in a spark ignition engine, the faulty nozzle is the one which, when its line is loosened, least affects the running of the engine. Remove the suspected nozzle from the engine as outlined in paragraph 40B; then reconnect the fuel line and with the discharge end directed where it will do no harm, crank the engine and observe the spray pattern as shown in Fig. 0489.

If the spray pattern is ragged, it is likely that the nozzle is the cause of the misfiring. To prove the diagnosis, install a new or rebuilt nozzle or a nozzle from a cylinder which is firing regularly. If the cylinder fires regularly with the other nozzle, the condemned nozzle should be serviced as per paragraph 40C. If cleaning and/or renewal of tip (body) does not restore the nozzle, it should be overhauled by a shop equipped to handle such work.

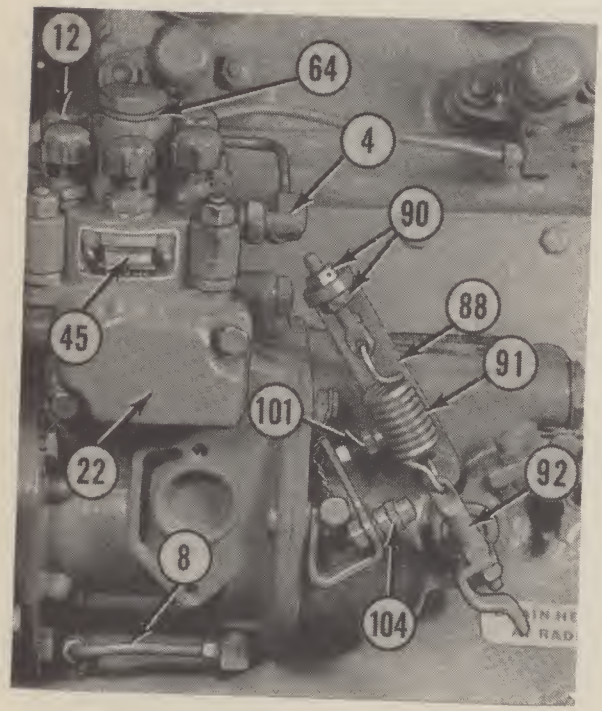


Fig. 0488—View of Bosch type PSB injection pump showing nuts (90) which control tension of governor spring (91) to vary the high idle engine speed.

8. Oil line (lubricating)
12. Outlets to nozzles
22. Timing window cover
45. Hydraulic head
64. Delivery valve cap
88. Operating lever
101. Low idle screw
104. Shut-off spacer

40B. **R&R OF (INJECTORS) NOZZLES.** These assemblies commonly are called nozzles or injectors, although the nozzle is strictly not a complete injector. Before loosening any lines, wash all connections with fuel oil.

Procedure for R&R of injector units varies according to the cylinder location as follows:

The number 6 unit can be removed after disconnecting the leak-off line and feed line.

The numbers 2, 3, 4, and 5 units can be removed in the usual manner after removing the 4 clamps from the line harness and springing the number 6 injector line up or down slightly for removal clearance.

The number 1 unit can be removed after disconnecting all lines and lifting the line harness assembly off the engine.

After disconnecting the high pressure and leak-off lines, cover open ends of lines and pump with tape or composition caps to prevent the entrance of dirt. Remove nozzle holder stud nuts and carefully withdraw injector from cylinder head being careful not to strike end of same against any hard surface.

Thoroughly clean the nozzle recess in the cylinder head before reinstalling the nozzle holder assembly. It is important that the seating surfaces of the recess be free of even the smallest particle of carbon which could cause the nozzle to be cocked and result in blowby of hot gases. No hard or sharp tools should be used for cleaning. Bosch recommends the use of a wooden dowel or brass bar stock which can be shaped for effective cleaning. Do not reuse the copper ring gasket; install a new one. Tighten the nozzle holder stud nuts to 14-16 foot-pounds torque.

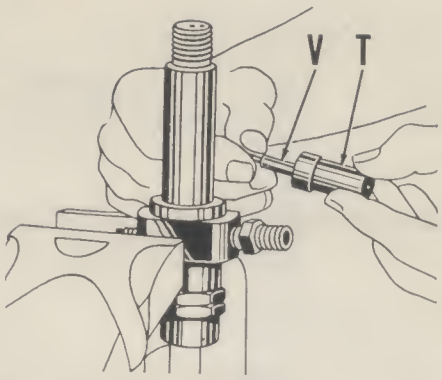


Fig. 0490—Removing Oliver Diesel engine injector nozzle tip (T) and the valve (V).

40C. **MINOR SERVICING OF NOZZLE.** Hard or sharp tools, emery cloth, crocus cloth, grinding compounds or abrasives of any kind should **NEVER** be used in the cleaning of nozzles.

Carefully clamp the nozzle holder in a vise and remove the cap nut and spray nozzle, consisting of the body or tip (T—Fig. 0490) and valve or nozzle body stem (V). Soak the nozzle in fuel oil, acetone, carbon-tetrachloride or a similar carbon solvent being careful not to permit any of the polished surfaces of the valve or tip to become nicked by contact with any hard substance.

All surfaces of the nozzle valve pintle should be bright and shiny except the contact line of the beveled seating surface. Polish the valve (pintle) with mutton tallow used on a soft cloth or felt pad. The valve may be held by its stem in a revolving chuck during this operation. A piece of soft wood well soaked in oil, or a brass wire brush will be helpful in removing carbon from the valve.

The inside of the nozzle body (tip) can be cleaned by forming a piece of soft wood to a point which will correspond to the angle of the nozzle valve (pintle) seat. The wood should be well soaked in oil. Some Bosch mechanics use an ignition distributor felt oiling wick instead of the soft wood rod, for cleaning the pintle seat in the tip. Delco-Remy part DR804076 is suitable for the purpose. Form the end of the wick, and coat the formed end with tallow for polishing.

The orifice at the end of the tip can be cleaned with a wood splinter. Outer surfaces of the nozzle body or tip should be cleaned with a brass

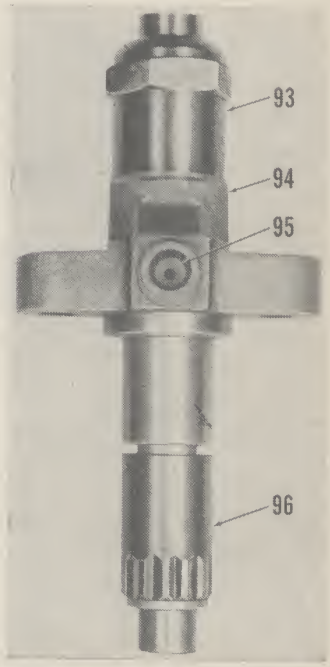


Fig. 0492—Bosch closed pintle type fuel nozzle as used on 6 cylinder Super 99 Diesel.

93. Cap
94. Nozzle holder
95. Fuel inlet
96. Cap nut

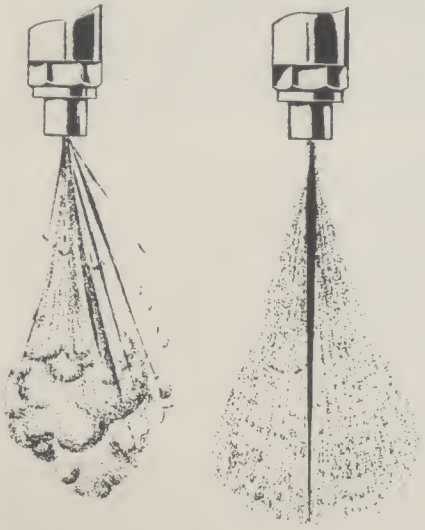


Fig. 0489 — Spray patterns of a standard pintle type nozzle. Left: A poor spray pattern. Right: Ideal spray pattern.

1. Nozzle tip (body)
2. Nozzle valve
3. Holder
4. Spring
5. Lock nut
6. Adjusting screw
7. Leak-off connection
8. Protection cap
9. Fuel in'et
10. Fuel passage

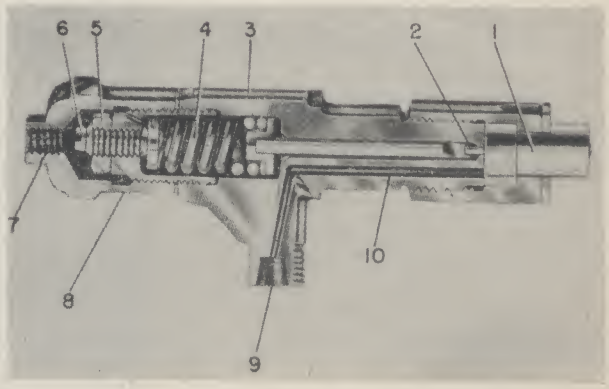


Fig. 0491—Sectional view of the closed pintle type nozzle used on the Oliver Diesel engines. Nozzle opening pressure of 1750 psi is controlled by adjusting screw (6).

wire brush and a soft cloth soaked in carbon solvent.

Before reassembling the nozzle to the holder, thoroughly rinse all parts in clean fuel oil and make certain that all carbon is removed from the cap nut. It is desirable that the nozzle body (tip) be perfectly centered in the cap nut. A centering sleeve, American Bosch tool TSE773, Fig. 0493, is available and should be used for this purpose. Avoid overtightening of the cap nut.

40D. Further disassembly of the nozzle holder should not be attempted except in an emergency or when a nozzle testing device is available for readjustment of the opening pressure. Recommended opening pressure for the nozzles is 1750 psi.

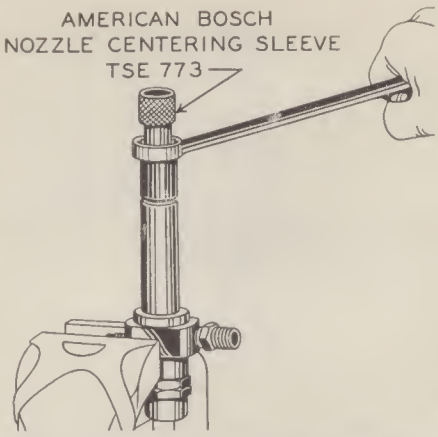


Fig. 0493—Using a Bosch tool No. TSE773 to center the nozzle tip in the cap nut.

DIESEL ENERGY CELLS

41. **R & R AND CLEAN.** Energy cells are located in the cylinder head on the side opposite to the injectors or nozzles. When the engine smokes excessively or the fuel consumption is above normal, the cause may be sometimes traced to an excessive amount of carbon deposit in the energy cells. An emergency job of cleaning the cells, Fig. 0494, can be done by removing the cell cap (99) and using a hooked wire to form a scraper.

To remove complete energy cell, first remove the threaded plug (97) and take out the retainer (98). With a pair of thin nosed pliers, remove energy cell cap (99). If the energy cell (100) will not come out with the fingers, screw a $\frac{15}{16}$—20 NF threaded bolt into the threaded end of the energy cell. A nut and collar on the bolt will make it function as a puller. If no puller is available, remove the injection nozzle and use a brass rod to drift the energy cell out of the cylinder head.

Clean all deposits from the front and rear craters of the cell body (100) and also from the small orifice using a brass carbon scraper or a shaped piece of hardwood. After cleaning the exterior surfaces with a wire brush, soak the parts in a carbon solvent. Reject any pieces that show leakage or burning anywhere on their surfaces. If parts are O. K. for leakage and burning, clean the lapped sealing surfaces by using a figure 8 motion on a tallow coated lapping plate.

DIESEL STARTING AID

Six Cylinder

42. A chevron type ether priming system utilizing ether filled cartridges is used as a starting aid. This element takes the place of the manifold preheater used on some other Oliver Diesel powered tractors. Control of the ether injector is located on a subpanel bolted to the instrument panel. Servicing procedures are conventional.

PRIMARY FUEL SUPPLY PUMP

43. Diesel engines are equipped with an AC automotive diaphragm type, primary fuel supply pump, Fig. 0494A, which is mounted on the right side of the engine. The pump, which is equipped with a hand operating priming lever for use in bleeding the low pressure side of the fuel system, is actuated by the engine camshaft. A satisfactory pump will show a 5-11 psi gage reading when checked at the outlet side.

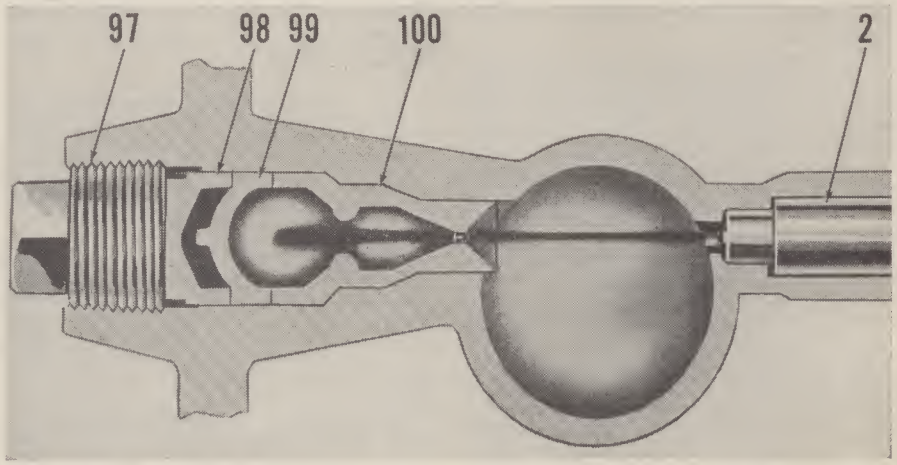


Fig. 0494—Energy cells (pre-combustion chambers) one for each cylinder, are located in cylinder head facing the injectors from opposite side of head.

2. Nozzle 97. Retaining plug 98. Retainer 99. Cell cap 100. Energy cell

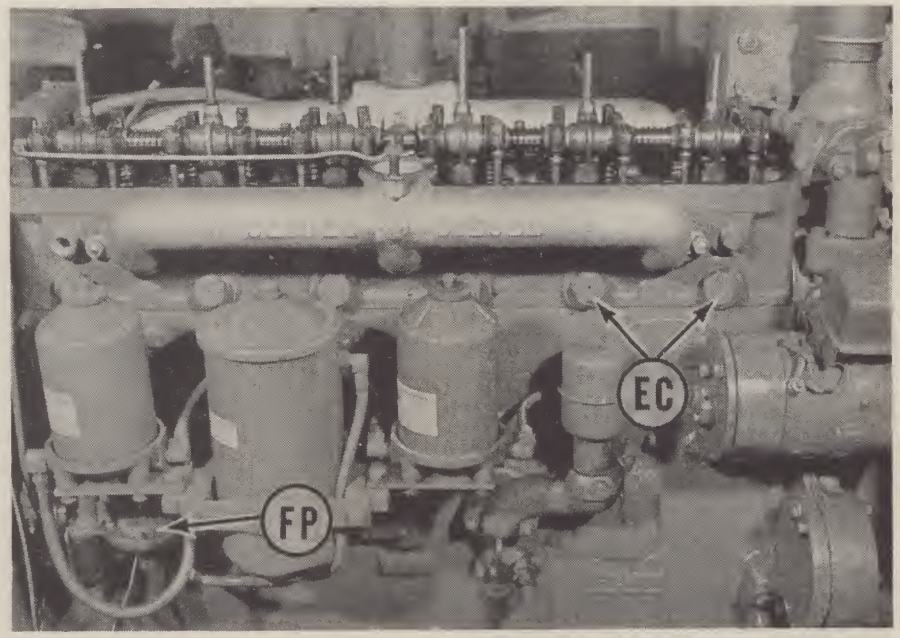


Fig. 0494A—Fuel filters side of 6 cylinder Super 99 Diesel engine. Two of the 6 energy cells are indicated at arrow (EC), primary fuel pump at (FP).

NON-DIESEL GOVERNOR

The flyweight type governor, Fig. 0496 as installed on non-Diesel engines is mounted on the front face of the timing gear cover, and is driven by the camshaft gear. For adjustment data on the Diesel engine governor, refer to paragraph 38A.

ADJUSTMENT

44. To adjust the governor on non-Diesel engines, first remove air cleaner; then, place the hand control lever in the full speed position. Disconnect carburetor throttle valve control rod (133—Fig. 0495) at the governor operating arm (118). Place carburetor throttle valve in the wide-open position, and the govenor unit lever in full forward position. Adjust length of rod (133) to provide approximately $\frac{1}{16}$ inch over-travel ($\frac{1}{16}$" longer than necessary) as shown; then, reconnect the rod.

Start and warm up engine. Turn bumper spring screw (116—Fig. 0496) "out" about 4 revolutions. Adjust carburetor mixture and idle stop screw to provide a closed throttle, no-load crankshaft speed of 350 rpm for battery ignition equipped models, or 600 rpm for magneto equipped models. High speed, no-load crankshaft rpm of 1925 is obtained by lengthening or shortening the hand control rear rod (136—Fig. 0497) after disconnecting it from the front (flat) rod (134) at bolt (B).

If engine speed surges at 1925 rpm, rotate bumper spring screw just enough to eliminate the surge but not enough to increase the engine speed.

R&R AND OVERHAUL

44A. Governor can be removed without disturbing the radiator by proceeding as follows: Remove the air cleaner cup. Disconnect governor linkage and remove governor to timing gear cover retaining cap screws. **Carefully withdraw the unit so as to prevent the loss of the drive gear bronze washer (123—Fig. 0496).**

Governor drive gear (133) is a press fit and is keyed to the governor shaft (139). Gear can be removed with the use of a suitable puller. Governor weight carrier (122) is a press fit and keyed to the shaft. The weight carrier should be removed from the shaft by pressing on the gear end of the shaft. Disassembly of the weight unit is self-evident after an examination. The bushings (126 & 129 & 131) require final sizing after installation to provide running clearance of 0.0015-0.002.

Governor gear hub rotates in a steel-backed babbitt bushing (41) and sleeve assembly which is pressed into the front face of the cylinder block. To renew the assembly, it will be necessary to remove timing gear cover and use a suitable puller to remove same as shown in Fig. 0498. Renew bushing when clearance exceeds 0.005. Pre-sized service bushings have a bore diameter of 1.002, and should be installed with a piloted drift. Refer to Fig. 0499A.

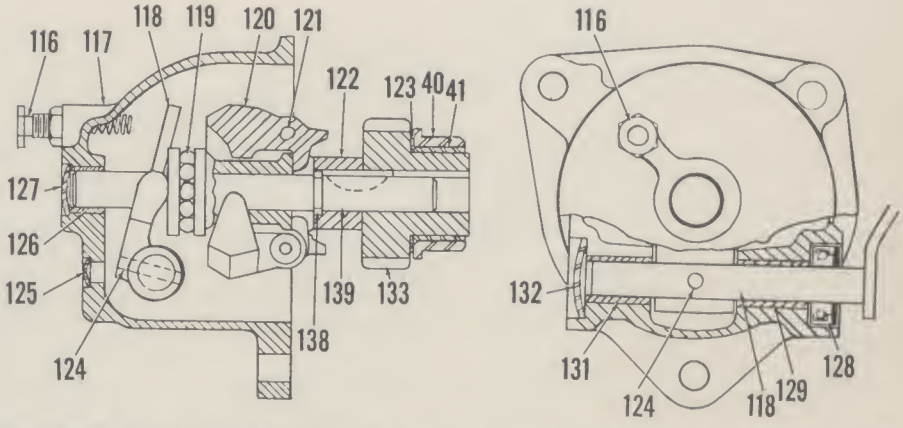


Fig. 0496—Speed governor assembly used on non-Diesel engines, cross-sectional view. Sleeve (40) and bushing (41) are located in the front face of the cylinder block.

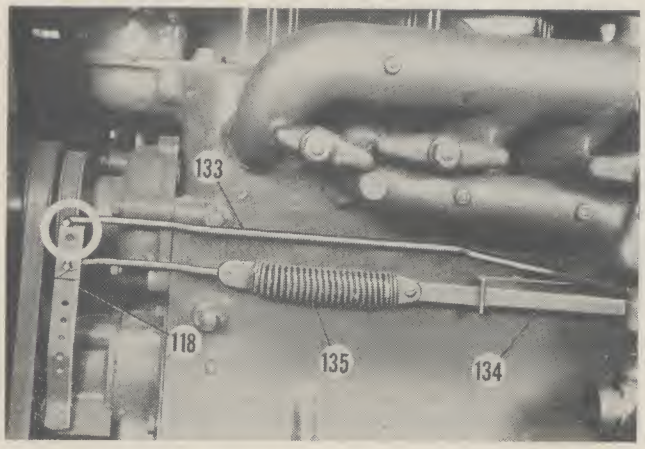


Fig. 0495—Rod which connects carburetor throttle to governor fork lever should be adjusted to 1/16 inch over-travel, that is, it should be 1/16 inch longer than the center distance. Illustration is of 88 tractor but Super 99 is basically similar.

118. Governor operating fork lever arm
134. Governor control rod (front)
135. Governor spring

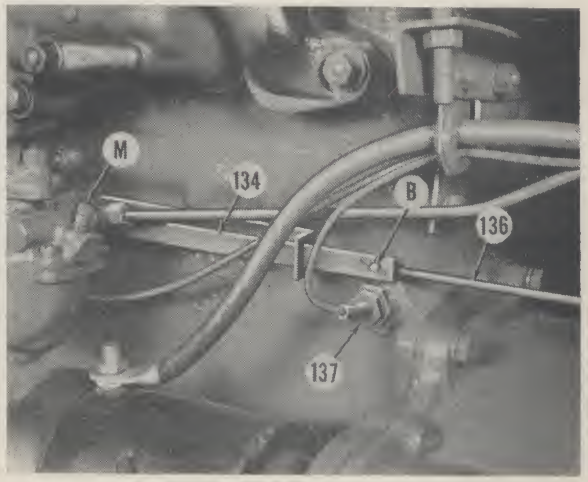


Fig. 0497—High idle, no-load engine crankshaft rpm of 1925 is controlled by lengthening or shortening the hand control rod (136). Shown is 88 tractor but Super 99 is basically similar with head of bolt (B) on outside.

COOLING SYSTEM (6 Cylinder)

(System for Three Cylinder Engine Begins with Paragraph 110)

RADIATOR

45. Procedure for removal of radiator which involves removal of the hood is as follows: Loosen front grille center strap bolts, remove two caps screws attaching front grilles to support and lift off grilles. Detach both headlights and disconnect the wires. Remove hood straps, precleaner, muffler, two wiring harness clips from right side of hood, and lift hood from tractor. Remove top radiator hose and disconnect lower hose. Remove radiator to front frame cap screws, two on each side, and shield to radiator shell screws, two on each side.

WATER PUMP

46. **REMOVE.** Pump can be removed without disturbing the radiator. Remove fan blades, top hose, lower hose and pipes. Drop fan blades to bottom of fan shroud. Remove cap screws attaching pump to cylinder block and lift off pump.

46A. **OVERHAUL.** Disassembly procedure is as follows: Using a puller, remove hub (8—Fig. 0499) from shaft. After removing cover (10), push shaft and impeller as a unit, rearward out of the bearings. If shaft does not move rearward easily out of bearings, pull impeller (2) from shaft, extract snap ring (9) and push shaft and bearings forward out of pump body. If bearings are renewed, install same with sealed ends facing outward and partially fill cavity in body with heavy oil or ball bearing grease. Always use a new seal unit.

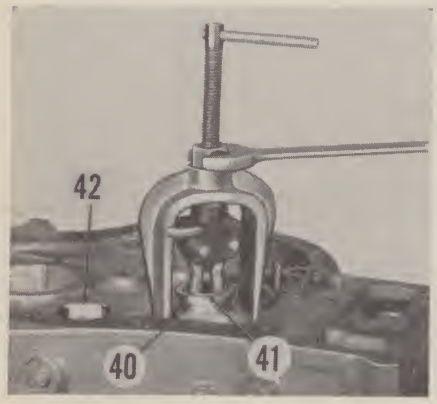
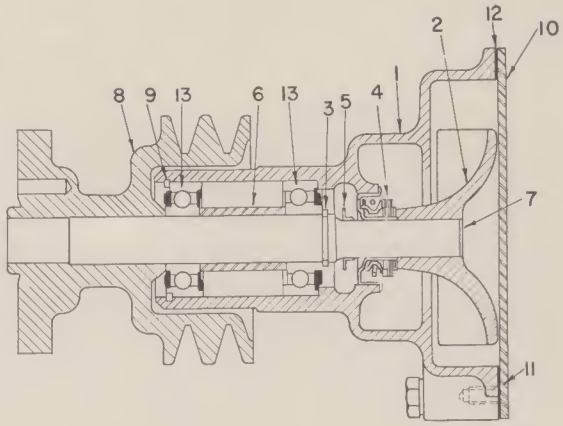


Fig. 0498—Using a puller to remove the governor gear sleeve (40) and bushing (41) assembly. Diesel engine idler gear shaft bore (42) is plugged on non-Diesel engines.

Fig. 0499 — Components of water pump. Note that impeller shaft is not integral with bearings.

1. Body
2. Impeller
3. Retaining ring
4. Seal assembly
5. Slinger
6. Bearing spacer
7. Shaft
8. Fan pulley
9. Retaining ring
10. Cover
13. Ball bearing



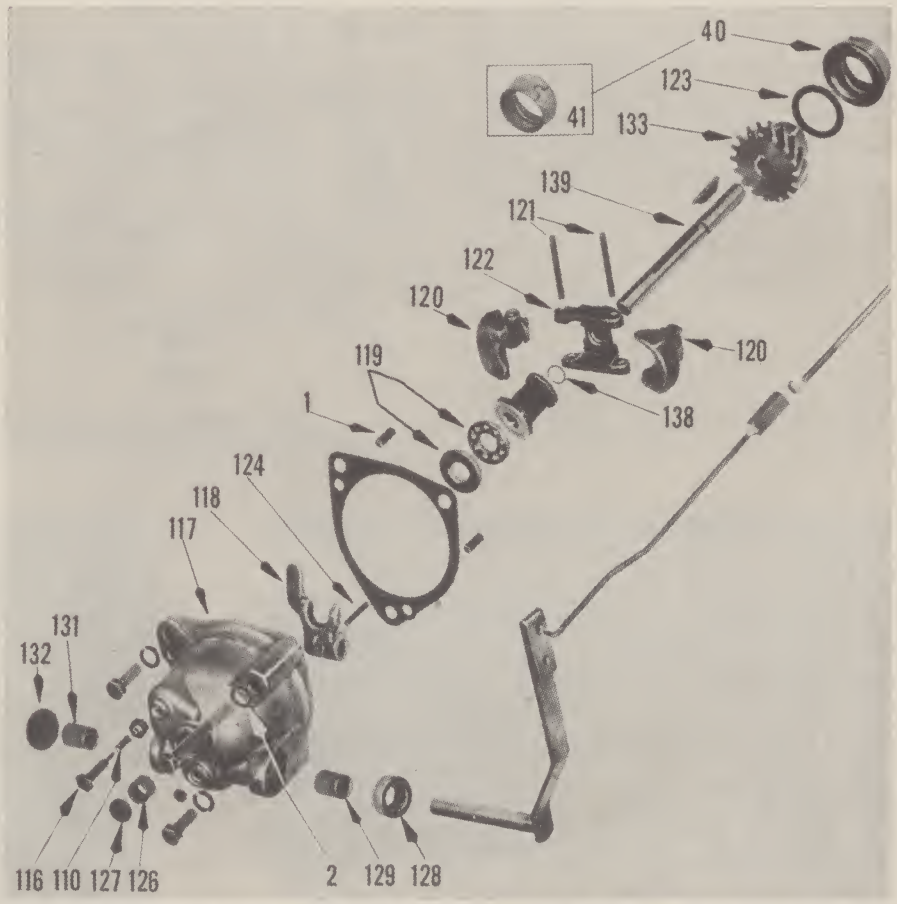


Fig. 0499A—Exploded view of speed governor. Refer also to Fig. 0496.

40. Sleeve
41. Bushing
116. Bumper spring adjusting screw
117. Housing
118. Fork
119. Thrust bearing
120. Weight
121. Weight pin
122. Weight carrier
123. Thrust washer
124. Fork retaining pin
125. Expansion plug
126. Bushing
127. Expansion plug
128. Oil seal
129. Bushing
131. Bushing
132. Expansion plug
133. Drive gear
138. Snap ring
139. Governor shaft

ELECTRICAL SYSTEM (6 Cylinder)

(Electrical system data for 3 cylinder engine begins with paragraph 115.)

GENERATOR AND REGULATOR

Six Cylinder

50. Non-Diesel engines are equipped with Delco-Remy 1100504, clockwise, 6 volt, third brush type generator. Hot output is 16-19 amperes @ 6.9-7.1 volts @ 2500 generator rpm. Brush spring tension is 16 ounces. Field current @ 80° F. is 2.5-2.72 amperes @ 6 volts.

Diesel engines are equipped with Delco-Remy 1100953, clockwise, 12 volt, third brush type generator. Hot output is 9-11 amperes @ 13.8-14.2 volts @ 2500 generator rpm. Brush spring tension is 16 ounces. Field current is 2.0-2.14 amperes @ 12 volts.

Generator cutout relay for 6 volt gasoline engines is Delco-Remy 111-8305; for 12 volt Diesel tractors, Delco-Remy 1118306.

These specifications are also contained in table form in the separate Standard Units Manual.

STARTING MOTOR

Six Cylinder

To remove starting motor from 6 cylinder tractor it will be necessary to first remove the stamped curved clutch cover.

51. Non-Diesel engines are equipped with Delco-Remy 1108951, clockwise, 6 volt motor fitted with Bendix drive. Tested at no load, current draw should be 60 amperes @ 5.7 volts @ 3300 rpm. Lock torque minimum should be 30 pounds feet @ 675 amperes @ 3300 rpm. Brush spring tension is 36-40 ounces.

Diesel engines are equipped with Delco-Remy 1109229, clockwise, 12 volt motor, fitted with over-running clutch drive. Tested at no load, current draw should be 95 amperes @ 11.7 volts @ 8000 rpm. Locked torque minimum should be 20 pounds feet @ 570 amperes @ 2.8 volts. Brush spring tension is 36-40 ounces.

These specifications are also contained in the separate Standard Units Manual.

IGNITION EQUIPMENT

Six Cylinder

52. Regular equipment is Delco-Remy 1118305 counter-clockwise battery distributor with centrifugal automatic advance. Optional equipment is a Wico XV6 vertical type, fixed spark, high tension magneto equipped with an impulse coupling.

Distributor specifications are as follows: Breaker point gap .022, cam angle 31°-37°, rotation counter-clockwise. Automatic advance starts @ 275 distributor rpm, should be 5-7 distributor degrees @ 400 rpm, 9-11 degrees @ 800 rpm and reach full advance of 14-16 distributor degrees @ 1300 distributor rpm. Multiply the foregoing values by 2 to obtain flywheel degrees.

Construction details and servicing information pertaining to the Wico XV6 type magneto model XVD-2292 are contained in the separate Standard Units Manual.

IGNITION TIMING

Six Cylinder

53. **BATTERY IGNITION.** Battery distributor rotates counter-clockwise viewed from the drive end. Engine firing order is 1-5-3-6-2-4. To time distributor to engine, proceed as follows: Adjust breaker gap to 0.020-0.022.

Crank engine until No. 1 piston (timing gear end) is on compression stroke, then rotate slowly until flywheel mark "TDC" is registered with notch at inspection port. Install distributor to engine with rotor positioned to fire No. 1 cylinder. Rotate distributor housing counter-clockwise until breaker contacts have just started to open, then, temporarily tighten the distributor clamping bolt.

Run engine at 1925 rpm (high idle) at which time a timing light should show spark occurring when flywheel mark "IGN" registers with notch at inspection port. Rotate distributor body to obtain registration, then tighten clamp bolt securely.

54. **MAGNETO.** Magneto rotates counter-clockwise, viewed from the drive end. Engine firing order is 1-5-3-6-2-4. To time magneto to engine, proceed as follows: Adjust breaker contacts to 0.015 gap. Crank engine until No. 1 piston (timing gear end) is on compression stroke, then, slowly rotate flywheel until flywheel mark "IGN" is registered with notch at inspection port.

Turn magneto shaft to position where rotor is ready to fire No. 1 cylinder and temporarily install to engine. Rotate magneto body counter-clockwise until impulse coupling releases with a sharp snap. Rotate body in opposite direction until breaker contacts are just starting to open, then, temporarily tighten magneto clamping bolt.

Run engine at 1925 rpm or higher at which time a timing light should show spark occurring when "IGN" mark registers with notch at inspection port. Rotate magneto body to obtain this registration, then tighten the clamp bolt securely.

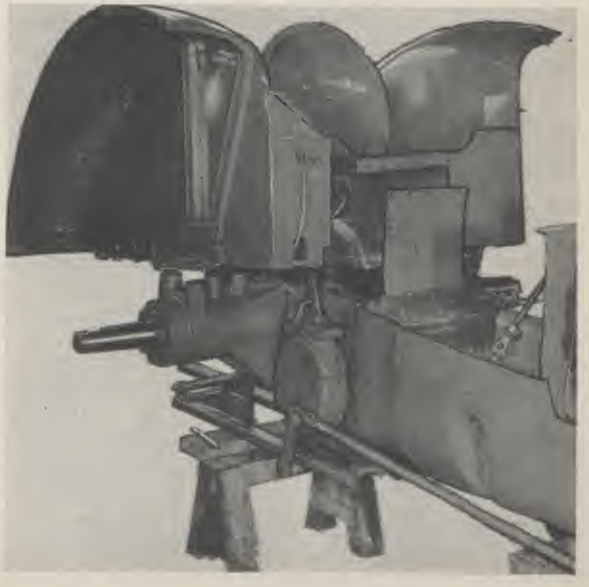


Fig. 0499B-Removing fenders, platform and bull gear cover as a single assembly. In most instances this is easiest method of removing bull gear cover from rear main frame.

ENGINE ASSEMBLY (GM Diesel 71 Series)

(Oliver Six Cylinder Type Engines Begin with Paragraph 10)

The model 3-71, 3023, type RB General Motors three cylinder, two-cycle Diesel engine is provided as the standard power unit for the Super 99 GM tractor. Other Super 99 tractors fitted with Oliver six cylinder Diesel and non-Diesel engines do not carry the "GM" suffix in the tractor model designation.

The two-cycle GM Diesel 71 series engines are offered in three, four and six cylinder models having the same bore and stroke, and using the same parts wherever possible. Thus, many of the engine parts are interchangeable.

Engine servicing procedures such as removal, reinstallation, overhaul and adjustment as covered herewith for the three cyinder engine, used in the Oliver Super 99 GM tractor, can also be applied to all other three, four and six cylinder 71 series engines. Exceptions to this statement apply only to the location of the various accessories and components on the engine as shown in Fig. 0499C, to the injection timing dimension which varies with the size of injector, and to the type of governor.

REMOVE AND REINSTALL

60. To remove GM engine assembly from tractor chassis, proceed as outlined in paragraphs 60A through 60G. Refer to Figs. 0500, 0501 and 0502.

60A. HOOD. Remove hood as follows: Loosen front grille center strap bolts, and remove two cap screws attaching front grilles to support and lift off grilles. Detach both headlights (each held by two bolts) and disconnect wires. Remove hood strap, precleaners, muffler, and two wiring harness clips from right side of hood. Lift off hood.

60B. PTO DRIVE SHAFT. If tractor is equipped with pto, remove the drive shaft of same as outlined in paragraph 145H.

60C. FUEL TANK. Shut off fuel supply at tank. Disconnect fuel line from strainer on fuel tank, and fuel return line at top front of tank. Remove governor control bell crank assembly and wiring harness clips from bottom of tank. Remove the fastenings attaching tank to rear bracket and lift tank from tractor.

60D. Remove batteries. Perform the following work on left side of tractor: Remove fuel tank to fuel pump line. Disconnect tachourmeter cable at drive unit (9); Chevron starting aid primer line (13) at air inlet housing on blower and remove one clip attaching line to blower housing; coolant temperature sending unit at water manifold; fuel shut-off cable (4) at governor;

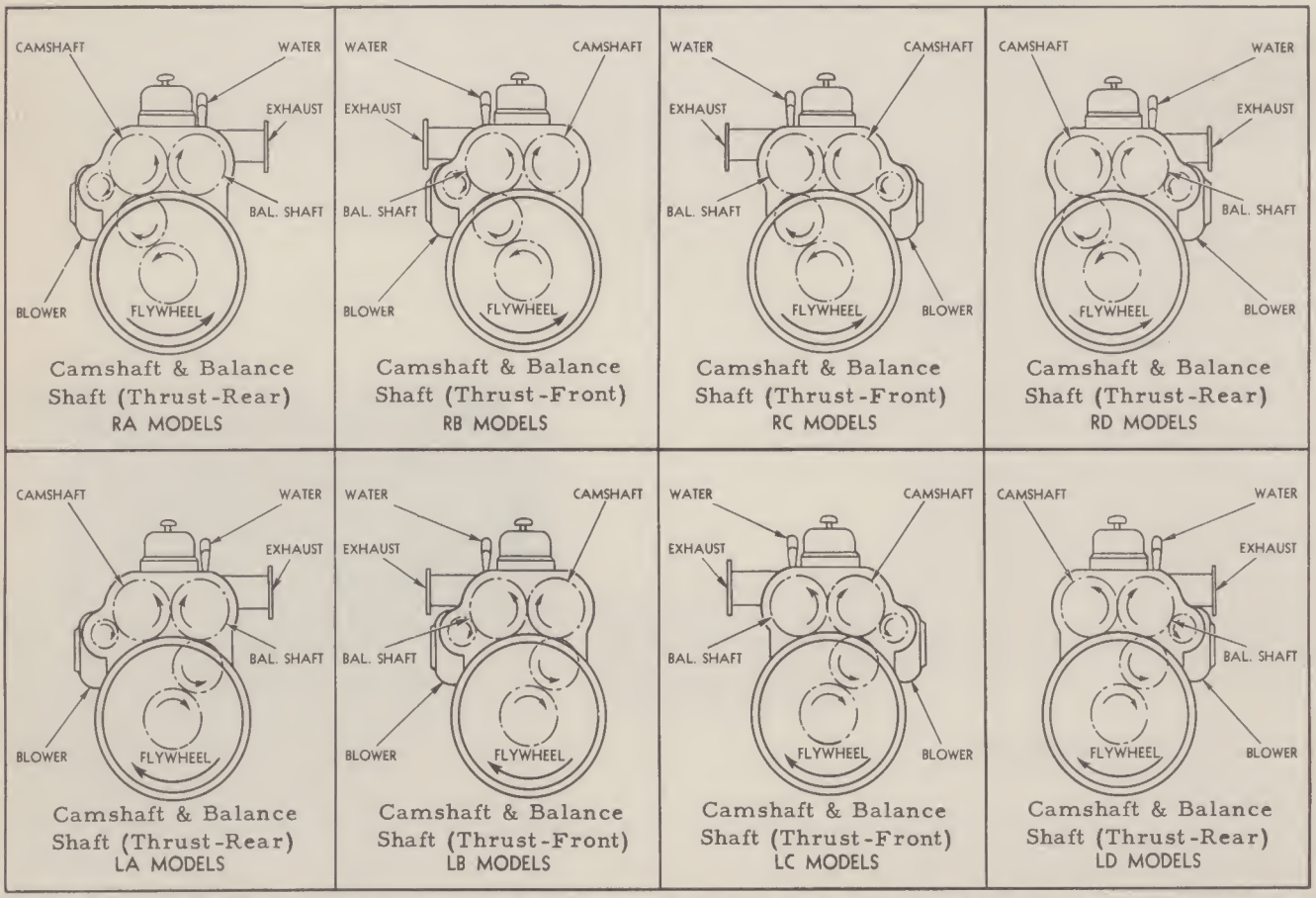


Fig. 0499C—Rotation and accessory arrangements for 3, 4 and 6 cylinder, 2 cycle, series 71 GM engines. A model RB, 3 cylinder series 71 GM engine is used in the Oliver Super 99 GM tractor. Views are from flywheel end of engine.

governor control rod (6) at governor; upper radiator hose; and oil cooler (1) to water pump hose.

Remove radiator to front frame cap screws (two on each side) and shield to radiator shell screws (two on each side). Disconnect radiator to oil cooler hose and lift radiator from tractor.

Disconnect engine oil cooler hoses at oil cooler, located in forward section of front frame.

Perform the following work on right side of tractor: Disconnect wiring harness at generator regulator; battery cables at starter; and oil pressure gage line (16) from cylinder block. Remove one clip attaching fuel shut-off cable (4) to side of cylinder head.

60E. CLUTCH SHAFT AND COUPLING. Remove clutch housing front cover after removing cap screws attaching it to front frame. Remove clutch housing flat dust cover after removing cap screws attaching it to front frame and to clutch release bearing carrier.

Refer to Fig. 0458 and remove chain (22) after extracting master link. Slide clutch shaft coupling (21) forward on shaft after removing coupling clamping bolt. Disconnect outer end of clutch shifter shaft, and loosen the set screw which retains shifter fork (26) to shifter shaft; then, bump shifter shaft out of fork toward left side of tractor. Withdraw clutch shaft (23) from clutch.

60F. LIFTING ENGINE. Remove the two front and two rear engine mounting bolts which may be provided with aligning shims. Be careful not to mix these shims. Attach a lifting bracket or sling to the two special lifting eyes on engine and hoist engine out of front frame as shown in Fig. 0502.

60G. REINSTALL AND ALIGN ENGINE. Engine to transmission alignment should be checked whenever a new front frame or engine is installed or whenever premature main clutch failures have occurred. A dial indicator rig, shown in Fig. 0460, can be used to check the alignment.

Make first check with button of indicator in contact with bore wall of clutch pilot bushing. If total indicated runout exceeds 0.015, vary the shims at front and rear engine mounts to bring reading within the 0.015 limit. Shims are available in thicknesses of 0.005 and 0.008.

After engine alignment has been corrected, check face runout of flywheel with gage hooked up as shown in Fig. 0460. If total indicator reading exceeds 0.015, check for a bent crankshaft mounting flange or dirt between the flywheel and crankshaft mounting flange.

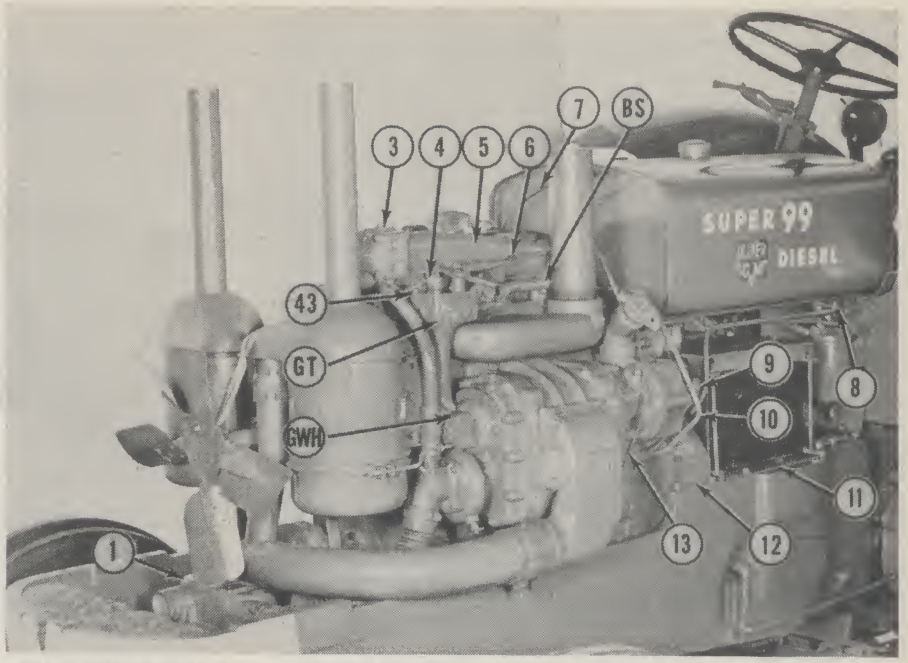


Fig. 0500—Left side view of a GM engine installation in an Oliver Super 99 tractor.

BS. Throttle booster spring
GT. Governor control housing
GWH. Governor weight housing
1. Oil cooler
3. Thermostat housing
4. Fuel shut-off cable
5. Water manifold
6. Governor control rod
7. Fuel return line
8. Governor control rod bell crank
9. Tachourmeter drive
10. Fuel pump outlet line
11. Clutch housing flat dust cover
12. Clutch housing front cover
13. Chevron starting aid primer line
43. Control housing cover

CYLINDER HEAD

Cylinder head, a one-piece casting, can be removed from the engine as an assembly. The head assembly contains cam followers, push rods, rocker arms, exhaust valves, fuel injectors, exhaust valve seats, injector hole copper tubes and cylinder head water nozzles.

61. **REMOVE HEAD.** Herewith is a procedure for R&R of cylinder head. Remove hood assembly as outlined in

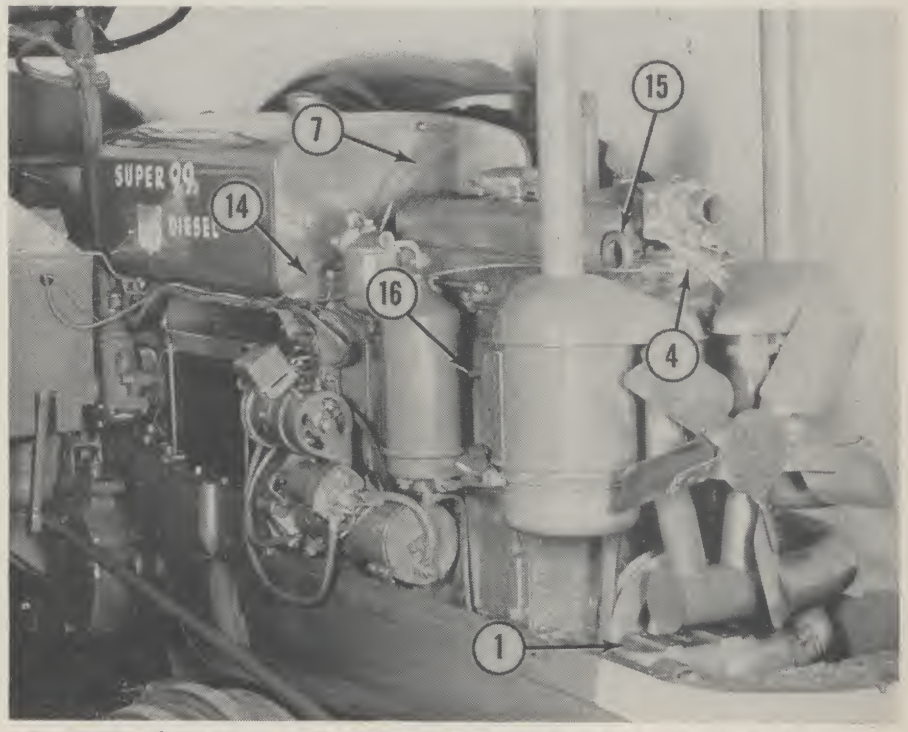


Fig. 0501—Right side view of a GM engine installation in an Oliver Super 99 tractor.

1. Oil cooler
4. Fuel shut-off cable
7. Fuel return line
14. Temperature sending unit line
15. Engine front lifting bracket
16. Oil pressure gage line

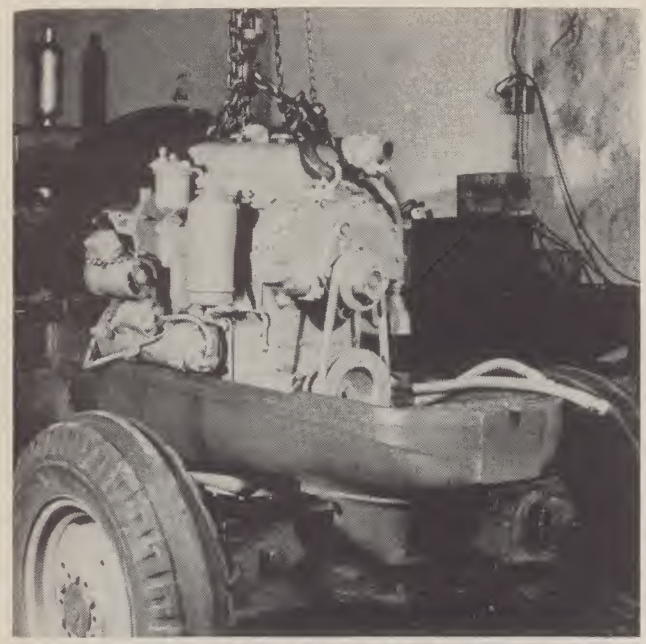


Fig. 0502—Hoisting a GM engine out of front frame by attaching a chain sling as shown.

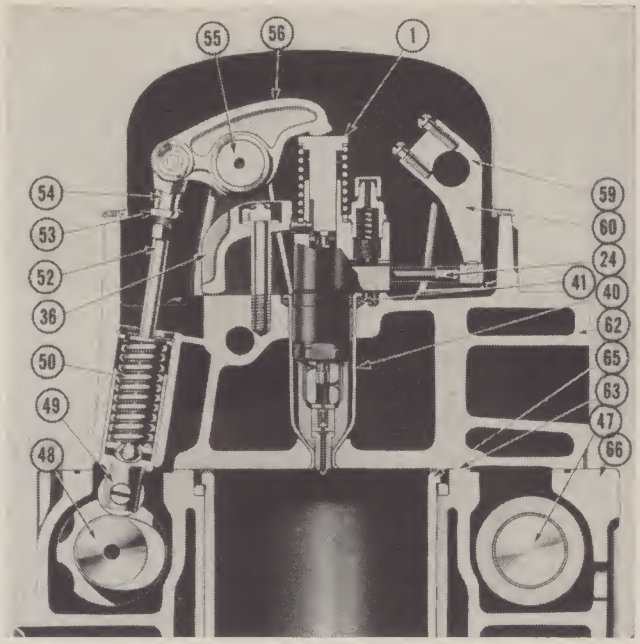


Fig. 0505A—GM engine. Showing location of injector and injector operating mechanism. A similar push rod, rocker arm and cam follower assembly is used to operate the exhaust valves.

24. Injector rack
36. Injector hold down clamp
40. Injector hole tube
41. Neoprene seal ring
47. Balance shaft
48. Camshaft
49. Cam follower
50. Follower spring
52. Push rod
54. Rocker arm clevis
56. Rocker arm
59. Injector rack control tube
60. Injector rack lever
65. Cylinder liner, dry type

paragraph 60A. Refer to Figs. 0500 and 0504.

Perform the following work on left (blower) side of engine: Drain engine coolant. Remove rocker arms cover. Disconnect upper radiator hose, and water pump to thermostat by-pass line hose. Remove thermostat housing (3) from water manifold (5). Remove coolant temperature sending unit from water manifold.

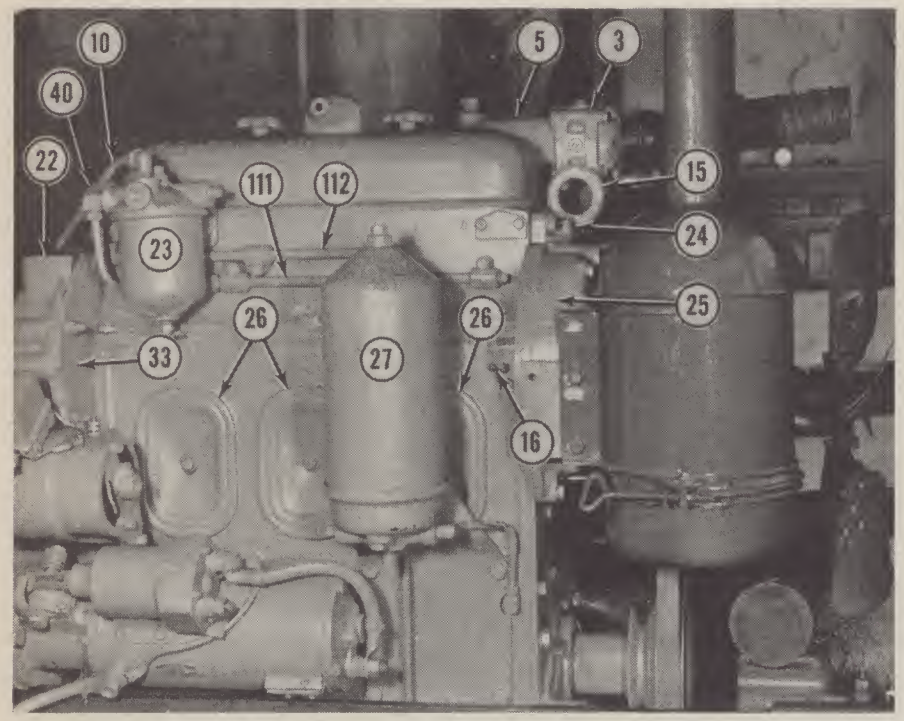


Fig. 0504—Right side view of a GM engine showing the various components mounted on the cylinder head.

3. Thermostat housing
5. Water manifold
10. Fuel pump line
15. Engine front lifting bracket
16. Oil pressure gage line fitting
22. Flywheel housing
23. Secondary fuel filter
24. Cap screw
25. Balance weight cover
26. Air box hand hole cover
27. Oil filter
33. Engine rear end plate
40. Engine rear lifting bracket
111. Fuel inlet manifold
112. Fuel outlet manifold

Remove governor control housing cover (43). Remove link, connecting injector rack control tube to governor differential lever. Disconnect throttle booster spring (BS) from governor. Remove two cap screws attaching governor control housing (GT) to cylinder head and four cap screws attaching governor control housing to governor weight housing (GWH). Pull upper end of control housing away from engine and at the same time push lower end of control housing in toward engine to free the dowels.

Remove cap screws attaching front lifting eye bracket (15) to balance weight cover and rear lifting bracket (40) to flywheel housing. Loosen (3 to 4 turns) the two cap screws, located directly below each lift eye bracket, which retain balance weight cover (25) and flywheel housing (22) to front and rear end plates of engine.

Perform the following work on right (starter motor) side of engine. Disconnect fuel pump to filter line (10) at the filter. Remove cap screws attaching injector rack control tube bracket to cylinder head and lift off injector rack control tube assembly.

If injector fuel lines and rocker arm shaft brackets were not removed pre-

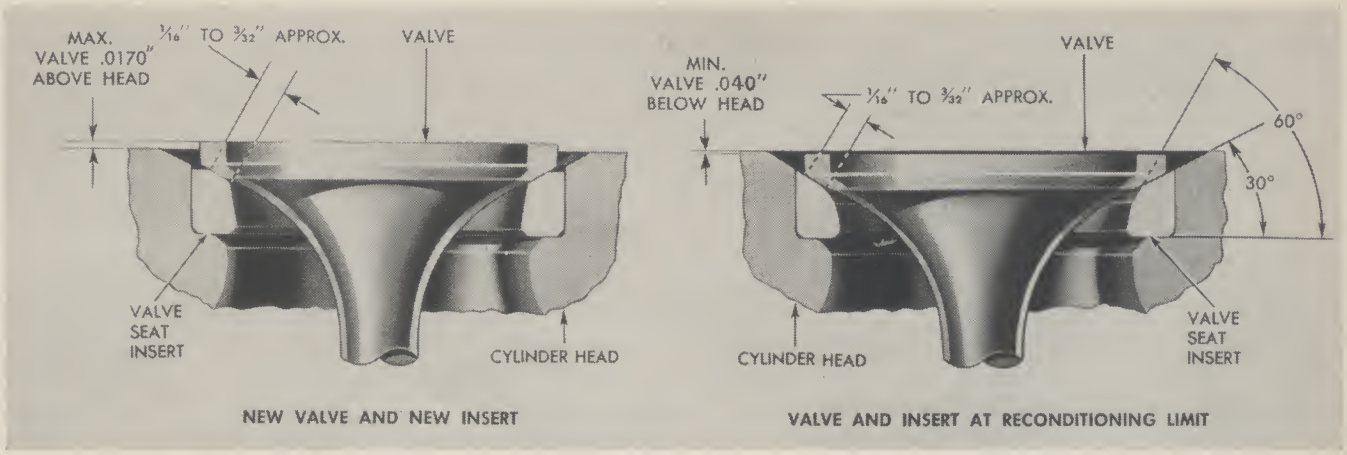


Fig. 0505B—GM engine. Showing relationship of top of valve head to machined surface of cylinder head.

viously, a thin-wall $\frac{15}{16}$ inch socket must be used to remove the head stud nuts. Remove eight cylinder head stud nuts and lift off head. Do not set cylinder head directly on the bench. Use wood blocks under head to prevent damaging tips of injectors and cam followers. Install hold-down clamps on cylinder liners to hold liners in place if crankshaft is to be rotated.

61A. **OVERHAUL.** Herewith are procedures for warpage inspections, for renewal of injector hole copper tubes and for renewal of cylinder head water nozzles.

61B. INSPECTION. Check cylinder head for warpage against the following: Maximum lengthwise warpage of 0.0055, and maximum widthwise warpage of 0.004. Reface head if above warpage limits are exceeded. Not over 0.020 total of metal should be removed from the cylinder head. When a cylinder head has been refaced, it will be necessary to check the protrusion dimensions of the valve head, Fig. 0505B, and of injector spray tip, Fig. 0506A, to prevent their striking the top of the piston. Excessive protrusion either of the valve head or injector spray tip can be corrected by reseating the valve seats, or renewing injector hole tubes.

61C. RENEW INJECTOR HOLE TUBES. Refer to Fig. 0505A. Each injector is inserted into a thin-walled copper tube (40) which passes through the water jacket in the cylinder head. The copper tube is flared-over at the lower end, and it is sealed at the upper with a neoprene ring (41). Effectiveness of the injector tube flared-over type seal and neoprene seal can be checked by subjecting the cylinder head water jacket to 80-100 psi air pressure and submerging the head in water heated to 180 deg. F.

Injector tubes can be removed as follows: Refer to Figs. 0507A and 0507B. With injector removed, thread tap (159), GM tool J5286-2 or equivalent, into upper end of injector tube (40) until ¾ inch of threads have been cut in tube. To prevent injector tube from turning while cutting the threads, use a tube holder tool, GM J5286-1 or equivalent, driven into lower or small end of tube. After cutting ¾ inch of threads in tube, remove tube holder tool. Then, using a small diameter rod, GM tool J5286-3 or equivalent, and inserted as shown in Fig. 0507B to contact end of thread tap (159), bump injector tube out of cylinder head.

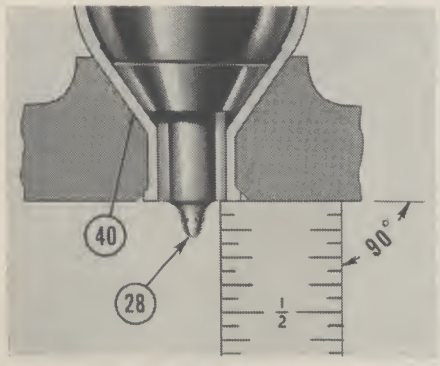


Fig. 0506A — GM engine. Showing flush condition of injector spray tip shoulder relative to machined surface of cylinder head.

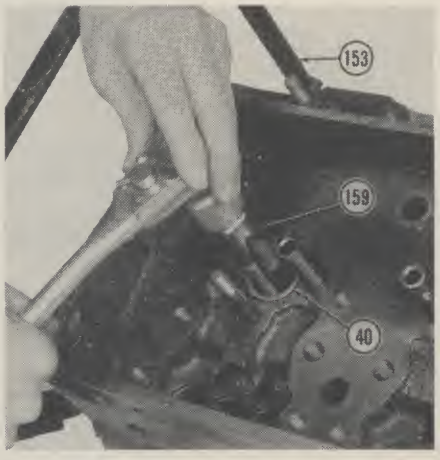


Fig. 0507A—GM engine. First step in removing an injector hole copper tube (40) is to cut ¾ inch of threads in tube using a thread tap, GM tool J5286-2 or equivalent.

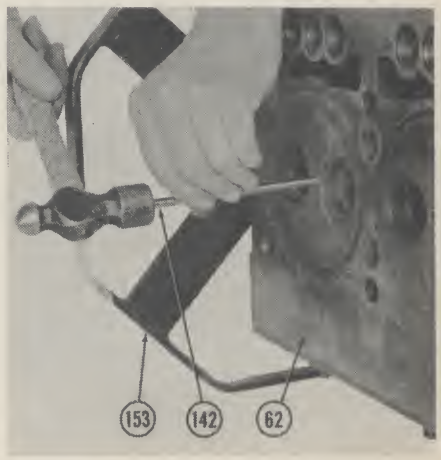


Fig. 0507B—GM engine. Second step in removing an injector hole copper tube is by bumping on end of thread tap using a small diameter rod (142).

Fig. 0508A—GM engine. Showing method of installing an injector hole copper tube (40) with driver (142).

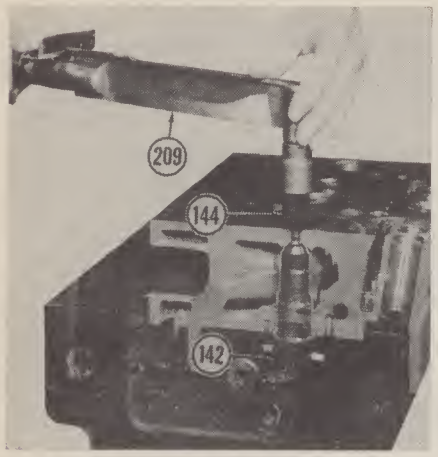


Fig. 0508B—GM engine. Upset or flare-over lower end of injector hole tube by applying 30 ft. lb. torque to upsetting die (144).

142. Driver, GM tool J 5286-4
144. Upsetting die, GM tool J 5286-6

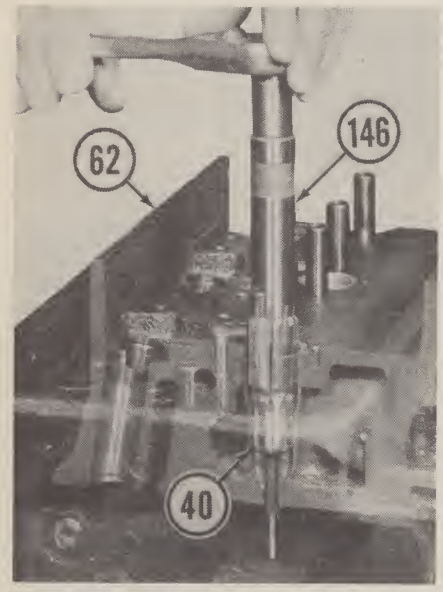


Fig. 0508C—GM engine. Resizing the injector hole tube for the injector body nut and spray tip with GM tool J 5286-7.

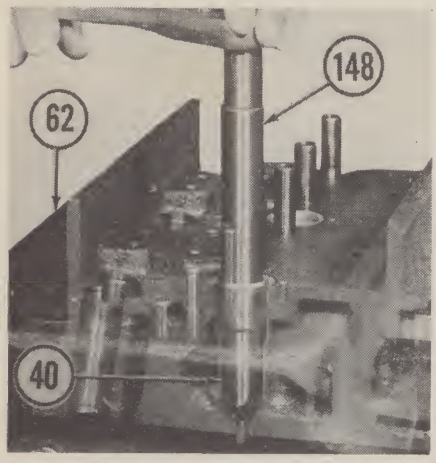


Fig. 0509A—GM engine. Reaming bevel seat in injector tube for the injector nut with GM tool J 5286-9.

61D. To install an injector tube proceed as follows: Refer to Figs. 0508A and 0508B. Place a new sealing ring (41) in counterbore of cylinder head and using installing tool and pilot, GM tools J5286-4 and J5286-5 or equivalent, bump injector tube in place. Using injector tube installing tool and upsetting die, GM tools J5286-5 and J5286-6 or equivalent, flare-over lower end of injector tube by applying 30 ft. lb. torque to upsetting die.

After installing injector tube, it must be finished in three operations: Hand reamed as shown in Fig. 0508C to receive injector body; spot faced at the flared-over end; and hand reamed to provide a sealing surface for the bevel seat on lower end of injector nut as shown in Fig. 0509A.

As shown in Fig. 0508C, ream injector tube, using GM tool J5286-7 or equivalent, until lower shoulder of reamer contacts injector tube.

Remove excess stock from flared-over end of injector tube using GM tool J5286-8 or equivalent, so that lower end of tube is from flush to 0.010 below finished surface of cylinder head.

The third step as shown in Fig. 0509A, reaming bevel seat in injector tube, should be performed with care as this operation controls the location of the injector spray tip relative to the surface of the cylinder head. Use an injector as a gage to check for the desired flush condition between cylinder head and the shoulder on the injector spray tip as shown in Fig. 0506A. Note: If pre-finished injector tubes are used (those which have a narrow land machined at the beveled seat as distinguished from tubes having a straight bevel seat) exercise care during the final reaming operation to prevent removal of too much metal from the thin wall of the tube.

Check effectiveness of the flared-over seal and neoprene seal on injector tube by subjecting the cylinder head water jacket to 80-100 psi air pressure and submerging the head in water heated to 180 deg. F.

61E. RENEW WATER NOZZLES. Refer to Fig. 0509B. A total of 8 water directional nozzles (5 and 6) are installed in the cylinder head. Large diameter water nozzles can be removed with a ¾ inch thread tap. Smaller nozzles can be removed in a similar manner using a small diameter thread tap.

Press new nozzles into place with nozzle openings (156) parallel to sides

5. Single jet nozzle
6. Double jet nozzle
42. Exhaust valves
43. Exhaust valve guides
47. Oil gallery
64. Neoprene seal ring

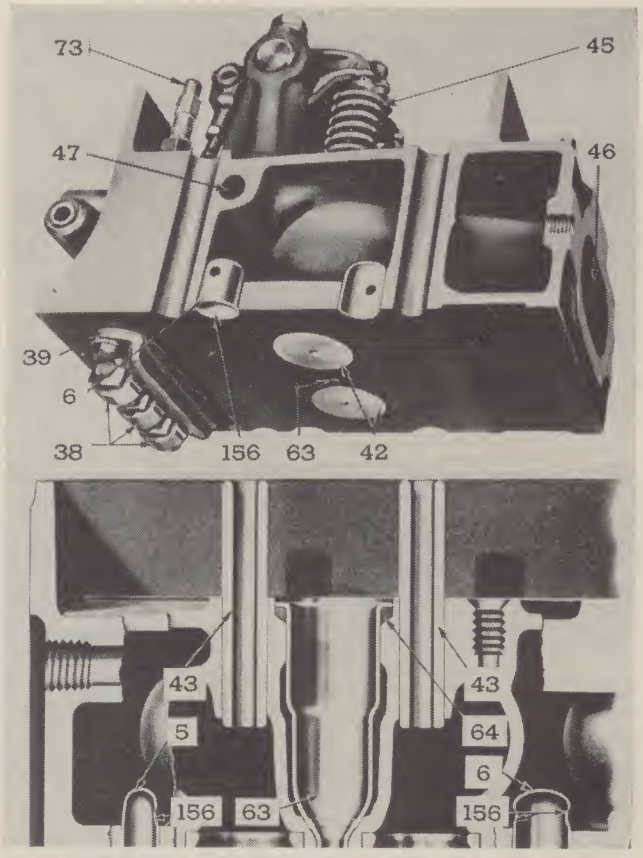


Fig. 0509B—GM engine. Showing location of water nozzles (5 and 6) in cylinder head.

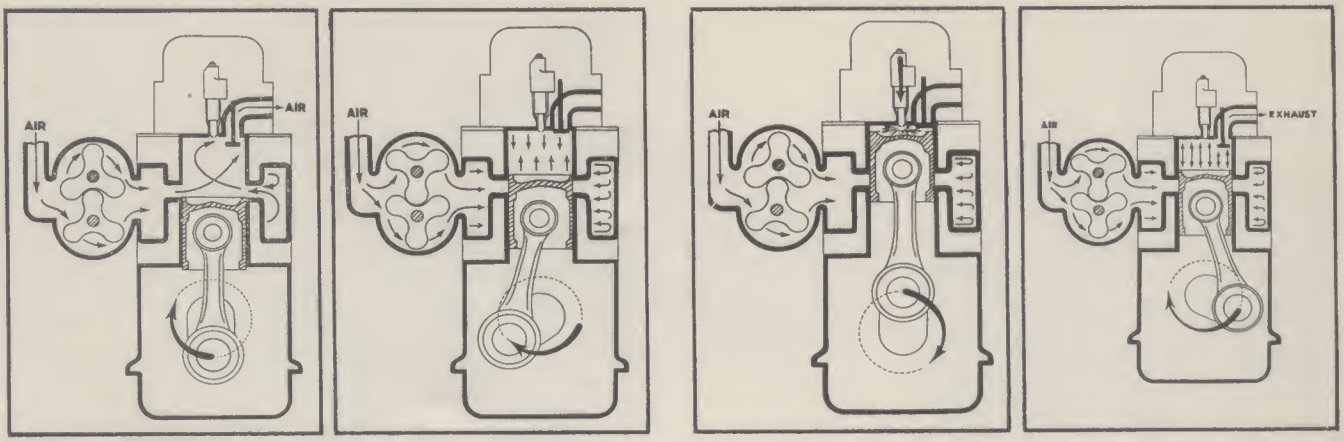


Fig. 0509C—Showing the two cycle principle of operation as employed in the GM series 71 engines. Left to right: Scavenging, compression, power, and exhaust.

of cylinder head. Nozzles should be installed from flush to $\frac{1}{32}$ inch below surface of cylinder head. If nozzle ports in cylinder head have been enlarged by corrosion, tin outside diameter of nozzles with solder so that a press fit can be obtained.

61F. REINSTALL HEAD. Before reinstalling cylinder head, check cylinder liner flange to top-of-block distance which is controlled by a liner insert (165—Fig. 0509D). On high block engines as used in the Oliver Super 99 GM, top surface of liner flange should be from 0.0465 to 0.050 below top surface of cylinder block and with not more than 0.002 variation in height between adjacent liners. On engines of the low block type, the top surface of liner flange should extend from 0.002 to 0.006 above the top surface of the block. Refer to paragraph 70D for data pertaining to this measurement.

Install new cylinder head compression gaskets (160), combined oil and water seals (163), water seals (161 and 162), and oil seal (164). Install oil seal (164) with flat surface up.

Install cylinder head and torque hold down nuts to 165-175 ft. lb. Adjust exhaust valve tappet gap to 0.012 cold and readjust to 0.009 hot.

Time injectors and position injector rack control tube levers as outlined in paragraphs 90, and 87 and 87A, respectively.

VALVES, SEATS AND GUIDES

62. Two exhaust valves, located in the cylinder head, are provided for each cylinder, Fig. 0510A. Inlet ports are in the cylinder liner. Valve head must not protrude more than 0.017 beyond the surface of cylinder head as shown in Fig. 0505B. Limiting the protrusion to a maximum of 0.017 will prevent the valve head from striking the top of the piston.

62A. Exhaust valves seat on renewable inserts in the cylinder head. Refer to Fig. 0505B for reconditioning limits of valve and insert.

62C. Shoulderless valve guides should be installed so that top or countersunk end of guide projects $1\frac{19}{32}$ inch above machined face of valve spring seat on cylinder head. Service guides, requiring a press fit of 0.0005-0.0035, are prefinished and do not require final sizing. Service valve guides are available with oversize outside diameters of 0.016. Oversize guides

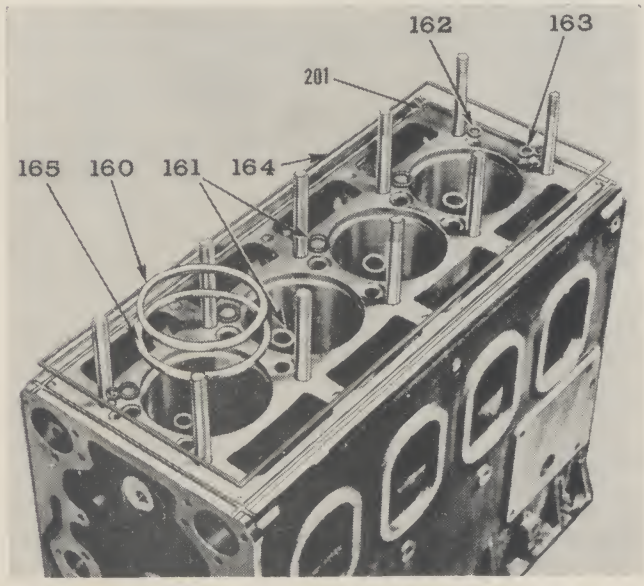


Fig. 0509D—GM engine. Location of cylinder head gaskets, oil and water seals for a high block design engine. Cylinder liner inserts (165) are installed under the liner flange.

160. Cylinder liner compression gasket
161. Water hole seal ring
162. Water hole seal ring
163. Water and oil holes seal ring
164. Cylinder head oil seal
201. Plug

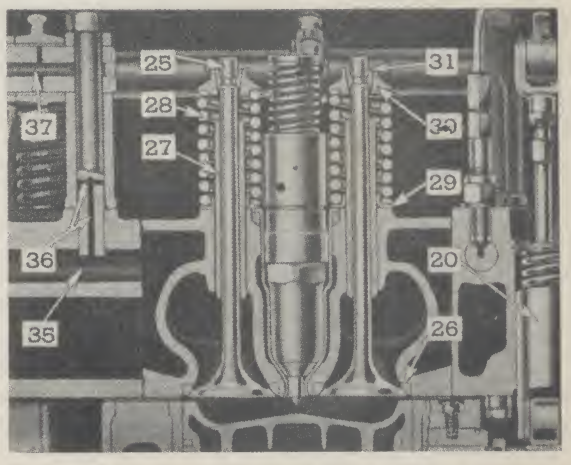


Fig. 0510A — A GM engine showing installation of exhaust valves, injector, and cam follower and push rod assembly.

20. Cam follower
26. Valve seat insert
27. Valve guide
29. Valve spring seat
30. Valve spring cap
35. Oil gallery
36. Rocker arms shaft bracket special bolt
37. Rocker arms shaft oil gallery

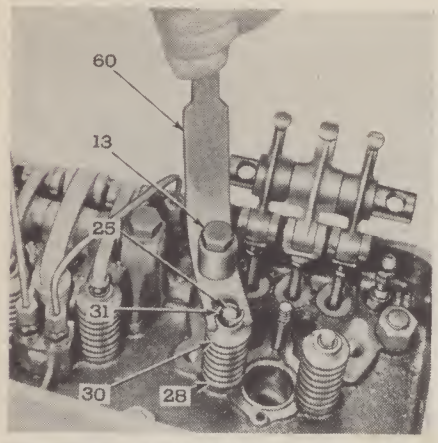


Fig. 0510B—A GM engine showing method of renewing valve springs without removing the cylinder head. Piston is at TDC.

13. Rocker arms shaft bracket bolt
60. Valve spring compressor—GM tool J 1227-A

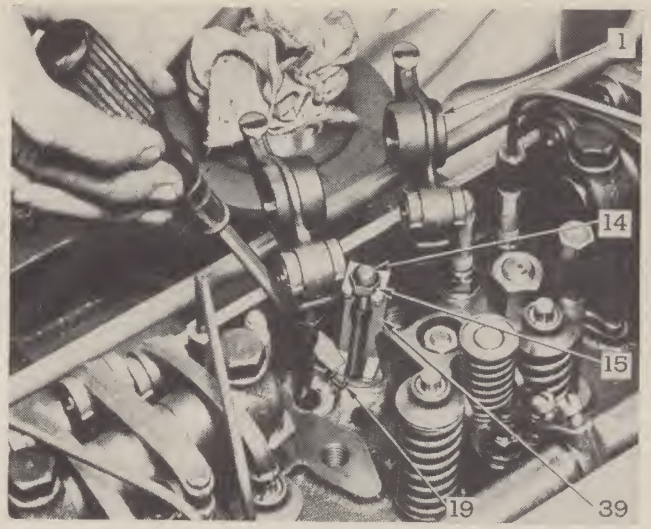


Fig. 0511A — A GM engine showing removal of cam follower and push rod assembly without removing cylinder head. Install sleeve (39) to compress push rod spring for removal of spring seat retainer (19).

can be identified by an annular groove located on port end of guide.

Valve Face Angle	30°
Valve Seat Angle	30°
Valve Tappet Gap—Hot	0.009
Valve Stem Diameter	0.342
Valve Clearance in Guide	0.002
Renew If Clearance Exceeds	0.006
Guide Height Above Spring Seat Surface On Cylinder Head—Inches	$1\frac{19}{32}$
Valve Seat Counterbore Diameter	1.6265
Valve Seat Counterbore Depth	0.377
Exhaust Valve Lift—Inches	0.394

VALVE SPRINGS

63. Any exhaust valve spring can be renewed, as shown in Fig. 0510B, without removing cylinder head. To renew a valve spring, first position the piston at TDC (TDC is indicated when injector plunger has traveled downward

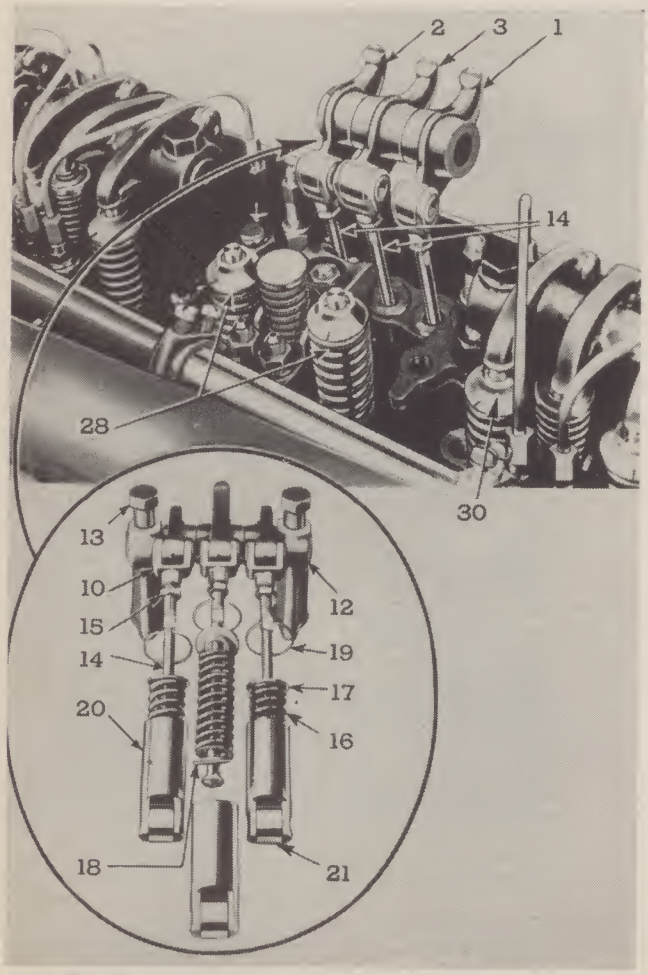


Fig. 0510C—GM engine valves and injector operating mechanism.

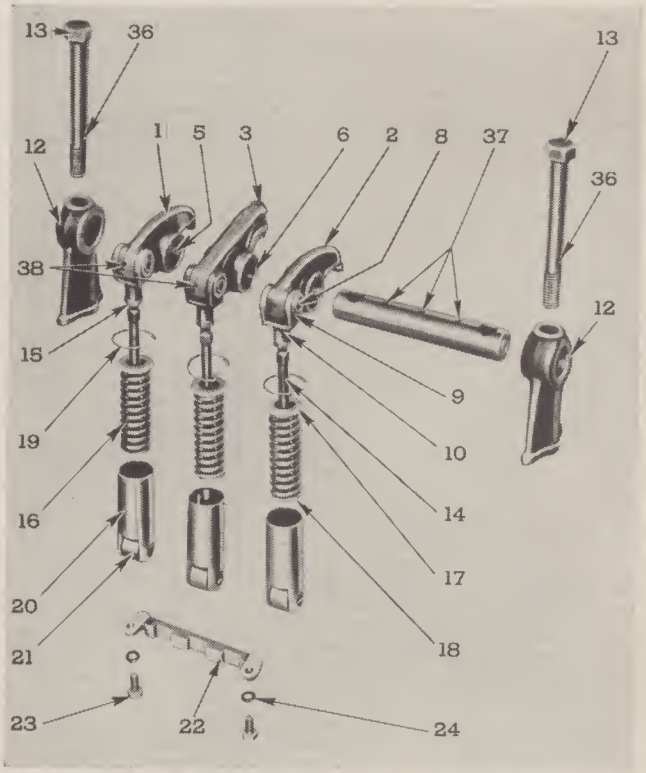


Fig. 0511B—A GM engine showing details of the valve and injector operating mechanism for one cylinder.

1. Rocker arm, left
2. Rocker arm, right
3. Injector rocker arm
5. Bushing
6. Bushing
8. Clevis pin
9. Bushing
10. Push rod clevis
12. Rocker shaft bracket
14. Push rod
15. Lock nut
16. Push rod spring
17. Push rod spring upper seat
18. Push rod spring lower seat
19. Spring seat retainer
20. Cam follower
21. Cam follower roller
22. Cam follower guide
36. Oil passage
37. Oil passage
38. Oil passage

approximately $\frac{3}{16}$ inch). Then, remove the injector fuel lines, cap screws attaching rocker arms shaft brackets to cylinder head, and injector.

Valve springs have a free length of $2\frac{3}{8}$ inches and should require 44 plus or minus 3 lb. to compress spring to a length of $2\frac{3}{16}$ inches; and 140 plus or minus 3 lb. for a compressed length of 1 51/64 inches.

CAM FOLLOWERS AND PUSH RODS

Cam followers, operating in unbushed bores located in the cylinder head, are of the roller type.

64. Refer to Fig. 0510C. A cam follower (20), push rod (14), push rod spring (16), spring seats (17 and 18) can be removed from the cylinder head without removing the cylinder head as follows: Refer to Fig. 0511A and remove fuel lines, injectors, rocker arms shaft brackets and shaft. Unscrew rocker arm from push rod to be removed. Compress push rod spring with a tool similar to the one as shown, and remove spring retainer (19). Pull push rod assembly and cam follower out through top of cylinder head.

Push rods and cam followers can be removed from combustion chamber side of cylinder head as follows: Remove cylinder head and disconnect push rod from rocker arm. Then remove two cap screws (23—Fig. 0511B) attaching cam follower guide (22) to cylinder head and withdraw cam follower assembly.

64A. Cam followers, available in standard size only, have a running clearance in bores of 0.001-0.006. Renew the followers if clearance exceeds 0.006. Cam follower roller bushing to roller pin clearance is 0.0008-0.0015. Roller, bushing and roller pin are available as service items.

64B. Install cam followers in cylinder head with oil hole in bottom of follower pointing away from the valves.

Time injectors and position injector control racks as outlined in paragraphs 90, and 87 and 87A, respectively.

ROCKER ARMS AND SHAFTS

Three rocker arms, two for the exhaust valves and one for the injector, are provided for each cylinder. Refer to Fig. 0510C.

65. Rocker arms are provided with renewable bushings both for the rocker arm shaft and rocker arm clevis pin. Running clearance of either bushing is 0.001-0.004. Renew bushings and/or shaft and pin if clearance exceeds 0.004.

Rocker arms can be removed after removing hood, rocker arms cover, injector fuel lines, rocker arms shaft bracket cap screws and disconnecting rocker arms from push rods. Removal of the rocker arms may be facilitated by rotating engine crankshaft until the three rocker arm clevises are on the same plane.

Rocker Shaft Diameter	0.8735
Rocker Arm Bushing	
Inside Diameter	0.8750
Running Clearance	0.001-0.004
Renew If Clearance Exceeds	0.004
Clevis Pin Bushing	
Inside Diameter	0.5645
Running Clearance	0.001-0.004
Renew If Clearance Exceeds	0.005
Valve Tappet Gap—Hot	0.009

GEAR TRAIN COVER (FLYWHEEL HOUSING)

The gear train, Figs. 0511C and 0512A, is located at the flywheel end of the engine, and it is housed by the flywheel housing.

66. **REMOVE.** To remove gear train cover, first remove engine as outlined in paragraphs 60 through 60F. Remove engine clutch from flywheel, starting motor, and generator. Remove generator drive pulley (pulley flange is threaded for cap screw type puller). Remove five cap screws attaching generator drive pulley hub oil seal retainer to flywheel housing and remove retainer. Remove tachourmeter drive from flywheel housing. Remove four

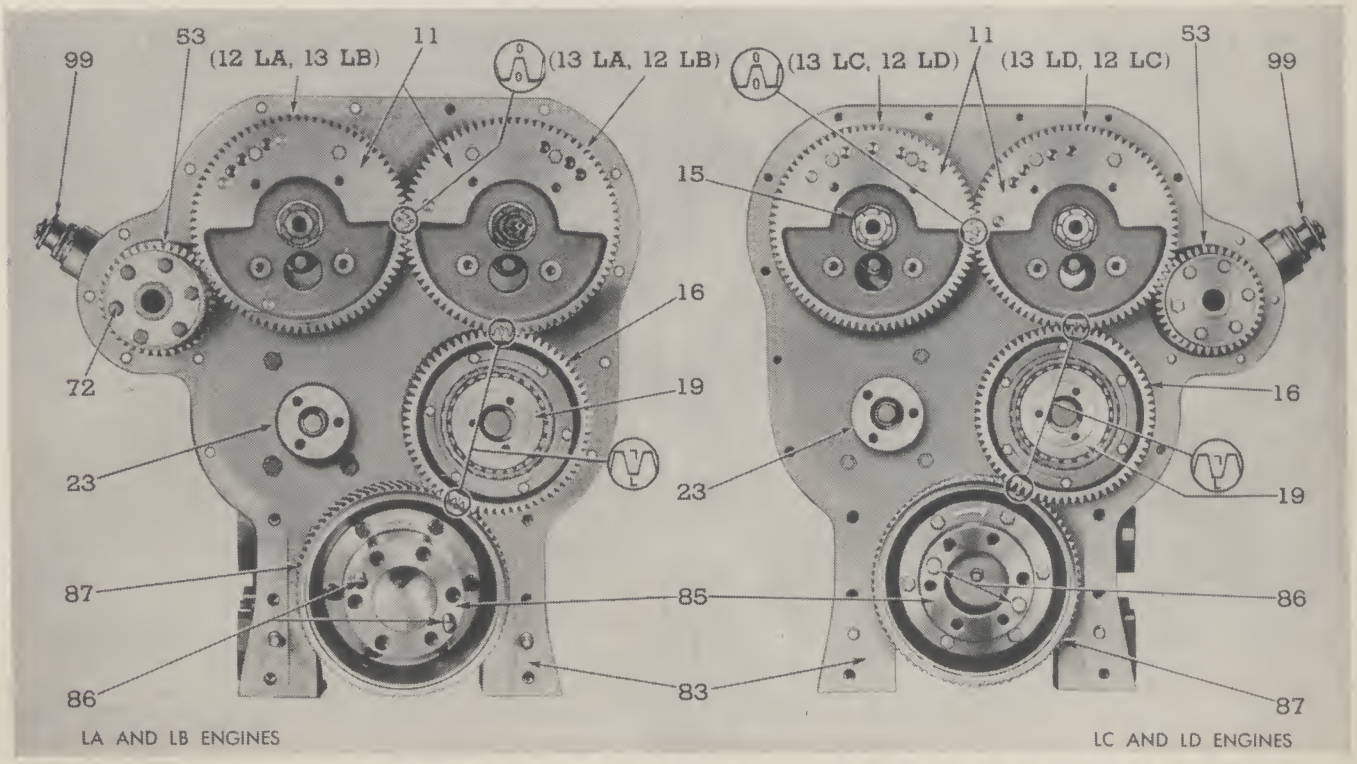


Fig. 0511C—A GM engine gear train, located at flywheel end of engine, shows timing marks for LA and LB engines. Oliver tractors are equipped with the RB engine which is shown in Fig. 0512A. Refer to Fig. 0512A for legend.

cap screws attaching oil pan to flywheel housing and loosen all others.

Support flywheel and remove flywheel attaching cap screws. Thread two $\frac{7}{16}$ x 4 inch standard thread cap screws into tapped holes in flywheel bolt flange and remove flywheel. Crankshaft rear lip type oil seal can be renewed at this time; refer to paragraph 72D.

Support flywheel housing at lifting eye bracket, and remove bolts and cap screws attaching housing to engine rear end plate. Refer to Fig. 0512B Install four guide studs as shown. Lift off housing by bumping same until it is free of the dowels.

66A. **REINSTALL.** Reinstall flywheel housing and tighten bolts and cap screws in sequence as shown in Fig. 0512C. Torque tighten flywheel attaching cap screws to 150-160 ft. lb.

TIMING GEARS

Refer to Figs. O511C and O512A, timing gear train, which is housed by the flywheel housing, consists of four helical gears and a blower drive gear. Normal backlash between mating gears is 0.003 to 0.008.

66B. **GEAR TIMING MARKS.** Refer to Figs. 0511C and 0512A. The four timing gears are marked for correct timing as follows: Camshaft gear mark "O", balance shaft gear marks "O" and "R", idler gear marks "R" and "R", and crankshaft gear mark "R".

With number one piston at TDC, gears are in time when "O" marks on balance shaft gear and camshaft gear are in register, and "R" mark on crankshaft gear is in register with one "R" mark on idler gear while the second "R" mark on idler gear is in register with an "R" mark on balance shaft gear.

66C. **CRANKSHAFT GEAR.** With flywheel housing removed, remove crankshaft gear (87) from shaft by using two cap screws which can be threaded into gear. Refer to Fig. 0513A. As one cap screw hole is offset, the gear can be installed in one position only.

66D. Reinstall crankshaft gear so that timing mark "R" is registered as outlined in paragraph 66B.

66E. **IDLER GEAR.** Refer to Fig. 0513B. With flywheel housing removed, remove cap screw attaching idler gear hub (19) to cylinder block.

Idler gear rotates on a double row taper roller bearing (17). Bearing preload is controlled by spacer ring (18), located between the bearing cones, and the clamping action exerted on the bearing cones by the cylinder block rear end plate (83) and a boss on the flywheel housing.

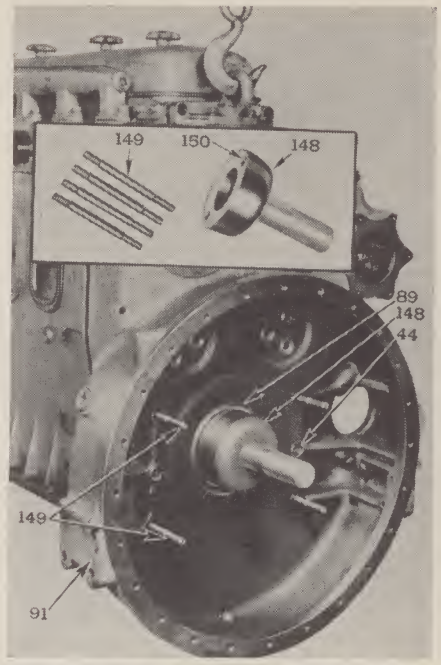


Fig. 0512B—A GM engine showing method of removing or installing the flywheel housing (gear train cover) by using aligning studs (149).

44. Dowel
89. Oil seal
148. Oil seal expander

Bearing preload is checked with idler gear assembly removed from engine. To check preload, mount idler gear assembly in a vise using two suitable metal plates which are positioned

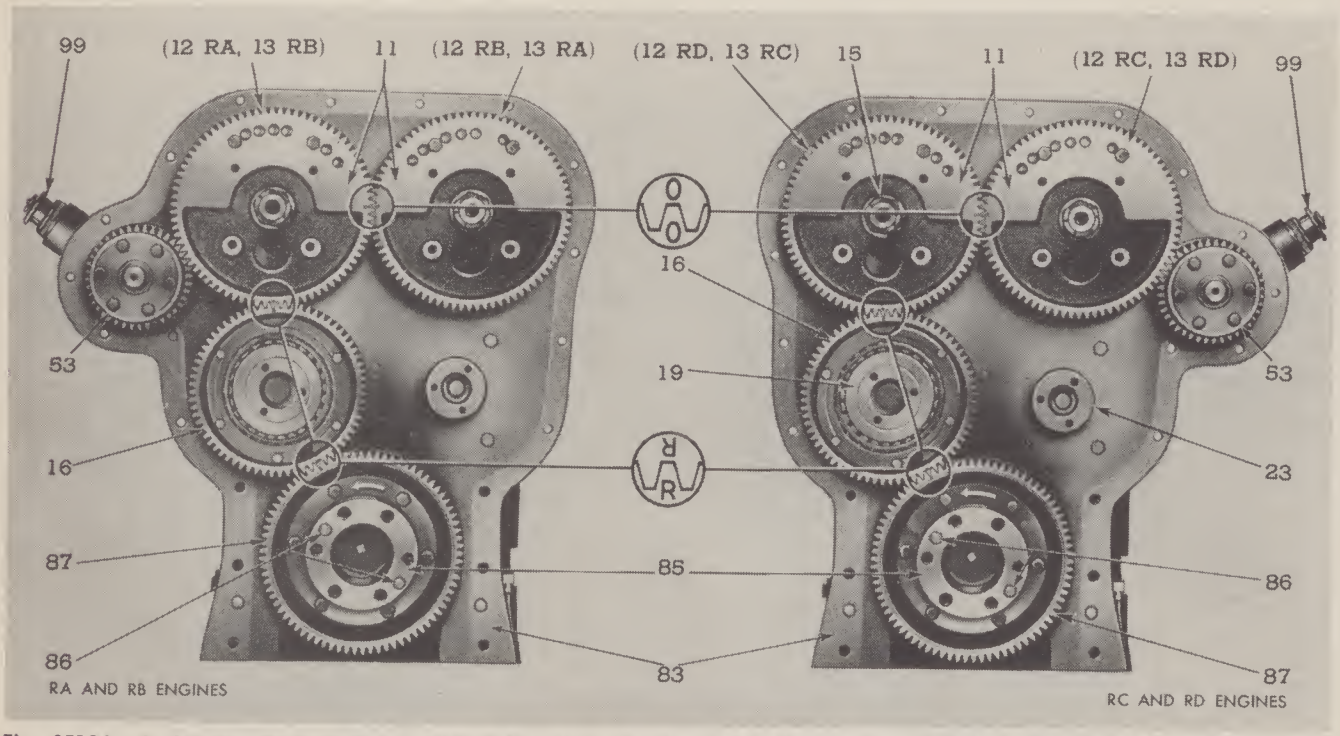


Fig. 0512A—A GM engine gear train which is located at flywheel end of engine shows timing marks for RA and RB engines. Oliver tractors are equipped with the RB engine which has the camshaft gear (12) at the upper right and the balance shaft gear (13) at the upper left.

12. Camshaft gear
13. Balance shaft gear
16. Idler gear
19. Idler gear hub
23. Spacer
53. Blower drive gear
83. Engine rear end plate
85. Crankshaft
86. Dowel
87. Crankshaft gear
99. Oil filler cap

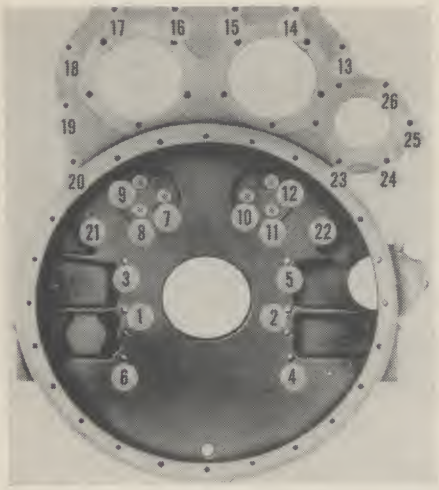


Fig. 0512C—A GM engine flywheel housing showing bolt and cap screw tightening sequence.

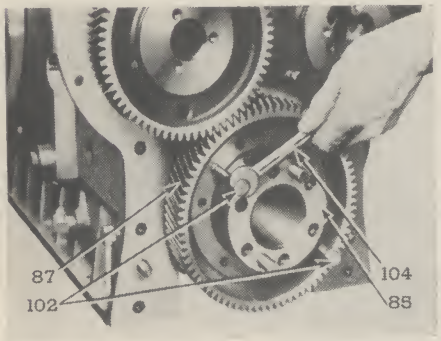


Fig. 0513A—A GM engine showing use of two cap screws (102) for removing crankshaft gear (87).

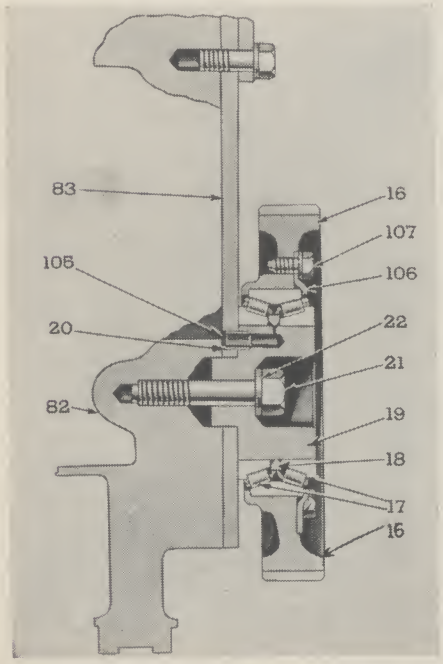


Fig. 0513B—A GM engine idler gear installation. Bearing preload is controlled by thickness of spacer ring (18) and clamping action which is exerted on bearing cones by engine rear end plate and a boss on flywheel housing.

so as to contact the ends of idler gear hub (19) and bearing cones. Using a spring scale attached to a cord wrapped around the gear, check for preload of ½ to 15 inch pounds. If preload is not within specified limits, renew the bearings, spacer (18) and idler gear hub which are available only as an assembly.

Reinstall idler gear and hub assembly so that timing marks on camshaft gear, balance shaft gear, crankshaft gear and idler gear are in register as outlined in paragraph 66B and as shown in Figs. 0511C or 0512A.

66F. **BLOWER DRIVE GEAR.** Refer to Fig. 0513C. Blower drive gear (53) can be removed after removing the flywheel housing, or blower and blower drive gear hub support assembly. If flywheel housing is removed, proceed as follows: Thread a $\frac{5}{16}$ inch—24 x 2 inch bolt into outer end of blower drive shaft (79) and remove snap ring (80) from outer end of shaft. Withdraw blower drive shaft. Remove six cap screws attaching gear and flexible coupling drive support (67) to blower drive gear hub (54) and lift off drive gear.

If blower drive gear hub (54) requires removal at this time, it will be necessary to remove the blower and drive gear hub support.

For removal and overhaul of blower drive gear hub (54), bushings (59), flexible coupling drive support (67)

20. Dowel pin, hollow
21. Hub-to-block cap screw
83. Engine rear end plate
105. Oil passage
106. Bearing retainer

47. Blower drive cover
51. Seal
52. Clamp
53. Blower drive gear
54. Gear hub
55. Lock ball
56. Thrust washer
57. Gear hub nut
58. Lock washer
59. Flanged bushings
61. Support
63. Gasket
67. Flexible drive coupling drive support
68. Flexible coupling drive cam
71. Retainer
75. Oil line
76. Oil line fitting
79. Blower drive shaft
80. Snap ring
81. Blower rotor gear hub
83. Engine rear end plate
91. Flywheel housing
92. Flywheel housing cover
93. Gasket

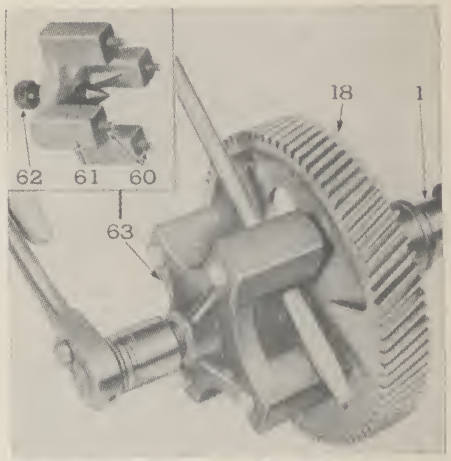


Fig. 0514A—A GM engine showing method used in removing either the camshaft gear or balance shaft gear.

and drive gear hub support (61), refer to paragraphs 78 through 79.

Reinstall blower drive gear so that cam lobes of flexible coupling are in line with the two oil grooves in blower drive gear hub.

66G. **BALANCE SHAFT GEAR.** Refer to Figs. 0511C or 0512A. With flywheel housing removed, remove balance shaft gear as shown in Fig. 0514A by using a puller attached either to two or four cap screws which can be threaded into gear.

When reinstalling balance shaft gear, heat same in oil to facilitate installation. Reinstall balance shaft gear so that timing marks on camshaft gear, balance shaft gear, idler gear and crankshaft gear are in register as outlined in paragraph 66B and shown in Figs. 0511C or 0512A.

66H. **CAMSHAFT GEAR.** Refer to Figs. 0511C or 0512A. With flywheel housing removed, gear can be removed from camshaft as shown in Fig.

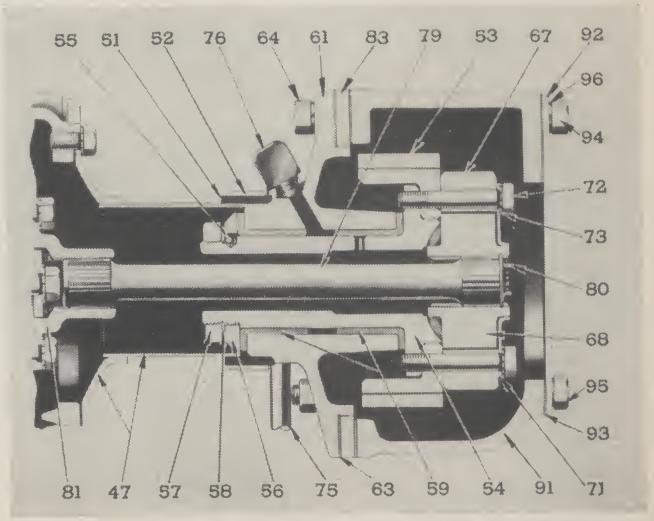


Fig. 0513C—A GM engine blower drive gear and support assembly.

0514A by using a puller attached either to two or four cap screws which can be threaded into gear.

When reinstalling camshaft gear, heat same in oil to facilitate installation. Timing marks on camshaft gear, balance shaft gear, idler gear and crankshaft gear should register as outlined in paragraph 66B and shown in Fig. 0511C or 0512A.

CAMSHAFT

67. Refer to Fig 0514B which shows camshaft installation for a six cylinder model. The two intermediate journals of the series 3-17 engine camshaft rotate in aluminum bearings (14); and front and rear journals rotate in supports, each containing two steel backed bronze bushings. The two-piece intermediate journal aluminum bearings are retained to the journal by lock rings. This construction enables the intermediate bearings to be installed with the camshaft as an assembly after which they are locked in the cylinder block by set screws which are accessible after removing the cylinder head.

67A. To remove camshaft, first remove gear train cover (flywheel housing) as outlined in paragraph 66 and cylinder head as outlined in paragraph 61. Remove both air cleaners, fan blades, fan drive belt, and balance weight cover. Refer to Fig. 0514C. Place a block of wood between the balance weights and remove nut (9—Fig. 0515A) retaining weight to shaft. Remove weight by prying off same as shown, and remove weight positioning Woodruff key and thrust washer. Other thrust washer is located on other side of front journal bearing support. Remove cap screws attaching rear journal bearing support to cylinder block. Remove two set screws which lock intermediate journal aluminum bearings in cylinder block. Set screws are accessible from top surface of block. Withdraw camshaft, intermediate journal bearings and gear assembly rearward and out of cylinder block.

67B. Renew aluminum bearings when maximum running clearance of 0.009 is exceeded or when thickness of bearing shells at their center is less than 0.340.

Front and rear journal support and bushing assemblies are available with bushings which are of 0.010 and 0.020 undersize; whereas bushings only are available in 0.020 undersize. Intermediate bearings with standard outside diameters are available with inside diameters in standard size and undersizes of 0.010-0.020. They are also available with a standard inside diameter and 0.010 oversize on the outside diameter to correct looseness between bearing and bore in cylinder block.

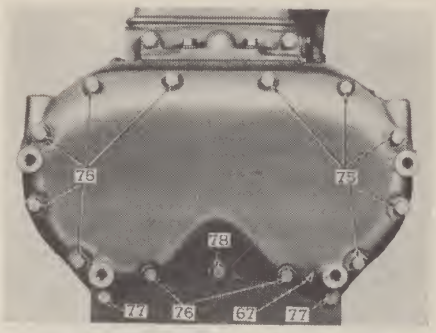


Fig. 0514C — GM engine balance weight cover which is located on front of engine.

75. Cap screw ⅜—24x2⅞ inches
76. Cap screw ⅜—16x3½ inches
77. Cap screw ⅜—16x1⅞ inches
78. Cap screw ⅜—24x1½ inches

Camshaft end play of 0.004-0.011 with a maximum of 0.018 is controlled by two thrust washers located on either side of the number one journal bearing support. Thrust washers which are available in standard thickness of 0.121 and oversizes of 0.005 and 0.010 are installed with the steel side next to the bearing support.

Tighten camshaft gear and balance weight retaining nuts to 300-325 ft. lb. torque.

Journal Diameters:

Front & Rear.....1.497
Intermediate 1.498

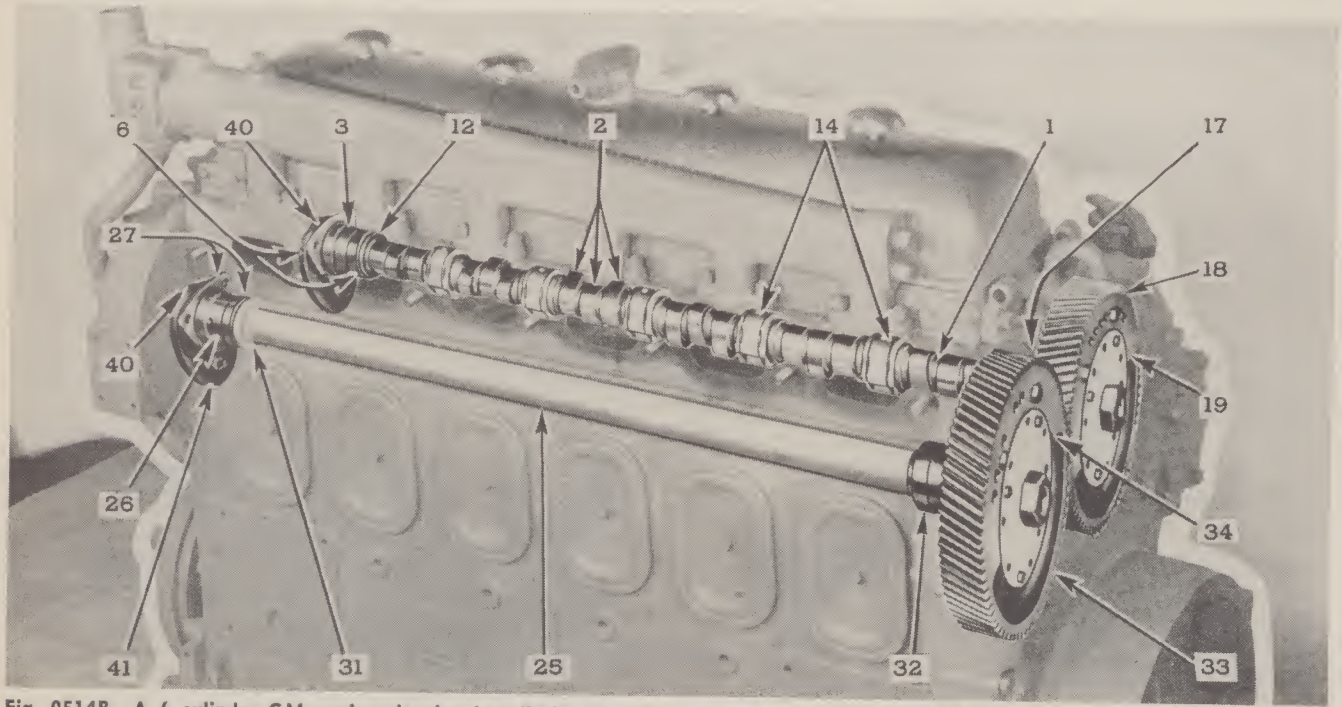


Fig. 0514B—A 6 cylinder GM engine showing installation of camshaft and balance shaft. A similar installation is used in the type RB engine for the Oliver Super 99 GM tractor. Location of camshaft (1), balance shaft (25), thrust washers (6 and 27) and thrust bearings (3 and 26) will vary according to engine type as shown in Fig. 0499C.

1. Camshaft
3. Front bearing
6. Thrust washers
12. Camshaft thrust shoulder
14. Intermediate bearings (2 used on 3-71 engine)
17. Camshaft rear bearing
18. Camshaft gear (left helix)
25. Balance shaft
26. Front bearing
27. Thrust washers
31. Balance shaft thrust shoulder
32. Balance shaft rear bearing
33. Balance shaft gear (right helix)
40. Balance weights
41. Balance weight hub (not used on 3 and 4 cylinder engines)

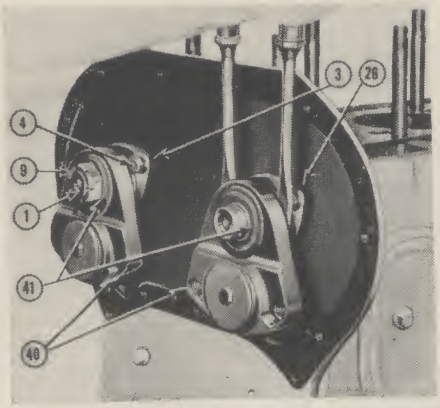


Fig. 0515A—A GM engine showing method of removing balance weight assemblies. Weights as illustrated are for a 6 cylinder engine. One-piece weights are used on all 3 and 4 cylinder engines.

1. Camshaft
3. Camshaft front bearing
26. Balance shaft front bearing
40. Balance weight
41. Balance weight hub (not used on 3 and 4 cylinder engines)

Bearings Inside Diameter:
Front & Rear.....1.500
Intermediate 1.501
Running Clearance:
Front & Rear.....0.0025-0.006
Intermediate 0.0025-0.009
Camshaft End Play.....0.004-0.018
Exhaust Valve Lift.....0.394

BALANCE SHAFT

69. Refer to Fig. 0514B. The front and rear journals of the balance shaft rotate in supports, each containing two steel backed bronze bushings.

69A. To remove balance shaft, first remove the gear train cover (flywheel housing) as outlined in paragraph 66. Remove the balance weight cover as follows: Remove both air cleaners, fan blades and fan belt and cap screws attaching balance weight cover to front face of engine and lift off the cover.

Place a block of wood between the balance weights and remove nut attaching weight to shaft. Remove weight by prying off same as shown in Fig. 0515A. Remove weight positioning Woodruff key, and cap screws attaching rear journal bearing support to cylinder block. Withdraw balance shaft and gear rearward and out of cylinder block.

Shaft journal recommended running clearance is 0.0025-0.006. Journal support and bushings assemblies are available with bushings which are 0.010 and 0.020 undersize; whereas bushings only are available in 0.020 undersize.

Balance shaft end play of 0.004-0.011 with a maximum of 0.018 is controlled by two thrust washers located on either side of the front journal bearing support. Thrust washers, available in a standard thickness of 0.121 and oversizes of 0.005 and 0.010, are installed with steel side next to bearing support. Tighten balance weight, and balance shaft gear retaining nuts to 300-325 ft. lb. torque.

ROD AND PISTON UNITS

70. Piston and connecting rod units are removed from above after removing cylinder head and oil pan. Number three rod and piston unit can be removed without performing additional work. Removal of either number one or two rod and piston units requires removal of oil pump and pump outlet line. Install cylinder liner hold down clamps to prevent liners from working upward while rotating the crankshaft or removing the piston and rod units. Piston and rod units can be installed as an assembly with the cylinder liner as shown in Fig. 0515C or without the cylinder liner by using conventional methods.

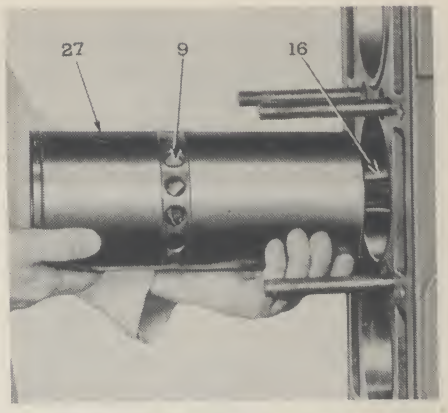


Fig. 0515C—GM engine. Showing method of installing piston and rod assembly with the cylinder liner.

Numbered side of connecting rod and cap should face blower side of engine. Torque the $\frac{7}{16}$ inch connecting rod bolts to 65-75 foot pounds.

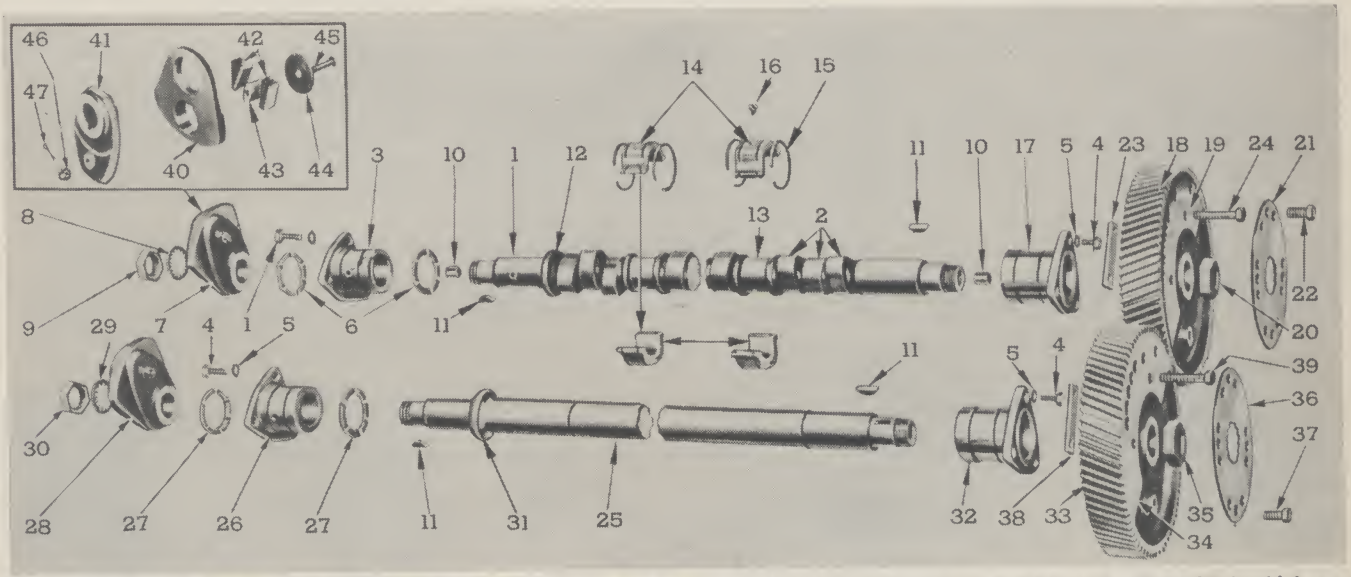


Fig. 0515B—A GM engine showing details of camshaft (1) and balance shaft (25). Camshaft intermediate bearings (14) which are removed when removing the camshaft are locked in cylinder block with set screws (16). Set screws are accessible after removing cylinder head. Spring loaded front balance weights (7 and 28) are used only on 6 cylinder engines whereas one-piece balance weights are used on all other engines.

3. Front bearing
6. Thrust washers
10. Plug
12. Thrust shoulder
15. Lock ring
17. Rear bearing
21. Gear nut retainer
23. Rear balance weights (used on 4 and 6 cylinder engines)
26. Front bearing
27. Thrust washers
31. Thrust shoulder
32. Rear bearing
36. Gear nut retainer
40-47. Spring loaded type of balance weight (used only on 6 cylinder engines)

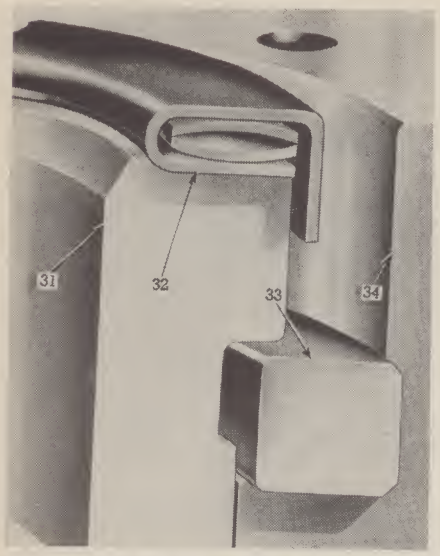


Fig. 0516A—A GM engine cylinder liner installation. Insert (33) controls relationship of top surface of liner flange to machined surface of cylinder block.

32. Compression gasket 34. Cylinder block

PISTONS, LINERS AND RINGS

70A. Cast steel, tin plated pistons equipped with four compression and two oil rings operate in dry slip fit type cylinder liners. Pistons are bushed for the full floating piston pin. Cylinder liners contain twenty air inlet ports of figure 8 design which are radially placed at mid length of sleeve.

70B. **PISTONS AND LINERS.** Pistons are supplied in standard size with a skirt diameter of 4.244 and oversizes of 0.010, 0.020 and 0.030. Refer to paragraph 70G for data on piston pin bushings.

Desired piston skirt clearance of 0.004-0.009 is checked with a spring scale pull of 6 lb., using a ½ inch wide feeler gage. The actual clearance will be 0.001 greater than the thickness of feeler gage. For example: When actual clearance is 0.006, a spring scale pull of approximately 6 lb. will be required to withdraw a 0.005 feeler gage.

70C. Cylinder liners are a slip fit (0.0005 to 0.0025 loose) in the cylinder block and can be removed, in most cases, without the use of a puller. Both the cylinder block bores and inside diameter of the sleeves can be bored and then honed to obtain desired fit of sleeve to block and of piston to sleeve. Inspect cylinder block bores for fit and contact of liner to bore. Check cylinder bore for out-of-round condition with limits of 0.001-0.003, and taper condition with limits of 0.001-0.002. If either of the preceding conditions are beyond maximum, it will be necessary to fit new liners by honing the cylinder block bores with 80 and 120 grit stones. Standard bore inside diameter is 4.6265 to 4.6275.

New liners with standard inside diameters of 4.2495 to 4.2505 are supplied with standard outside diameters of 4.6255 plus oversizes of 0.005, 0.010, 0.020 and 0.030. The oversize liners make it possible to obtain a 0.0005-0.0025 loose fit of the liner when clean-up honing of the cylinder bore is necessary.

Check inside diameter of liner for taper and out-of-round conditions with maximum limits of 0.002. These checks should be with liner installed in cylinder block.

70D. Before reinstalling the cylinder liner, place a liner insert (33—Fig. 0516A) into cylinder block counterbore for liner flange and then install the liner. Cylinder liners are installed dry and without any coating such as oil-mixed aluminum powder, etc. Clamp liner in position and measure distance from top of liner to top of cylinder block. Top surface of liner flange on high block type engines used in the Oliver Super 99 tractor should be from 0.0465-0.050 below surface of cylinder block, and with a maximum of 0.002 difference in height between adjacent liners. Make corrections either by reducing the thickness of the flange insert or by plating the insert.

70E. **RINGS** There are four compression and two oil rings per piston. Refer to Fig. 0516B.

Check ring gap and side clearance against the following limits.

End Gap:

Compression Rings	0.025 -0.040
Oil Control Rings	0.010 -0.020

Side Clearance:

1st Compression	0.010 -0.022
2nd Compression	0.008 -0.015
3rd & 4th Comp.	0.006 -0.013
Oil Control	0.0015-0.008

PISTON PINS AND BUSHINGS

70F. Hollow type piston pin which is of the full floating type, rotates in bushed bores of the piston and in similar bushings located in the small end of the connecting rod.

70G. Piston pins are retained in piston by stamped metal retainers (8—Fig. 0516B) and lock rings (2). Since the fit of metal retainers may vary from 0.001 loose to 0.0005 press, it may be necessary to pry out the retainer by punching a hole through its center.

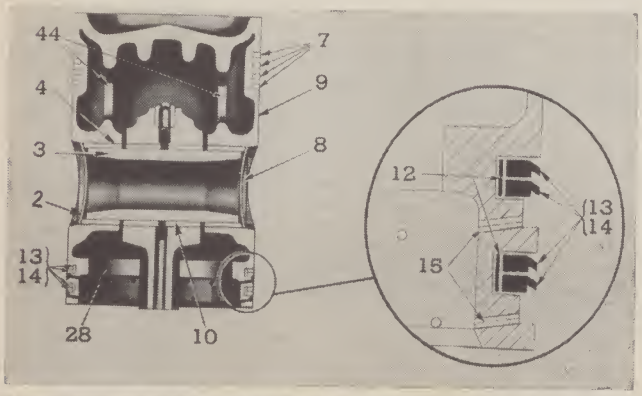
The standard 1.4996-1.500 diameter piston pin is available in 0.010 oversize. Maximum allowable limit of piston pin clearance in either bushing is 0.010.

The split type bushings should be installed in piston with split side at bottom of piston and with inner end of bushing flush with edge of pin boss. Rod bushings should be installed in rod with split side at top of rod, as shown in Fig. 0517A, and with outer edge of bushings flush with edge of rod.

New bushings should be sized after installation to provide a pin clearance of 0.0025-0.0035 in piston bushings, and 0.0015-0.0025 clearance in rod. Connecting rod center to center length is 10.124-10.126 inches.

CONNECTING RODS AND BEARINGS

70H. The precision type, steel backed aluminum rod bearings are renew-



4. Bushing, piston
7. Compression rings
8. Piston pin retainer
9. Piston
10. Bushing, rod
12. Ring expander
13. Oil control rings
14. Oil control rings

Fig. 0516B—A GM engine piston, rings and piston pin assembly.

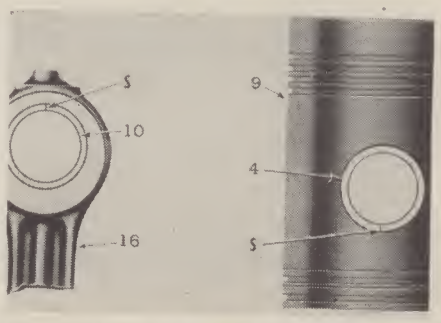


Fig. 0517A—GM engine. Showing location of bushing split (S) in piston pin bushings (4 and 10) for piston and connecting rod.

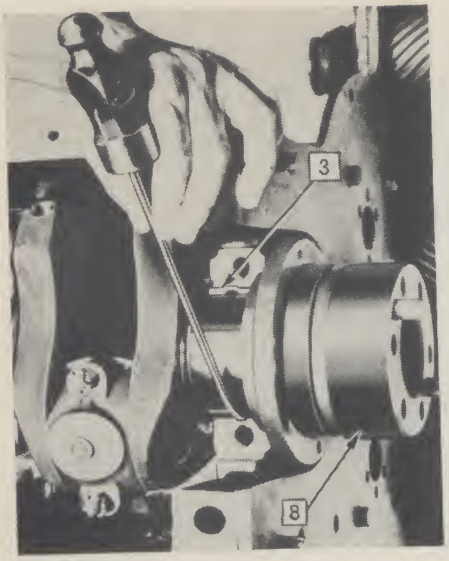


Fig. 0517B—A GM engine showing the use of a small diameter rod to remove rear main bearing upper shell (3) when crankshaft is installed.

able from below without removing the rods from the engine. Bearing shells are supplied in undersizes of 0.002, 0.010, 0.020 and 0.030.

Check crankpins and bearings for wear, scoring and out-of-round conditions.

Crankpin Diameter	2.7495
Taper, Maximum	0.003
Out-of-Round, Max.	0.003
Bearing Running Clearance	0.0015-0.0045
Renew if Clearance Exceeds	0.006
End Play	0.006 -0.012
Rod, Center to Center Length	10.125

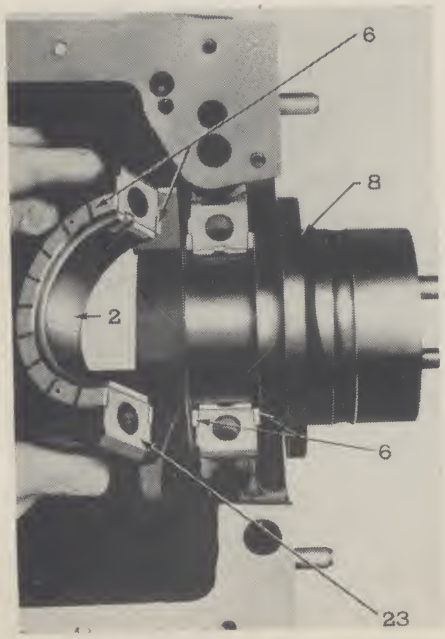


Fig. 0518A—A GM engine showing separate thrust washers (6) at rear main bearing to control crankshaft end play.

CRANKSHAFT AND BEARINGS

71. The induction hardened crankshaft rotates in four precision type, steel backed aluminum bearings which are renewable from below without removing the crankshaft. A special bolt or pin inserted in the crankshaft main journal oil hole will facilitate removal of upper shells for main journals 1, 2 and 3. Rear main journal upper bearing shell can be removed with a small diameter curved rod as shown in Fig. 0517B. Identification numbers on main bearing caps face blower side of engine.

Bearing shells are supplied in undersizes of 0.002, 0.010, 0.020 and 0.030. In regrinding crankshafts for use with undersize bearings, all journal fillets must have 0.130 to 0.160 radius between crank check and journal.

71A. Crankshaft can be removed after removing the engine from tractor chassis, flywheel housing, oil pan, rod caps, crankshaft front cover, and main bearing caps.

71B. Crankshaft end play of 0.004-0.011 with a maximum of 0.018 is controlled by varying the thickness of thrust washer halves (6—Fig. 0518A), located on either side of the rear main bearing journal. Grooved face of thrust washers contact thrust surface on crankshaft. Thrust washers are supplied in oversizes of 0.005 and 0.010. If thrust surfaces of crankshaft are worn or ridged excessively, they should be reground. Standard dimensions at rear main bearing thrust washer surfaces, indicating that standard thrust washers of 0.1220 thickness should be used, are shown in Fig. 0518B.

Excessive grooving of the crankshaft where rear oil seal lip contacts the surface can be corrected by installing a seal sleeve on the crankshaft and using an oversize oil seal. For data on crankshaft front and rear oil seals, refer to paragraphs 72 through 72G.

71C. Check shaft and main bearings for wear, scoring and out-of-round conditions.

Main Journal Diameter	3.500
Running Clear., Mains	0.0015-0.0045
Renew If Clearance Exceeds	0.006
Crankpin Diameter	2.7495
Running Clearance, Crankpins	0.0015-0.0045
Renew If Clearance Exceeds	0.006
Main & Rod Journal Out-of-Round, Max.	0.003
Main & Rod Journal Taper, Max.	0.003

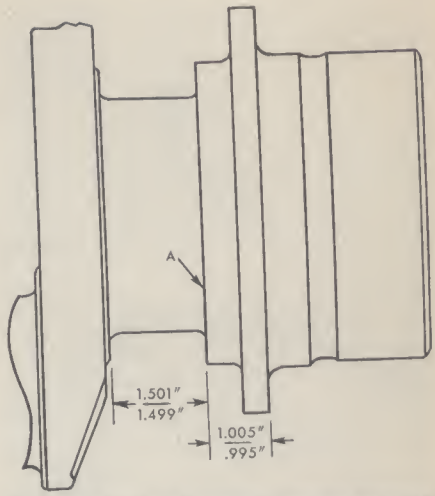


Fig. 0518B—A GM engine showing standard dimensions of the crankshaft rear main journal thrust surfaces for the use of standard thickness thrust washers.

Crankshaft End Play, Recommended	0.004-0.011
Crankshaft End Play Control	No. 4 Brg.
Main Brg. Bolt Tightening Torque—Ft.-Lb.	180-190

CRANKSHAFT OIL SEALS

72. **REAR OIL SEAL.** The lip type oil seal (20—Fig. 0519A) for the rear end of the crankshaft is mounted in the flywheel housing. Oil seal can be renewed after removing the flywheel as outlined in paragraphs 72A through 72D.

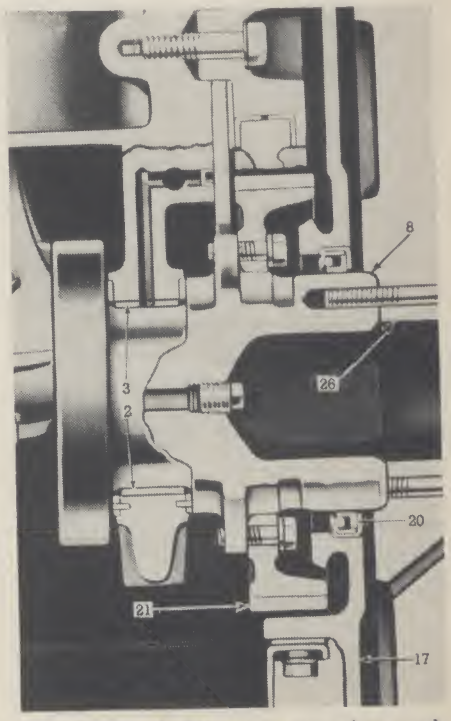


Fig. 0519A—A GM engine showing crankshaft rear oil seal (20) which is located in flywheel housing (17). Remove flywheel to renew seal.

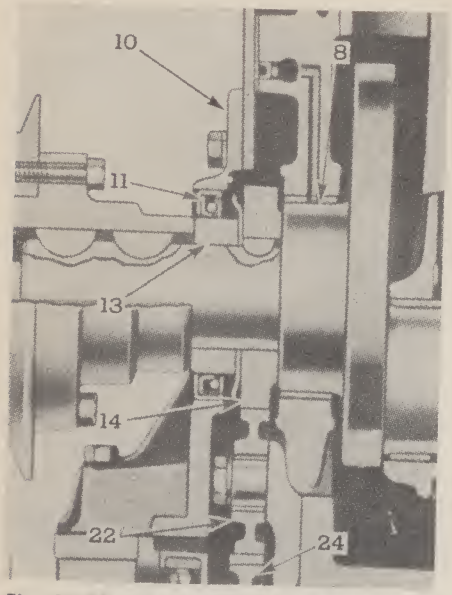
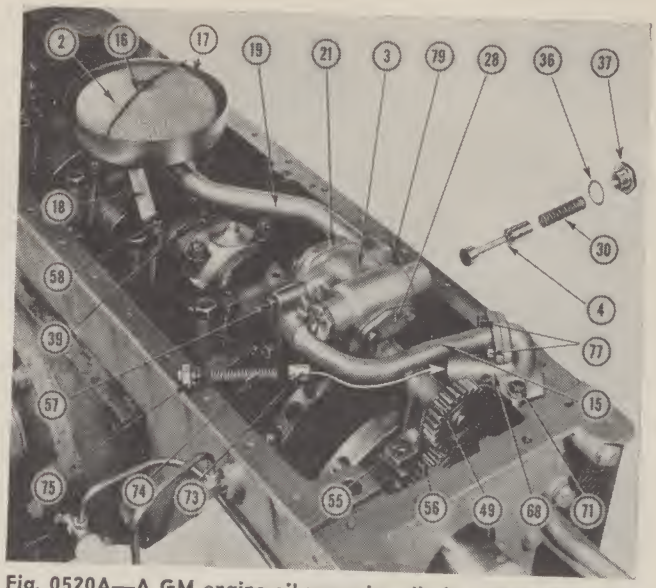


Fig. 0519B—GM engine. Crankshaft front oil seal (11) is located in crankshaft front cover (10). Remove crankshaft pulley and oil seal spacer ring (13) to renew seal.

14. Oil pump drive gear
22. Oil pump drive idler gear
24. Oil pump driven gear



3. Oil pump
4. Pump relief valve
36. Copper gasket
56. Idler gear
73. Regulator valve

Fig. 0520A—A GM engine oil pump installation. Non-adjustable pump relief valve (4) is preset for 100 psi, and non-adjustable oil regulator valve (73) is preset for 45 psi.

72A. If tractor is equipped with pto, remove the drive shaft of same as outlined in paragraph 145H. PTO drive shaft is splined into the flywheel.

72B. Remove storage batteries, clutch housing front cover, and flat dust cover which is attached both to the front frame and to the clutch release bearing carrier. Referring to Fig. 0458, remove master link from clutch shaft coupling chain (22). Remove chain and slide coupling (21) forward after removing the coupling clamp bolt. Disconnect outer end of clutch shifter shaft and loosen set screw which locates the shifter fork (26) on shaft. Bump shifter shaft out of shifter fork toward left side of tractor. Lift clutch shaft (23) rearward and out.

72C. Correlation mark clutch and flywheel, then unbolt clutch from flywheel. Support flywheel and remove flywheel attaching cap screws. Thread two $\frac{7}{16}$ x 4 inch standard thread cap screws into tapped holes provided at flywheel bolt flange to remove flywheel.

72D. Oil seal can be renewed after removing the flywheel. Excessive grooving of the oil seal lip contacting surface on the crankshaft can be corrected by installing a seal sleeve (GM part No. 5193413) and an oversize oil seal (GM part No. 5192776). Seal sleeve is a slip fit on the crankshaft.

72E. **FRONT OIL SEAL.** The lip type oil seal (11—Fig. 0519B) for the front end of the crankshaft is mounted in the crankshaft front cover (10). Oil seal can be renewed after removing the crankshaft pulley as outlined in paragraphs 72F and 72G.

72F. First remove tractor hood and radiator is outlined in paragraph 110. After removing radiator, remove air cleaner to blower pipe. Remove four cap screws attaching oil cooler to mounting bracket in front frame and lay oil cooler aside. Remove fan belt. Remove crankshaft pulley retaining cap screw. Remove pulley by using a puller attached to two cap screws which are threaded into the pulley. Crankshaft front oil seal can be renewed at this time.

72G. The lip of the crankshaft front oil seal does not contact the crankshaft; instead the lip contacts a renewable seal sleeve (13) which is a slip fit on the crankshaft. Check lip con-

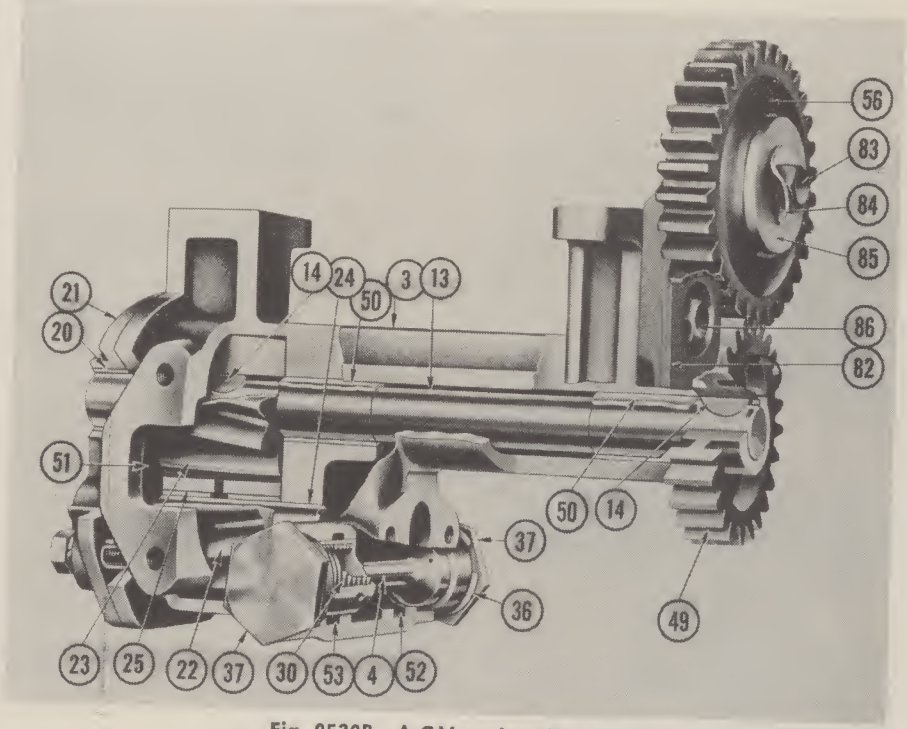


Fig. 0520B—A GM engine oil pump.

3. Pump body
4. Pressure relief valve (non-adjustable)
20. Bushing
21. Pump body cover
22. Driven gear
23. Drive gear
24. Driven gear shaft
25. Bushing
36. Copper gasket
37. Relief valve port plug
50. Bushing
56. Idler gear
82. Idler gear support
85. Thrust washer
86. Cap screw

tacting surface of seal sleeve, and renew or reverse the sleeve if necessary.

FLYWHEEL AND RING GEAR

73. Remove flywheel as outlined in paragraphs 72A through 72C.

Ring gear can be renewed after removing the flywheel. To install a new ring gear heat same to 400 degrees F. and install with either side facing the engine. Torque tighten flywheel attaching cap screws to 150-160 ft. lb.

OIL PUMP AND SYSTEM

74. The components which make-up the lubricating system include a gear type pump which is located on the underside of the cylinder block and gear driven by a gear located on the forward end of the crankshaft; an oil pump relief valve (preset to 100 psi) to by-pass excess oil from discharge side of pump to inlet side of pump; an oil pressure regulator (preset to 45 psi) to maintain a constant engine oiling pressure; an oil cooler by-pass valve (preset to 40 psi) to by-pass the oil cooler should it become restricted; an oil cooler; and a partial flow type oil filter.

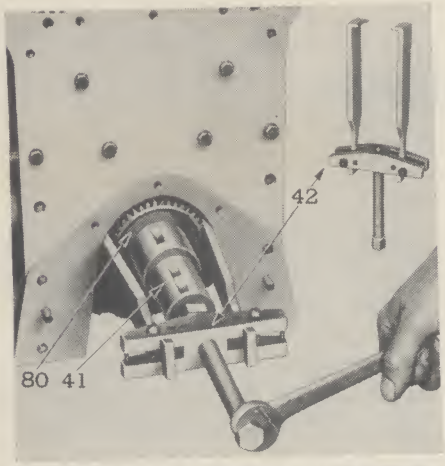


Fig. 0521A—A GM engine showing method of removing oil pump drive gear from crankshaft.

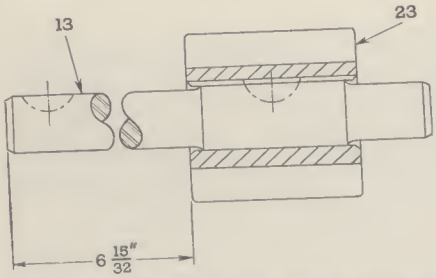


Fig. 0521B—A GM engine showing location of oil pump gear (23) on drive shaft (13).

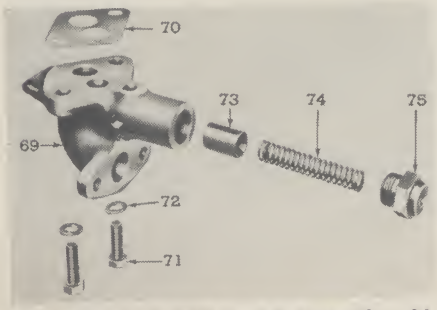


Fig. 0521C—A GM engine non-adjustable type oil pressure regulator which is preset for 45 psi.

109. Oil cooler housing
114. By-pass valve (preset for 40 psi)
115. Spring
116. Gasket
117. Plug
127. Oil cooler drain valve
138. Oil cooler cover
139. Gasket
140. Gasket
141. Gasket
143. Element

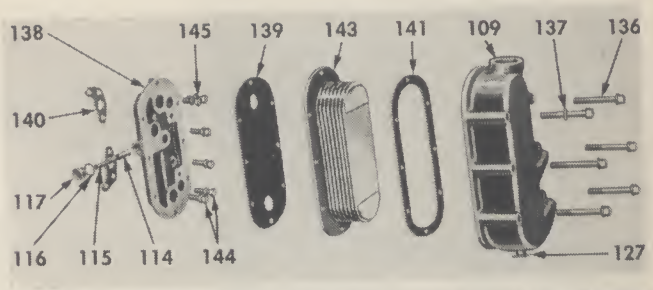


Fig. 0522A—A GM engine oil cooler and oil cooler by-pass valve details. Oil cooler is mounted in the tractor front frame.

74A. **PUMP.** The gear type pump, Fig. 0520A, which is driven by a gear located on the forward end of the crankshaft through an idler gear is mounted on the underside of the cylinder block. To remove pump first remove oil pan. Remove cap screws attaching oil pressure regulator, oil pump and pump intake screen support bracket to engine block.

Shims located between pump mounting base and main bearing cap are used to adjust backlash of pump idler gear to pump drive gear on crankshaft to 0.005-0.020. A 0.005 shim will change the backlash approximately 0.0035.

74B. Pump drive gear located on forward end of crankshaft can be removed after removing crankshaft pulley as outlined in paragraph 72F. Support engine, and remove engine front mounting bolts and crankshaft front cover. Refer to Fig. 0521A and use a similar puller set-up to remove pump drive gear from crankshaft.

Install pump drive gear so that chamfer on gear hub is toward main bearing cap.

74C. Pump disassembly procedure is self-evident. Refer to Fig. 0520B. Use a suitable puller to remove pump driven gear (49) before disassembling the pump.

Bushings (20 and 50) for the drive shaft (two bushings in pump body and one in pump cover), bushings (25) for pump driven gear (two bushings) and a bushing for the idler gear (one bushing) are supplied for service. Final size bushings to provide a free-running fit for the shaft and without perceptable looseness.

Pump body and cover are assembled without a gasket. Pump drive idler gear (56) is installed with flush side of hub and gear teeth facing the idler gear support (82). Install pump gear (23) on drive shaft (13) so that location of gear is $6\frac{15}{32}$ inches from keyway end of shaft as shown in Fig. 0521B. Press pump driven gear (49 — Fig. 0520B) on keyway end of shaft to a point where a 0.005 feeler gage can be inserted between the pump body and the end of the gear hub.

74D. **PUMP RELIEF VALVE.** Refer to Fig. 0520A. The non-adjustable pump relief valve, located in the pump body, by-passes oil from the pump outlet to the pump inlet when pump pressure exceeds 100 psi. The relief valve is accessible after removing the oil pan.

74E. **OIL PRESSURE REGULATOR VALVE.** An oil pressure of 45 psi is maintained within the engine, regardless of engine speed and oil temperatures by means of a regulator (73—Fig. 0520A) installed between pump outlet and oil gallery in cylinder block. Removal and disassembly of the non-adjustable oil pressure regulator, Fig. 0521C, is self-evident.

74F. **OIL COOLER BY-PASS VALVE.** A by-pass valve is located between the inlet side of the oil cooler and oil cooler element to by-pass the oil if the element becomes restricted.

The non-adjustable by-pass valve (114—Fig. 0522A), preset for 40 psi, can be removed from oil cooler adaptor cover (138) without disturbing any of the engine components.

74G. **OIL COOLER.** An oil cooler of the heat exchanger type, using engine water as the coolant is mounted in the tractor front frame between the crankshaft pulley and radiator. Water from the outlet side of radiator flows through the oil cooler, which is a cast iron housing surrounding the exchanger core for the oil, to the inlet

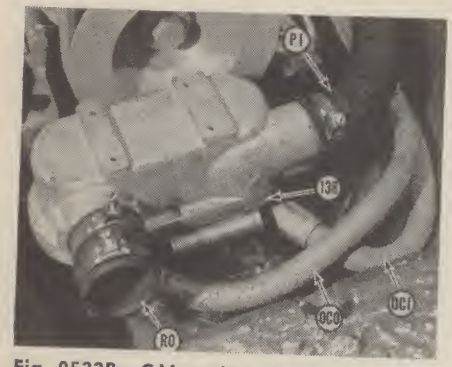


Fig. 0522B—GM engine oil cooler which is located in tractor front frame is accessible after removing tractor radiator.

138. Oil cooler cover
OCI. Oil cooler inlet oil line
OCO. Oil cooler outlet oil line
PI. Water pump inlet hose
RO. Radiator outlet hose

side of the engine cooling system pump.

To remove oil cooler from tractor frame, Fig. 0522B, first remove tractor hood and radiator. Oil cooler is attached to a mounting bracket with four cap screws.

Disassembly of the oil cooler is self-evident. Use carbon tetrachloride or any of the recommended steam detergent solutions as a cleaning agent for the oil side of the cooler.

OIL PAN

75. Oil pan can be removed in the conventional manner without disturbing any of the engine or tractor components.

New oil pan gaskets of cork have four punched holes which serve as guides in positioning the gasket on the engine block. All other cap screw holes are punched out when installing the oil pan attaching cap screws. Before installing the oil pan, clean out (remove) punch out cork from the four blind cap screw holes in the flywheel housing and from the four blind cap screw holes in the crankshaft front cover.

BLOWER (SUPERCHARGER)

76. Refer to Fig. 0523A. The Roots type blower, mounted on the left side of the engine, supplies fresh air needed for combustion and scavenging. Normal air box pressure is 4.2 inches Mercury or 2.06 psi @ 1200 crankshaft rpm, and 7.6 inches Hg. or 3.73 psi at 1600 crankshaft rpm. Blower drive at approximately twice engine speed is supplied by the blower drive gear which is located in the gear train of the engine. Engine accessory units such as the fuel pump (101), water pump (99) and governor weight housing (100) are mounted on the blower and are driven by the blower rotor shafts.

GENERAL INSPECTION

76A. Blower may be inspected for any of the following conditions while it is installed on the engine. To make the inspections remove the blower air inlet housing (78).

76B. **OIL SEAL LEAKAGE.** Damage or leaking oil seals are usually apparent by the presence of oil on blower rotors or inside surfaces of the housing. A further check for leaking oil seals can be made with engine operating at idle speed. A thin film of oil in the rotor compartment, radiating away from the seal (sun burst pattern), is indicative of an oil seal failure.

Remove blower and blower end plates to renew oil seals.

76C. **WORN BLOWER DRIVE.** Wear or damage in the blower drive flexible coupling is indicated by a rattling type of noise, and may be detected as follows: Grasp upper rotor and rotate it in either direction as far as possible; then release the rotor. Rotor can be rotated approximately ⅜ to ⅝ inch when measured at the lobe crown. Spring back when released should be at least ¼ inch. If rotors cannot be moved or if they move too freely, remove blower drive flexible coupling for further inspection.

To remove and inspect blower drive flexible coupling remove flywheel housing, or remove blower and blower drive gear hub support assembly.

76D. **LOOSE ROTOR SHAFTS OR DAMAGED BEARINGS.** A loose shaft causes rubbing or scoring between rotors, and between rotors and end plates. Worn or damaged bearings will cause rubbing at some point between mating rotor lobes or scoring of the

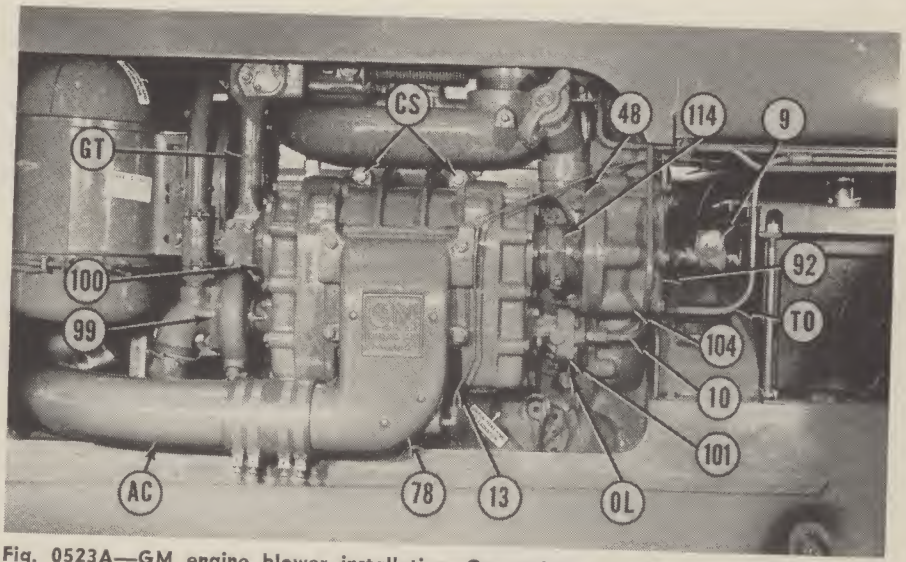


Fig. 0523A—GM engine blower installation. On engines used in Oliver Super 99 GM tractors blower is mounted on left side of engine.

AC. Air cleaner to blower pipe
GT. Governor control housing
OL. Blower drive gear hub oil line
TO. Tank to fuel pump line
9. Tachourmeter drive
10. Fuel pump outlet line
13. Chevron starting aid primer line
48. Blower drive gear hub support
78. Blower inlet housing
92. Flywheel housing cover
99. Water pump
100. Governor weight housing
101. Fuel pump
104. Flywheel housing
114. Blower drive seal and clamp

blower housing at the end where the bearings have failed.

Remove blower for complete overhaul.

76E. **EXCESSIVE BACKLASH.** Rubbing or scoring of rotor lobes through their entire length is caused by excessive backlash in blower timing gears.

Remove blower for complete overhaul.

REMOVE AND OVERHAUL

77. **BLOWER DRIVE SHAFT.** Refer to Figs. 0523A and 0523B. To remove blower drive shaft (79), proceed as follows: Remove battery from left side of tractor and disconnect tachometer drive cable at drive unit (9). Remove six cap screws attaching flywheel housing cover (92) to flywheel housing and lift off cover. Thread a $\frac{5}{16}$ inch—24 x 2 inch bolt into exposed end of blower drive shaft (79). Remove snap ring (80) from exposed end of blower drive shaft and withdraw the shaft.

77A. If blower drive shaft is broken and the pieces cannot be removed as outlined in preceding paragraph 77, it will be necessary to remove the blower, as outlined in paragraph 80, to permit removal of shaft pieces.

78. **BLOWER DRIVE GEAR AND FLEXIBLE COUPLING.** Refer to Fig. 0523B. Blower drive gear (53) is located in the timing gear train of the engine and is housed by the flywheel housing.

Blower drive gear can be removed either by removing the engine flywheel housing (91) or by removing the blower and blower drive gear hub support (61).

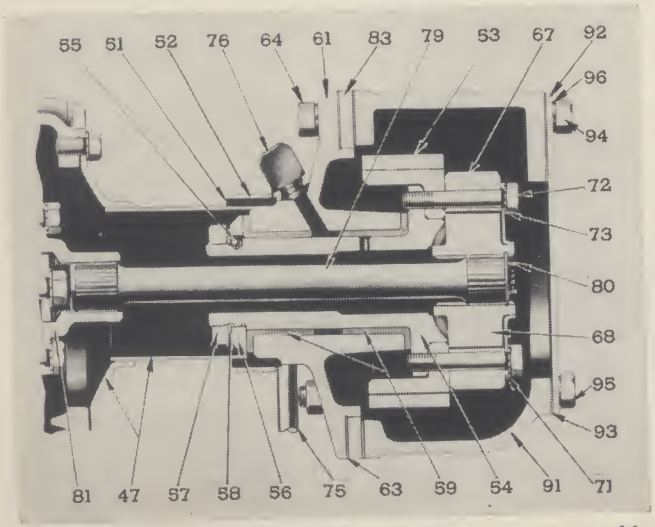
78A. R&R IF FLYWHEEL HOUSING IS REMOVED. Refer to Fig. 0523B. To remove blower drive gear and flexible coupling if flywheel housing is removed proceed as follows: Thread a $\frac{5}{16}$ inch—24 x 2 inch bolt into exposed end of blower drive shaft (79). Remove snap ring (80) from exposed end of blower drive shaft and withdraw the shaft. Remove six cap screws (72) attaching blower drive gear and flexible coupling to blower drive gear hub (54), and lift off drive gear and flexible coupling.

Reinstall flexible coupling so that cam lobes of the drive cam are in line with two oil grooves located in blower drive gear hub.

78B. R&R IF BLOWER IS REMOVED. To remove blower drive gear and flexible coupling if blower is removed, proceed as follows: Remove bearing oil line (OL—Fig. 0523A) from blower drive support. Refer to Fig. 0523B. Remove bolts and cap screws attaching blower drive support (61) to engine rear end plate. Withdraw blower drive support assembly from rear end plate. (There are no timing marks on blower drive gear.) Remove six cap screws attaching drive gear (53) and flexible coupling (67) to blower drive gear hub (54), and lift off gear and flexible coupling.

Reinstall flexible coupling so that cam lobes of the drive cam are in line with two oil grooves located in blower drive gear hub.

78C. OVERHAUL. Refer to Fig. 0524A. With blower drive flexible coupling removed from blower drive gear hub disassemble the flexible coupling by pushing coupling cam (68) out of coupling support (67).



47. Blower drive cover
51. Seal
52. Clamp
53. Blower drive gear
54. Gear hub
55. Lock ball
56. Thrust washer
57. Gear hub nut
58. Lock washer
59. Flanged bushings
61. Support
63. Gasket
67. Flexible coupling drive support
71. Retainer
75. Oil line
76. Oil line fitting
79. Blower drive shaft
80. Snap ring
81. Blower rotor gear hub
83. Engine rear end plate
91. Flywheel housing
92. Flywheel housing cover
93. Gasket

Fig. 0523B—A GM engine blower drive gear and support assembly.

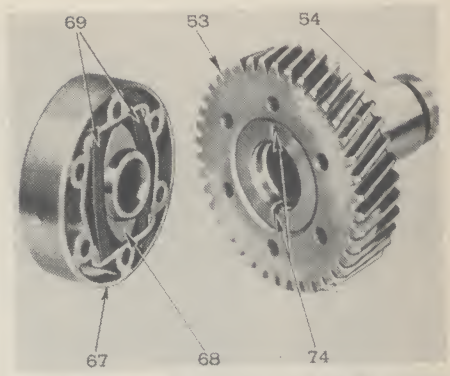


Fig. 0524A — Relationship of GM engine blower flexible coupling drive cam (68) to oil grooves (74) which are located in blower drive gear hub (54).

53. Blower drive gear
67. Flexible coupling drive support
69. Spring pack (21 leaves per pack)

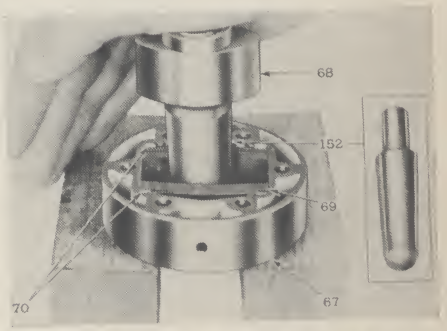


Fig. 0524B—Using a tapered sleeve to install flexible coupling drive cam (68) between spring packs (69).

67. Coupling drive support
70. Spring pack seats
152. Tapered sleeve, GM tool J 1471

Check blower drive shaft serrations in coupling cam for wear and damage. Check spring packs (69) which consist of 21 leaves per pack for breakage. Check spring pack contacting surface of coupling cam for wear.

Reassemble flexible coupling, as shown in Fig. 0524B, by placing the spring packs, each pack containing 21 leaves, in bore of coupling support. A small amount of grease will hold leaves together to form a pack. Install a coupling spring seat (70) in each of the four grooves located in coupling support. Place blower drive cam (68) on end of GM Special tool J1471 or a similar type tapered sleeve; then insert tool between the springs to force them apart while pressing the cam into position.

Backlash between balance shaft gear and blower drive gear is 0.003-0.008.

79. **BLOWER DRIVE GEAR HUB AND SUPPORT.** Refer to Figs. 0523B and 0525B. To renew either blower drive gear hub (54) or the bushings (59), first remove the blower as outlined in paragraph 80; then proceed as outlined in paragraph 78B.

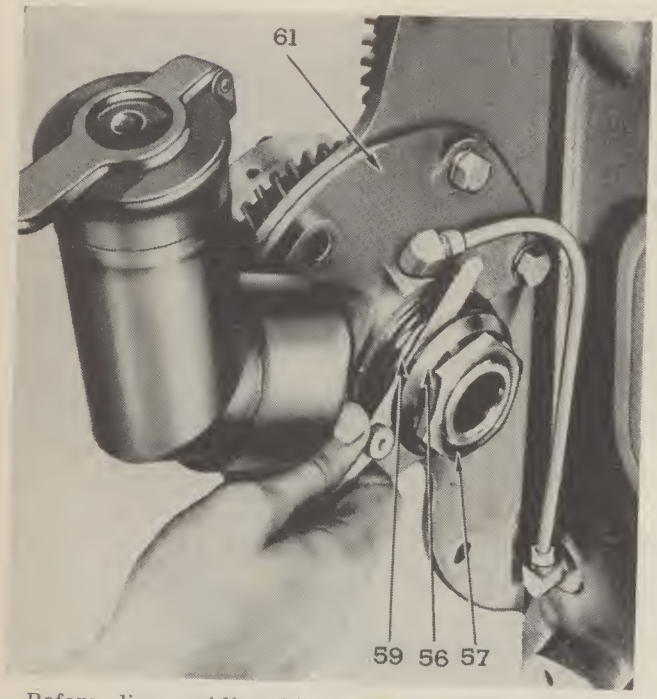


Fig. 0525A—Checking end clearance of GM engine blower drive gear hub assembly by inserting feeler gage between thrust washer (56) and flange of bushing (59). Recommended clearance is 0.005-0.010.

Before disassembling blower drive gear hub support, check clearance between flange of gear hub bearing (59—Fig. 0525A) and thrust washer (56) as shown. If clearance exceeds recommended clearance of 0.005-0.010, it will be necessary to renew the gear hub support and bushings as an assembly. Steel backed babbitt bushings (59) are not available separately for service.

Disassemble drive gear hub support by removing nut (57) from end of drive gear hub. Desired running clearance between hub and bushings is 0.001-0.005. Inside diameter of new bushings is 1.6260-1.6265.

80. **BLOWER R&R.** Refer to Fig. 0523A. To remove blower assembly from engine, proceed as follows: Drain engine coolant. Remove tractor hood as outlined in paragraph 60A.

Remove cover from top of governor control housing (GT), and remove rocker arms cover. Remove link connecting injector rack control tube to governor differential lever. Disconnect throttle booster spring from governor. Remove two cap screws attaching governor control housing to cylinder head, and four cap screws attaching governor weight housing (100) to governor control housing. Pull upper end of control housing away from cylinder head while pushing lower end of control housing toward engine to free the dowels, and lift off governor control housing.

Disconnect fuel lines (TO and 10) at fuel pump (101), and chevron starting aid line (13) from air inlet housing (78). Loosen hose clamps on hose connecting air cleaner pipe (AC) to blower air inlet housing, and slide hose toward the air cleaner.

Detach water pump inlet hose, bypass, and pump outlet connections on the pump.

Remove battery from left side of tractor and disconnect tachourmeter drive cable at drive unit (9). Remove six cap screws attaching flywheel housing cover (92) to flywheel housing and lift off cover. Thread a $\frac{5}{16}$ inch—24 x 2 inch bolt into exposed end of blower drive shaft. Remove snap ring from exposed end of blower drive shaft and withdraw the shaft.

Loosen clamp (114) on blower drive shaft cover seal. Remove four cap screws (CS) attaching blower assembly to cylinder block. Slide blower assembly slightly forward to withdraw blower drive shaft cover from seal, and lift blower assembly off engine.

Fuel pump (101) water pump (99) and governor weight housing (100) can be removed either before or after removing blower assembly from engine.

80A. **BLOWER OVERHAUL.** Refer to Fig. 0526A. Normal wear of blower rotor gears (13 and 14) causes a decrease of rotor-to-rotor clearance between the leading edge of the upper rotor lobes and the trailing edge of the lower rotor lobes. Clearance between the opposite sides of the rotor

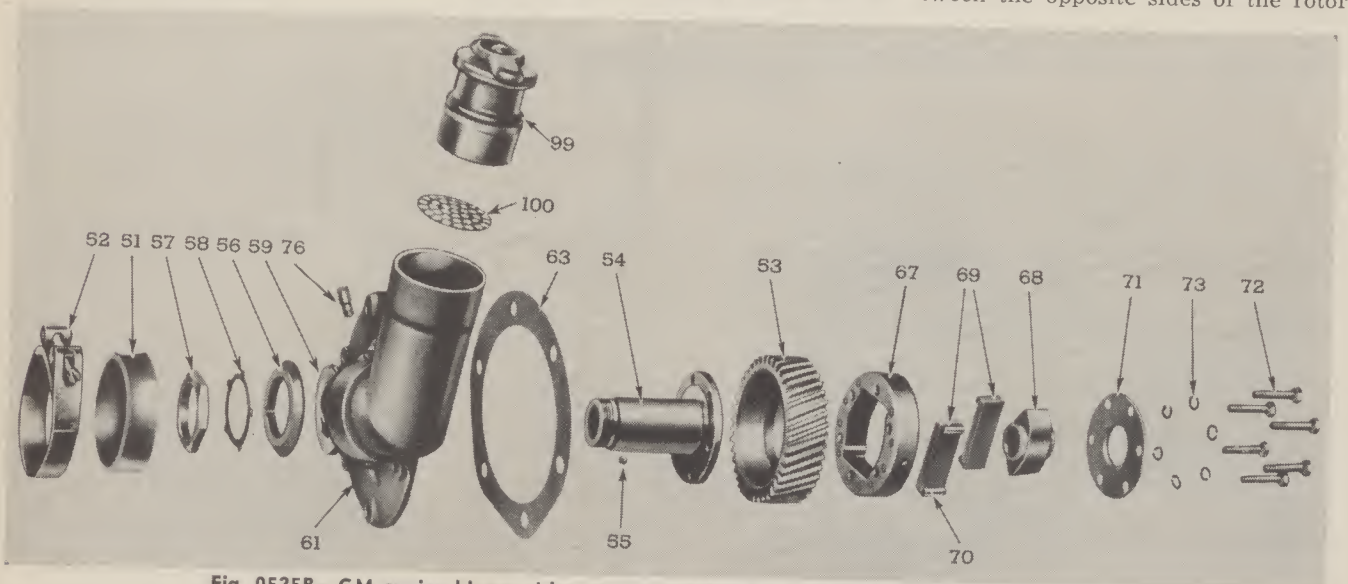


Fig. 0525B—GM engine blower drive gear unit details and relative location of components.

51. Drive cover seal
52. Clamp
53. Blower drive gear
54. Blower drive gear hub
55. Lock ball
56. Thrust washer
57. Nut
58. Lock washer
59. Bushings
61. Support
63. Gasket
67. Coupling drive support
68. Flexible coupling drive cam
69. Spring pack
70. Spring seat
71. Retainer
76. Oil line fitting
100. Screen.

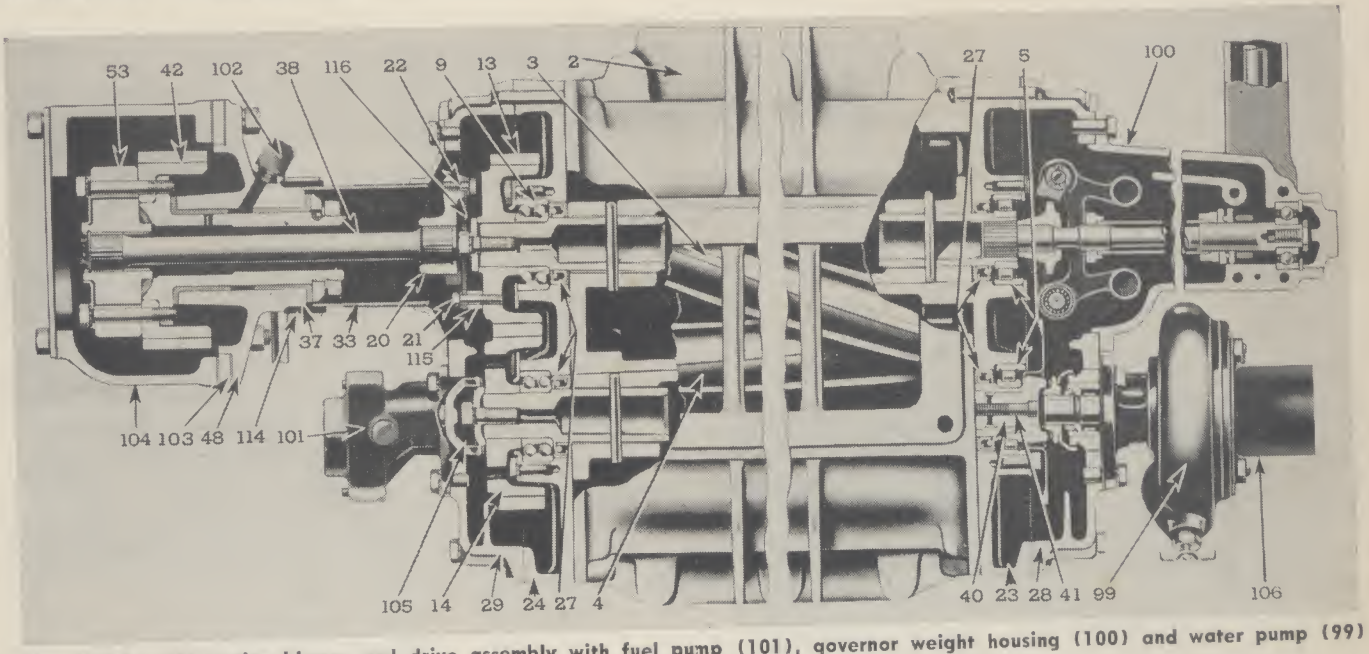


Fig. 0526A—GM engine blower and drive assembly with fuel pump (101), governor weight housing (100) and water pump (99) attached to blower.

2. Blower housing
3. Upper rotor (right helix)
4. Lower rotor (left helix)
5. Roller bearing (front)
9. Ball thrust bearing (rear)
13. Upper rotor gear (right helix)
14. Lower rotor gear (left helix)
20. Rotor drive gear hub
23. End plate (front)
24. End plate (rear)
27. Oil seal
28. End plate cover (front)
29. End plate cover (rear)
33. Drive shaft cover
37. Cover seal
38. Blower drive shaft
40. Water pump drive coupling and slinger
41. Allen screw
42. Blower drive gear
48. Support
53. Flexible coupling drive assembly
102. Oil line fitting
103. Engine rear end plate
104. Flywheel housing
105. Fuel pump drive coupling
114. Cover seal clamp
115. Plate to gear spacer
116. Rotor drive hub plate

lobes is increased correspondingly. While rotor lobe clearances can be corrected, rotor drive gear backlash cannot be corrected. If backlash of blower rotor drive gears exceeds 0.005, it will be necessary to renew both gears as a matched pair.

80B. DISASSEMBLY. With blower removed from engine, and governor weight housing, fuel pump and water pump removed from blower end plate covers, proceed as follows: Remove 10 cap screws attaching each blower end plate cover to blower end plates.

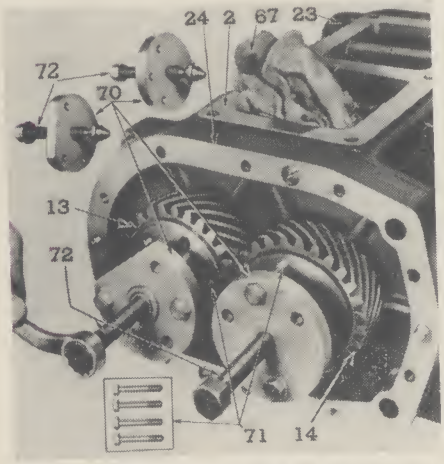


Fig. 0526B—Showing puller set-up to remove blower rotor timing gears. A clean rag (67) placed between the rotors prevents their turning when removing the gears.

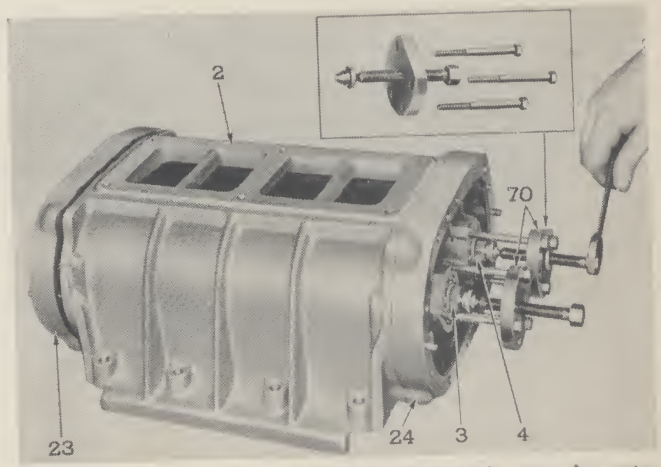
13. Upper rotor gear (right helix)
14. Lower rotor gear (left helix)

Remove Allen screw (41) retaining water pump drive coupling (40) to rotor shaft. Pull coupling from shaft by threading a ½ inch—20 cap screw into tapped hole of coupling.

Remove rotor gear hub drive plates (116), gear hub (20) and spacers (115) from drive end of upper rotor shaft. Remove cap screws retaining rotor drive gears on rotor shafts. Place a clean cloth between rotors to prevent their turning when pulling the rotor gears. Remove rotor gears (13 and 14), using GM special tool J1682-CB or equivalent, as shown in Fig. 0526B. The two gears must be pulled simultaneously from the rotor shafts. Shims (17—Fig. 0527B) located under the gears are used to obtain correct rotor timing (trailing and leading rotor edge clearances of the rotor lobes). Keep shims with their respective gears.

Remove rotor shaft bearing retainers (6 and 10). Remove two fillister head screws (26) attaching the front end plate to blower housing, and loosen two fillister head screws attaching the rear plate approximately three turns. Attach GM special tool set J1682-CB or equivalent as shown in Fig. 0527A to push simultaneously both rotor shafts out of their rear bearings.

Use a similar tool set-up to remove the front end plate and bearings from



3. Upper rotor (right helix)
4. Lower rotor (left helix)
23. End plate (front)
24. End plate (rear)
70. GM tool set J 1682-CB

Fig. 0527A—Showing method and tools used in removing rotor shafts from rear bearings, and front end plate from housing on a GM blower.

the rotor shafts.

Bearings and oil seals for rotor shafts can be removed from the end plates and renewed at this time. Excessive grooving of oil seal contacting surface on rotor shaft can be corrected by installing a seal sleeve wear ring (GM part No. 5192439) and an oversize seal (GM part No. 5192438). Seal sleeve wear rings are a shrink fit to rotor shaft and can be installed by using heat to expand the rings. Oil seals are installed with their lip facing away from the rotors.

80C. INSPECTION. Check the blower rotors, and internal surfaces of the blower housing and end plates for score marks and burrs. Minor score marks and burrs can be removed with crocus cloth.

80D. ASSEMBLE. Observe the following points when reassembling a blower. Lobes on upper rotor and teeth on its drive gear form a right-hand helix. The lower rotor and gear have left-hand helices. Helix can be determined by holding the gear or rotor and observing the direction of the twist. A right-hand helix will have the lobes or gear teeth pointing to the right; whereas a left-hand helix will have the lobes or gear teeth pointing to the left.

Install rotors in blower housing so that the blind or omitted serration on rotor shafts and gears face up.

Install oil seals with their lip facing away from the rotors.

Roller bearings are installed at the front end of the rotor shaft. Double row ball bearings are installed at the rear end of the rotor shaft. Install bearings with markings on race facing away from the rotors.

Insert same thickness of shims, as were removed, between rotor drive gear and inner race of rotor shaft bearings. These shims are used to obtain correct rotor timing (trailing and leading edge clearances of the rotor lobes). Refer to next paragraph 80E for method of checking and adjusting blower rotor timing.

Check backlash of blower rotor gears. If backlash exceeds 0.005, the gears should be renewed. Gears are supplied only as a matched pair.

After adjusting the blower rotor timing, install rotor drive gear hub (20) and hub plates (116) on upper rotor drive gear (13). Check run-out of hub splines. Splines in hub should run true within 0.005 total indicator reading.

80E. BLOWER TIMING. Refer to Fig. 0528A. Blower rotors must be timed or positioned to provide the correct trailing and leading edge clearances between the rotor lobes. This timing check is made after the rotors and gears have been installed in blower housing.

Rotor timing or rotor clearance adjustment is varied by moving one of the rotor drive helical gears in or out on the rotor shaft relative to the other gear. Moving the gears in or out on the

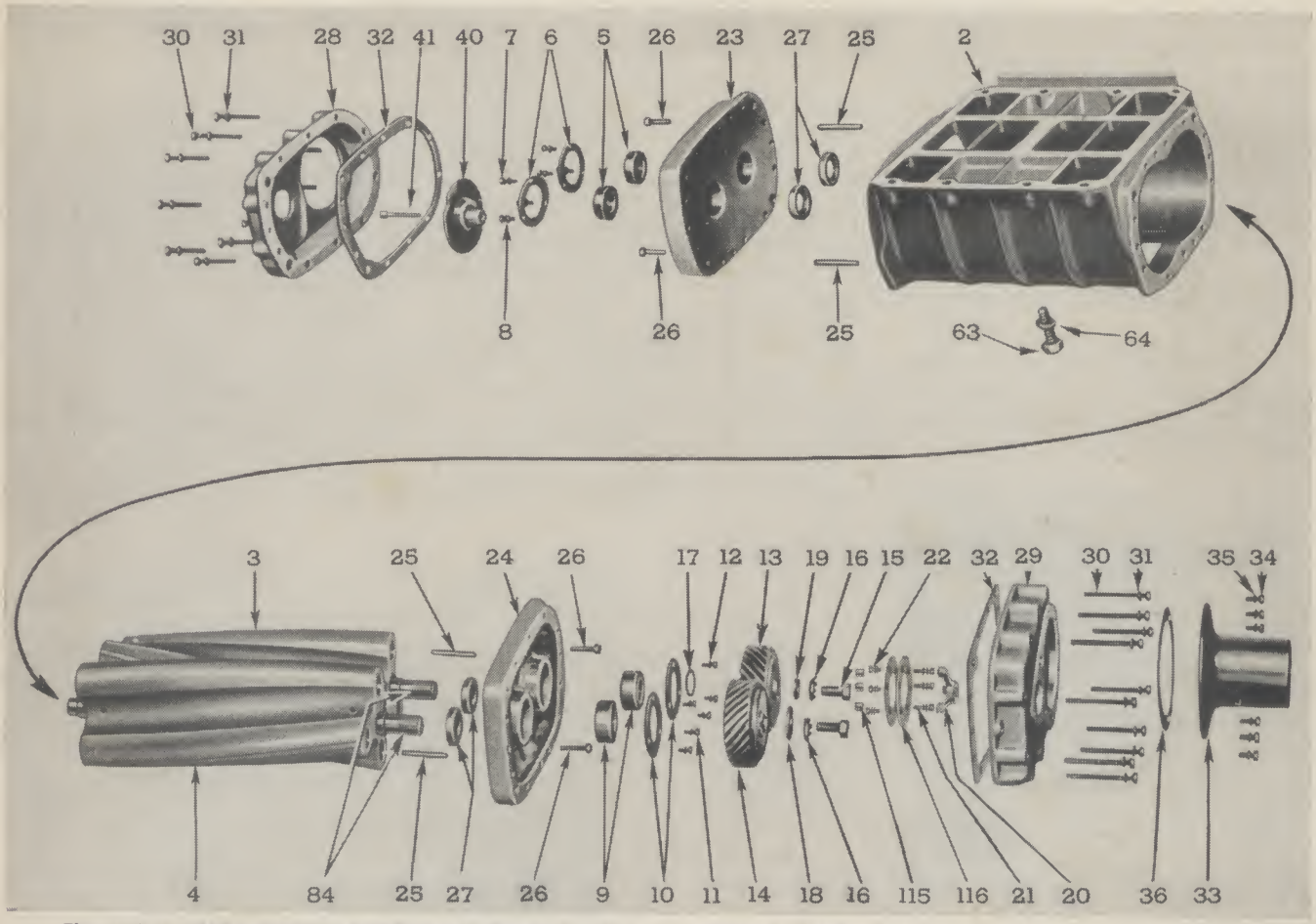
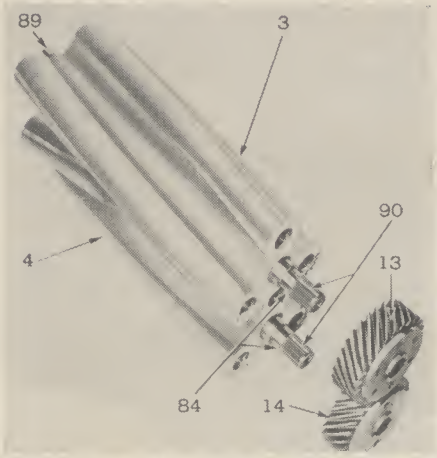


Fig. 0527B—GM engine blower details and relative location of components. Shims (17) control rotor clearances (timing).

2. Blower housing
3. Upper rotor (right helix)
4. Lower rotor (left helix)
5. Roller bearing (front)
6. Bearing retainer
9. Ball thrust bearing (rear)
10. Bearing retainer
13. Upper rotor gear (right helix)
14. Lower rotor gear (left helix)
17. Shim (for timing rotors)
18. Fuel pump drive coupling disc
20. Rotor drive gear hub
23. End plate (front)
24. End plate (rear)
25. Dowel pin
27. Oil seal
28. End plate cover (front)
29. End plate cover (rear)
32. Gasket
33. Drive shaft cover
36. Gasket
40. Intermediate drive shaft and coupling
41. Allen screw
84. Blower rotor shaft
115. Spacer
116. Rotor drive hub plate



20. Rotor gear drive hub
23. End plate (front)
24. End plate (rear)
91. Blower outlet side
92. Leading edge for upper rotor
96. Trailing edge for upper rotor

Fig. 0527C—Lobes on upper rotor (3) and teeth on its drive gear (13) form a right hand helix. Lower rotor (4) and gear (14) have left hand helices.

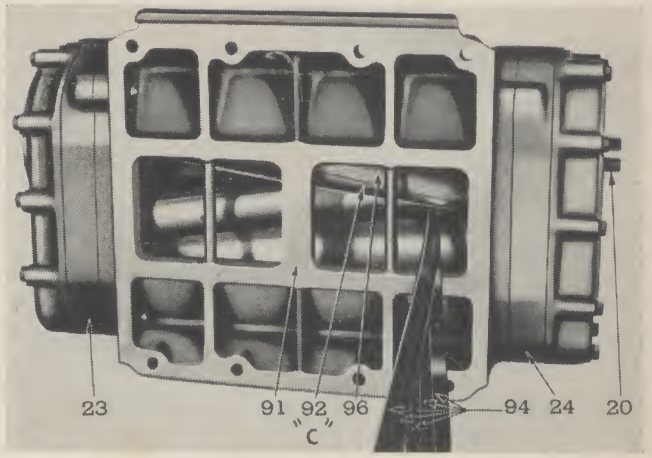
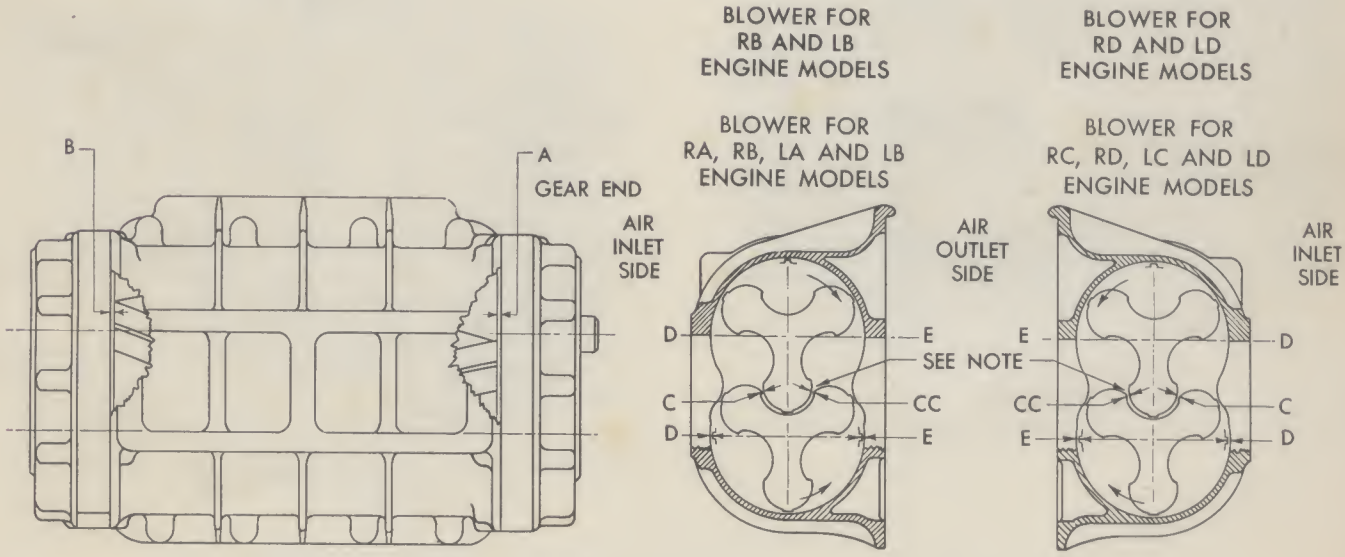


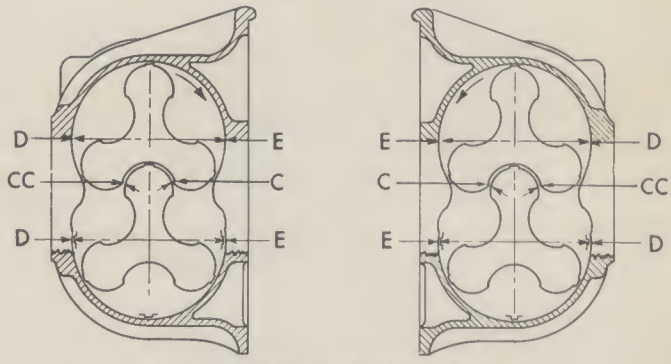
Fig. 0528B—Method of checking rotor clearance with feeler gage ribbons. Measurements should be made both from inlet and outlet sides of blower.



		A	B	C	CC	D	E
3-71	MIN.	.007	.007	.012	.002	.016	.004
	MAX.				.006		
4-71	MIN.	.007	.009	.014	.002	.016	.004
	MAX.				.006		
6-71	MIN.	.007	.014	.014	.002	.016	.004
	MAX.				.006		

TIME ROTORS TO DIMENSIONS ABOVE

NOTE: TIME ROTORS TO DIMENSION ON CHART FOR CLEARANCE BETWEEN TRAILING SIDE OF UPPER ROTOR AND LEADING SIDE OF LOWER ROTOR (CC) FROM BOTH OUTLET AND INLET SIDE OF BLOWER



ALL VIEWS FROM REAR OF ENGINE

Fig. 0528A—Timing dimensions (rotor to rotor clearances and rotor to end plate clearances) for GM engine blowers. For GM model RB engines, as used in the Oliver Super 99 GM tractors, make clearance measurements as shown for engine models RA, RB, LA and LB.

rotor shafts is accomplished by removing or adding shims between the gear and rotor shaft bearing. A 0.003 shim will change the rotor clearance 0.001. Shims are available in thickness of 0.002, 0.003, 0.005 and 0.010.

If the upper gear which has a right-hand helix is moved away from the rotor (adding shims), the upper rotor which has a right hand helix will turn counter-clockwise when viewed from the gear end. Adding shims under the upper gear will increase the clearance (C) which is measured at leading edge of upper rotor lobes and trailing edge of lower rotor lobes. Recommended minimum clearance measured at point (C) is 0.012 for the 3-71 engine blower.

If the lower gear which has a left-hand helix is moved away from the rotor (adding shims), the lower rotor which has a left helix will turn clockwise when viewed from the gear end. Adding shims under the lower gear will increase the clearance (CC) which is measured at trailing edge of upper rotor lobes and leading edge of lower rotor lobes. Recommended clearance at point (CC) is 0.002-0.006.

80F. The clearances between rotor lobes should be checked with ½ inch wide feeler gage ribbons as shown in Figs. 0528B and 0528C. Clearances should be measured both from the inlet and outlet sides of the blower and at three points on each lobe.

If it is necessary to add or remove shims, remove and reinstall both rotor gears simultaneously as shown in Fig. 0526B.

After obtaining correct rotor lobe timing or clearances, check the clearance between ends of rotor lobes and blower housing end plates as shown in Fig. 0529A. The recommended end clearance, represented as A & B in Fig. 0528A, is a minimum of 0.007 for the 3-71 engine blower.

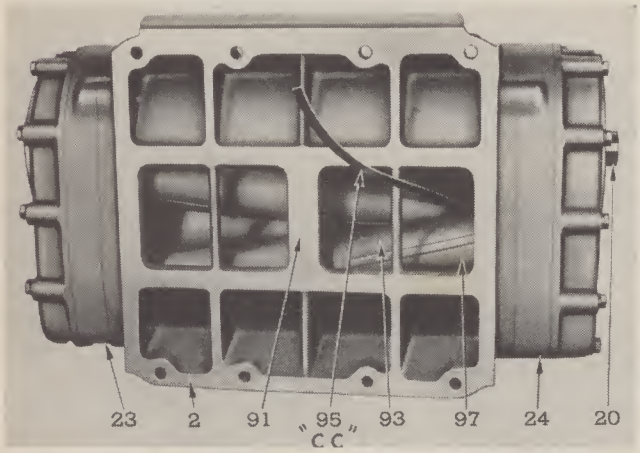


Fig. 0528C—Method of checking rotor clearance "CC" with feeler gage ribbons. Measurements should be made both from inlet and outlet sides of blower.

93. Trailing edge for lower rotor 97. Leading edge for lower rotor

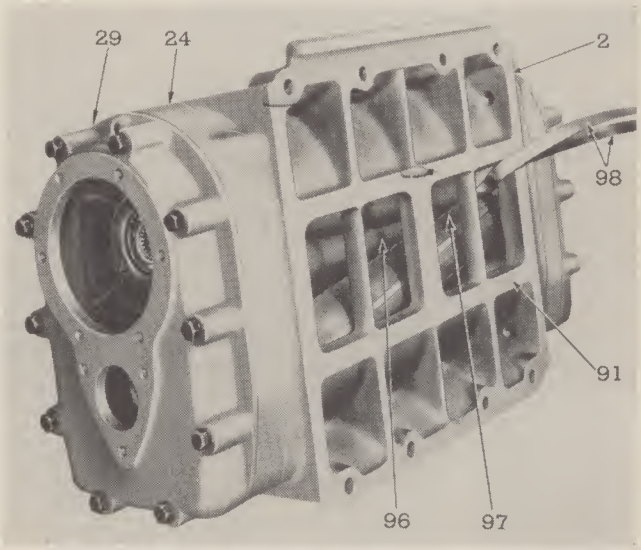


Fig. 0529A—Method of checking end clearance between rotors and blower end plates.

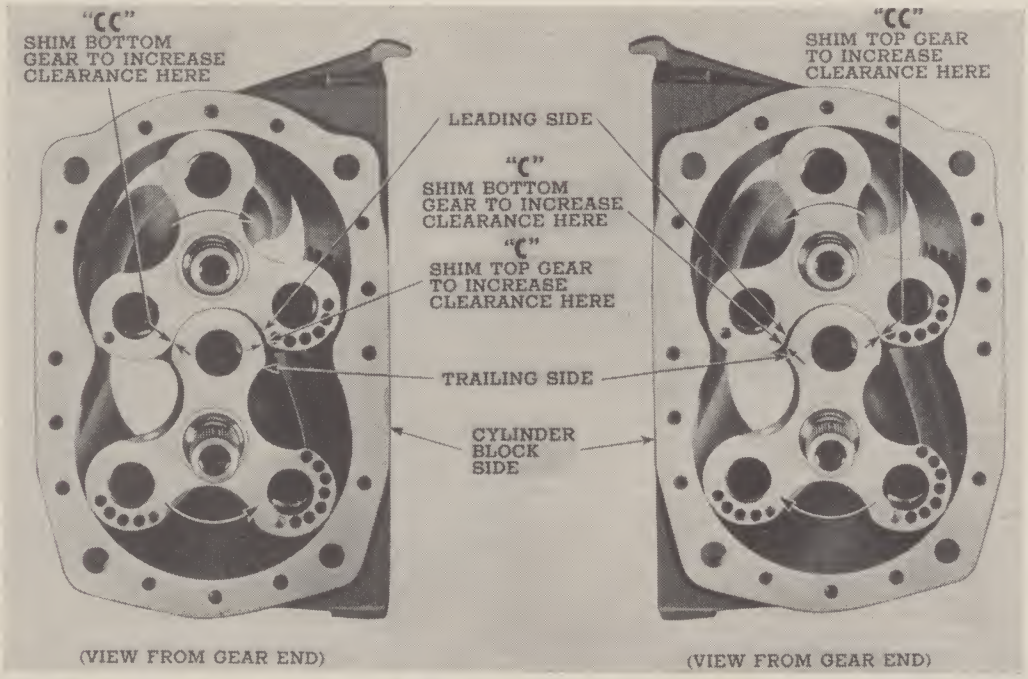


Fig. 0528D—Showing proper location of shims to obtain correct rotor lobe clearances "C" and "CC".

DIESEL FUEL SYSTEM (GM Diesel 71 Series)

85. Main components of the Diesel fuel system are: Fuel supply tank; a gear type fuel pump, mounted on the blower and driven by the lower rotor shaft of the blower; inlet and outlet fuel manifolds located on the cylinder head to connect fuel supply pump to injectors and injectors to fuel supply tank; unit type fuel injectors; and an injector rack control tube which transfers governor action to the injector racks for metering control of the fuel.

TROUBLE SHOOTING

85A. The following data, supplied by General Motors Detroit Diesel Engine Division, should be helpful in locating trouble on the GM-71 series engine.

85B. **HARD STARTING.** Cranking speed, engine compression and engine air supply are okay.

Check for no fuel which could be caused by air leaks, faulty pump, or obstruction in fuel line. Also could be caused by injector racks not in full fuel position.

85C. **NO FUEL OR INSUFFICIENT FUEL.** Check for air leaks in fuel system, fuel flow obstruction, faulty fuel pump or missing restriction fitting located in return fuel manifold. For the latter, check system pressure as outlined in paragraph 99B.

85D. **UNEVEN RUNNING OR FREQUENT STALLING.** Check for below normal coolant temperature, no fuel or insufficient fuel, improper injector timing, incorrect injector rack control setting, leaking injector spray tips, faulty governor adjustments or binding in injector rack control tube.

85E. **DETONATION.** The trouble can be caused either by oil in the inlet supply of air for the engine, by low engine coolant temperature or by faulty injection. Oil in the engine air supply can be traced either to restricted air box drains, to a defective gasket between blower and engine, to defective blower oil seals, or to excessive oil supply in air cleaner oil cups. Check injectors for incorrect timing, for leaking check valve, for enlarged spray tip holes or for a damaged spray tip.

85F. **LACK OF POWER.** Check governor, injector rack control, injector timing and exhaust valve clearance for correct adjustment. Also check for insufficient fuel or insufficient air supply.

85G. **EXHAUST SMOKE ANALYSIS.** Black or gray color of the exhaust smoke indicates incomplete burning of fuel. Check for insufficient air supply, excess fuel or irregular fuel distribution, lugging engine and incorrect grade of fuel.

Blue color of the exhaust smoke indicates fuel or lube oil not being burn-

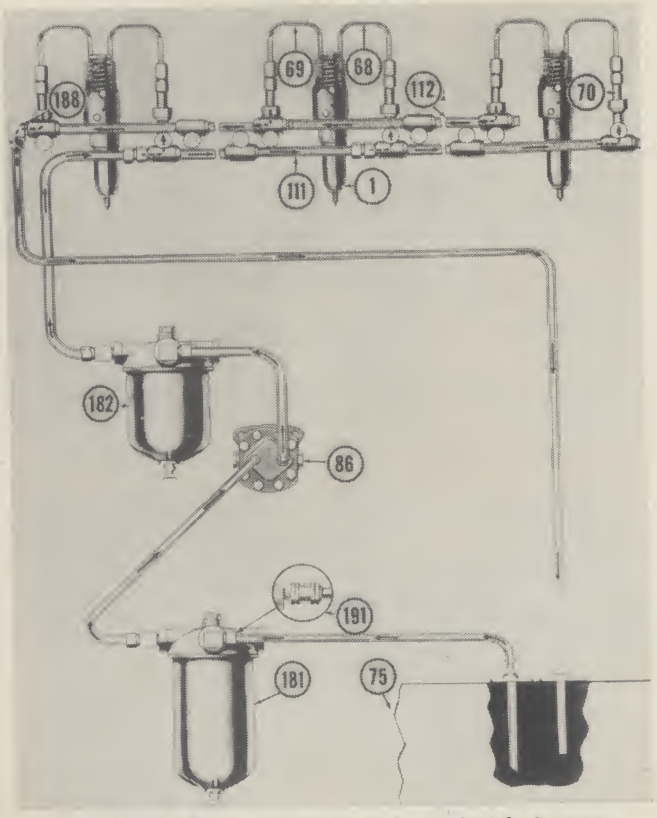


Fig. 0529B—Schematic diagram of a typical fuel system.

1. Injector
68. Inlet pipe
69. Outlet pipe
70. Fuel connector
86. Fuel pump
111. Inlet manifold
112. Outlet manifold
181. Fuel strainer
182. Fuel filter
188. Restriction elbow
191. Check valve (industrial engines only)

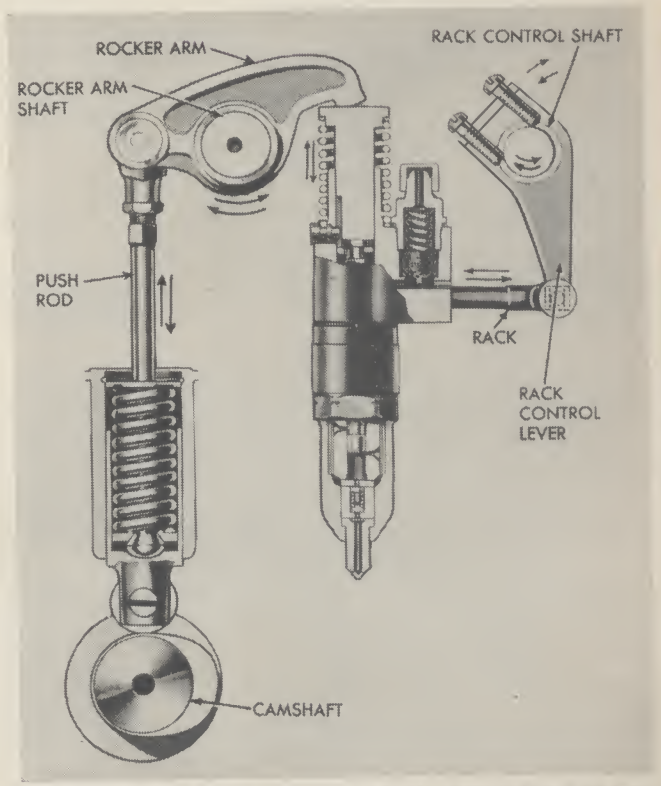
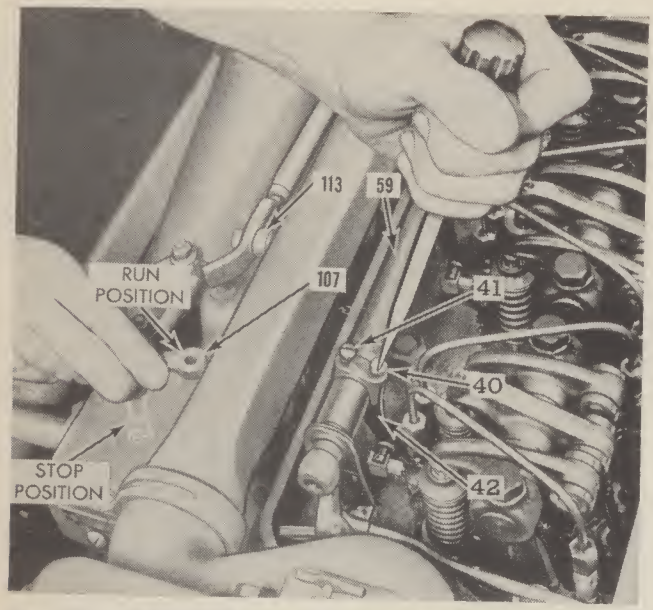


Fig. 0529C—GM 3-71 engines used in the Oliver Super 99 tractors are equipped with 70MM high valve unit type injectors.



42. Control tube lever
59. Injector rack lever control tube
107. Governor control lever
113. Variable speed control lever

Fig. 0530A—Position of injector racks are set with speed control lever in full-speed position. First synchronize position of No. 1 injector rack with the governor; then synchronize the position of all remaining racks to the No. 1 injector rack.

ed in the cylinder; that is, fuel or lube oil is being blown through the cylinder during the scavenging period. Check for internal fuel or lube oil leaks and for excessive oil supply in air cleaner cups.

White color of the exhaust smoke usually indicates a mis-firing cylinder. Check for faulty injectors, low compression, and low cetane fuel.

TUNE-UP

86. The following adjustments are necessary to completely tune-up a GM series 71 engine. Governor adjustments as listed apply to the variable speed type governor which is used on the GM 3-71 engine for the Oliver Super 99 tractor. Adjustments should be made after the engine has reached operating temperature.

A. Adjust exhaust valve tappet clearance to 0.009 hot.

B. Adjust injector timing on engine used in Oliver tractors to 1.460 inches for 70MM injectors with special tool J1853. If injectors are of 60MM type the timing dimension is 1.484 inches. Timing dimension for 80MM injectors is 1.460 inches. Refer to paragraph 90.

C. Adjust variable governor spring plunger setting (governor gap) to 0.005-0.007 as outlined in paragraph 103B.

D. Adjust injector rack control tube levers as outlined in paragraph 87.

E. Adjust engine idle speed to a no-load crankshaft speed of 500 rpm as outlined in paragraph 103C.

INJECTOR RACK CONTROL TUBE

87. **ADJUSTMENT.** Refer to Fig. 0530A. The position of the injector racks must be correctly set in relation to the governor. This relationship is established by adjusting the injector rack control tube lever for No. 1 cylinder first, and then synchronizing the position of all remaining injector rack control tube levers to the No. 1 injector rack.

To adjust the injector racks, proceed as follows: Remove tractor hood and engine rocker arms cover. Back out buffer screw on governor until it extends about $\frac{5}{8}$ inch from housing. Loosen, approximately three turns, adjusting and lock screws (40 & 41) on all injector rack control levers (42). Be sure that all levers swing freely on rack control tube. Place governor variable speed control lever (113) in full-speed position (rearward) and governor control lever (107) in the stop position.

Starting with No. 1 injector rack control tube lever, rotate adjusting screw (40) until screw just bottoms. Slowly move governor control lever (107) toward the run position, but do not force it past any point where resistance to movement is encountered. If resistance to movement is encountered hold governor control lever at this point, and back out the lever adjusting screw until governor control lever (107) can be moved without resistance. Lock the adjustment with lock screw (41).

Check the adjustment of No. 1 injector rack control tube lever as follows: Move governor control lever to extreme end of governor cam while noting the resistance required to move

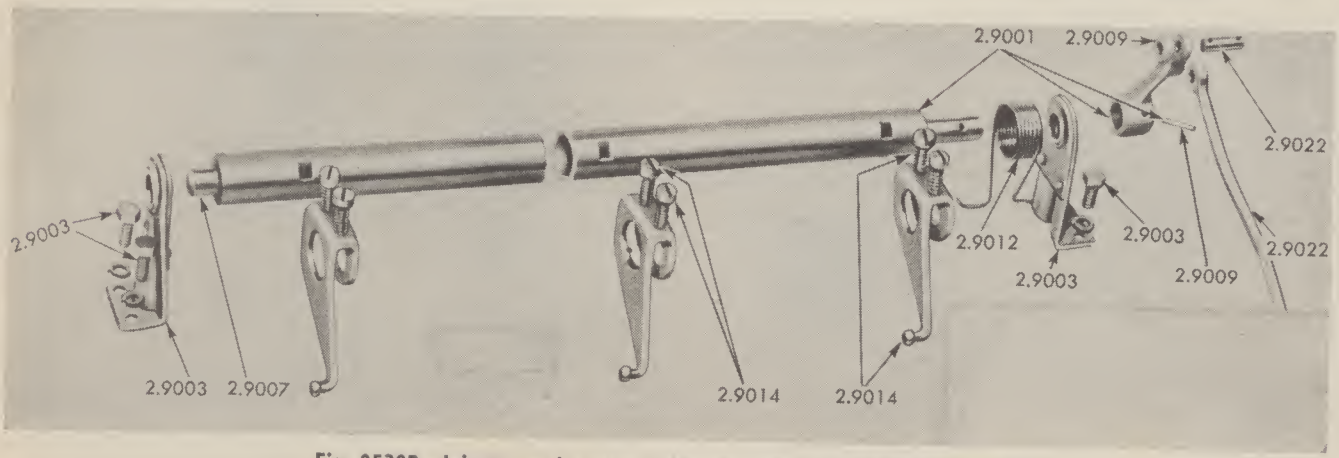


Fig. 0530B—Injector rack control tube and control tube levers assembly.

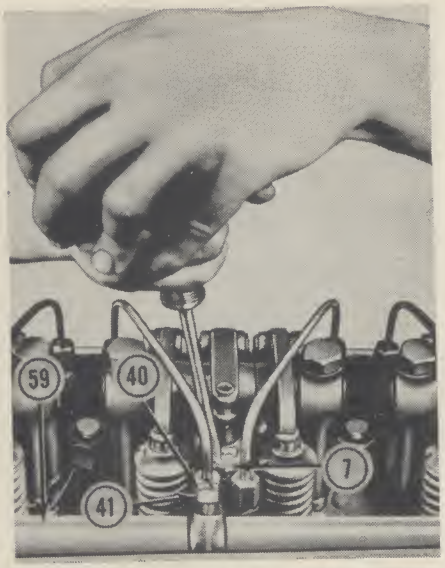


Fig. 0531A—To locate a misfiring cylinder, make the injector inoperative by holding down the injector follower guide (7) with a screw driver.

the lever. If a step-up in resistance is encountered, the injector rack is too tight. Correct this condition by slightly loosening the adjusting screw. Recheck adjustment.

If governor control lever can be moved to extreme end of governor cam without encountering any step-up in resistance, continue the check as follows: Hold governor control lever in full run position (extreme end of governor cam) and check for free movement at injector rack coupling by applying light finger pressure to coupling end of rack. If rack cannot be moved, the adjustment is okay. If injector rack can be moved with light finger pressure, the rack lever adjustment is too loose. Correct this looseness by slightly tightening the adjusting screw (40). Recheck the adjustment.

After the No. 1 injector rack control tube lever is correctly positioned, do not change this adjustment while adjusting the remaining injector rack levers.

87A. Adjust remaining rack levers as follows: Place and hold governor control lever in full run position (extreme end of governor cam). Rotate adjusting screw (40) on No. 2 control tube lever while checking for rotary movement at injector rack coupling. When rack coupling loses its rotary movement, lock the adjustment.

Check adjustment of No. 2 rack lever with that of No. 1 lever by comparing looseness or tightness of rack couplings. If No. 1 rack coupling feels loose, No. 2 rack is too tight. If No. 2 rack feels loose, it should be tightened. Do not change adjustment of No. 1 injector rack lever.

Adjust all remaining rack levers in a similar manner and always check the adjustment by comparing it with No. 1 injector rack.

88. **REMOVE AND REINSTALL.** To remove injector rack control tube and levers assembly, proceed as follows: Remove tractor hood and engine rocker arms cover. Remove governor control housing cover, and remove link which connects injector rack control tube to governor differential lever. Remove injector rack control tube bracket cap screws using a $\frac{7}{16}$ inch thin-wall socket. Lift control tube assembly up and away from cylinder head.

88A. When reinstalling the control tube assembly, position control tube spring so that the control tube will return injector racks to no fuel position. After installing the control tube assembly and before connecting the control tube lever to governor differential lever linkage, check for binding conditions between injector rack and rack operating lever on control tube. Changing position of control tube brackets on cylinder head or shifting control tube rack levers on control tube will sometimes correct a binding condition.

INJECTORS

89. The 70MM high valve injectors as used in the Oliver Super 99 tractor GM 3-71 Diesel engine are of the unit type, and are made by General Motors. The unit type fuel injectors, one for each cylinder, combines in a single unit all of the parts necessary to meter and inject fuel, create high fuel pressure, atomize fuel, and by-pass fuel through the injector body. By-passed fuel serves as a coolant and eliminator of air pockets.

89A. **LOCATING A MISFIRING CYLINDER.** If one engine cylinder is misfiring, it is reasonable to suspect a faulty injector. Generally, a faulty injector can be located by making each injector inoperative. As in checking spark plugs in a spark ignition engine, the faulty injector is one which, when it is made inoperative, least affects the running of the engine.

With engine running at idle speed, make the injectors inoperative, one at a time, by holding down the injector follower guide (7—Fig. 0531A) with a screw driver as shown.

89B. A misfiring cylinder because of dirt under the spray tip valve may be corrected by flushing the injector as follows: With engine operating, set throttle in idle position. Loosen, approximately six turns, both adjusting screws (40 & 41) on the rack control

G. Timing gage
LN. Lock nut
PR. Push rod
RA. Rocker arm
2. Injector body
7. Follower guide

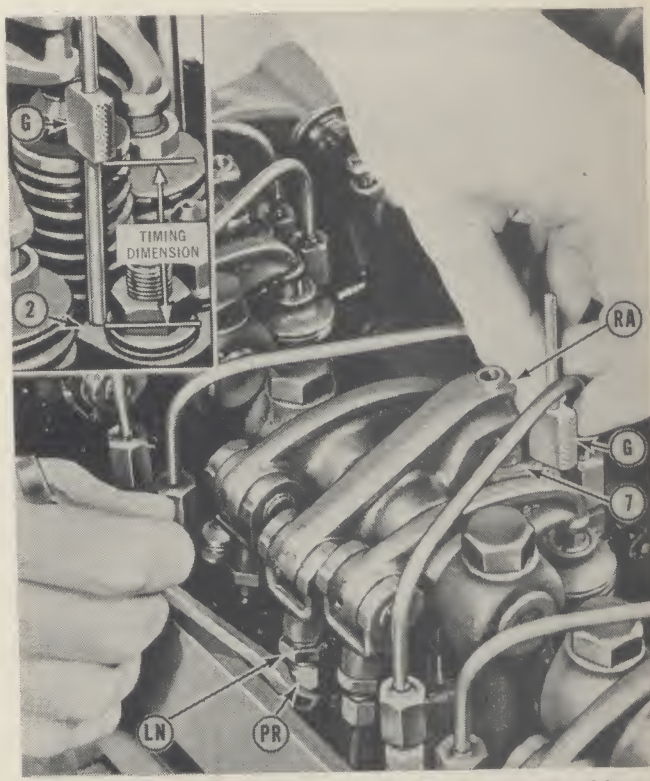


Fig. 0531B—Time injectors (synchronizing the no fuel position of each injector) by positioning the injector follower guide to a certain distance above the injector body. Timing dimension for 60 MM injectors is 1.484 inches; for 70 and 80 MM injectors, 1.460 inches.

lever of the injector to be flushed. Move the injector rack control lever into the full fuel position. This will cause a maximum amount of fuel to be forced through the injector. During this time the engine will detonate, but do not allow detonation to continue for more than a few seconds. If detonation does not occur, continued flushing of the injector will not correct a misfiring cylinder.

Remove and test the condemned injector as outlined in paragraphs 91 through 92E.

90. **TIMING INJECTORS.** This adjustment synchronizes the no fuel position of each injector by positioning the top surface of each injector follower guide (7) a certain distance, depending on the size of the injector, above the machined face of the injector body (2—Fig. 0531B). For Oliver tractors equipped with GM 3-71 engines using 70MM injectors this measurement is 1.460 inches and is made with a GM special timing gage J1853. For 60MM injector applications this measurement is 1.484 and is made with timing gage J1242. For 80MM injectors use data and gage applying to the 70MM injectors.

To time the injectors proceed as follows: Place governor control lever in no fuel (off) position. Rotate engine crankshaft until both exhaust valves are opened fully. Position injector timing gage so that one end of gage enters the drilled hole located in top surface of injector body. Loosen push rod lock nut (LN). Adjust injector rocker arm (RA) by lengthening or shortening rocker arm push rod (PR) until bottom face of timing gage head will just touch the top of injector follower guide (7). Tighten push rod lock nut and recheck the timing dimension.

Check and adjust the timing of each injector in a similar manner.

91. **R&R INJECTORS.** Refer to Fig. 0532A. To remove any or all injectors, proceed as follows: First remove tractor hood and engine rocker arms cover. Remove fuel lines (68 & 69), connecting inlet and outlet fuel manifolds to injector body. Cover each fuel fitting with a shipping cap to prevent dirt from entering the injector and fuel lines.

Rotate engine crankshaft so that the clevis pins of the three rocker arms for one cylinder are on the same plane. Remove rocker arms shaft support bolts, then swing rocker arms assembly over and away from the valves and injector.

Remove injector hold-down clamp (36) and special washer (38). Using GM tool J1227-A or equivalent placed under the injector body, free the injector from its seat. Lift injector from its seat while disengaging the injector rack from the control lever.

91A. After installing the injector, torque tighten the injector clamp retaining nut to 20-25 ft. lb.

Time injectors as outlined in preceding paragraph 90, and adjust injector rack control tube levers as outlined in paragraphs 87 and 87A.

92. **INJECTOR BENCH TEST.** Refer to Fig. 0534. The unit type injector must pass five different bench tests. The five tests are: Rack freeness, binding plunger, spray tip orifice, valve opening pressure, and holding pressure. The latter three tests require an injector test fixture.

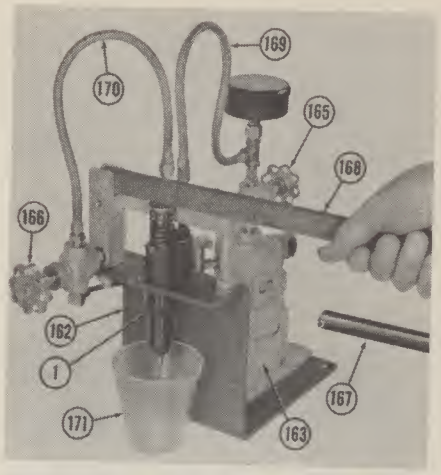


Fig. 0533A—Test fixture set-up for popping the injector to check spray tip orifices.

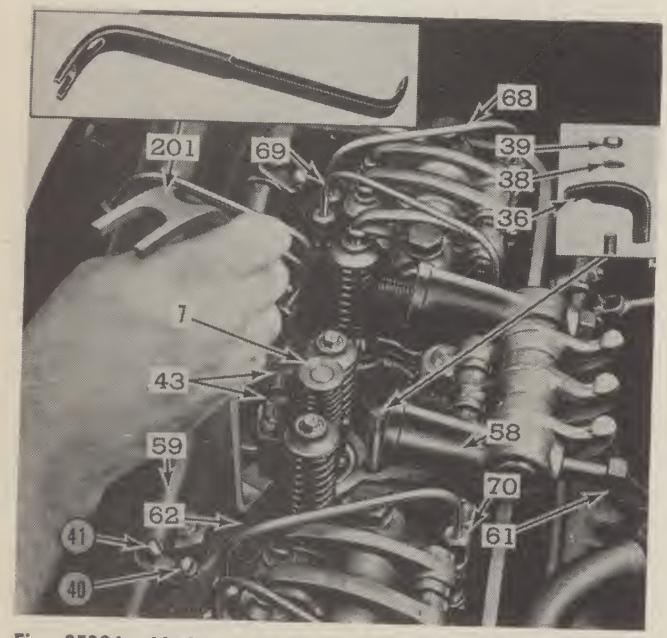
169. Fuel supply line 170. Fuel return line

The extreme pressure of the injector spray is dangerous and can cause the fuel to penetrate the human flesh. Avoid this source of danger when checking injectors by directing the spray away from your person.

92A. RACK FREENESS TEST. If the various parts of the injector have been assembled correctly or are free of defects and dirt, the injector rack (24) will move through its full length by its own weight.

Hold injector in a horizontal plane with coupling end of rack facing up. Now, turn injector about its long-axis until coupling end of rack points downward. The rack should move through its full length by its own weight.

92B. BINDING PLUNGER TEST. To check for a binding plunger (17) in



36. Injector hold down clamp
59. Injector rack lever control tube
68. Fuel inlet pipe
69. Fuel outlet pipe

Fig. 0532A—Method of removing an injector with GM tool J 1227-A.

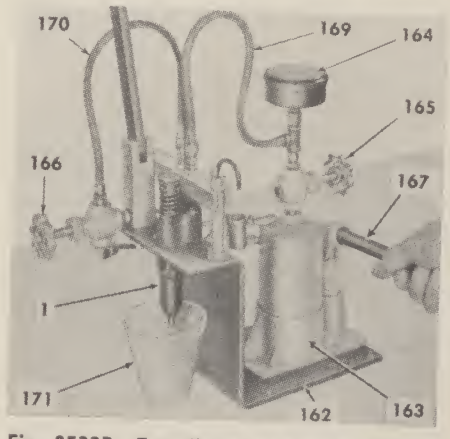


Fig. 0533B—Test fixture set-up for testing injector valve opening pressure and valve holding pressure.

169. Fuel supply line 170. Fuel return line

plunger bushing (18) install injector spring side up in a holding fixture or test fixture. Depress plunger (17), then release it while noting its action on the return stroke. Perform this test with injector rack in full fuel position, no fuel position and midway between these two positions.

A sticking plunger will show up as a slow return when the depressed plunger is suddenly released. A free plunger will return with a definite snap.

92C. SPRAY TIP ORIFICE TEST. This test is called the popping test. Refer to Fig. 0533A. Mount injector in a test fixture. Keep the injector supplied with fuel at 10-15 psi gage pressure. Operate the injector test fixture popping handle (168) at 60 strokes per minute while observing the spray pattern. An equal amount of fuel should be discharged in a fogged condition from each of the seven orifices.

92D. VALVE OPENING PRESSURE TEST. This test is made to determine the condition of the valve sealing surfaces of items (29, 30, 32, 33 & 34—Fig. 0534) and the condition of spray tip valve spring (31). The test should not be confused with the actual injection pressure because after the valve opens the fuel pressure continues to increase until injection is completed.

To make the valve opening pressure test, mount injector in a test fixture. Operate fuel supply pump on test fixture with even strokes while noting gage pressure reading when injector sprays fuel. Injector should start spraying fuel between 350 to 850 psi. A gage reading of less than 350 psi indicates either dirty or defective valve sealing surfaces.

92E. HOLDING PRESSURE TEST. This test is made for three reasons. The first reason is to determine the condition (clearance) of plunger (17—Fig. 0534) and bushing (18). The other

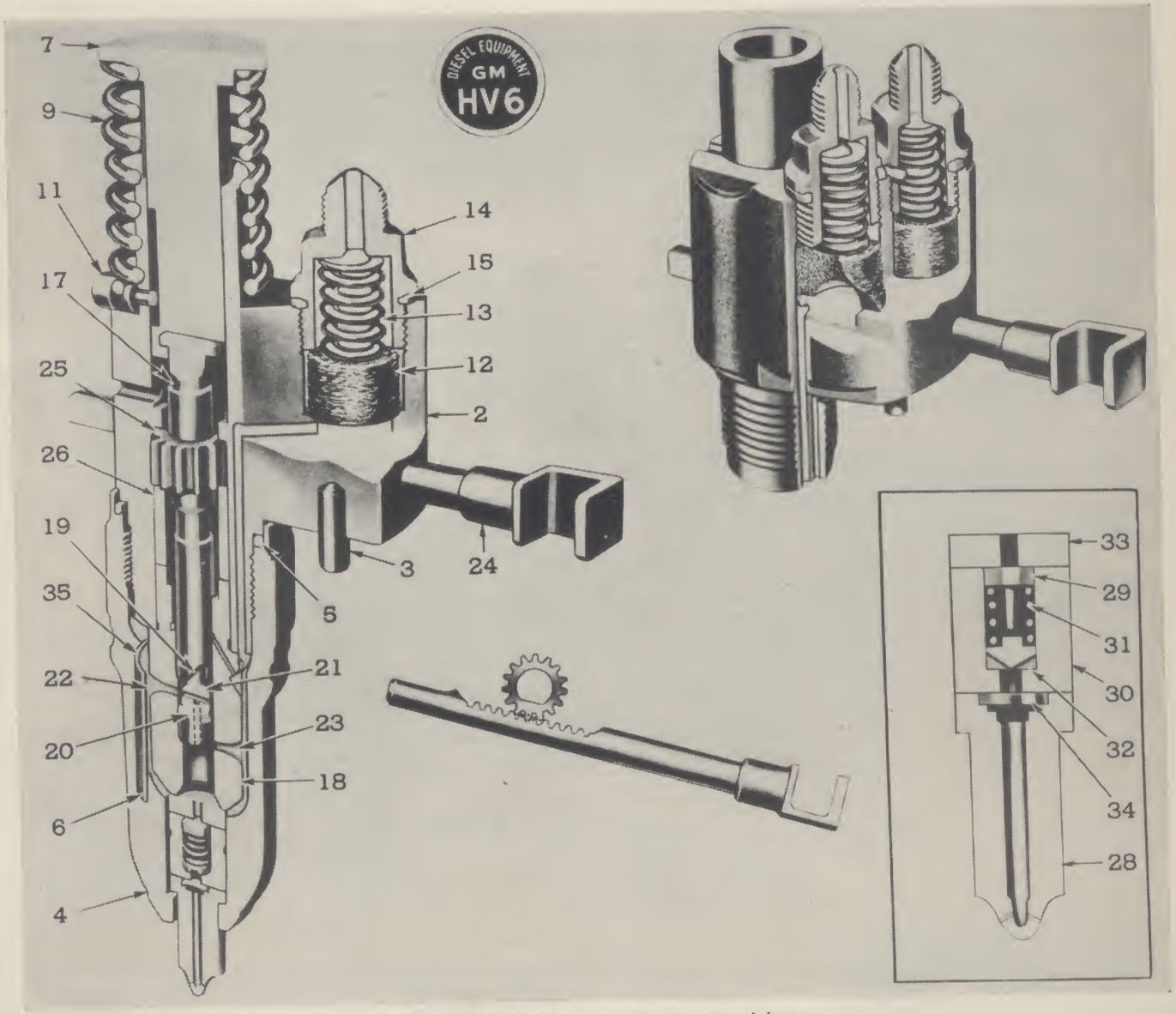


Fig. 0534—A GM engine high valve type injector.

2. Injector body
3. Dowel
4. Injector nut
5. Rubber seal ring
6. Spill deflector
7. Injector follower
9. Plunger spring
11. Stop pin
12. Filter
13. Spring
14. Cap
15. Gasket, copper
17. Plunger
18. Plunger bushing
19. Upper helix on plunger
20. Lower helix on plunger
21. Metering recess
22. Upper port
23. Lower port
24. Rack
25. Gear
26. Gear retainer
28. Spray tip
29. Spray tip valve
30. Valve cage
31. Valve spring
32. Valve stop
33. Valve seat
34. Check valve
35. Fuel supply chamber

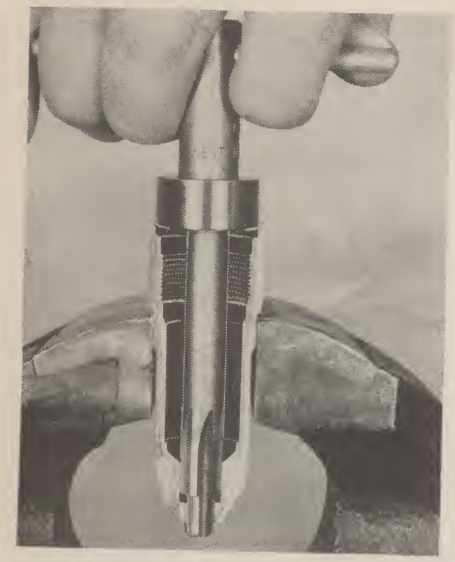


Fig. 0535A—Cleaning carbon from spray tip seat in injector nut with GM tool J4986-1.

reasons are: To determine if there is internal leakage between plunger bushing (18) and injector body, and to determine if there are any internal leaks at the seal ring, spray tip or injector body fuel line fittings.

Refer to Fig. 0533B. To make the hold pressure test, operate fuel supply pump on test fixture until gage pressure is just below the popping or minimum valve opening pressure of 350 psi. Lock this pressure in the injector by turning pump valve (165) to the closed position; then observe pressure drop on gage.

The time required for gage pressure to drop from 350 psi to 150 psi should not exceed 50 seconds for a new injector or 35 seconds for a used injector. If pressure drop exceeds these limits, locate the leak as follows: Thoroughly dry outside of injector by blowing off excess fuel with compressed air. Operate fuel pump occasionally to maintain testing pressure while looking for moist spots of fuel. A leak at the rack opening in injector body indicates either excessive clearance between plunger and bushing or a defective fit between bushing and injector body. A dribble or drop of fuel at the spray tip orifices indicates faulty sealing surfaces in the valve parts.

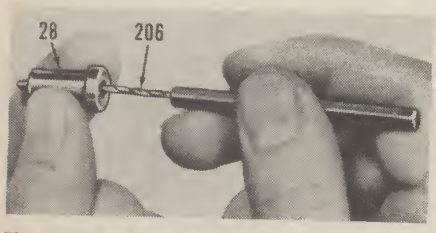


Fig. 0535B—Reaming injector spray tip with GM tool J 1243.

93. **INJECTOR OVERHAUL.** The GM unit type injector can be partially disassembled either for inspection and cleaning of the spray tip and valve parts, or for inspection of the plunger, plunger bushing, rack and gear.

Unless the shop is equipped with the necessary tools and a test fixture, servicing of injectors should not be attemped. For shops equipped to service GM unit type injectors, the following data can be used and applied.

93A. SPRAY TIP. Refer to Fig. 0536B. To disassemble the injector spray tip, proceed as follows: Carefully clamp injector body in a vise or special fixture, and remove injector nut (4) from injector body. The injector nut contains the spray tip (28), valves and valve seats (items 29, 30, 32, 33 & 34), valve spring (31) and spill deflector (6). Removal of the injector nut will release the plunger bushing (18) from injector body. Handle injector spray tip, bushing and the related valves with care as the sealing action between each part depends on a lapped surface.

If the spray tip cannot be removed from the injector nut because of carbon, proceed as follows: Place injector nut with open side on a wood surface. Using hollow brass tubing placed on the shoulder of spray tip, bump spray tip out of injector nut. The inside diameter of the brass tube must be large enough so that tube contacts only the outside edge or shoulder of the spray tip.

Wash all injector parts in clean fuel oil.

93B. Since sealing action of the various valve parts depends on a lapped mirror finish surface, carefully inspect these parts with a magnifying glass. Slight imperfections such as burrs, scratches and stains can be removed effectively by lapping. Parts which are damaged, scored, pitted or chipped should be renewed. Injector bushing and plunger are supplied only as a matched set.

Clean carbon deposits from spray tip seat and bore in injector nut with a special reamer, GM special tool J4986-1 or equivalent, as shown in Fig. 0535A. Carefully operate the reamer during this cleaning process so as to prevent removal of any metal.

The inside of the injector spray tip can be cleaned with a spray tip reamer, GM Special tool J1243 or equivalent, as shown in Fig. 0535B. Clean the seven orifices in the spray tip with 0.007 diameter wire. Before using the wire, remove any sharp burrs on the wire with a fine grade abrasive stone. Carefully inspect the spray tip orifices.

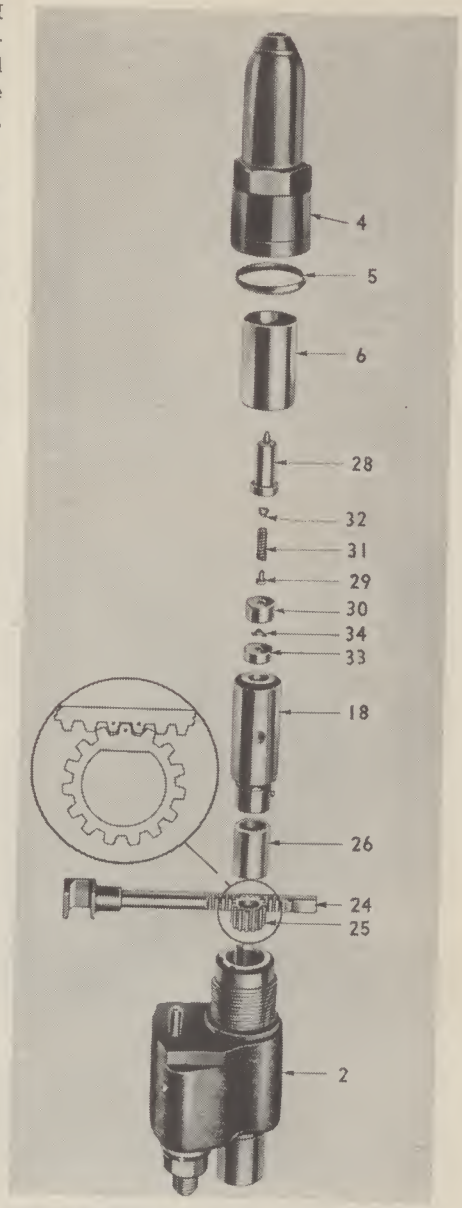


Fig. 0536B—Injector rack, gear, and spray tip details and relative location of parts. Refer to Fig. 0534 for legend.

18. Plunger bushing
28. Spray tip
29. Spray tip valve
30. Valve cage
33. Valve seat
34. Check valve

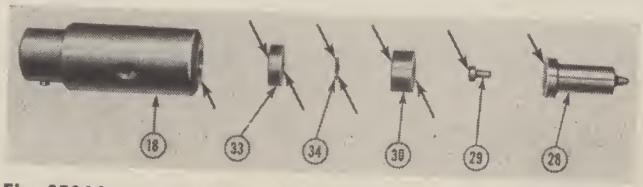


Fig. 0536A—Arrows indicate injector sealing surfaces which may require lapping.

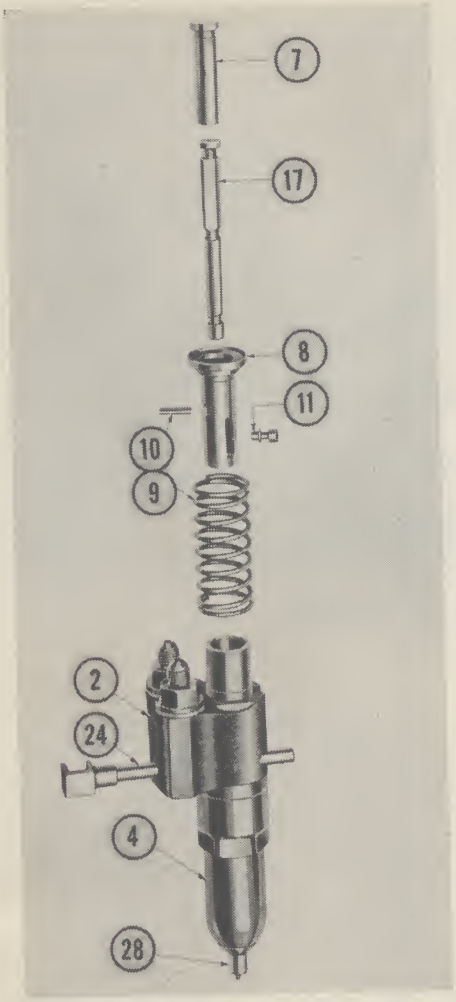


Fig. 0537A— Non high valve type injector plunger and follower details. Follower (7) and guide (8) are integral on high valve type injectors.

2. Injector body
4. Injector nut
9. Plunger spring
10. Follower pin (used on non high valve types only)
11. Stop pin
17. Plunger
24. Rack
28. Spray tip

Fig. 0537B—Checking concentricity of injector spray tip to injector nut with GM tool J 5119.

Sealing surfaces of the injector which may require lapping are indicating in Fig. 0536A. These surfaces should be lapped on a suitable lapping block with lapping compound or Carborundum H40, 600 grain size Norton Alundum or equivalent. Light pressure lap the sealing surfaces, using a figure 8 motion, until surface is flat. Then, wash the part in clean fuel oil and dry lap the surface of the part to a mirror finish. Dry lapping or mirror finishing should be done on a different lapping block than that used for abrasive lapping. Thoroughly wash and inspect the parts frequently during the lapping process.

93C. Reassemble spray tip and related valve parts to the injector body in the order as shown in Fig. 0536B. Install a new injector nut to body gasket on injector body. Place recessed side of valve seat (30) over check valve (34). Lubricate the injector nut threads and carefully place the nut, containing spill deflector, over the assembled valve parts. Hand tighten injector nut while rotating end of spray tip to make certain that none of the valve parts have shifted. Torque tighten the injector nut to 55-65 ft. lb.

After torque tightening the injector nut, check the outside surface of the spray tip for concentricity to the outer surface of the injector nut as shown in Fig 0537B. Spray tip and injector nut must be concentric within 0.008 total indicator reading. If indicator reading exceeds 0.008, loosen injector nut and recenter the spray tip until the reading is within the recommended runout.

93D. COMPLETE DISASSEMBLY. Refer to Fig. 0537A. The injector can be completely disassembled as follows: Support injector in a holding fixture or vise. Compress plunger spring (9) by hand, then raise the spring from stop pin (11) with a screw driver and withdraw the pin as shown in Fig. 0538B. Remove follower guide (8—Fig. 0537A) which is used only on non high valve injectors, follower (7), plunger spring (9) and plunger (17) from injector body (2). On non high valve injectors remove the follower pin (10) to separate the previously mentioned parts.

Remove injector nut, spray tip, valve parts and plunger bushing from injector body as outlined in paragraph 93A.

Bump lower side of injector body on a piece of wood to jar gear retainer (26—Fig. 0536B) and gear from injector body. Pull rack (24) out of injector body.

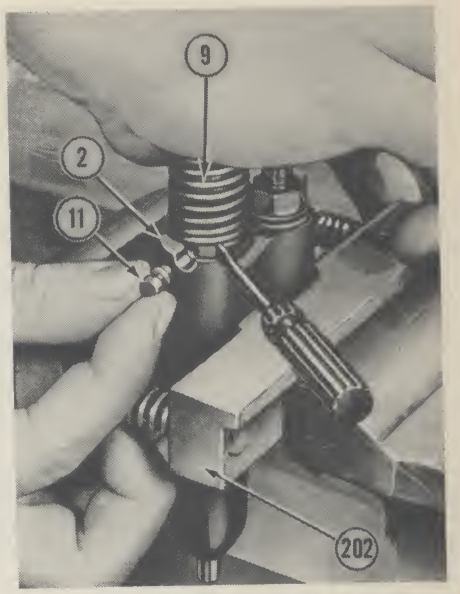


Fig. 0538B—Showing method of removing stop pin (11) to remove injector plunger.

Remove the two fuel filter caps (14—Fig. 0539), filters (12) and springs (13) from injector body.

Carefully handle and thoroughly wash all injector parts with a soft bristle brush in clean fuel oil. Inspect and if necessary lap the injector spray tip and valves as outlined in paragraph 93B.

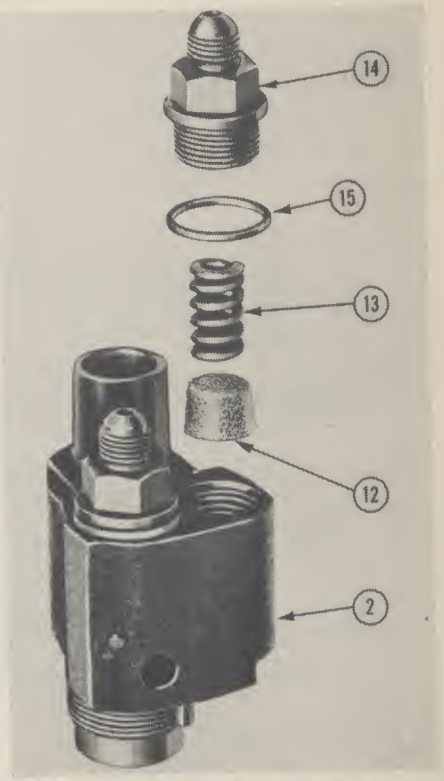


Fig. 0539—Details of injector filters, spring, and caps.

2. Injector body
12. Filter
13. Spring
14. Filter cap
15. Gasket, copper

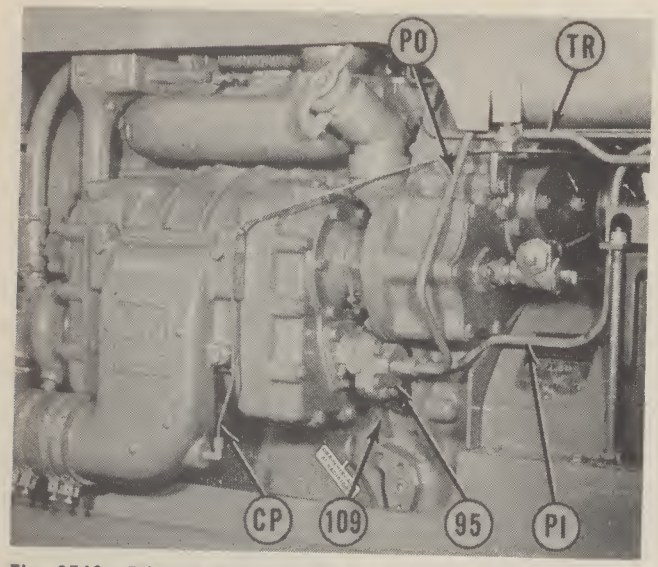


Fig. 0540—Primary fuel supply pump which is mounted on the blower is driven by the lower rotor shaft of the blower.

CP. Chevron starting aid primer line
PI. Pump inlet line
PO. Pump outlet line
TR. Governor control rod
95. Fuel pump
109. Fuel pump drain

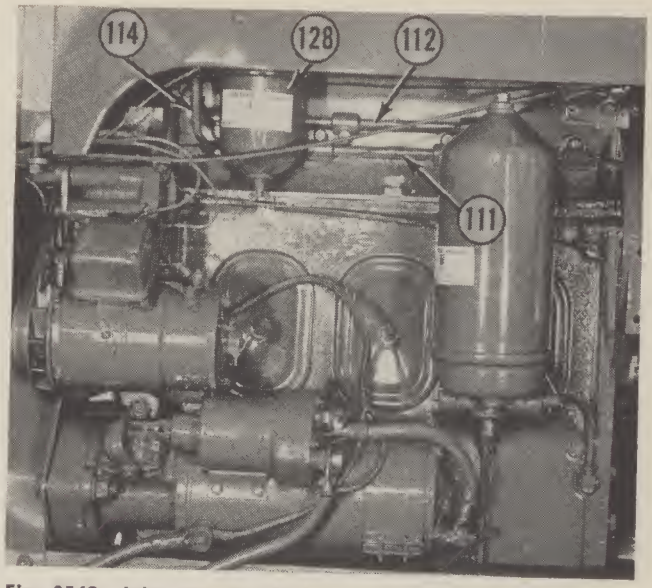


Fig. 0543—Inlet fuel manifold (111) and outlet fuel manifold (112) are located on right side of cylinder head.

114. Restricted fitting
128. Secondary fuel filter

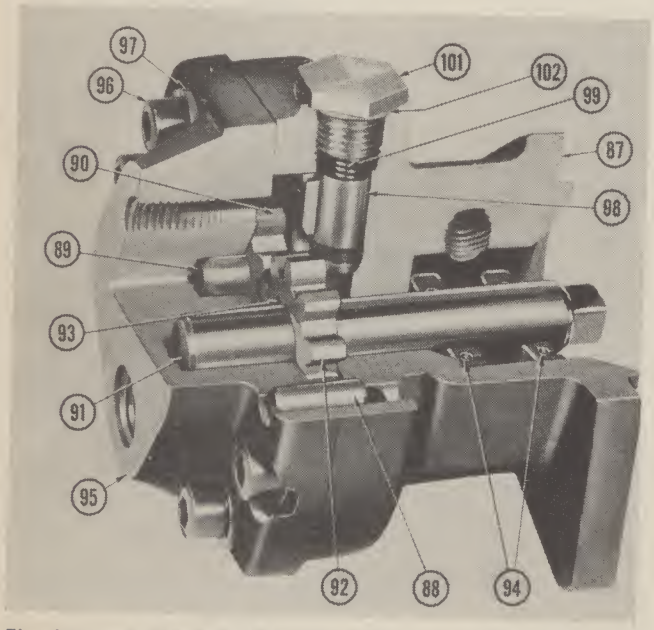
Inspect and clean both the plunger bushing and plunger with clean fuel oil and tissue. Do not attempt to polish these highly finished surfaces. If for any reason either of these parts require renewal, both the plunger and bushing should be renewed as a matched pair.

93E. Reassemble the injector gear and rack as follows: Insert rack in injector body so that marked teeth on rack are visible from gear retainer side of the injector body. Holding the rack in this position, slide gear (25) into engagement with gear rack so that gear and rack teeth marks are registered as shown in Fig. 0536B. Install gear retainer (26) to hold gear and rack in proper mesh.

Reassemble plunger bushing, spray tip and injector nut to injector body as outlined in paragraph 93C.

Reassemble the plunger, spring and related parts to injector body by reversing the disassembly procedure and with reference to Figs. 0534 and 0537A. Install new filters (12) with concave side of filter facing bottom of hole in injector body.

After reassembling the injector, make a bench test, involving five tests, as outlined in paragraphs 92 through 92E.



93. Ball (gear retaining)
94. Oil seals
98. Relief valve
99. Spring
102. Gasket

Fig. 0541—A GM engine primary fuel supply pump. Install oil seals (94) with lips facing drive end of shaft (91).

INJECTOR HOLE TUBES

95. To insure efficient injector cooling, each injector is inserted into a thin-walled copper tube (40 — Fig. 0505A) which passes through the water jacket in the cylinder head. The copper tube is flared-over at the lower end and sealed at top with a neoprene ring.

To renew the tubes which involves removal of the cylinder head, refer to paragraphs 61C and 61D.

PRIMARY FUEL SUPPLY PUMP

99. The GM 71 series Diesel engine is equipped with a gear type primary fuel supply pump, Fig. 0540, which is mounted on the blower assembly and is driven by the lower rotor shaft of the blower. This pump provides a continuous flow of fuel from the supply tank through the fuel chambers within the injectors and then, back to the tank. A restriction (114—Fig. 0543) placed in the outlet elbow of the outlet fuel manifold (112) provides sufficient resistance to maintain a fuel pressure of 60-65 psi throughout the fuel system.

99A. **SEAL LEAKAGE.** The two tapped holes located in lower side of pump body carry off fuel oil which passes the pump shaft seals. If leakage exceeds one drop per minute when checked at fuel pump body drain tube (109—Fig. 0540), the seals must be renewed. Pump shaft oil seals are installed with their lip facing drive end of pump.

99B. **FUEL FLOW CHECK.** To check fuel flow, disconnect fuel return line

at supply tank. Operate engine at 1200 rpm and measure the fuel flow for a period of one minute. At least one half gallon of fuel should flow from the return line in one minute.

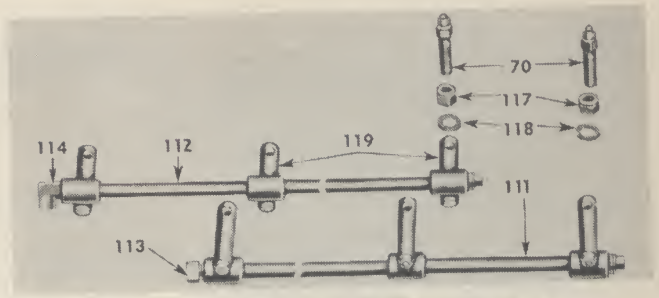
If fuel flow is insufficient check for air leaks in fuel system by immersing end of fuel return line in clean fuel oil. Air bubbles indicate an air leak on the suction side of the pump. Also check for a restricted fuel strainer on suction side of pump, for a restricted fuel filter on outlet side of pump or for an inoperative pressure relief valve which is located in the pump body. Pressure relief valve can be removed without removing the pump assembly.

99C. **REMOVE & REINSTALL.** To remove fuel pump proceed as follows: Disconnect suction and pressure lines from pump. Remove three cap screws which attach pump to blower housing and lift pump from blower. Copper type flat washers are used with the three attaching cap screws.

Non-adjustable pump pressure relief valve can be removed without removing the pump assembly from blower housing. Pressure relief valve opens at 60-65 psi.

99E. **DISASSEMBLE & OVERHAUL.** Refer to Figs. 0541 and 0544. Disassembly of the pump is self-evident after an examination of the unit.

Pump shaft (91) rotates in unbushed bores of the pump body. Install pump driven gear (90) with slot in face of gear facing pump cover. Install the two lip type oil seals (94) with lips facing drive end of pump. The pump body and cover are assembled without a gasket.



70. Fuel connector
111. Inlet manifold
112. Outlet manifold
113. Fitting
114. Restricted elbow
117. Lock nut
118. Washer, copper
119. "T" connector

Fig. 0544A—GM engine fuel manifold details.

FUEL MANIFOLDS

100. Refer to Figs. 0543 and 0544A. Two fuel manifolds, one an inlet (111), the other an outlet (112), are mounted on the right side of the cylinder head. These fuel manifolds plus short detachable pipes complete the flow of fuel from the supply pump to the injectors and from the injectors to supply tank. A restriction placed in the outlet fuel manifold elbow (114) provides sufficient resistance to maintain a fuel pressure of 60-65 psi in the fuel circuit. The restricted elbow fitting can be identified by a letter "R"

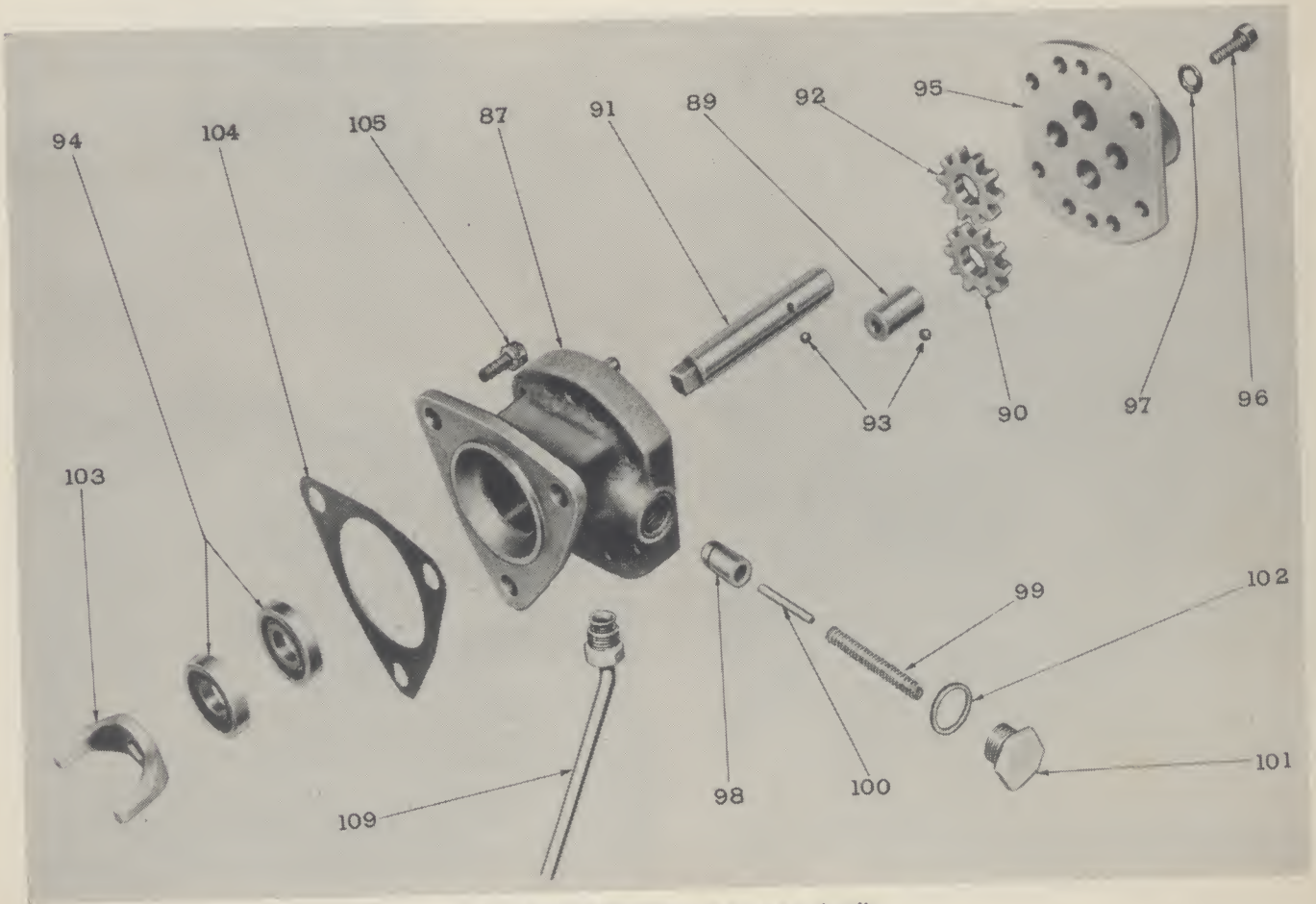


Fig. 0544—GM engine fuel pump details.

87. Pump body
89. Shaft, driven
90. Gear, driven
91. Shaft, drive
92. Gear, drive
93. Ball, gear retaining
94. Oil seals
95. Cover
98. Relief valve
99. Spring
100. Pin
102. Gasket
103. Coupling
104. Gasket
109. Fuel pump drain line

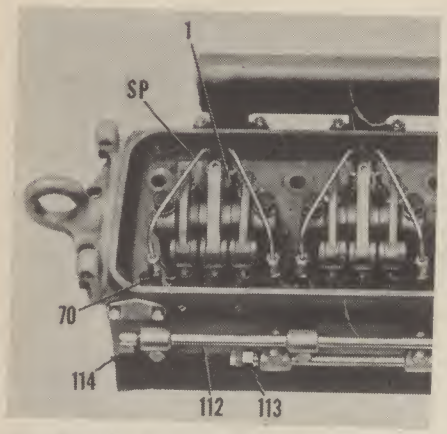


Fig. 0546A—Fuel manifold assembly installation. Refer to Fig. 0544A for legend.

stamped on the body of the fitting.

100A. To remove either fuel manifold, proceed as follows: Remove tractor hood, engine rocker arms cover and secondary fuel filter (128). Remove inlet and outlet pipes connecting injectors to fuel manifold. Remove cap screws attaching manifold "T" connectors (119) to cylinder head. Remove fuel connectors (70) that seat into tapered seats which are located in the manifold "T" connectors. Remove manifolds.

When reinstalling fuel manifolds, install and tighten fuel connectors (70) before installing cap screws attaching manifold "T" connectors to cylinder head. After installing the fuel manifold check for fuel leakage where the "T" connecters enter the cylinder. head. Fuel leakage at this point indicates a faulty seal between the fuel connectors and "T" connectors.

DIESEL STARTING AID

101. A chevron type ether priming system, utilizing ether filled cartridges, is used as a starting aid in cold weather. This element is used in lieu of the manifold pre-heater which is used on some of the other Oliver Diesel powered tractors. Control of the ether injector is located on a subpanel, bolted to the instrument panel. Servicing procedures are conventional.

GOVERNOR
(GM Diesel 71 Series)

A flyweight, variable speed centrifugal governor, Fig. O548A, which is located on the left side of the engine is used on the GM engine for the Oliver tractor. Governor receives its drive from the upper rotor shaft of the blower.

ADJUSTMENT

103. The three main adjustments on the variable speed governor are: A. Governor Spring Plunger Setting or Governor Gap, B. Engine Idle Speed Adjustment and C. Maximum No-load Speed Adjustment. A fourth adjustment, considered minor, is the throttle booster spring adjustment. All governor adjustments should be made with engine at operating temperature.

103A. **HIGH SPEED ADJUSTMENT.** High speed no-load crankshaft rpm of 1840 is obtained by varying the number of shims (102) which are located between variable speed spring (101) and spring retainer (104). Add shims, available in thicknesses of 0.015 and 0.078, to increase the speed.

Shims are accessible after removing tractor hood, governor control housing cover (3), and two cap screws attaching variable speed spring hous-

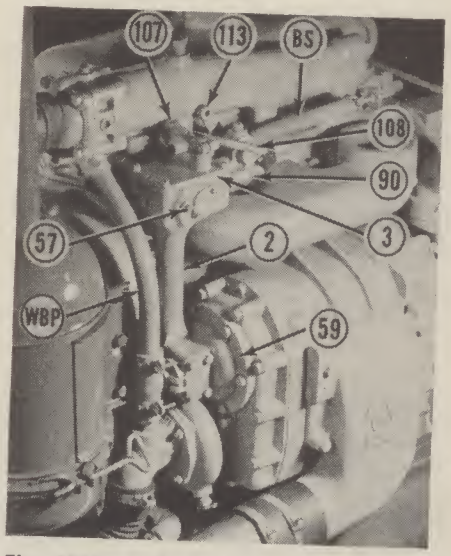


Fig. 0548—A GM engine variable speed type governor installation.

BS. Booster spring
WBP. Water by-pass
2. Control housing
3. Cover
57. Buffer screw
59. Weight housing
90. Variable speed spring housing
107. Control lever
108. Lever retracting spring
113. Speed control lever

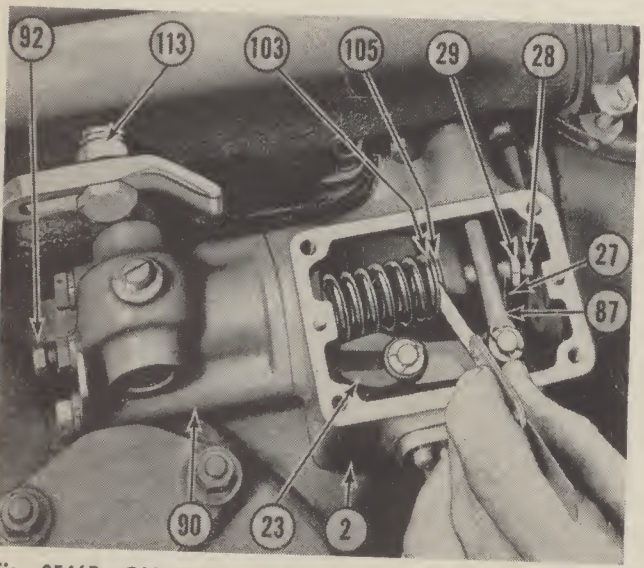


Fig. 0546B—GM engine variable speed type governor spring plunger setting (governor gap) of 0.005-0.007 is measured between spring plunger (103) and plunger guide (105) when speed control lever (113) is at one-half speed or better. Capscrew (28) controls this setting.

2. Control housing
23. Differential lever
27. Operating shaft lever
29. Lock nut
87. Injector rack control tube to governor link
90. Variable speed spring housing
92. Idle speed adjusting screw
103. Spring plunger
105. Spring plunger guide

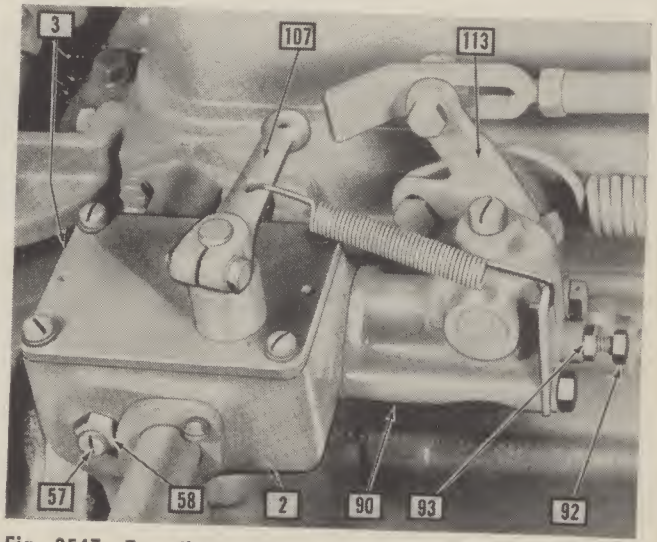


Fig. 0547—To adjust engine no-load idle speed to 450 rpm, place speed control lever (113) in idle position (forward) and rotate screw (92) in or out.

2. Control housing
3. Cover
57. Buffer screw
90. Variable speed spring housing
107. Control lever

ing (90) to governor control housing (2).

103B. **GOVERNOR SPRING PLUNGER SETTING (TORQUE CONTROL).** To obtain proper performance and full engine power, the governor spring plunger (103—Fig. 0546B) must be adjusted correctly in relation to the spring plunger guide (105). This is referred to as the governor gap adjustment.

To adjust governor gap, first remove tractor hood and governor control housing cover. Place speed control lever (113) at one-half speed position or better so as to place spring tension against the spring plunger. Governor gap adjustment of 0.005-0.007 between spring plunger guide (105) and spring plunger (103) can be obtained by rotating the gap adjusting screw (28) which is located in the operating shaft lever.

After adjusting the governor gap, check adjustment of injector racks as outlined in paragraphs 87 and 87A.

103C. **IDLE SPEED ADJUSTMENT.** Refer to Fig. 0547. Start and warm-up engine. Place variable speed control lever (113) in the idle position, making sure it is all the way forward. If engine surges excessively, rotate buffer screw (57) just enough to eliminate the surge. Rotate idle speed adjusting screw (92) to obtain recommended no-load crankshaft speed. Set engine idling speed 10 to 20 rpm below recommended speed of 500 rpm. If engine does not surge or roll, increase idling speed to recommended 500 rpm with buffer screw.

Recheck adjustment of buffer screw (57) as follows: Accelerate engine by moving variable speed control lever (113); then quickly return the engine to idle speed while observing the action of the injector racks and control tube. Injector racks and control tube should cease movement after one or two surges.

103D. **THROTTLE BOOSTER SPRING.** Refer to Fig. 0548. Adjust tension of throttle booster spring (BS) until variable speed control lever (113) can be moved rearward to the full throttle position with ease.

R&R AND OVERHAUL

104. Refer to Fig. 0548. Governor assembly consists of two main sub-assemblies which

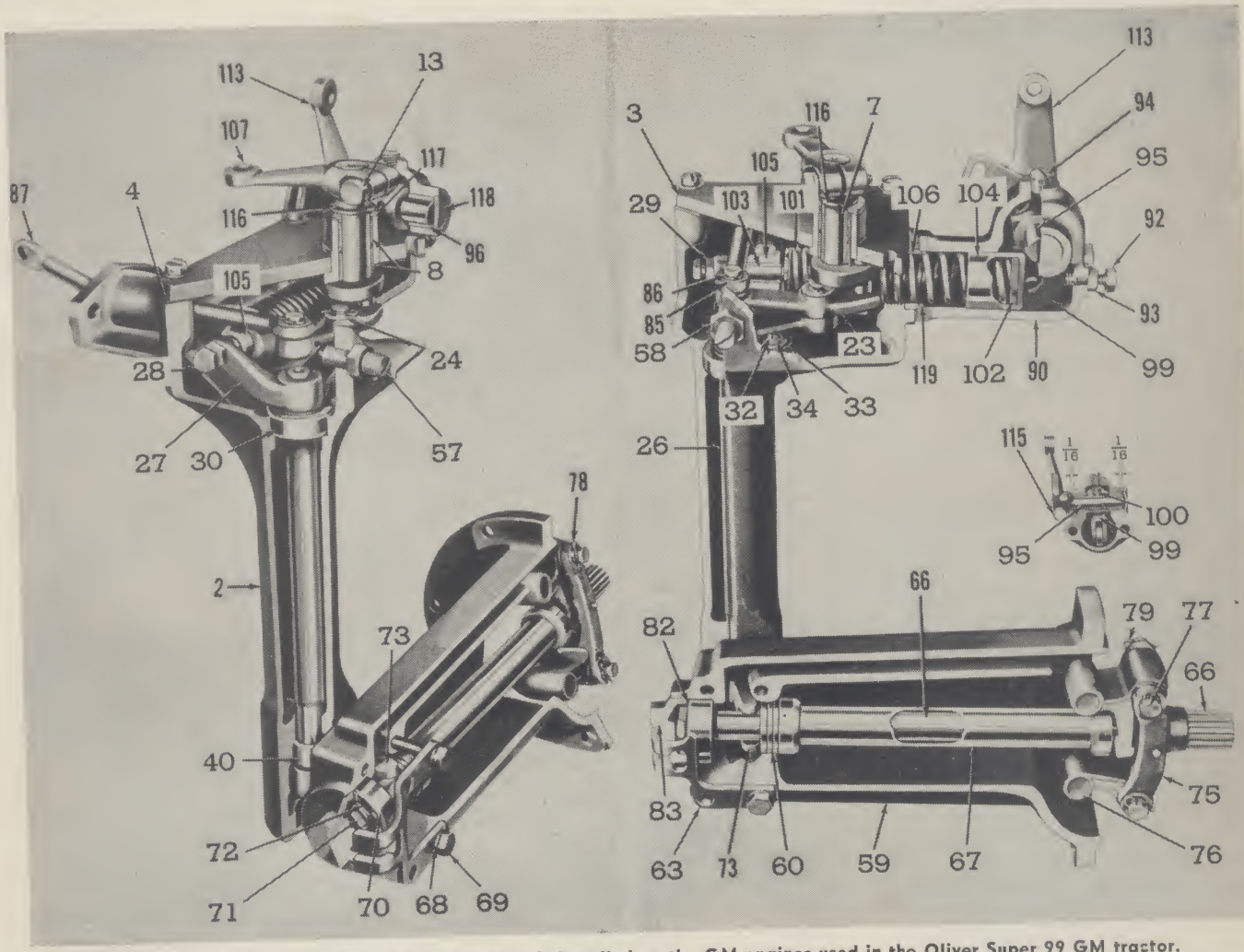


Fig. 0548A—A variable speed type governor is installed on the GM engines used in the Oliver Super 99 GM tractor.

2. Control housing
3. Cover
4. Gasket
7. Throttle shaft
8. Needle bearing
23. Differential lever
24. Washer
26. Operating shaft
27. Operating shaft lever
28. Gap adjusting screw
30. Bearing
32. Bearing retaining screw
40. Oilite bushing
57. Buffer screw
59. Weight housing
60. Riser thrust bearing
63. Cover
66. Weight shaft
67. Riser
70. Bearing
73. Operating shaft fork
75. Weight carrier
76. Weight
77. Weight pin
79. Snap ring
82. Gasket
83. Cap
86. Spring retainer
87. Injector rack control tube to governor link
90. Variable speed spring housing
92. Idle speed adjusting screw
96. Needle bearing
99. Spring lever
101. Variable speed spring
102. Shims
103. Spring plunger
104. Spring retainer
105. Spring plunger guide
106. Spring retainer stop
107. Control lever
113. Speed control lever
116. Retaining ring
117. Washer
119. Spring retainer stop spacer (not used in Oliver application)

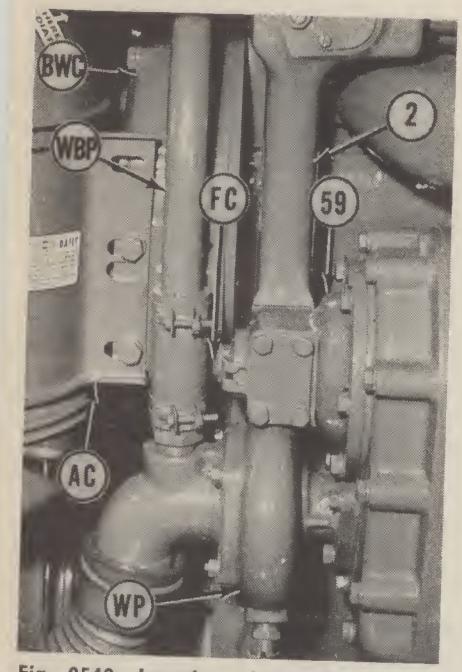


Fig. 0549—Location of the sharp corner (FC) on balance weight housing which interferes with complete removal of governor weight housing (59).

are: A. Weight Carrier Housing (59), and B. Control Housing (2).

104A. **REMOVE.** To remove the governor control housing (2) which is also called the governor tower, first remove tractor hood and engine rocker arms cover. Disconnect throttle booster spring (BS), retracting spring (108) and control linkage from variable speed control lever (113). Remove governor control housing cover (3); and remove linkage (87—Fig. 0548A) by disconnecting it from injector rack control tube lever, and differential lever (23). Remove two cap screws attaching governor control housing to cylinder head, and four cap screws attaching governor control housing to weight housing (59). Pull upper end of control housing away from cylinder head, and at the same time push lower end of control housing toward the engine to free the dowels. Lift off control housing. Governor weight housing is still attached to the blower.

104B. Governor carrier weight housing (59) can be removed after removing the governor control housing either by removing the blower, or modifying the air cleaner bracket mounting pad surface which is located on the balance weight cover. Modification of this surface involves filing or grinding off the sharp corner which interferes with removal of the weight housing.

To modify the air cleaner bracket mounting pad surface on the balance weight cover, proceed as follows: Refer to Fig. 0549. Remove water bypass tube (WBP). File or grind off the sharp corner of the mounting pad surface (FC) to produce a ½ inch radius, or just enough to permit removal of the weight housing.

Remove six cap screws attaching governor weight housing to blower. Separate weight shaft (66—Fig. 0554) from blower rotor shaft by pulling weight housing away from blower.

105. **OVERHAUL.** Herewith are procedures for overhaul of the components which make up the governor assembly.

105A. CONTROL HOUSING COVER. Refer to Fig. 0550. Needle bearings (8) for throttle shaft (7) can be renewed after removing control lever clamp bolt (89) and withdrawing the throttle shaft. Install new needle bearings so that lower bearing is flush with lower end of bearing boss, and upper bearing is approximately ⅛ inch below upper end of bearing boss.

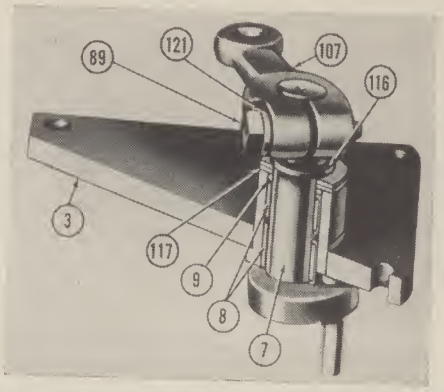


Fig. 0552—A GM engine variable speed type governor control housing cover.

7. Throttle shaft
8. Needle bearing
9. Seal ring
107. Governor control lever
116. Retaining ring
117. Seal ring washer

105B. SPRING HOUSING AND SPEED CONTROL LEVER SHAFT. Refer to Figs. 0550 and 0551. It is not necessary to remove governor control housing to service the units contained in the spring housing. First, remove governor control housing cover. Remove two cap screws attaching spring housing (90) to control housing; and remove spring retainer (104), shims (102), spring retainer stop (106), spring (101), speed spring plunger (103) and plunger guide (105).

Shims (102) (approximately a 0.325 shim pack) and spring retainer stop (106) are used to adjust crankshaft maximum no-load speed of 1840 rpm.

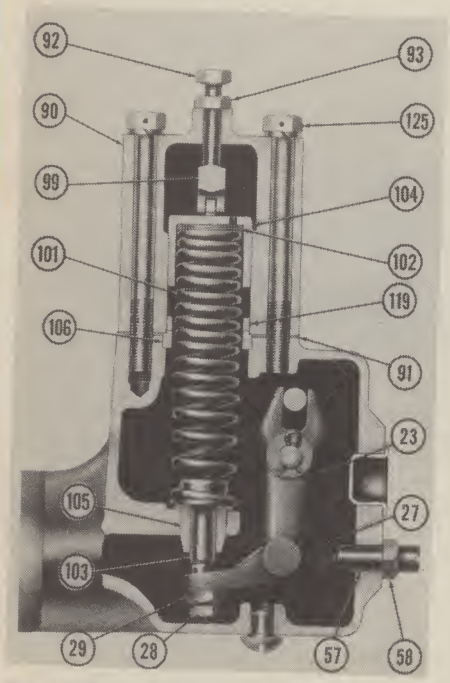


Fig. 0550 — Details of governor variable speed spring and lever.

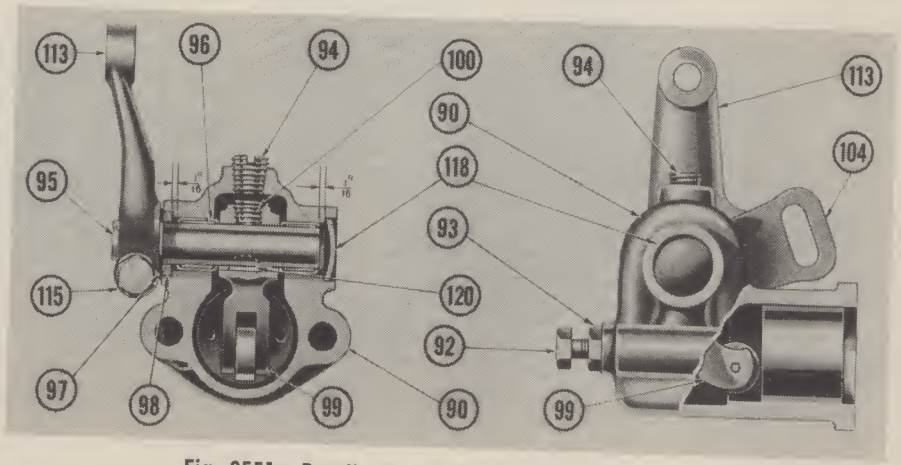


Fig. 0551—Details of variable speed spring housing.

23. Differential lever
27. Operating shaft lever
28. Governor gap adjusting screw
57. Buffer screw
90. Spring housing
92. Idle speed adjusting screw
95. Spring lever shaft
96. Needle bearings
97. Washer
98. Packing
99. Spring lever
100. Set screw
101. Variable speed spring
102. Shims
103. Spring plunger
104. Spring retainer
105. Spring plunger guide
106. Spring retainer stop
113. Speed control lever
119. Spring retainer stop spacer (not used in Oliver application)
120. Woodruff key

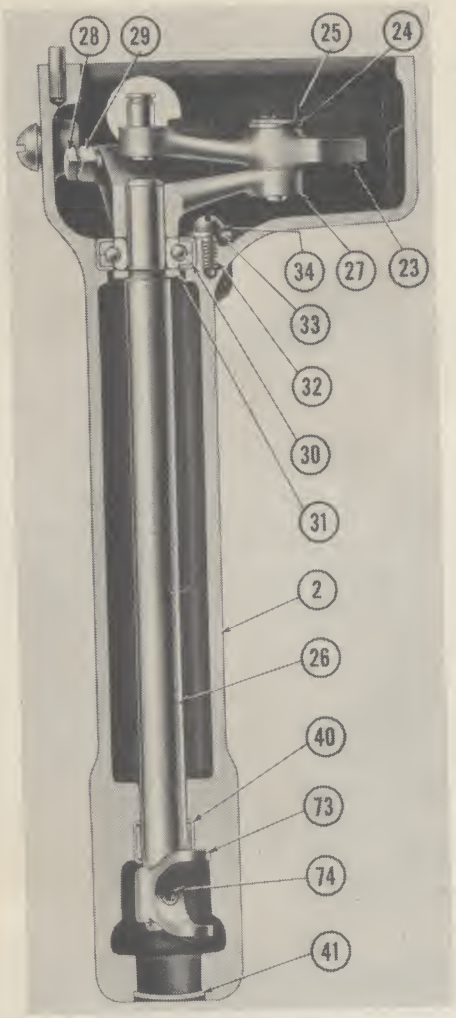


Fig. 0553—Details of variable speed type governor control housing.

2. Control housing
23. Differential lever
24. Washer
25. Retainer
26. Operating shaft
27. Operating shaft lever
28. Governor gap adjusting screw
30. Bearing
32. Bearing retaining screw
40. Oilite bushing (current production models)
41. Expansion plug
73. Operating shaft fork
74. Set screw

Needle bearings (96) for spring lever shaft (95), and spring lever (99) can be renewed as follows: First, remove threaded plug (94) from top of spring housing. Working through plug opening, remove set screw (100) from spring lever (99). Remove speed control lever (113) from shaft (95) and Woodruff key. Support housing and press on speed control lever end of spring lever shaft (95). Press shaft, expansion plug (118) and needle bearing from housing, thus releasing spring lever (99) from shaft.

Install needle bearings (96) approximately $\frac{1}{16}$ inch below counterbore in spring housing as shown in Fig. 0551. The same thickness of shims (102) should be installed as were removed. Variable speed spring (101) should be installed with closely wound coils in speed spring retainer (104).

If crankshaft maximum no-load speed of 1840 rpm cannot be obtained and injector timing and injector rack setting are in correct adjustment, it will be necessary to vary the thickness of shims (102). Add shims to increase the speed.

105C. CONTROL HOUSING. Refer to Fig. 0553. First, remove control housing from weight housing as outlined in paragraph 104A, and spring housing as outlined in paragraph 105B. To remove operating shaft (26), first remove differential lever (23) from operating lever (27). Working through opening in lower side of control housing (2) bump out expansion plug (41) from housing. Use a $\frac{1}{8}$ inch Allen wrench to loosen Allen screw (74) which retains operating fork (73) to lower end of operating shaft. Remove operating shaft upper bearing retaining screw (34); then press operating shaft assembly out of operating fork (73). Operating shaft lever (27) is a press fit on operating shaft.

Oilite bushing (40) and ball bearing (30) can be renewed at this time.

105D. WEIGHT CARRIER HOUSING. Refer to Fig. 0554. First, remove weight carrier housing as outlined in paragraph 104B. Start disassembly of weight carrier housing by removing governor weight housing cap (83) and bearing retainer screw (71). Insert a long $\frac{5}{16}$ inch—24 thread cap screw in threaded end of weight shaft. Press on head of this cap screw to remove weight shaft assembly from weight housing. Weight carrier is a press fit

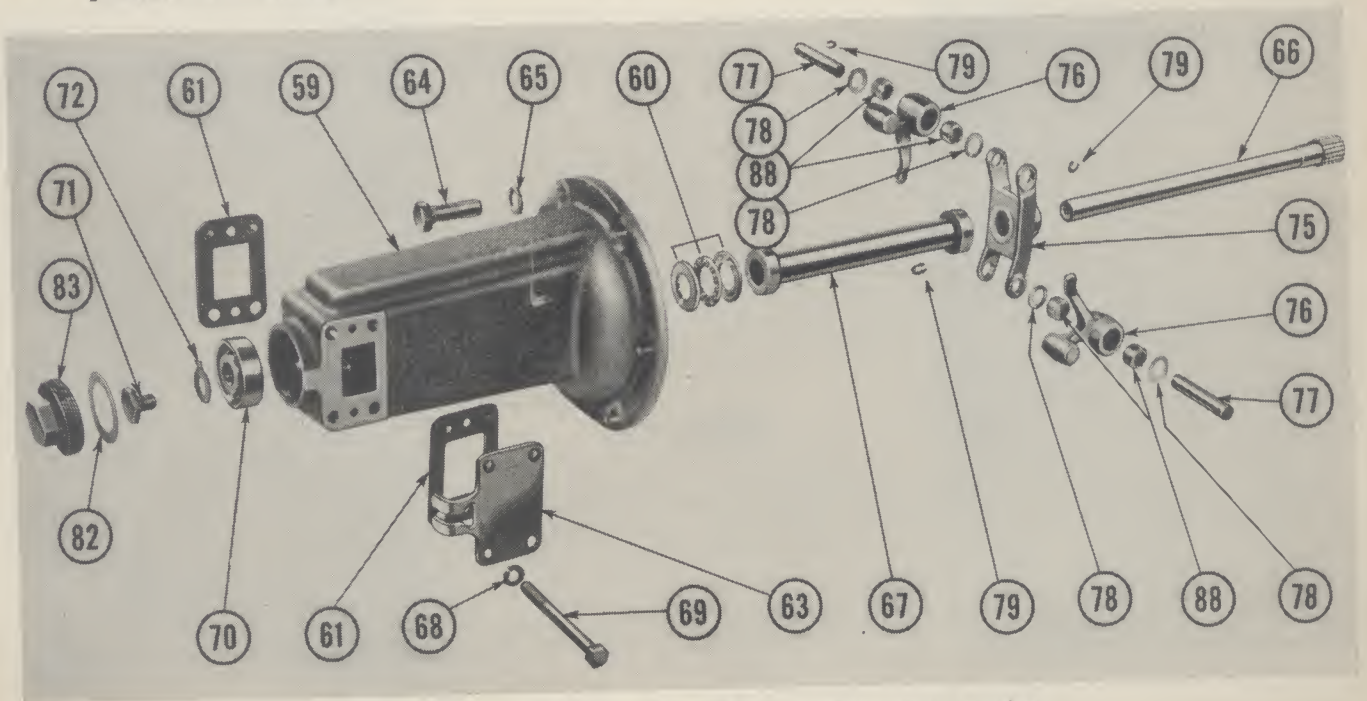


Fig. 0554—Details of variable speed type governor weight housing.

59. Weight housing
60. Riser thrust bearing
61. Gasket
63. Cover
66. Weight shaft
67. Riser
70. Bearing
75. Weight carrier
76. Weight
77. Weight pin
79. Retainer
88. Needle bearings

on weight shaft (66). If weights are to be removed from weight carrier, place correlation marks on weights and carrier for correct reassembly.

Weight shaft bearing (70) is a thrust bearing designed with a certain amount of looseness between the cone and cup. Weights operate on needle bearings (88). Renew weight pins (77) if worn more than 0.002 out-of-round.

When reassembling the weight carrier housing assembly install governor riser thrust bearing (60) so that the bearing race which has the larger inside diameter contacts the operating shaft fork. Install weight shaft bearing (70) with bearing numbers facing weight housing cap (83).

COOLING SYSTEM (GM Diesel 71 Series)

RADIATOR

110. Procedure for removal of radiator which involves removal of the hood is as follows: Loosen front grille center strap bolts, and remove two cap screws attaching front grilles to support. Lift off grilles. Detach both headlights and disconnect the wires. Remove hood rear strap, muffler, precleaners, two wiring harness clips from right side of hood, and lift hood from tractor. Remove radiator top hose and disconnect lower hose from oil cooler. Remove radiator to front frame cap screws, two on each side, and shield to radiator shell screws, two on each side. Lift off radiator.

Radiator filler neck cap is of the pressure type which is rated at 4 psi.

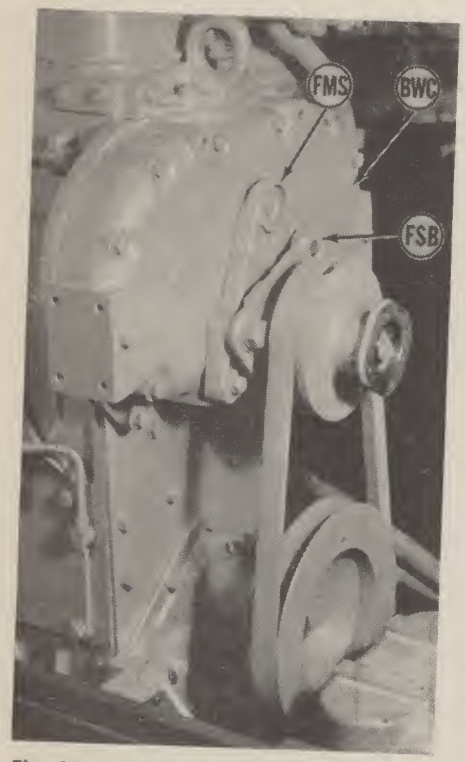


Fig. 0555—Fan belt tension is adjusted by pivoting fan pulley shaft bracket (FSB).

BWC. Balance weight cover
FMS. Pulley shaft bracket mounting support

FAN AND FAN BELT

111. To renew fan belt, remove air cleaner located on right side of engine.

Adjust tension of fan belt by means of fan bracket (FSB—Fig. 0555).

111A. To remove fan blades, first remove air cleaner located on right side of engine. Remove four bolts attaching fan to fan pulley hub extension, and lift off fan blades.

111B. To renew fan pulley or the prelubricated type ball bearings for the fan shaft, first remove fan blades, fan belt and three cap screws attaching fan support bracket (FSB) to fan mounting support (FMS).

Disassembly is self-evident after examining the unit.

THERMOSTAT

112. Cooling system is equipped with a thermostat which starts to open at 170 deg. F. and is fully opened at 185 deg. F.

Thermostat is located in housing (T—Fig. 0556) which is located between radiator top hose and water manifold. To renew thermostat, first remove tractor hood and radiator top hose. Remove four cap screws attaching thermostat housing to water manifold. Lift off thermostat housing water outlet elbow and remove the thermostat.

WATER PUMP

113. **REMOVE.** Pump can be removed as follows: Disconnect oil cooler to water pump hose, and by-pass hose at the pump. Remove three cap screws attaching pump to blower, and two cap screws attaching water pump outlet packing flange to cylinder block. Lift off pump.

113A. **OVERHAUL.** Disassembly procedure is as follows: Remove pump cover (15—Fig. 0557) and pump body drain plug (18). Working through drain plug opening, bump out taper pin (37) which retains impeller to shaft. Support pump on mounting flange end, and press impeller shaft out of the impeller and pump body. Drive coupling (24) is also a press fit on pump shaft.

113B. Prelubricated bearings and shaft are renewed as an assembly. Pump seal seat insert (27) which is available for service is a press fit in pump body.

Install water slinger (21) on pump shaft so that slinger is $\frac{5}{16}$ inch away from end of shaft bearing. After installing pump shaft and bearing as-

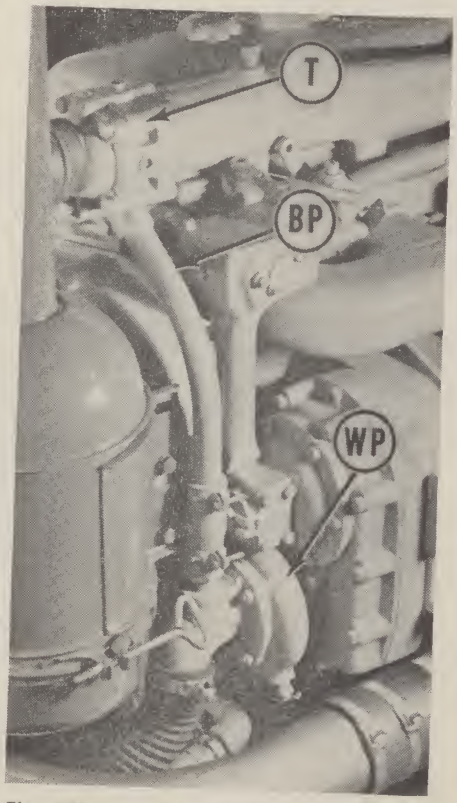


Fig. 0556 — GM engine water pump is mounted on the blower.

T. Thermostat housing
BP. By-pass
WP. Water pump Assembly

sembly in pump body and before installing the drive coupling, stake pump shaft bearing in bearing bore at three or four places.

Position impeller on shaft so that pin hole in shaft is midway between two blades on the impeller; then press impeller on shaft until end of impeller hub is 0.052 to 0.072 below the machined surface for pump body cover. Rotate pump shaft and check for recommended clearance of 0.005-0.045 between impeller blades and pump body. Insert a 0.184 inch drill in pin hole of shaft and drill through hub of impeller; then install a taper pin through the shaft and impeller.

2. Pump body
3. Impeller
4. Seal washer
5. Seal
6. Spring
8. Guide
10. Seal clamp ring
12. Retaining cup
13. Gasket
15. Pump cover
18. Drain valve
21. Slinger
22. Bearing and shaft assembly
23. Bearing and shaft assembly
24. Drive coupling
25. Slinger
26. Stake points for bearing
27. Seat insert
37. Pin

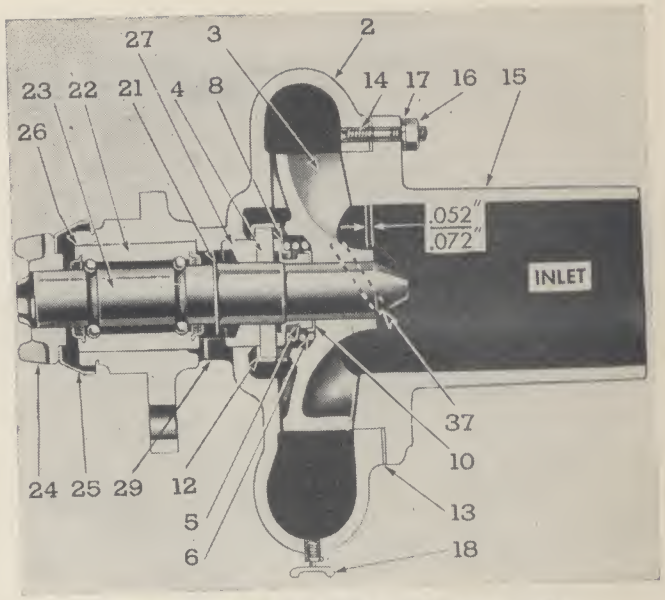


Fig. 0557—Details of GM engine water pump.

ELECTRICAL SYSTEM (GM Diesel 71 Series)

GENERATOR AND REGULATOR

115. GM 3-71 engines as installed in the Oliver Super 99 tractors are equipped with a Delco-Remy model 1100316, 12 volt, third brush type generator. Cold output is 20.0 amperes @ 14.0 volts @ 2300 generator rpm. Brush spring tension is 28 ounces. Field current draw is 1.58-1.67 amperes @ 12 volts @ 80 deg. F.

A model 1118791 Delco-Remy regulator is used.

STARTING MOTOR

116. GM 3-71 engines as installed in Oliver Super 99 tractors are equipped with a Delco-Remy model 1108801, 12 volt motor, fitted with a Dyer drive and a D-R model 1118095, 12 volt starter solenoid.

Tested at no-load, the starter current draw should be 115 amperes @ 11.6 volts @ 7000 rpm. Minimum locked torque should be 20 pounds feet @ 570 amperes @ 2.3 volts. Brush spring tension is 36-40 ounces.

Solenoid specifications are: Current consumption for both windings, 49.0-55.0 amperes @ 10.0 volts; and for hold-in winding, 11.0-13.0 amperes @ 10.0 volts. Relay on solenoid point opening voltage is 8.5 volts; and point closing voltage, 3.5-4.2 volts.

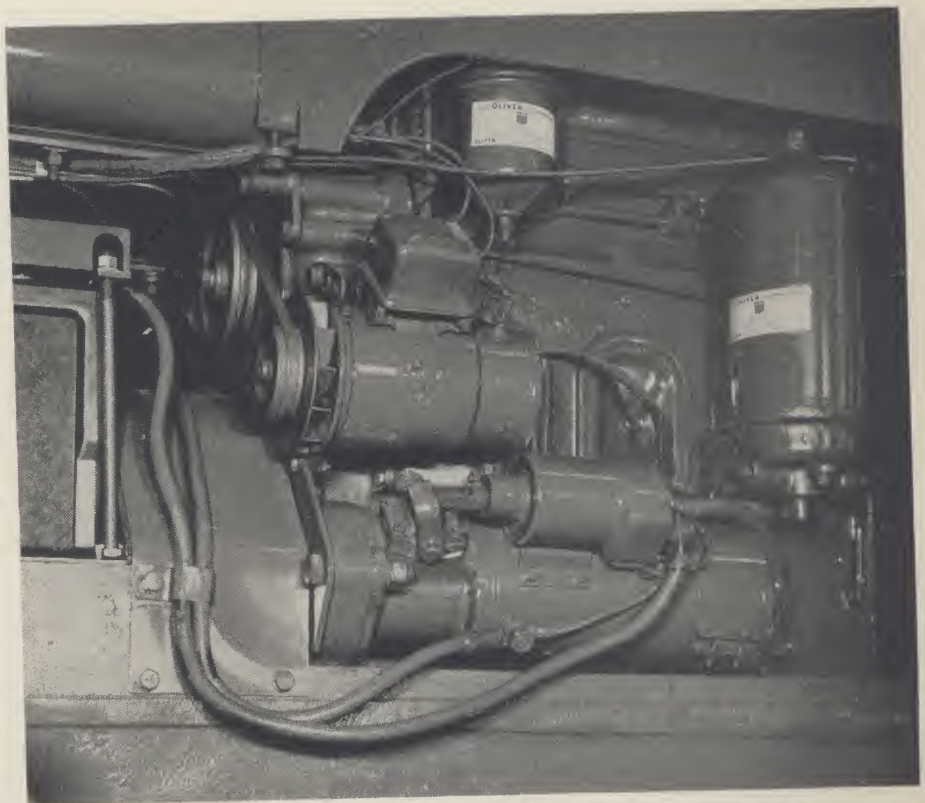


Fig. 0558—Installation view of generator and starting motor on a GM 3-71 engine.

CLUTCH AND CONTROLS

125. Main clutch is a spring loaded, single plate Borg & Beck 12E on 6 cylinder HC and Diesel; Rockford 14-TT on GM Diesel. An over-center type Rockford is available optionally on all models.

ADJUSTMENT

125A. **SPRING LOADED TYPE.** Recommended pedal free travel is 2¼ inches for 6 cylinder models; $2\frac{9}{16}$ inches for GM Diesel. Obtain stated free play or as close thereto as possible by lengthening the external shifter rod at the clevis end of same.

125B. **OVER-CENTER TYPE.** Correct adjustment is when a force of 30-35 pounds is required to engage clutch into over-center position. Measure the force with a spring scale hooked to upper end of shifter handle. Access to clutch adjusting ring Figs. 0575 and 0576 is obtained by removing batteries and clutch housing front cover and dust cover. Loosen clutch adjusting ring lock and rotate ring clockwise to "tighten" the adjustment.

OVERHAUL

125C. Herewith is procedure for removing both types of clutches from the tractor. If pto is continuous type remove the drive shaft of same as per paragraph 145J.

Remove battery or batteries and clutch housing front cover (31—Figs. 0457 and 0457A). On six speed tractors, remove the flat dust cover (40) by removing the screws which attach it to the front frame and to the clutch release bearing carrier. On four speed tractors, remove the screws retaining the clutch release bearing carrier to the carrier support.

Refer to Figs. 0458 and 0577. Remove chain (22) after extracting master link. Slide clutch shaft coupling (21) forward after loosening clamp bolt. Disconnect outer end of clutch shifter shaft, loosen set screw which retains fork (26) to shifter shaft then bump shaft out of fork toward left side of tractor. On spring loaded clutches the clutch shaft can now be removed. Unbolt clutch cover from flywheel and lift out the clutch or clutch and clutch shaft.

On GM Diesels with spring loaded clutch, removal will be facilitated if clutch cover is first secured to pressure plate (to compress springs) with 3 cap screws (⅜ x 2¼) screwed into pressure plate through the holes between release lever adjusting nuts.

On spring loaded installations only, before installing dust cover make sure that travel limit screw (28B — Fig. 0458) is set to prevent over-travel of the release bearing. There should be a gap of ½ inch between underside of screw head and support when the latter is held upright in the installed position. Obtain this setting by rotating the limit screw.

125D. **OVERHAUL SPRING LOADED TYPE.** Procedure for disassembly is contained in the Standard Units Manual. Checking standards are as follows: All parts numbers are Borg-Warner numbers.

Borg-Warner Model	B & B 12E	Rock. 14TT
Cover Assembly	361216	165360
Pressure Plate	305293	M5246-1
Number of Pressure Springs	16	15

BORG & BECK 12E. Of the 16 pressure springs, 8 are No. 3814 painted purple for service. These should show a pressure of 130-140 pounds when compressed to a length of $1\frac{11}{16}$ inches. The 8 other heavier, uncolored springs are No. 3951. These should show a pressure of 150-160 pounds at length of $1\frac{11}{16}$ inches.

Lever setting is $2\frac{5}{32}$ inches using $\frac{11}{32}$ (0.340) inch keystock instead of the lined plate with clutch assembled.

ROCKFORD 14TT. Pressure springs No. 505-2 should show pressure of 170-180 pounds when compressed to their working height of $1\frac{13}{16}$ inches. Lever setting is $1\frac{15}{16}$ inches measured from the bearing surface of each lever to the friction surface of the **pressure plate.** Using Borg-Warner fixture, lever height is 1⅝ inches with 3K4 sleeves (0.701) in place.

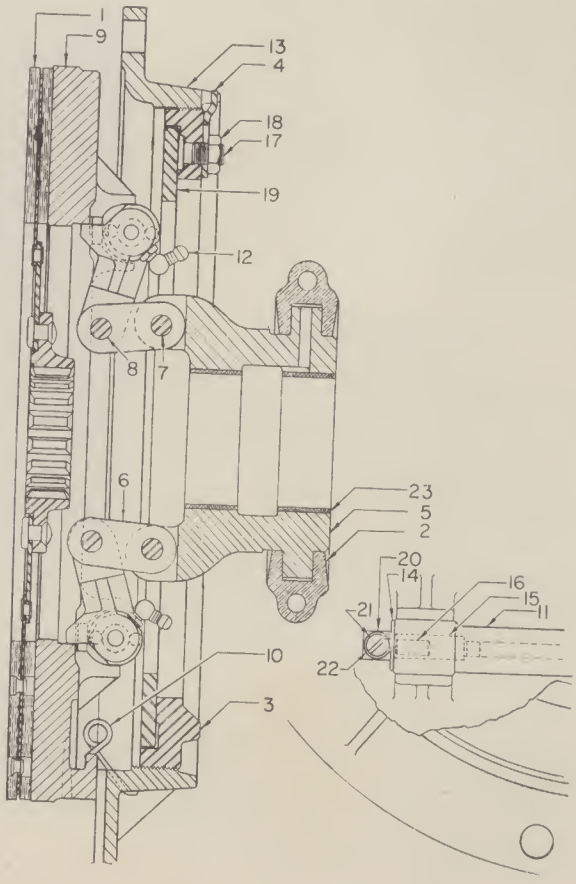


Fig. 0575—Over-center type clutch as used optionally on 6 cylinder Super 99 tractors.

1. Driven (lined) member
2. Release bearing
3. Adjusting ring
4. Adjusting lock
5. Sleeve
6. Connecting link
9. Pressure plate
10. Return spring
11. Camshaft
13. Back plate
14. Retainer plate
15. Roller
16. Roller
19. Adjusting ring plate
20. Cam plate
23. Sleeve bushing

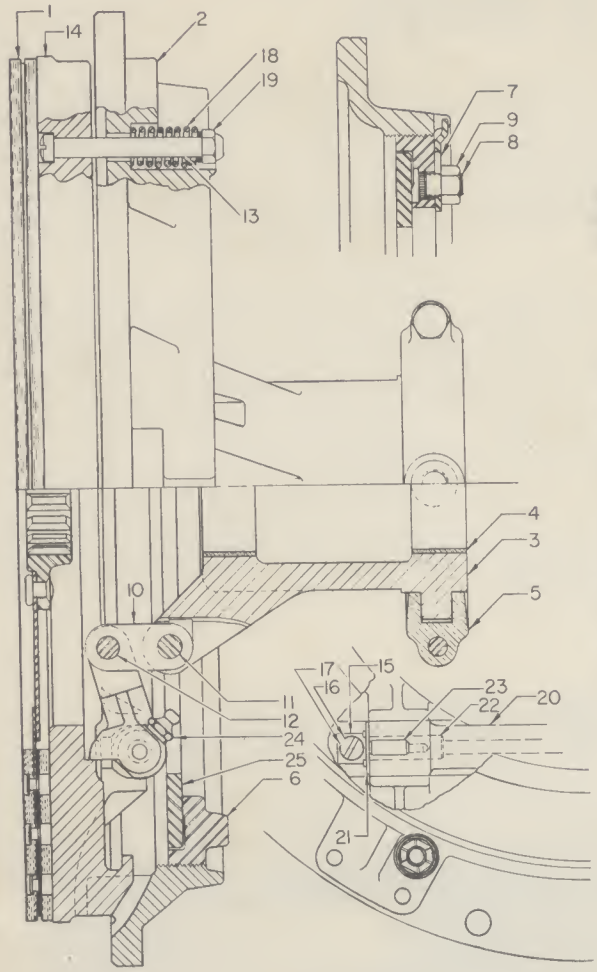


Fig. 0576—Over-center type clutch as used optionally on Super 99 GM Diesel tractors.

1. Driven (lined) member
2. Back plate
3. Sleeve
4. Sleeve bushing
5. Release bearing
6. Adjusting ring
7. Adjusting lock
10. Connecting link
14. Pressure plate
15. Cam block
18. Return spring
20. Camshaft
21. Retainer plate
22. Roller
23. Roller
25. Adjusting ring plate

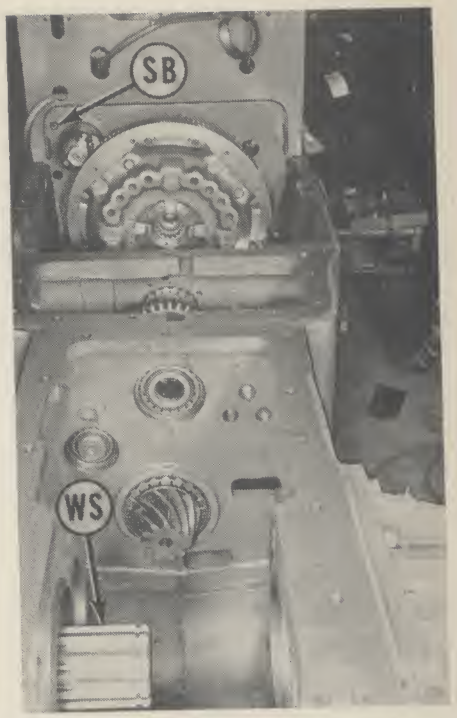


Fig. 0577A—Rear view six cylinder model showing spring loaded Borg-Beck 12E clutch. Pressed steel cover shown at (31) in Fig. 0457 must be removed for access to starter mounting bolts (SB). Wheel axle shaft is (WS).

S. Clutch retaining screws
1. Pilot bushing
21. Coupling half
22. Coupling chain
23. Clutch shaft (hollow)
24. Shifter shaft
26. Shifter fork
27. Bushing for shaft 24
28. Release bearing carrier
29. Support for carrier 28
31. Housing front cover
36. Dust shield
40. Dust cover
40A. PTO drive hub
44. Shifter rod
53. Pedal return spring
58. Release bearing

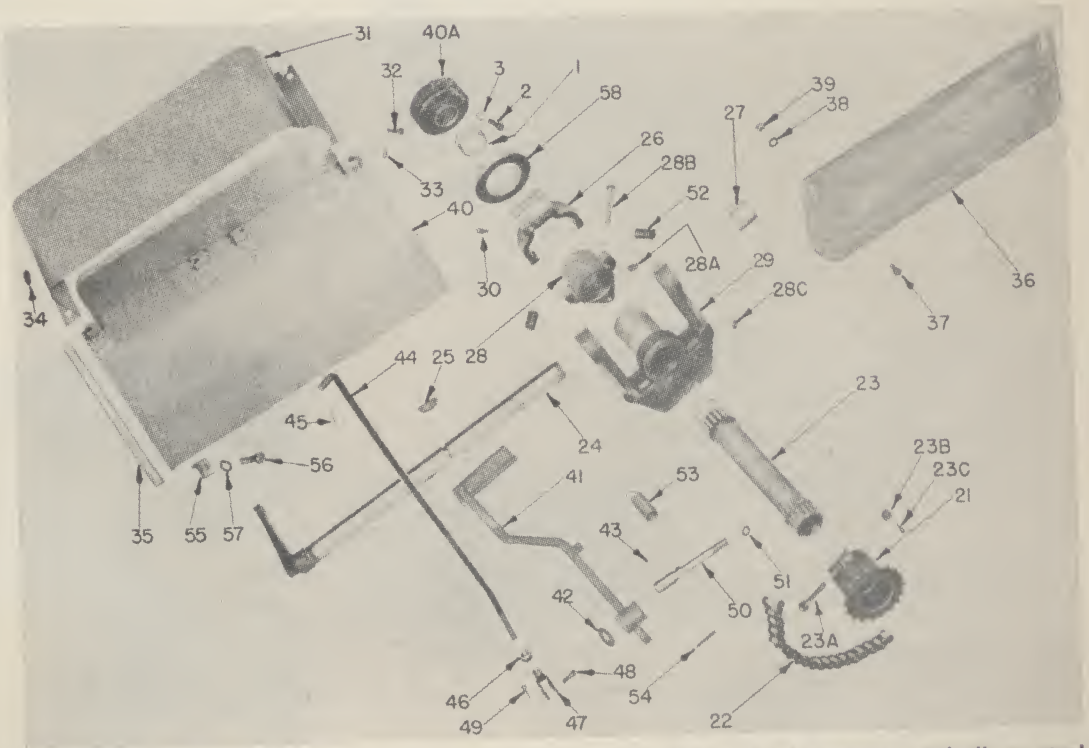


Fig. 0577—Components of main clutch control system. Dust shield (36) is mounted vertically to steel adaptor plate at rear of engine block.

TRANSMISSION 6 SPEED

126. For 4 speed transmission refer to paragraphs 129 through 129D.

The transmission housing which is called the rear frame, is divided into two compartments by a wall in the casting. In the front compartment are the transmission gears and shafts. On the rear side of the wall are the bevel gear end of the transmission bevel pinion shaft, the bevel ring gear, differential, and bull gears and bull pinions.

All shafts except the reverse idler are carried on adjustable type roller bearings.

OVERHAUL

127. **GUIDE TO LOCALIZED REPAIRS.** Although most transmission repair jobs do and should include complete disassembly there are exceptions. These exceptions are the infrequent instances where the location of a worn or failed part is such that the resultant metal cuttings are not likely to get into the bearings or between gear teeth. Information contained in paragraphs 127A through 127D is intended as a general guide only, not a procedure, for completing localized repairs.

127A. Input Shaft. This shaft and its bearings shown at (25) in Fig. 0581 can be removed without disturbing shifter forks or rails after removing the transmission top cover, clutch dust cover, bull gear cover, pto drive shaft if so equipped, and the main clutch shaft. For detailed procedure refer to paragraph 128J.

127B. Intermediate Shaft. This shaft (24—Fig. 0586) and its bearings can be removed without disturbing shifter forks and rails after removing the transmission top cover, clutch dust cover and bull gear cover. For detailed procedure refer to paragraph 128F.

127C. Bevel Pinion Shaft. This shaft (10) and bearings for same as shown in Figs. 0586 and 0589 is cleared for removal after doing the following preliminary work: Remove bevel ring gear and differential assembly, right axle shaft and bull gear, left bull gear, transmission input shaft and intermediate shaft. For detailed procedure refer to paragraphs 128K through 128N.

127D. Gear Shifter Forks & Rails. To remove the various parts of the shifter mechanism refer to paragraphs 128A through 128D.

128. GENERAL. The procedure outlined in paragraphs 128A through 128M may not be the fastest but it is arranged in a sequence that permits localized repair of each shaft and its bearings. If it is known at the outset that unit is to be completely disassembled it will be slightly more efficient to remove fenders, platform and bull gear cover as a single unit as shown in Fig. 0499B.

128A. **GEAR SHIFTING MECHANISM.** To remove all of the shifter rails and forks it is necessary to either remove the engine flywheel or to detach the rear frame from front frame. The inner rail can be removed without disturbing the flywheel when the differential is out.

128B. POPPET INTERLOCK BLOCK. To remove the shifter poppet and interlock block (2—Fig. 0579) proceed as follows: Remove batteries from tractor. Remove clutch front cover (31—Fig. 0457) and the flat dust cover (40) located aft of the front cover. Remove dust cover from gear shift lever, extract the snap ring and lift the shift lever out of the tower.

Refer to Fig. 0578 and remove the inspection hand hole cover (48) from the bull gear cover (39). Refer to Fig. 0579 and remove the cap screws retaining the interlocking spring retainer (R) to the block (2) and those retaining the block to the transmission. Refer to Fig. 0580 and using a ¼ inch pencil magnet or other means, extract 3 detent springs and three $\frac{7}{16}$ inch balls from the holes in the retainer.

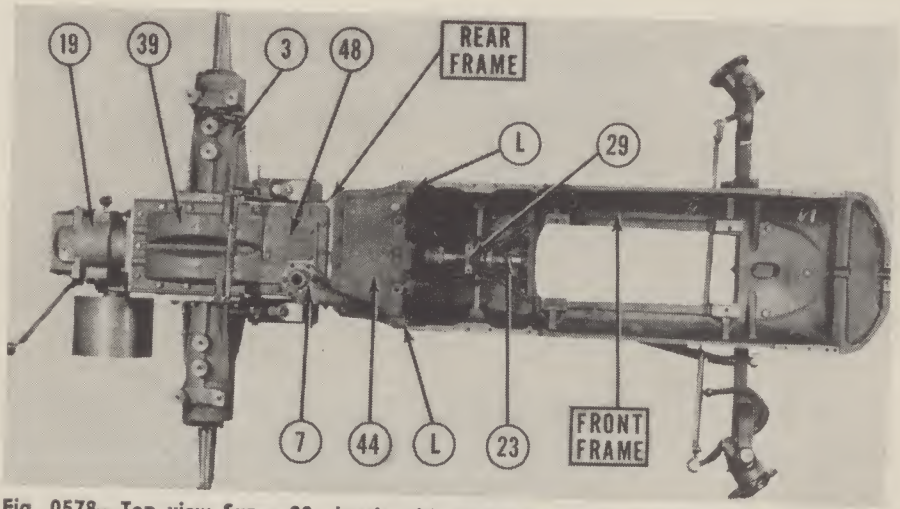


Fig. 0578—Top view Super 99 chassis with engine removed. Not shown are the clutch front cover located immediately forward of the transmission top cover (44), and the clutch dust cover which is located directly above support (29) to which it is bolted.

L. Clip
3. Wheel axle carrier
7. Gear shift tower
19. PTO housing
23. Clutch shaft
29. Carrier support
39. Bull gear cover
44. Transmission cover
48. Hand hole cover

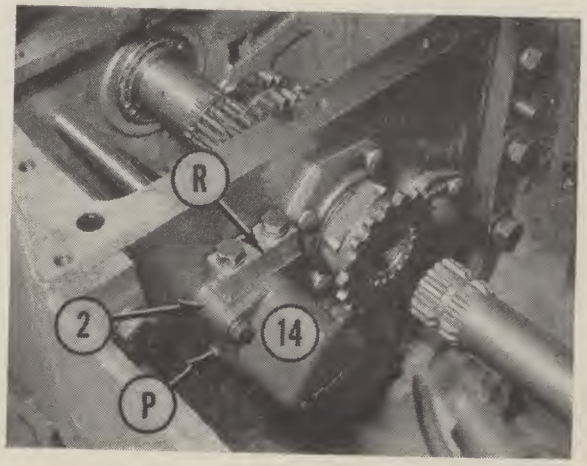


Fig. 0579—View of gearshift interlock block (2) containing 7 shifter detent and interlock balls. It can be removed without removing transmission top cover. Item (R) is retainer, (14) is cover and (P) is Welch plug.

Working through the hand hole cover opening slide the upper shifter rail (U) back (rearward) until it is disengaged from block, then lift block off case wall. Two ½ inch diameter interlocking balls are mounted in a cross passage in the block and two additional $\frac{7}{16}$ balls are in the center vertical hole. Be careful not to lose these when block is withdrawn from transmission.

When reinstalling the block place top shifter rail (rod) in rearward position and two lower rails in forward position. Insert the two ½ inch balls into block via the shift rail holes. While holding both balls in center of block passage, slide the block over the two lower rails. Install block to case gasket and install the block to transmission retaining cap screws finger tight. With top rail towards front of tractor insert two $\frac{7}{16}$ balls into center vertical hole in block. Slide upper rail into block and with all rails in neutral position drop one $\frac{7}{16}$ inch ball in each of the 3 holes in top of block. Insert a detent spring in each of the 3 holes then install the retainer.

Check rails for binding. If rails are free tighten all cap screws securely.

128C. RAILS AND FORKS. To remove all rails and forks first remove the interlock block as outlined in paragraph 128B then proceed as follows: Remove fuel tank rear support and lay instrument panel on fuel tank.

Remove cap screws retaining the transmission top cover (44—Fig. 0578) and withdraw cover by tilting front edge up and out toward left side of tractor. Remove set screws (13—Fig. 0581) from the three shifter forks. Working through opening at hand hole inspection cover (48—Fig. 0578) in bull gear cover (39) rotate upper shift rail to position where a wrench can be used on lug retaining set screw (14—Fig. 0582) and remove set screw. Remove set screw from lugs on the two other rails and remove lugs from rails.

Forks for the two bottom rails can be removed at this time by sliding the outer and inner lower rails rearward and withdrawing forks out through top opening in transmission. To remove center rail fork it will be necessary to remove flywheel or detach front frame from rear frame or remove the transmission intermediate shaft.

128D. To remove all of the shifter rails from the transmission, either remove the clutch from the flywheel as per paragraph 125C and flywheel from crankshaft or, detach front frame from rear frame. The lower inner rail can be removed without disturbing flywheel by removing the differential.

Install all rails with their notches at front. Install upper (center) fork and lower right fork with their hubs at front; left fork hub at rear. After rails and forks are installed, reinstall interlock block as per last half of paragraph 128B.

128F. **INTERMEDIATE SHAFT.** To remove this shaft (24—Fig. 0586) proceed as follows:

Remove clutch front cover (31—Fig. 0457) and the flat dust cover (40) located aft of the front cover. Remove fuel tank rear support and lay instrument panel on tank. Remove the cap screws retaining the transmission

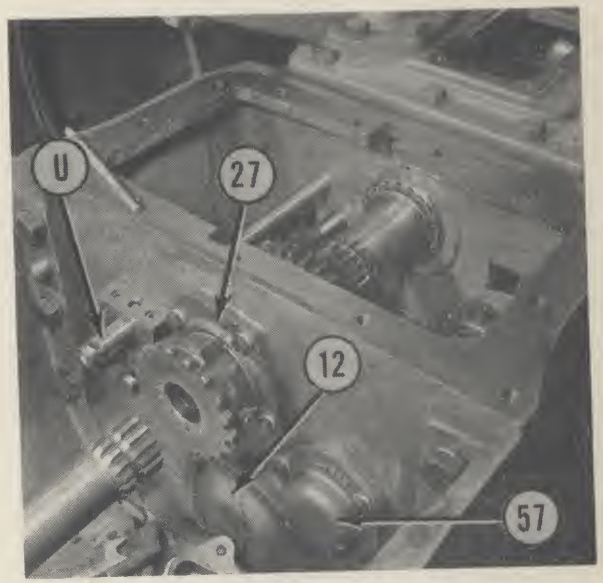


Fig. 0580—Showing gearshift interlock block with retainer removed. Top shifter rail (rod) is (U). Use a magnet to remove detent balls from block.

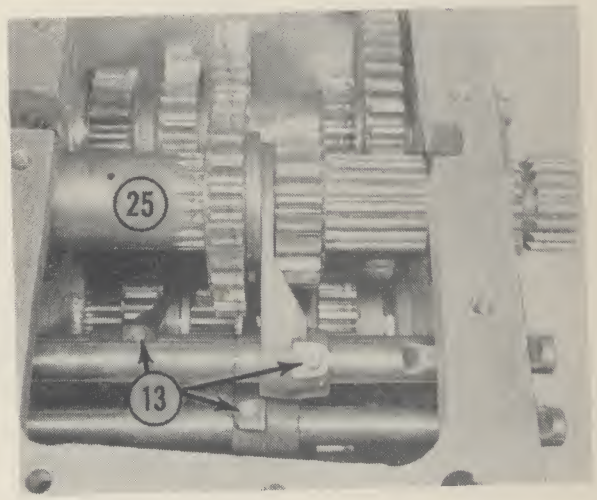


Fig. 0581—Shifter forks but not the shifter rails, can be removed without removing flywheel. Screws (13) retain forks to shifter rails. Item (25) is the input shaft.

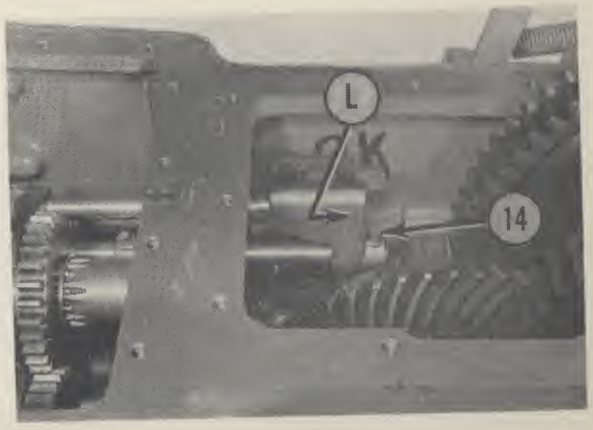


Fig. 0582 — View of shifter rail lugs (L) with bull gear cover removed. Lugs can be removed without disturbing bull gear cover by working through inspection hole cover opening in bull gear cover.

top cover (44—Fig. 0578) and withdraw cover by tilting front edge up and out toward left side of tractor.

Remove gear shift tower from bull gear cover and drop arm from steering gear. Remove platform, fenders and bull gear cover as a single assembly as shown in Fig. 0499B after removing the necessary fastenings; or cover alone after removing seat cover bolts, cover to platform bolts and cover to frame bolts.

128G. Refer to Figs. 0583, 0584 and 0585. Remove oil cup (70) from wall of transmission, bearing cover (57) from front wall and castellated nut from front end of intermediate shaft. Bump front end of shaft several times to loosen bearings, then extract the snap ring (60) from rear end of shaft. Bump shaft forward out of gears and out of rear bearing cone or, pull shaft forward using a puller with reaction legs. Rear bearing cup remains in transmission, front cone remains on shaft.

When reinstalling shaft place rear bearing cone in rear cup, enter shaft from front while threading gears and spacer on to shaft in the order shown in Fig. 0585. Start rear bearing cone on to shaft. Use a short piece of pipe or tubing and a pry bar to buck up the cone while bumping shaft rearward into the cone. Install snap ring to rear end of shaft. Tighten and secure shaft nut with cotter pin. Adjust shaft bearings to 0.000-0.002 end play by varying the shims. Because shims are used without sealing gaskets coat them with castor oil to obtain sealing effect. Coat sealing surface of oil cup (70—Fig. 0583) with rubber cement before installing.

128H. **REVERSE IDLER.** Reverse idler (53—Fig. 0587) can be removed after the intermediate shaft is out. Remove lock wire (LW) from Roll-Pin and with a straight drift bump pin down and out of boss. Bump idler shaft forward and remove shaft and gear.

The steel-backed bronze bushing in gear should be renewed when running clearance exceeds 0.006. After Roll-Pin is installed secure it with lock wire.

128J. **INPUT SHAFT.** To remove the input shaft which is joined to the rear end of the clutch shaft it is necessary to first remove transmission top cover, bull gear cover etc., as outlined in paragraph 128F then proceed as follows (refer to Figs. 0584 and 0583):

Remove rear half of shaft coupling from front of input shaft (25), also bearing retainer (27) sleeve and "O" ring. Remove oil cup (71) from rear wall of transmission. Bump shaft forward until front bearing cup is out of front wall. Using a puller move front bearing cone about one inch towards front end of shaft. Move shaft forward then swing rear end of shaft toward left side of cover opening and lift out the assembly. Rear bearing cup remains in transmission, bearing cones remain on shaft. Procedure for further disassembly is apparent.

Beginning with tractor serial 521300, an improved input shaft entered production. New shaft can be installed in place of old by changing the bearing cones and oil seal.

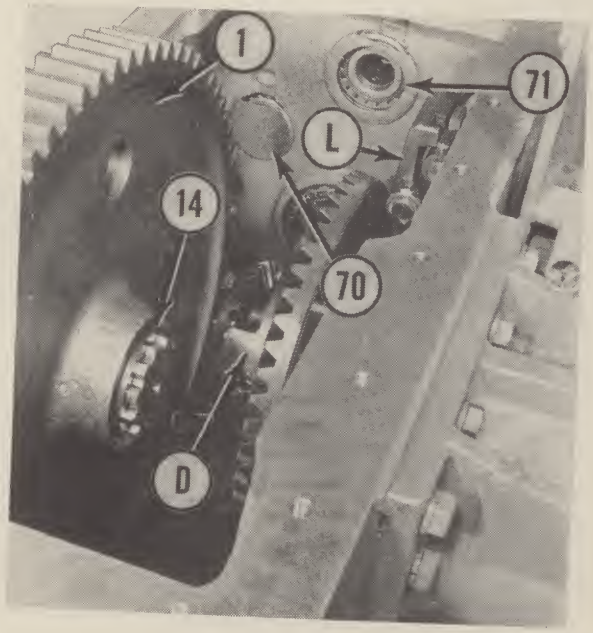


Fig. 0583—To remove bevel pinion shaft from 6 speed transmission it is necessary to remove both bull gears and the differential (D).

L. Shifter lugs
14. Retainer ring
70. Oil cup
71. Oil cup

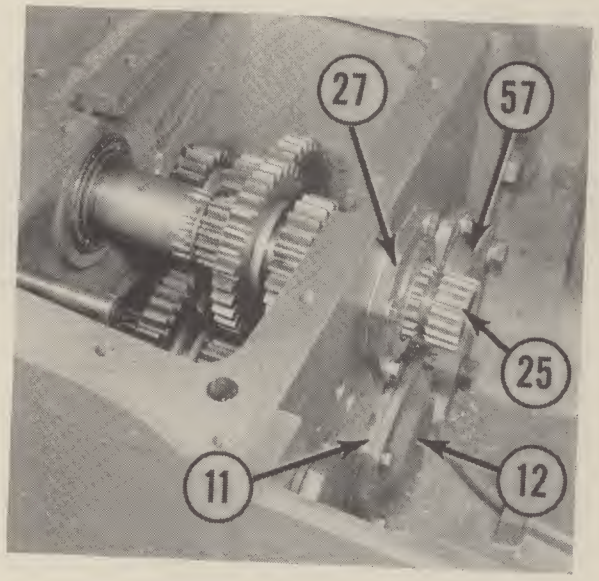


Fig. 0584—Input shaft (25) of 6 speed transmission with shifter forks removed. An improved version is used in tractors after serial 521299.

11. Bevel pinion shaft bearing carrier
25. Input shaft
27. Input shaft bearing carrier
57. Bearing cover for intermediate shaft

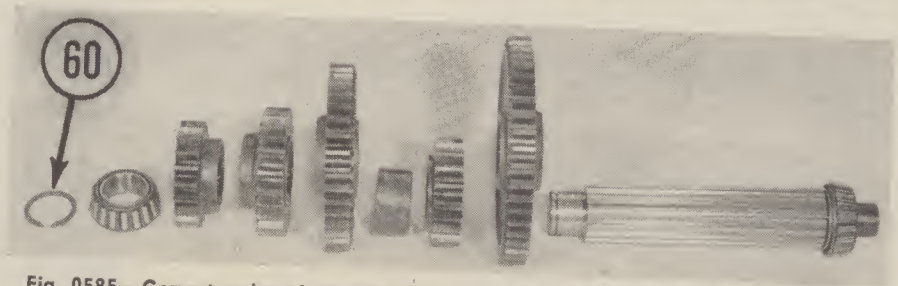


Fig. 0585—Correct order of assembly of intermediate shaft for 6 speed transmission.

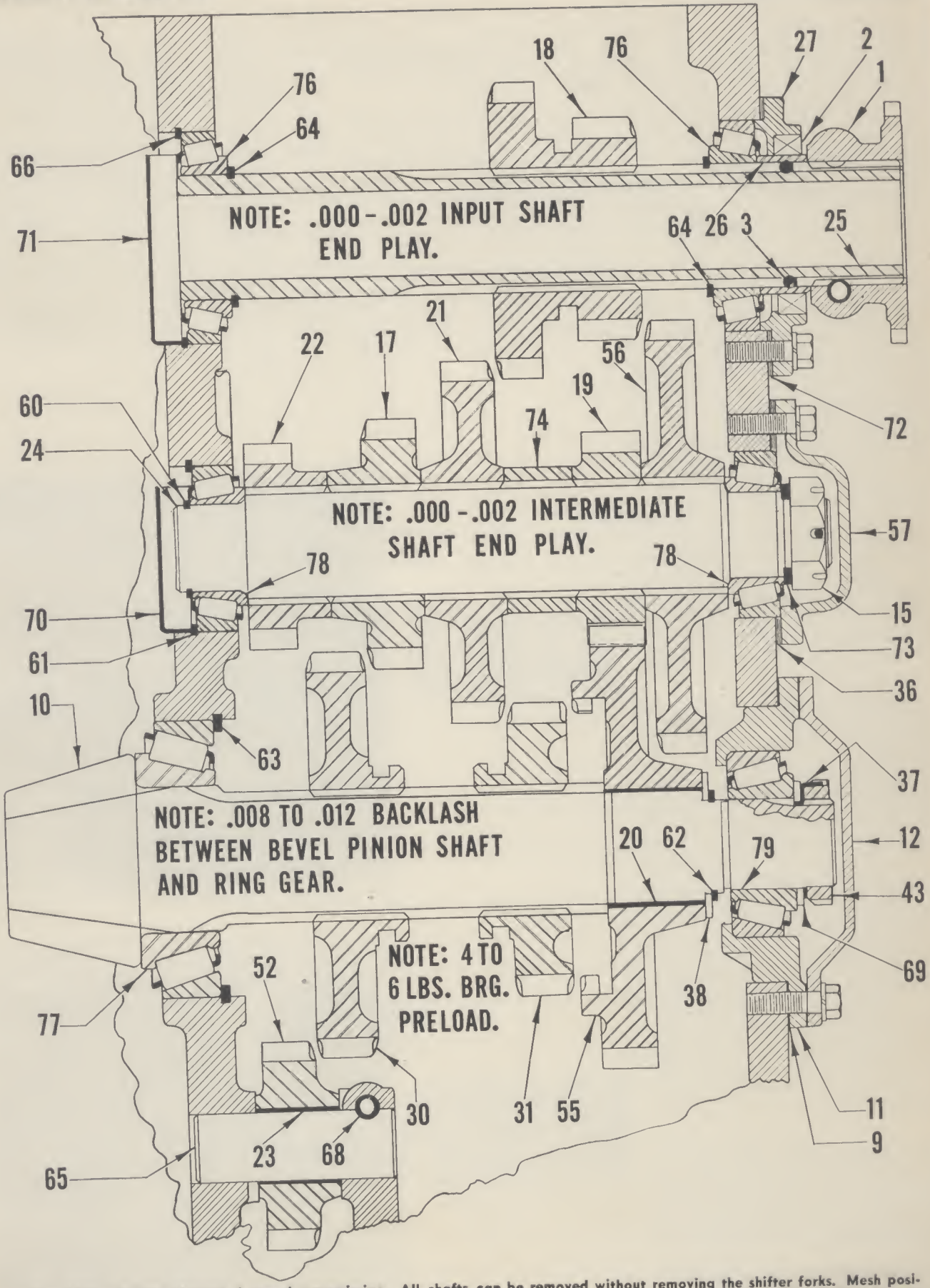


Fig. 0586—Section through 6 speed transmission. All shafts can be removed without removing the shifter forks. Mesh position of bevel pinion shaft is fixed. Removal of this shaft requires removal of right hand wheel axle shaft and bull gear, left bull gear and the differential. Input shaft (71) is slightly different beginning with tractor serial 521300. Refer to Fig. 0589 for parts legend.

When reinstalling the input shaft the front bearing retainer (27) and cap screws can be utilized as a pusher to force front bearing cup into front wall of case and also to force cone on to shaft. Adjust shaft bearings to 0.000-0.002 end play by varying the shims (72). Because shims are used without gaskets coat them with castor oil before installing, to obtain sealing effect. Coat sealing surface of oil cup (71) with rubber cement before installing. Refer also to Fig. 0586.

128K. **BEVEL PINION SHAFT.** To remove the bevel pinion shaft (10—Fig. 0587) it is necessary to first remove the input shaft, intermediate shaft, bevel ring gear and differential assembly, right axle shaft and bull gear and left bull gear. Assuming that intermediate shaft and input shaft are already removed as outlined in paragraphs 128F through 128J, the remaining procedure is as follows:

Jack up rear of tractor, remove both rear wheels and tires assemblies and bearing cover from outer end of right hand wheel axle shaft carrier. Remove spiral type retaining ring from inner end of right wheel axle shaft then bump shaft out of bull gear. Lift or hoist right bull gear out of rear frame.

128L. Remove both brake covers and the lined inner disks and wear plates. Refer to Fig. 0606 and remove brake wear plate and backing plate (18). Extract sheet metal closure plug (P—Fig. 0588) from hollow end of each bull pinion shaft. Use a puller which will enter shaft and engage jaws of puller on shaft shoulder located about 7 inches in from end then pull bull pinion and bull pinion bearing cup as a unit out of the rear frame.

Move differential and bevel ring gear unit (D) over against right hand wall of rear frame (transmission) as shown in Fig. 0612. Remove retaining ring (14) from left hand axle shaft then pry bull gear off of left axle shaft and hoist out. Remove left side gear and lift differential and ring gear unit out by raising left end of differential shaft.

128M. Refer to Fig. 0584. Remove bevel pinion shaft bearing cover (12) from front wall, unstake the lockwasher and remove the spanner nut from front end of shaft. Rotate bearing carrier (11) slightly then thread two ½ inch standard thread cap screws into tapped holes of same to force carrier and front bearing out of transmission. Bump front end of shaft rearward out of case. Rear bearing cup will remain in rear wall of case, cone stays on shaft. Bushing in hub of front gear is renewable.

128N. Reassemble and install various parts as per Fig. 0589 by reversing the disassembly procedure. Observe these points while doing so:

Before locking the splined nut on front end of shaft adjust bearings by means of same nut until 10-15 inch pounds torque is required to rotate the shaft, with all other shafts out of case. This amount of torque is obtained when a spring scale hooked to teeth of smallest gear on shaft reads 4-6 pounds pull to rotate shaft.

Install new oil seals (lips facing inward) to brake backing plates. By means of shims located under backing plates adjust bull pinion bearings to obtain 0.001-0.003 end play. Because shims are used without sealing gasket coat them with castor oil to obtain sealing effect. AFTER this adjustment is obtained and using the same shims, vary them from one backing plate to the other to obtain 0.008-0.012 backlash between bevel pinion and ring gear teeth or, the amount of backlash stamped on ring gear.

Adjust wheel shaft bearings by means of shims, to 0.000-0.002 end play.

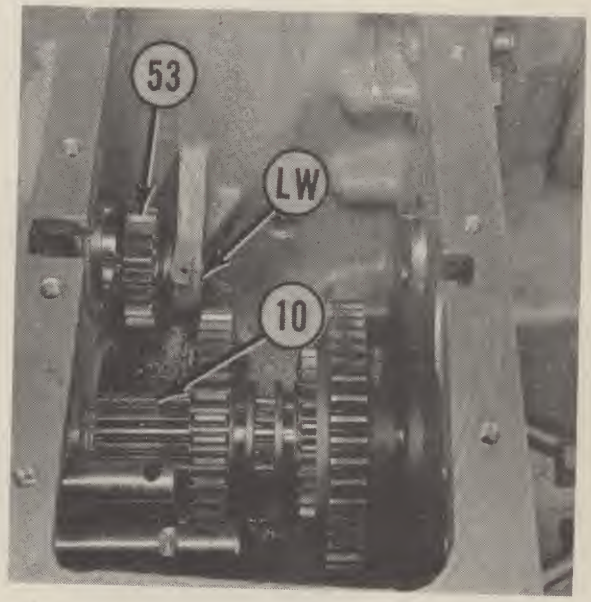


Fig. 0587—Details of reverse idler (53) and bevel pinion shaft (10) used in 6 speed transmission. Roll-Pin for reverse idler shaft is secured by lockwire (LW).

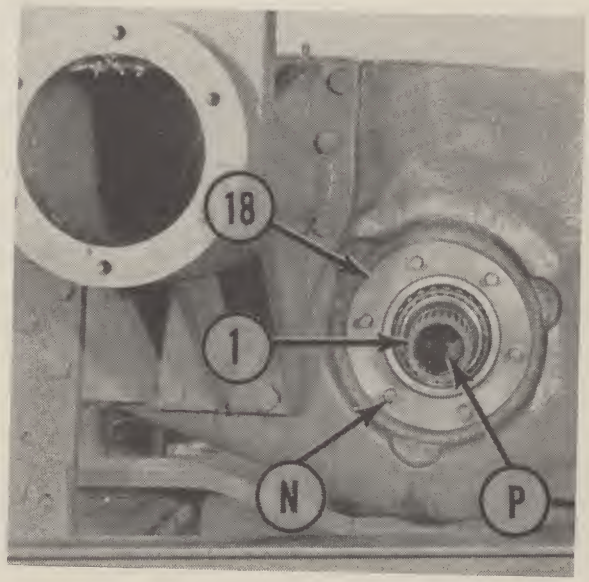


Fig. 0588 — Left side view 6 speed tractor showing bull pinion ready for removal. To remove bull pinion (1) and bearing as a unit, extract plug (P) and engage puller on inside shoulder of pinion.

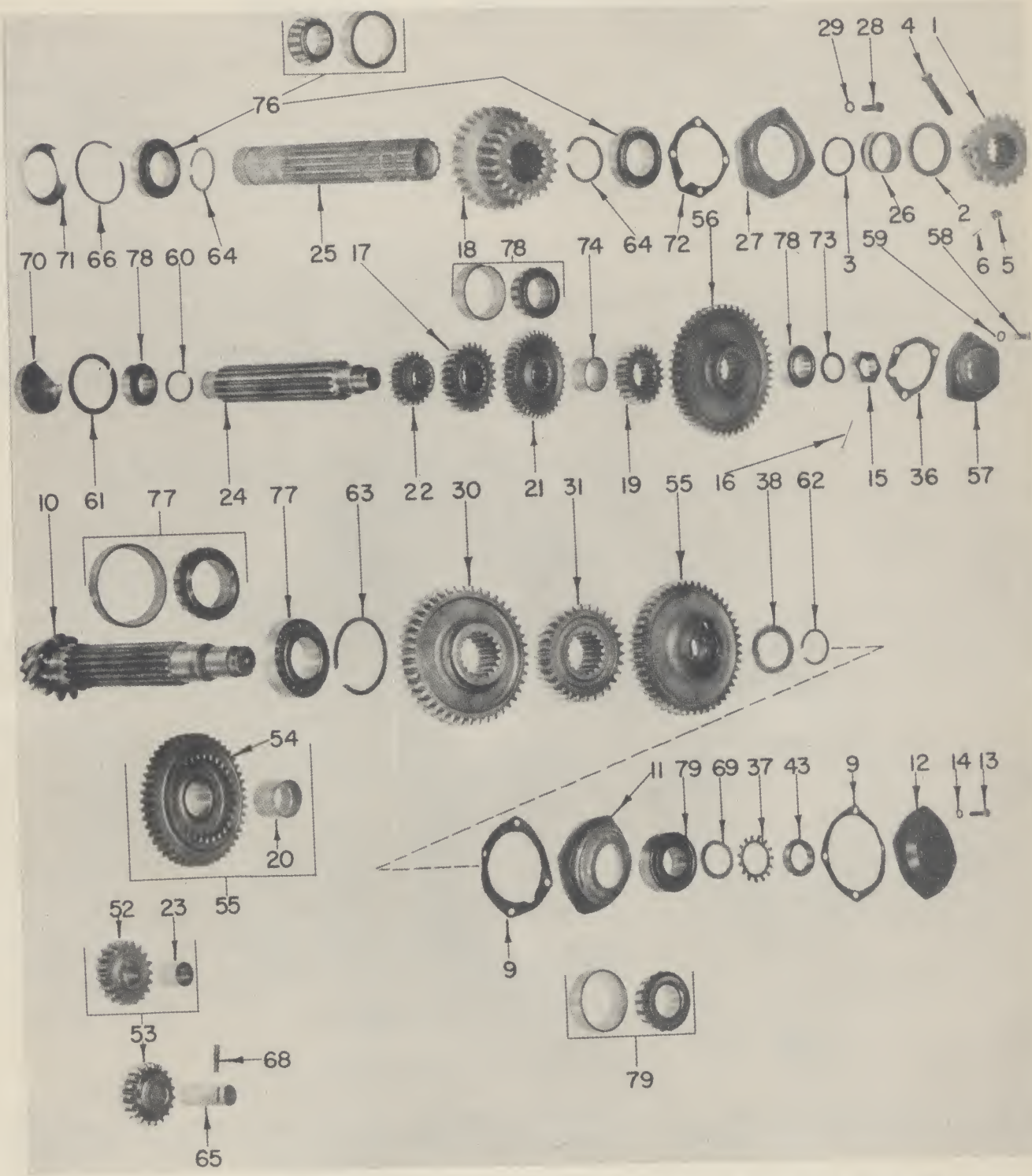


Fig. 0589—Components of 6 speed transmission with adjustable bearings for all shafts except reverse idler.

1. Coupling, rear half
2. Oil seal
3. "O" ring
10. Bevel pinion shaft
11. Bearing carrier
12. Bearing cover
17. Intermediate second gear
18. Input sliding gear
19. Intermediate first gear
20. Idler gear bushing
21. Intermediate high gear
22. Intermediate reverse gear
23. Reverse idler bushing
24. Intermediate shaft
25. Input shaft
26. Seal sleeve
27. Bearing retainer
30. Reverse, second, fourth sliding gear
31. First, third, fifth, sixth sliding gear
36. Shim
37. Lockwasher
38. Locating washer
43. Lock nut
52. Reverse idler gear
55. Pinion idler gear
56. Intermediate low gear
57. Bearing cover
60. Snap ring
61. Snap ring
62. Snap ring
63. Snap ring
64. Snap ring
65. Idler shaft
66. Snap ring
68. Roll pin
69. Retainer washer
70. Bearing oil cup
71. Bearing oil cup
72. Shim
73. Retainer washer
74. Spacer
76. Bearing
77. Bearing
78. Bearing
79. Bearing

TRANSMISSION 4 SPEED

Early production 6 cylinder tractors were equipped with the same 4 speed transmission as used in the late production 4 cylinder models 90 and 99. Procedure for overhaul of 6 speed transmissions begins with paragraph 128.

OVERHAUL

129. **SHIFTER FORKS AND RAILS.** Procedure for servicing these parts is as follows: Disconnect battery or batteries from wiring. Remove fuel supply tank and tank support and lay instrument panel on platform or other resting place. Remove clutch front cover (31—Fig. 0457A) and pto drive shaft if so equipped. Remove pulley and steering gear unit from belt pulley carrier. Remove belt pulley carrier assembly as shown in Fig. 0594. Refer to Fig. 0595 then remove cap screws retaining the shifter assembly to top of case and lift off.

129A. **SLIDING GEAR (INPUT) SHAFT.** To remove this shaft, Fig. 0596 or (31—Fig. 0590), first remove the pulley carrier assembly and the shifter mechanism as per paragraph 129. Remove coupling chain (22—Fig. 0458) after extracting the master link. Slide clutch shaft (23) forward after removing the clamp bolt. Disconnect outer end of clutch shifter shaft. Loosen the set screw which locates the shifter fork (26) to shifter shaft, then bump shaft out of fork toward left side of tractor. Withdraw release bearing carrier (29) and the clutch shaft.

Remove the coupling rear half from front end of sliding gear shaft and cap screws from front bearing retainer and pry retainer off shaft. Using a drift on rear gear, bump shaft and rear bearing rearward as shown in Fig. 0596 and withdraw shaft through gears

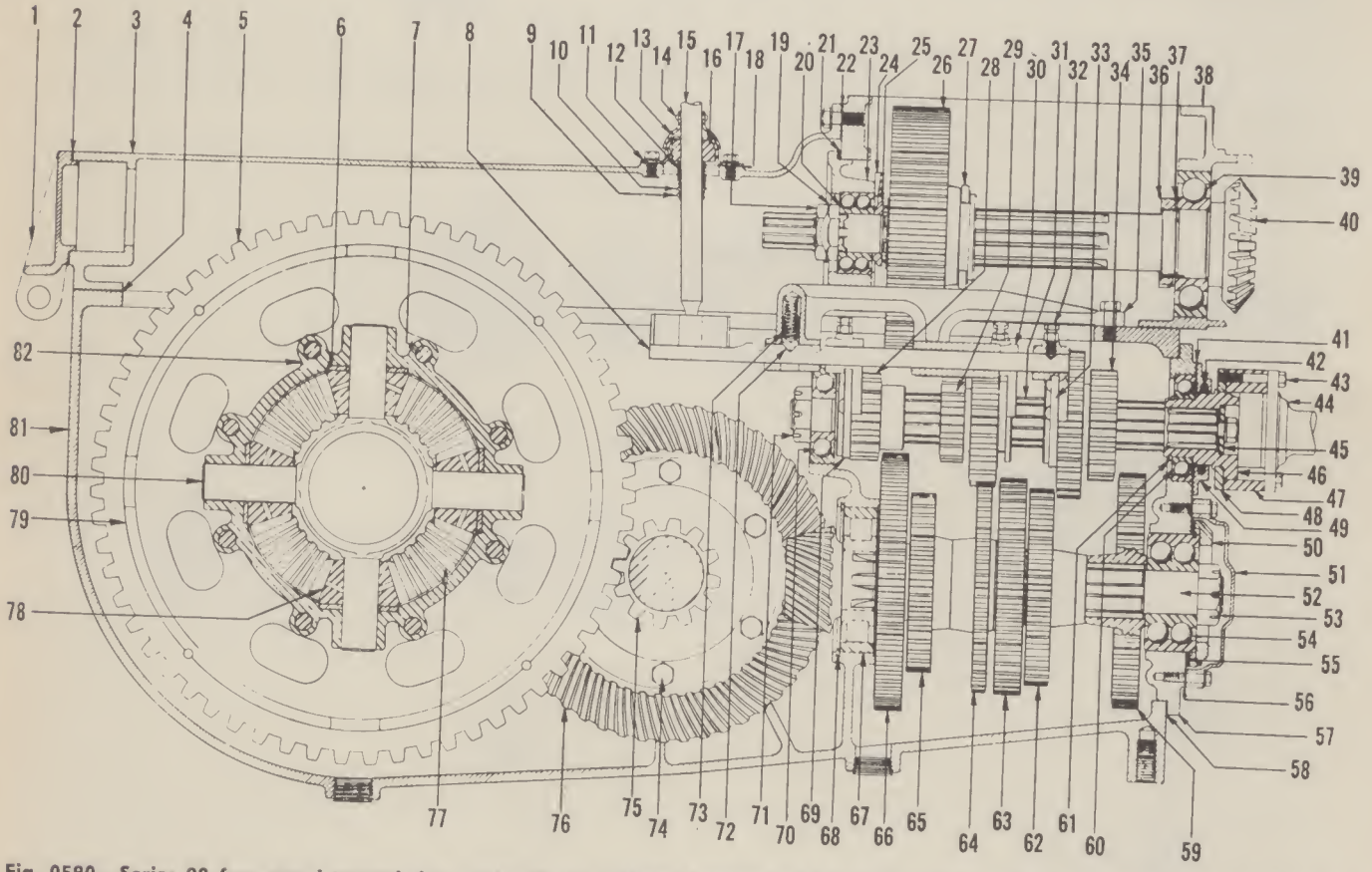


Fig. 0590—Series 99 four speed transmission. Super 99 six cylinder 4 speed unit has chain type coupling retained by clamp bolt but is otherwise the same. Bevel drive pinion and shaft sold separately or as a set with matching bevel ring gear. Shims (55) control position of bevel pinion gear. Correct backlash is etched on bevel ring gear.

3. Bull gear cover
5. Bull gear
6. Differential pinion
8. Shifter rails
10. Spring stop
11. Shift lever bearing
12. Shift lever spring
13. Shift lever cap
21. Shim
23. Bearing cage
24. Retainer
25. Thrust washer
26. Pulley drive gear
27. Shifter fork
28. Sliding gear
29. Sliding gear
30. Center fork
33. Front fork
34. Sliding gear
35. Rail support
38. Pulley carrier
40. Pulley gear and shaft
42. Felt washer
44. Clutch shaft
46. Clutch coupling
49. Retainer
50. Retainer
52. Bevel pinion shaft
55. Bearing shim
57. Front end plate
59. Stationary gear
61. Snap ring
62. Stationary gear
63. Stationary gear
64. Oiler gear
65. Reverse gear
66. Stationary gear
68. Snap ring
69. Rear fork
72. Rail poppet
73. Poppet spring
75. Bull pinion and shaft
76. Bevel ring gear
77. Differential gear
78. Differential pinion
80. Pinion carrier
81. Main frame
82. Differential housing (left)

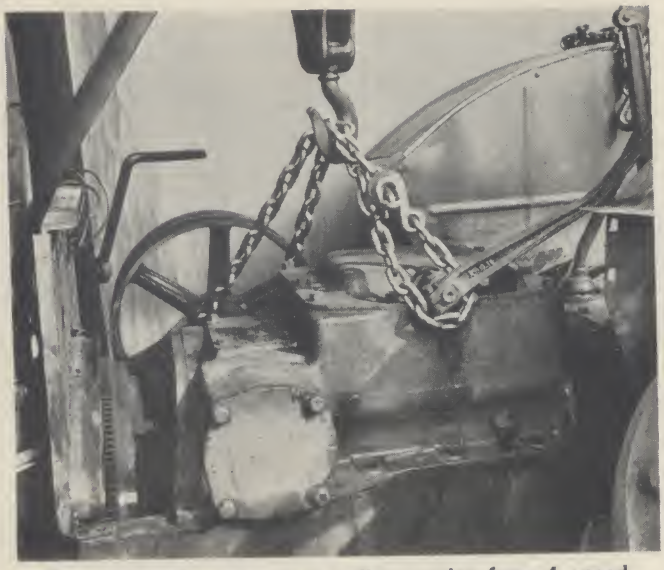


Fig. 0594—Removing belt pulley carrier from 4 speed tractors. Unit will be easier to handle if pulley is removed before removing carrier unit.

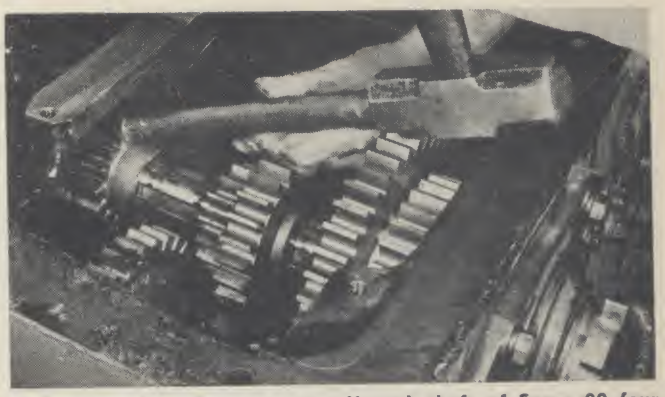


Fig. 0596—Bumping the spline (input) shaft of Super 99 four speed transmission backward prior to removal of shaft.

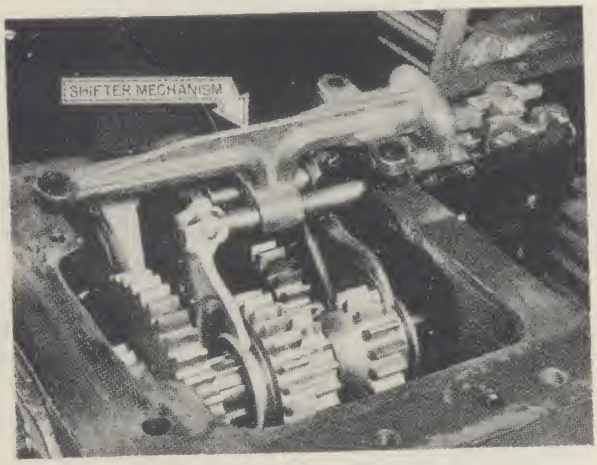


Fig. 0595—Removing gear shifters and forks assembly from Super 99 four speed transmission.

Fig. 0598 — Withdrawing of spline (input) shaft from Super 99 four speed transmission.

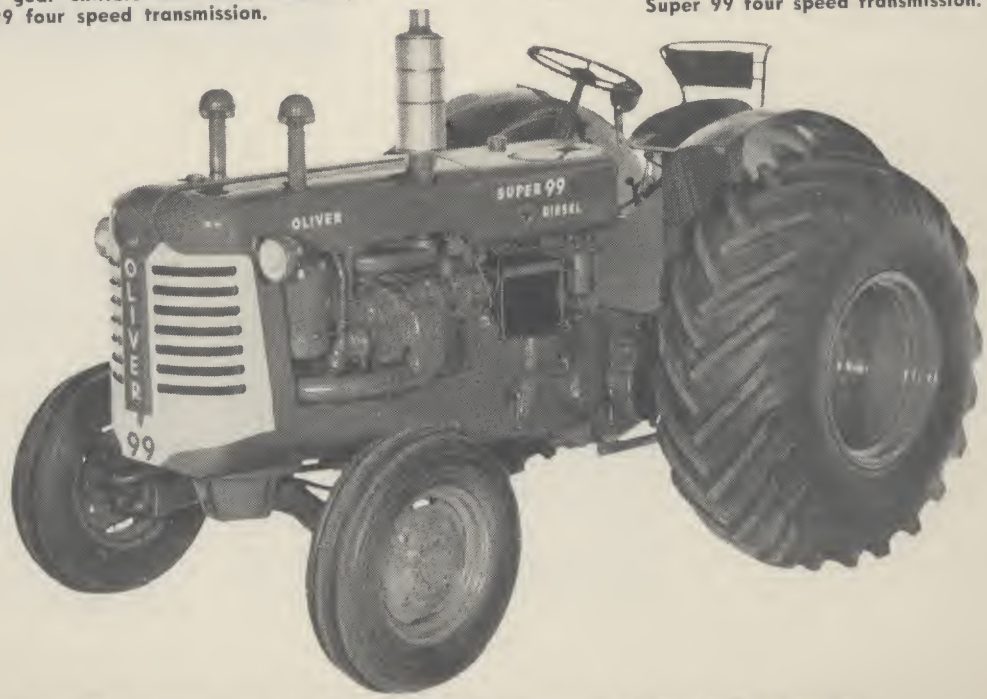


Fig. 0595A—Super 99 GM tractor showing supercharger on the three cylinder engine.

and rear top opening as shown in Fig. 0598.

129B. **REVERSE IDLER GEAR.** After the sliding gear shaft is out the procedure for removing reverse idler gear is self-evident after referring to Fig. 0599.

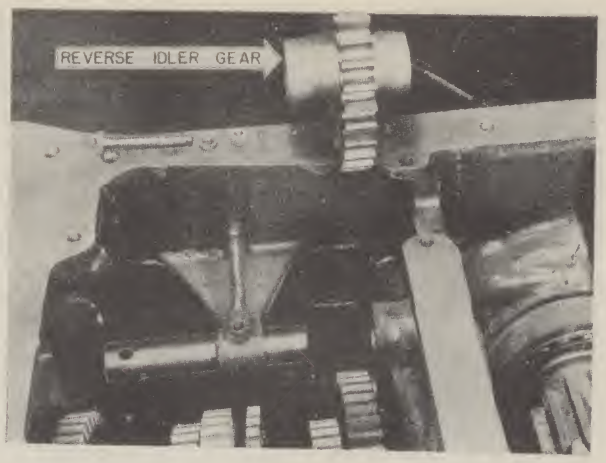


Fig. 0599—Removal of reverse idler gear from Super 99 four speed transmission.

129C. **BEVEL PINION SHAFT.** To remove this shaft shown at (52) in Fig. 0590, first remove the pulley carrier, shifter unit, sliding gear shaft and reverse idler gear as outlined in paragraphs 129 through 129B then proceed as follows:

Remove bearing cover and bearing retainer from transmission front end cover as shown in Figs. 0601 and 0602. Remove snap ring from bearing and shims from behind snap ring and tie the shims to the snap ring for identity. Remove dowels from transmission front cover using a ⅝—11 nut for a puller then remove front cover as shown in Fig. 0600. Bump pinion shaft forward until rear bearing and gear have cleared the bearing bore in case then lift the assembled unit out of the case.

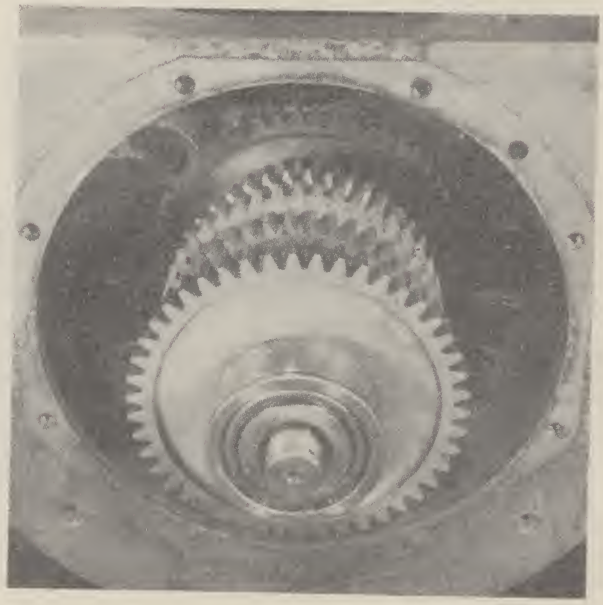


Fig. 0600 — Super 99 four speed transmission with front cover removed showing bevel pinion shaft and gears assembly.

Procedure for disassembling the bevel pinion shaft is self-evident after referring to Figs. 0590 and 0603. The oiler gear bushing (26—Fig. 0603) should have 0.004-0.007 running clearance on hub of adjacent gear. If running clearance exceeds 0.010 renew the bushing which may require sizing after installation. Make sure that oil holes in bushing register with oil holes in gear. If outside diameter of hub of adjacent gear is less than 2.866 renew the gear.

129D. When reassembling the original or a new bevel pinion shaft use the shims (49—Fig. 0603) under the front bearing retainer to bring the heels of the bevel pinion teeth flush with the toes of the teeth on the bevel ring gear.

If the bevel pinion to ring gear backlash is now within the limits of 0.006-0.012, the job is completed. If measured backlash is not within the stated limits it should be adjusted as outlined in paragraph 129E.

129E. To adjust backlash, proceed as follows: By means of the shims under each bull pinion bearing carrier, adjust bearings so that bevel ring gear rotates freely but has minimum end play. After bearings are so adjusted, vary the same shims until the amount of backlash shown stamped on end of pinion (or 0.006-0.012 backlash) is obtained.

Fig. 0601—Half shims are used behind the bevel pinion shaft front bearing snap ring in the Super 99 four speed transmission. Shims control mesh position of pinion.

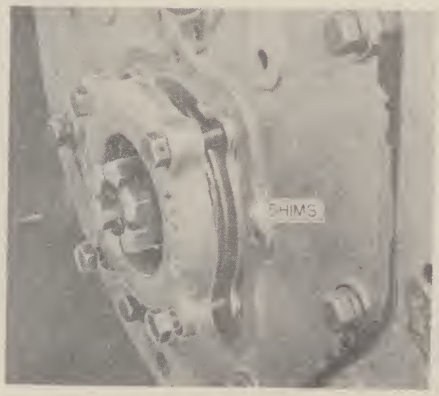


Fig. 0602 — Removing bevel pinion shaft front bearing retainer from transmission front cover on Super 99 four speed tractor.

DIFFERENTIAL AND MAIN DRIVE BEVEL GEARS

DIFFERENTIAL (6 Speed)

(Type used with 4 speed transmissions begins with paragraph 131.)

The differential is combined with the main drive bevel ring in the rear compartment of the transmission case which is called the rear frame. Also mounted on the differential as shown in Fig. 0606 are the two spur gear type bull pinions which drive the final drive bull gears. Beginning with serial 521300, a four pinion differential is used.

130. **REMOVE AND INSTALL.** Procedure for removal of differential, bevel ring gear and bull pinions as a single assembly is as follows: Remove gearshift tower and drop arm from steering gear. Disconnect foot accelerator linkage on tractors so equipped. Remove platform, fenders and bull gear cover as a single unit as shown in Fig. 0499B or, the cover alone by removing seat cover bolts also the cover to platform and cover to rear frame bolts.

Remove both rear wheels and tires assemblies and the bearing cover from outer end of right hand wheel axle shaft carrier. Remove spiral type retaining ring from inner end of right wheel axle shaft then bump shaft out of bull gear. Hoist gear out of rear frame. Remove both brake covers and wear plates (18—Fig. 0606).

Extract sheet metal closure plug (P—Fig. 0588) from each bull pinion shaft. Use a puller which will enter the shaft and engage jaws of puller on shaft shoulder located about 7 inches in, then pull bull pinion and bull pinion bearing cup as a unit out of the rear frame.

Move differential and bevel ring gear unit (D) over against right hand wall of rear frame (transmission) as shown in Fig. 0612. Remove retaining ring (14) from left hand axle shaft then pry bull gear off left hand axle shaft and hoist out. Remove left differential side gear and lift differential

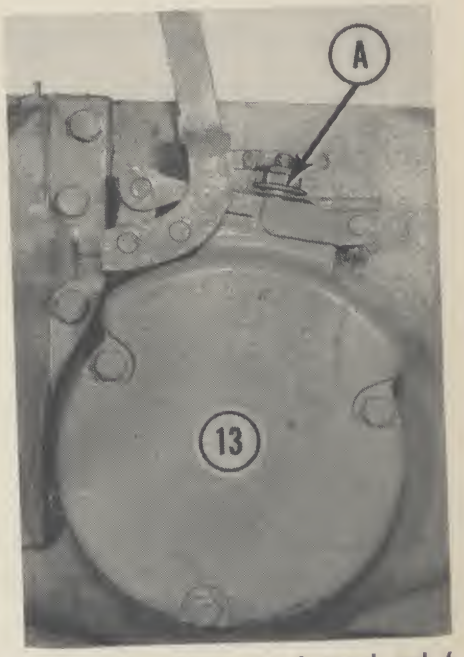


Fig. 0603A — Brakes on 4 speed and 6 speed tractors are adjusted by turning the nut (A). Item (13) is brake cover.

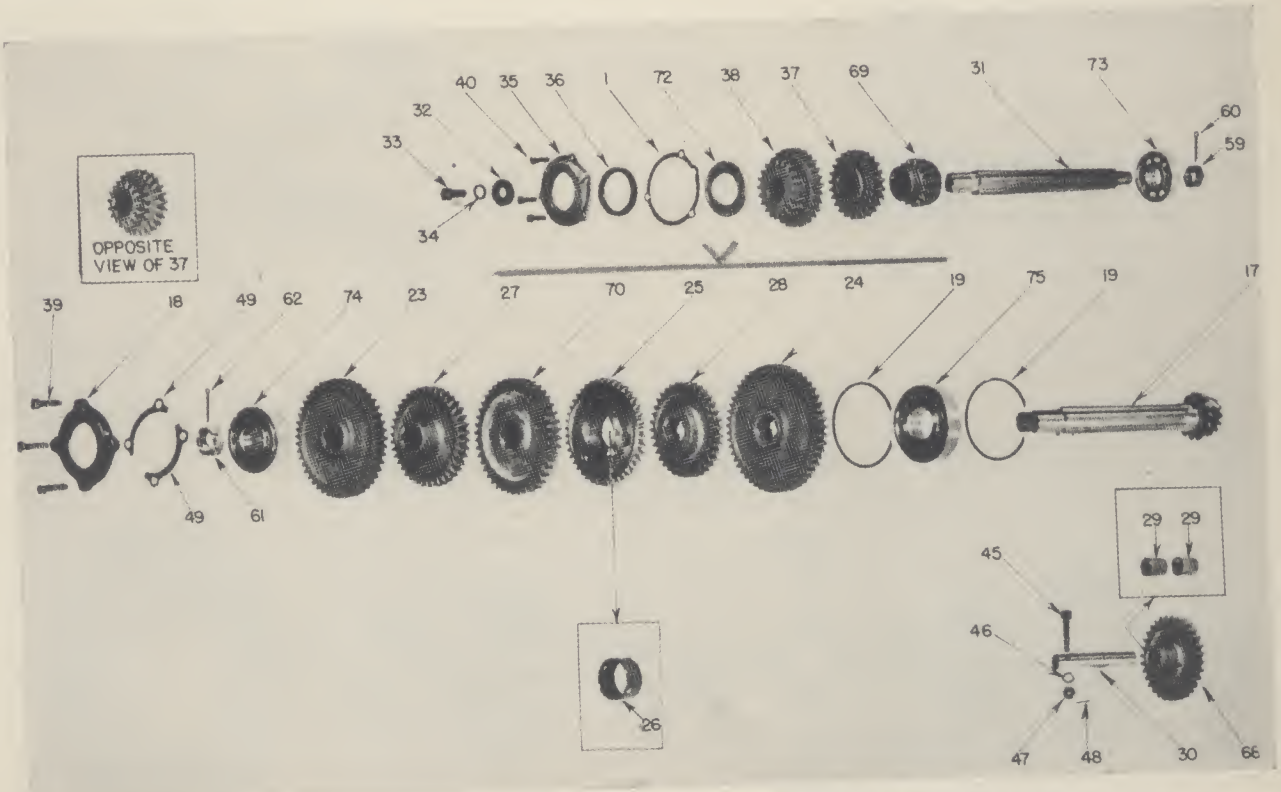


Fig. 0603—Components of 4 speed transmission used in early production Super 99 six cylinder tractors.

17. Bevel pinion shaft
18. Pinion bearing retainer
19. Snap ring
25. Oiler gear
28. Reverse gear
29. Reverse idler bushing
30. Reverse idler shaft
31. Spline shaft
49. Bevel pinion adjusting shim
66. Reverse idler gear

and ring gear unit out by raising left end of differential shaft.

130A. When reinstalling the differential observe the following points: Assemble new oil seals to backing plates with lips of seals facing inward. No gaskets are provided between backing plates and transmission; obtain sealing effect by coating shims with castor oil. Adjust bearings by means of shims (4—Fig. 0606) to obtain 0.002-0.003 end play, making sure that bevel gear teeth are not bottomed on bevel pinion teeth. AFTER this adjustment is obtained, and using the same shims, vary them from one backing plate to the other to obtain 0.008-0.012 backlash between teeth of bevel gears, or, the amount of backlash stamped on ring gear.

Adjust axle shaft bearings to 0.000-0.002 end play. Refer to caption Fig. 0586 for data on later four pinion differential.

130B. **OVERHAUL.** Observe the following points when overhauling the removed differential: To remove pinions (5) extract snap rings (12) from pins (11) then use puller in threaded holes to extract pinion pins from spider.

When riveting ring gear heat rivets to orange color.

Before installing overhauled differential check backlash between differential pinions (5) and differential side gears (6). This can be done by mounting bull pinion upright with side gear installed on top of same. Lower differential assembly into operating position on bull pinion and measure backlash. Turn differential over and check backlash on opposite side. If backlash is less than 0.006 look for a worn spider at thrust face (S). Backlash up to 0.018 is O. K.

Coat shims with castor oil before installing. Normal starting shim pack is 0.094 on each side.

DIFFERENTIAL (4 Speed)

(Six speed type begins with paragraph 130.)

On these tractors the differential is combined with the single final drive bull gear in the rear portion of the transmission case. The bull gear itself is riveted to either the right half of the differential housing or to a separate hub called the spider. A bolted-together assembly located ahead of the bull gear combines the single bull pinion, and main drive bevel ring gear. These tractors are not ordinarily equipped with pinion shaft brakes.

131. **R & R AND OVERHAUL.** Refer to Fig. 0605. To remove the differential and bull gear assembly first block up the rear of tractor and remove the rear wheels. Remove wheel guards and platforms assembled. Remove pto if so equipped and bull gear cover from top of transmission. Disconnect brake linkage if tractor is equipped with rear wheel brakes. Support bull gear in hoist. Remove both rear wheel carriers with their axle shafts, as assemblies, from transmission. Hoist bull gear and differential unit out of transmission.

131A. Procedure for bench overhaul of the assembly is self-evident after an examination of Fig. 0604. The bull gear is available only as an assembly with its spider or right hand differential case to which it is riveted. Carrier bearings (12) complete with their outer races will remain on the differential case and can be renewed after removing the snap rings (11).

MAIN DRIVE BEVEL GEARS (6 Speed)

(Four speed type begins with paragraph 134.)

132. **BEVEL PINION.** The bevel pinion is also the transmission sliding gear shaft and is available separately from the bevel ring gear. The mesh (fore and aft) position of pinion is not adjustable. To remove or renew the bevel pinion follow the procedure outlined in paragraphs 128K through 128N.

133. **BEVEL RING GEAR.** Bevel ring gear is available separately from the bevel pinion. To remove or renew the bevel ring gear independently of the bevel pinion follow the procedure outlined in paragraphs 130 through 130B.

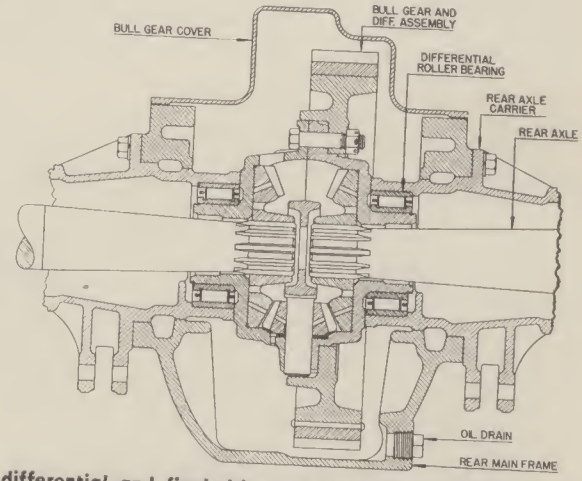


Fig. 0605—Rear view through differential and final drive of 4 speed Super 99 tractor. This design is same as used on late 4 cylinder models 90 and 99 tractors.

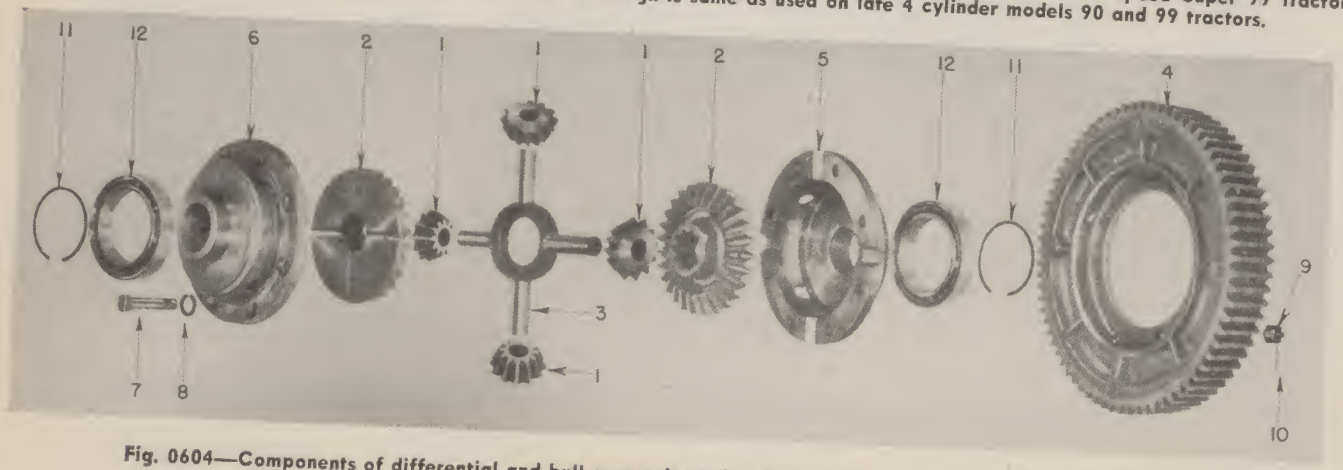


Fig. 0604—Components of differential and bull gear unit used on Super 97 tractors with 4 speed transmissions.

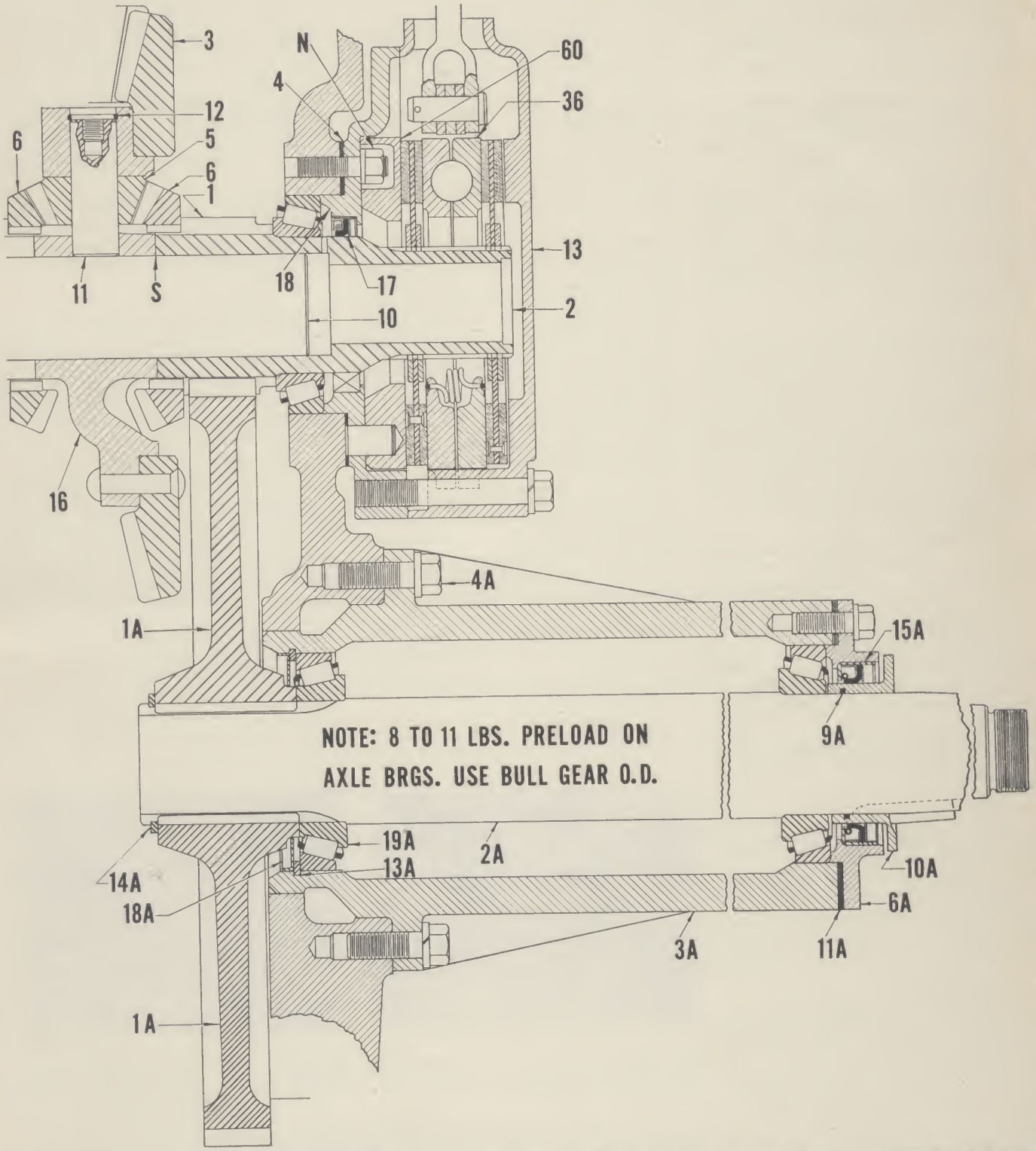


Fig. 0606—Details of bull pinion differential, bevel ring gear, brakes and final drive for one side of tractor equipped with 6 speed transmission. Beginning with serial 521300, the differential is of the four pinion type. The four pinion type can be used in place of the two pinion unit by also changing the bevel ring gear and side gears.

1. Bull pinion
1A. Bull gear
2. Expansion plug
2A. Wheel axle shaft
3. Bevel ring gear
3A. Axle carrier
4. Shims
4A. Shaft carrier screw
5. Differential pinion
6. Side gear
6A. Bearing cover
9A. "O" ring
10. Differential shaft
10A. Oil seal sleeve
11. Differential pin
11A. Shim
12. Retaining ring
13. Brake cover
13A. Snap ring
14A. Snap ring
15A. Oil seal
16. Differential spider
17. Oil seal
18. Brake backing plate
18A. Oil cup
19A. Bearing
36. Actuating disc
60. Brake wear plate

133A. **BEVEL PINION & RING GEAR.** To remove or renew the bevel pinion and ring gear follow the procedure outlined in paragraph 128K to cover the R & R of both gears and 130A and 130B to cover bench overhaul of the ring gear-differential unit.

MAIN DRIVE BEVEL GEARS (4 Speed)

(Six speed type begins with paragraph 132.)

134. **BEVEL PINION.** The spiral bevel pinion which is also the output shaft of the transmission can be removed without disturbing the bevel ring gear or the bull gear by following the procedure outlined in paragraphs 129C through 129E.

135. **BEVEL RING GEAR.** The bevel ring gear and/or the bull pinion can be removed or renewed after first removing either the bull gear as outlined in paragraph 131 or the bevel pinion as outlined in paragraphs 129C through 129E. If the bevel pinion has already been removed, complete the removal of the bevel ring gear as outlined in paragraph 135A.

135A. Remove cap screws from the bull pinion bearing carriers and pry same from the transmission as shown in Fig. 0607. Tie the shims to their mating bearing carriers. Remove bearing cone from right hand end of bull pinion shaft using a suitable puller. Remove the bolts which hold the ring gear to the bull pinion. While supporting the bevel ring gear with a hoist as shown in Fig. 0609, force the bull pinion shaft to the right as far as possible.

Remove the bull pinion shaft and bevel ring gear from the transmission. To reinstall the bearing cone to the right hand end of the bull pinion shaft (which must be done after the shaft is in the main frame) heat the cone in oil to about 300 degrees F. Adjust bull pinion carrier bearings as outlined in paragraph 135B.

135B. Adjust bull pinion shaft carrier bearings so that shaft turns freely without any end play. **After** bearings are adjusted, adjust the bevel ring gear to bevel pinion backlash to 0.006-0.012 by removing shims from one bearing carrier and installing the same shims under the opposite bearing carrier.

135C. **BEVEL PINION & RING GEAR.** To renew the bevel pinion and ring gear, follow the procedure as outlined in paragraphs 129C through 129E for the pinion, and paragraph 135A through 135B for the bevel ring gear.

BULL GEARS, PINIONS, WHEEL AXLES (6 Speed)

(Four speed type begins with paragraph 140.)

136. **BULL PINION & BEARINGS.** Herewith is procedure for renewal of bull pinions and bearings: Remove gearshift tower and drop arm from steering gear. Remove platform, fenders and bull gear cover as a single unit Fig. 0499B or, the bull gear cover alone by removing seat cover bolts also the cover to platform and cover to rear frame bolts.

136A. Remove brake cover from one side of tractor and the lined inner disks and wear plate. Refer to Fig. 0588 and remove 6 nuts (N) from brake backing plate (18). Extract closure plug from hollow outer end of pinion shaft. Use a puller which will enter shaft and engage shoulder, then pull backing plate, bull pinion and bull pinion bearing cup out of transmission. Differential side gear will remain in transmission.

Bearings and oil seals can be renewed at this time. Refer to Fig. 0606 for details. Ordinarily the renewal of pinion or bearings should not change the bearing adjustment or the backlash of bevel gears enough to warrant readjustment, providing the original shims are re-used. It will be advisable however to check the need for adjustment and the procedure for adjusting, by referring to paragraph 130A.

137. **BULL GEAR.** To remove or renew a bull gear proceed as follows: Remove bull gear cover as per first section of paragraph 130.

Refer to Fig. 0606 and remove bearing cover (6A) and sleeve (10A) from outer end of wheel axle shaft carrier. Remove spiral type snap ring (14A) from bull gear end of axle shaft. Bump axle shaft out of bull gear and lift gear out of case. Axle shaft inner bearing cup will remain in axle carrier, both bearing cones will remain on shaft.

Shaft and/or bearings and seals can be renewed at this time. Inner bearing cup can be removed from carrier after removing the oil cup (18A) and snap ring (13A).

137A. Before reassembling shaft and gear to carrier remove any burrs on shaft keyway which might damage the "O" ring (9A) when sleeve and ring are bumped into place. Coat "O" ring and inner and outer surface of sleeve with oil, before installing.

Adjust shaft bearings by means of shims (11A) to 0.000-0.002 end play or, if gear is de-meshed from pinion adjust to 8-11 pounds pull on spring scale hooked into one of the the teeth of bull gear. Normal shim pack is 0.039 thick and shims are available in thicknesses of 0.005, 0.007 and 0.020. Coat shims with castor oil to obtain sealing.

138. **WHEEL AXLE SHAFT & BEARINGS.** To adjust wheel axle shaft bearings remove or add shims (11A—Fig. 0606) located under wheel axle carrier cover (6A). Shims are available in thicknesses of 0.005, 0.007

Fig. 0607—Using a pry bar to remove bull pinion bearing cages from 4 speed transmission.

Fig. 0609—To remove bull pinion or bevel ring gear on 4 speed transmissions without removing the bull gear, the components must be positioned as shown.

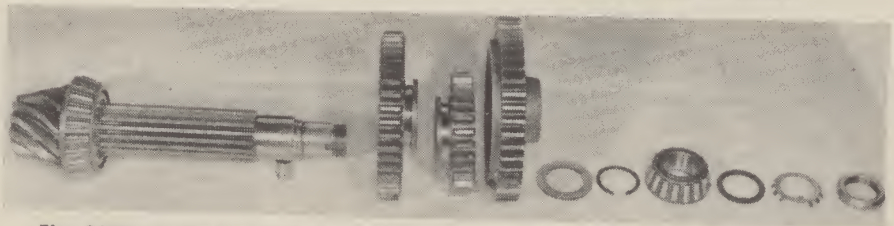


Fig. 0608—Correct arrangement of components of bevel pinion shaft for 6 speed transmission.

and 0.020. Coat shims with castor oil to obtain sealing effect.

138A. To remove or renew wheel axle shaft or bearings follow the procedure for renewal of bull gear as per paragraph 137.

139. **AXLE CARRIER (HOUSING).** To remove or renew the axle carrier (3A—Fig. 0606) proceed as for removing bull gear as per paragraph 137 and R & R carrier from transmission (rear frame) by R & R of cap screws (4A) retaining carrier to rear frame.

BULL GEARS, PINIONS AND WHEEL AXLES (4 Speed)

(Six speed type begins with paragraph 136.)

These tractors are equipped with only one bull pinion and one bull gear. The bull pinion is bolted to the bevel ring gear. The diameter of the bolt flange on the bull pinion is such that the pinion cannot be removed unless either the bull gear or the bevel pinion shaft of the transmission is first removed.

140. **BULL PINION AND BEARINGS.** The bearings for the single bull pinion can be removed or renewed without removing the bull gear by removing the top rear cover from the transmission and the pinion bearing carriers from the transmission. A suitable puller can then be used to extract the bearing cones from the pinion shaft.

To remove or renew the bull pinion first remove the single bull gear as outlined in paragraph 141, then proceed as follows: Remove cap screws from the bull pinion bearing carriers and pry same from the transmission. Bump the bevel ring gear and bull pinion to the left as far as possible then hoist the unit from the transmission housing. Bearings can be easily renewed at this time.

141. **BULL GEAR.** Refer to Fig. 0605. To remove or renew the single bull gear which is integral with the differential, proceed as follows: Block up the tractor and remove rear wheels. Remove wheel guards and platform assembled. Remove pto if so equipped and bull gear cover from top of transmission. Disconnect brake linkage from brakes if tractor is equipped with rear wheel brakes. Support bull gear in hoist while removing both rear wheel carrier and axle shaft assemblies from transmission housing. Hoist the bull gear and differential assembly from the tractor. The differential carrier bearings complete with their outer races will remain on the differential case portion of the bull gear and can be renewed after removing the snap rings (11—Fig. 0604).

142. **WHEEL AXLE SHAFT & BEARINGS.** Rear wheel must be off tractor when adjusting the bearings for one wheel axle shaft as follows: Vary the shims under the bearing cap (36—Fig. 0611) until axle rotates freely but without end play. To do an accurate job of checking the adjustment, the oil seal should be removed from the cap. Apply a light coat of sealing compound or castor oil to shims to prevent oil leakage.

142A. To remove or renew one wheel axle shaft or shaft bearings, refer to Fig. 0611 and remove rear wheel. Apply brakes and hold in applied position to keep brake splines in alignment. Remove bearing cap from outer end of wheel carrier housing and using a suitable puller extract the shaft, outer bearing cup and both bearing cones as a single unit. The inner cup remaining in the carrier can be extracted with a suitable puller entered from outer end.

Lip of the spring loaded oil seal should face inward. It should be noted from the illustration that a spacer (43) is interposed between the axle shaft and the seals. Be careful when reinstalling shaft to avoid damaging inner oil seal (IS). Renew rubber seal ring interposed between the inner face of the wheel hub and the outer face of the spacer on some tractors. Adjust the wheel bearings as outlined in paragraph 142.

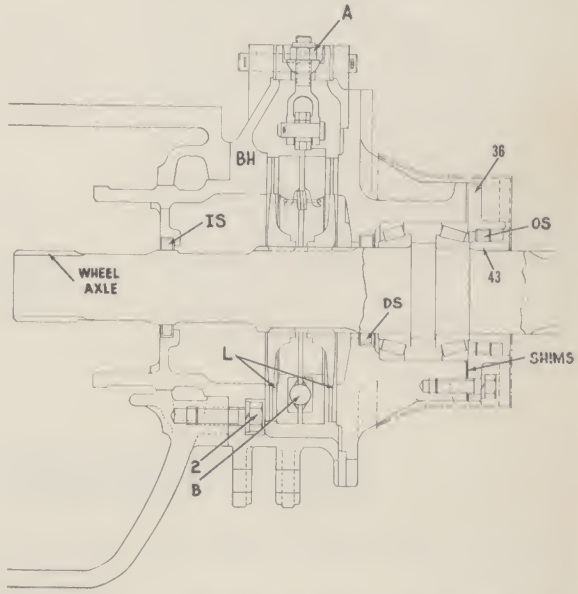


Fig. 0611—Sectional view of wheel axle shaft and disc brakes used on 4 speed Super 99 transmission. Brakes are adjusted by rotating the nut (A).

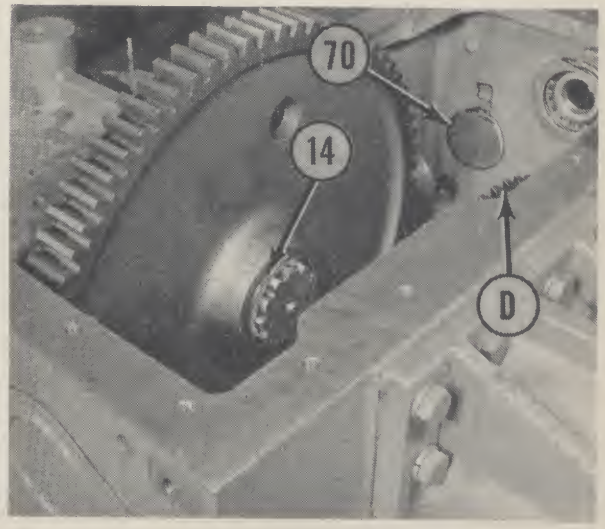


Fig. 0612—Removal of bevel pinion shaft of 6 speed transmission involves removal of bull gears and bevel ring gear and differential unit.

BRAKES

Double disc type brakes located on the rear wheel axle shafts are used on tractors equipped with 4 speed transmissions; similar brakes mounted on the bull pinion shafts are used on 6 speed transmissions.

143. **ADJUSTMENT.** To "take up" on the brakes, rotate nut (A) shown Figs. 0612A and 0606. All of the drum the same to the other brake. Equalize the brakes by backing off on the tight brake. Synchronize the pedals by varying the length of the pedal rods.

143A. **DISCS, DRUMS AND SEALS.** The procedure for removing the lined discs is self-evident after referring to Figs. 0612A and 0606. All of the drum surfaces can be renewed. If brake compartment on wheel brakes (4 speed) contains oil deposits, renew the inner oil seal (IS) Fig. 0611. Grease deposits in the brake compartment indicate leakage through the middle seal (DS). To renew the inner seal (IS) it is necessary to remove the brake housing (BH) and install the seal from the inner side of the housing.

On bull pinion brakes the presence of oil in brake compartment is corrected by renewal of the bull pinion oil seal (17) shown in Fig. 0612A.

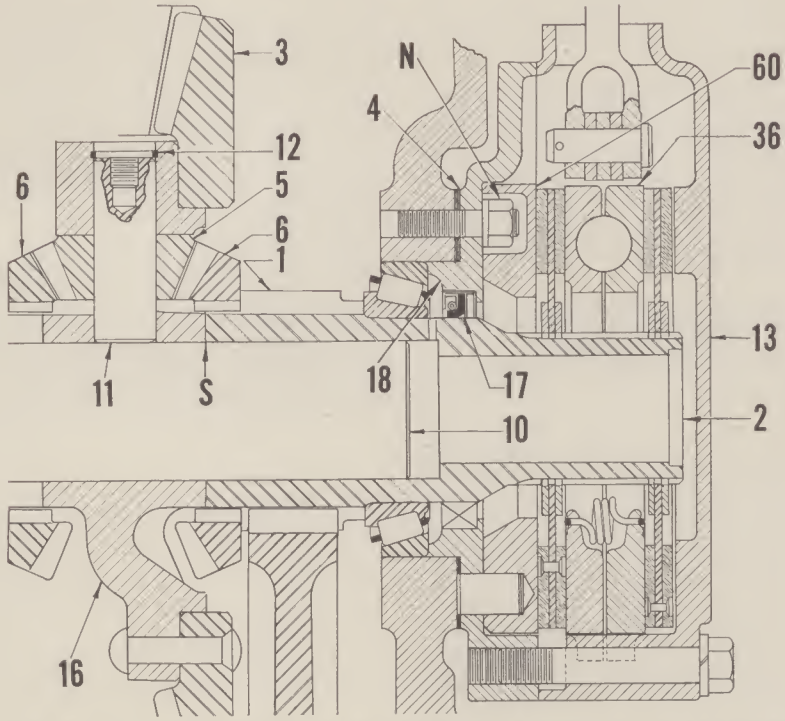


Fig. 0612A—Section through bull pinion and disk brakes on one side of 6 speed tractor. Brakes are adjusted by turning nut (A) shown in Figs. 0603A, 0611.

BELT PULLEY AND PTO (6 Speed)

(Data for 4 speed tractors begins with paragraph 146.)

145. The continuous type pto unit mounted on the rear face of the main rear frame (transmission) as shown in Fig. 0613 is driven from the engine flywheel by a long drive shaft which extends through the hollow clutch shaft and hollow transmission input shaft. As will be seen in Fig. 0614 the pto housing contains the long drive shaft (43) also an overcenter clutch, reduction gears and external output pto shaft (39). The belt pulley element (18) when used, is mounted in place of the cover (16) shown in Fig. 0613.

Paragraphs 145A through 145K cover the servicing of the complete unit and are arranged in an order of coverage which begins with the belt pulley portion of the system, proceeds to the clutch and long drive shaft and ends with the external pto shaft.

BELT PULLEY CARRIER

145A. **R & R AND OVERHAUL.** Procedure for removal of the belt pulley is conventional. Pulley shaft and bearing carrier are removed as an assembly after removing the 4 carrier retaining cap screws. Be careful to wire the shim pack together as these shims control the mesh position of the pulley shaft bevel pinion.

145B. Refer to Figs. 0614 and 0615. To disassemble the already removed carrier, mount shaft flange in vise and remove nut (33). Press or pull bevel gear (8) off of shaft. Pull shaft out of carrier (18). Bearing cups will remain in carrier, cones remain on gear and shaft. Oil seal (21) will be damaged in removal. Cones may be renewed using a knife edge puller, cups may be bumped out.

145C. Reassembly procedure is as follows: Grease the lip of a new oil seal (21) and slide same on to pulley shaft. Assemble bearing cones to bevel gear (8) and to pulley shaft. Insert Woodruff key into pulley shaft and assemble both bearing cups to the carrier (18). Place carrier on press bed as shown in Fig. 0615. Insert a suitably sized split type collar "K" as

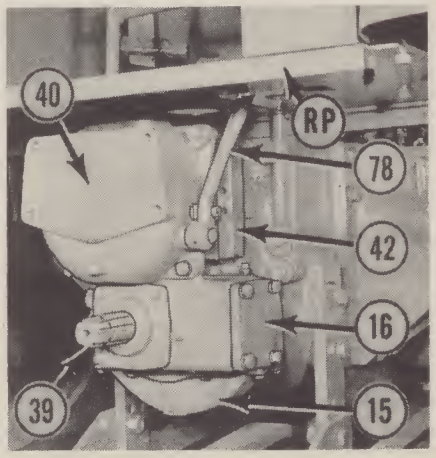


Fig. 0613—Continuous type pto is mounted on rear face of rear main frame as shown.

RP. Rear platform
15. Pan
16. Cover for pulley mounting
39. PTO shaft
40. Clutch housing cover
42. Hand hole cover
78. Operating lever

shown, or two pieces of ¼ inch key stock between inner face of shaft flange and outer face of seal as shown. Now by pressing downward on the pulley end of shaft, force the oil seal (21) squarely into place flush with end of carrier.

Turn the assembly upside down and press the bevel gear on to shaft until shaft has only about 0.010 end play in bearings. Now mount pulley end of shaft vertically in a vise and with a spring scale measure amount of pull (torque) required to rotate carrier around shaft. This amount of pull is the drag of the oil seal and the value should be noted. Install and tighten the gear nut (33) until the spring scale pull required to rotate carrier is 7-10 pounds **higher** than the seal drag reading. Lock the nut by staking.

If shims have become lost or if a new bevel pinion has been installed it will be advisable to check the mesh position of the pinion and to reset if necessary, as outlined in paragraph 145D.

145D. MESH POSITION OF PINION. To check mesh position without removing pto housing from tractor proceed as follows: Remove the bearing cover (28—Fig. 0614) and with the pulley carrier (18) and gasket shims (22) removed, measure the distance (with a depth micrometer) "B" from outer race of bearing (98) to end face of pto housing as shown in Figs. 0614 and 0617. With pinion assembled to carrier (lay or clamp straightedge to end face of bevel pinion) measure the distance "A" from end face of pinion to gasket contacting shoulder surface of the carrier (18) as shown. Record these two measurements.

Note the plus or minus stamped on the face of the pinion and record it. Now add .010 to dimension "B" and subtract the total from dimension "A". To the remainder after the subtraction, add the plus value stamped on the pinion, or if the stamped value has a minus sign, subtract it. This total represents the thickness of the shim pack (22—Fig. 0614) which when installed will automatically locate the proper mesh position of bevel pinion.

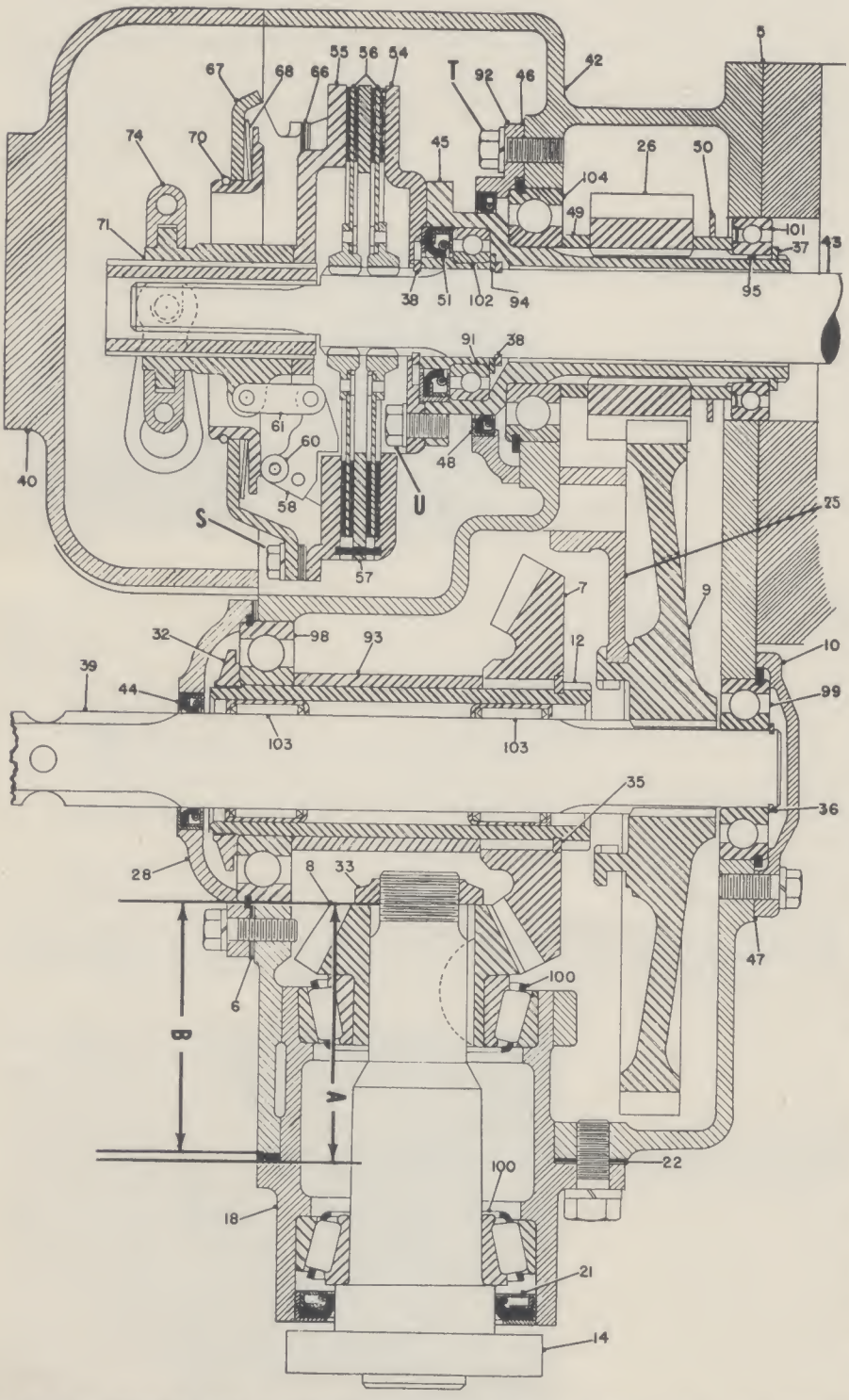


Fig. 0614—Sectional view of combined continuous type pto and belt pulley drive. Shaft (43) passes through hollow transmission and clutch shafts to engage the engine flywheel. Refer to Fig. 0619 for parts legends.

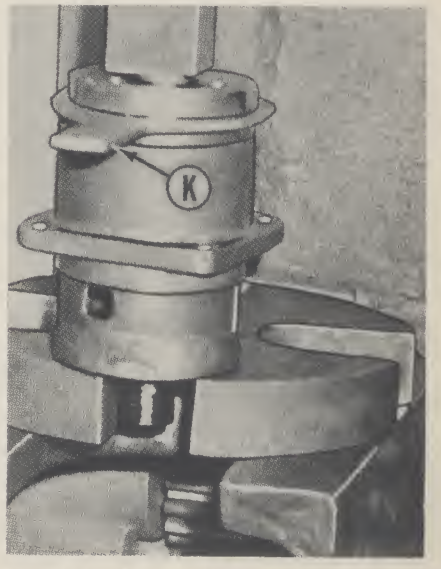


Fig. 0615—Oil seal (21) assembled to shaft (14) is installed into (18) as a single unit using split collar (K) or keystock as shown.

EXAMPLE: Dimension "A" is 4.018
Dimension "B" is 3.926
"B" plus .010 is 3.936
Pinion face marked +0.008
So: 4.018
3.936

0.082 plus 0.008 is 0.090 which is shim pack thickness

(if stamped value on pinion was —0.008 the shim pack would be 0.082 minus 0.008 or 0.074)

Therefore under the above stated conditions with a pinion stamped "+0.008" we would install a shim pack 0.090 thick to set the pinion at the correct mesh position.

The same results can be obtained without calculation if the checking is done when the pto shaft (39) is out of the housing. By this method the pto shaft rear bearing (98) is installed to pto housing and bumped inward (snap ring removed) until only about ⅛ inch of it remains in the pto housing. Now push the pinion and carrier assembly (minus the shims) into the pto housing until the end face of pinion contacts the bearing. Using feeler blades measure the gap at shim pack location (22) and install a shim pack of the same thickness. This will locate the pinion correctly.

After pinion mesh position is established adjust backlash of bevel gears (7 & 8) to 0.005-0.010 by varying the shims (6) located under bearing cap (28).

PTO MECHANISM

145E. **ADJUST PTO CLUTCH.** If clutch slips under load it should be "tightened" as follows: Remove shift lever (78—Fig. 0613) and clutch cover (40). Remove one pair of clutch back plate screws (S—Fig. 0614) and one shim pack (66) therefrom. Remove 2 or 3 shims from pack and reinstall shim pack and screws. Do the same to the remaining two pairs of screws. Reinstall the removed parts and test. If clutch is too tight as manifested by difficulty in bringing it into engagement again remove the stated parts and install a shim to each of the 3 packs.

145F. **CLUTCH OVERHAUL.** The pto clutch can be disassembled and overhauled without removing the drive shaft (43—Fig. 0614) or the pto housing from the rear frame. Procedure is as follows: Remove housing cover (40) and release lever. Remove hand hole covers from each side of housing.

145G. Refer to Figs. 0614 and 0616. Remove clutch back plate screws (S) and lift back plate and release linkage off the shaft. The lined plates (driven members 56) can now be withdrawn. To remove clutch cover (54) remove screws (U). Oil seal (51) can now be renewed. Any further work in the clutch compartment will require removal of the pto drive shaft (43).

145H. **R & R PTO DRIVE SHAFT.** If the pto clutch has been previously removed as in paragraphs 145F and 145G the drive shaft can be withdrawn by removing bearing retainer screws (T) which will permit withdrawal of of the shaft rearward with the sleeve (45), gear (26) and bearings (101 & 104) as a single unit.

145J. The drive shaft (43) can also be removed along with the clutch assembly as a single unit. This procedure which would be followed when it is known that the clutch requires no attention is as follows: Remove clutch housing cover (40) and release lever. Remove hand hole cover from each side of housing. Working through hand hole cover openings remove the 4 bearing retainer cap screws (T—Fig. 0614) and pull shaft and clutch assembly rearward as shown in Fig. 0618.

145K. **OVERHAUL PTO DRIVE SHAFT.** Disassemble the removed drive shaft and clutch assembly as follows: Lift off the release sleeve. Remove back plate screws (S) and lift off the pressure plate, lined plates

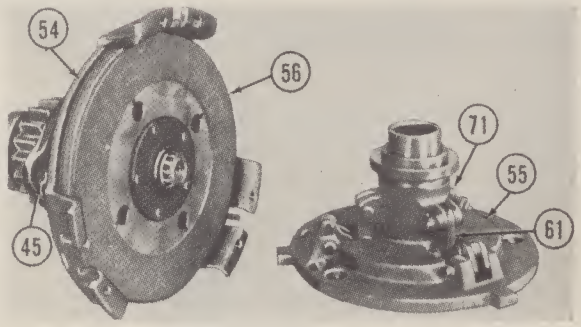


Fig. 0616—Main components of pto disk clutch.

45. Mounting sleeve
54. Clutch housing
55. Pressure plate
56. Driven members
61. Connecting link
71. Release sleeve

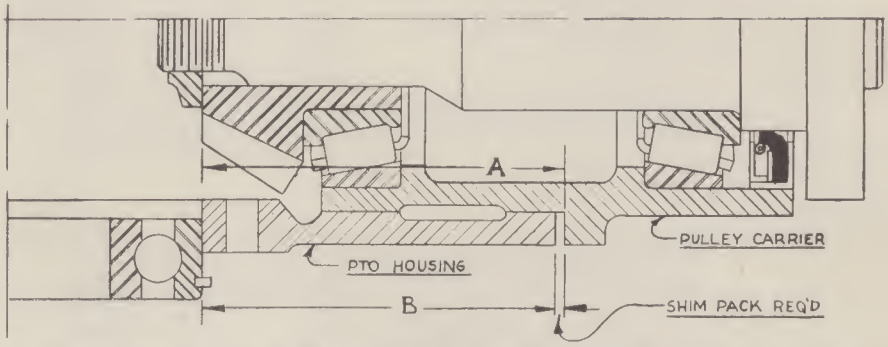


Fig. 0617—Section through belt pulley carrier and pto housing on 6 speed tractors, showing measurements (A) and (B) required for determination of thickness of shim pack to obtain correct mesh position of bevel pinion. Refer to text for formula.

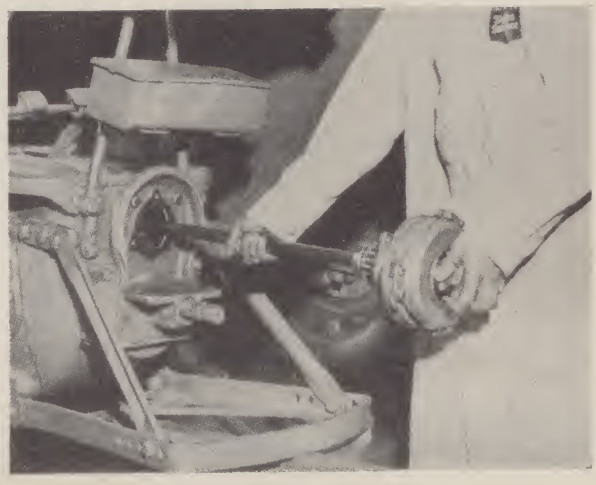


Fig. 0618 — Removing pto clutch and drive shaft assembly as a single unit.

and clutch housing (54). Bump front end of drive shaft (43—Fig. 0614) which will dislodge bearing (102) and seal (51) from the seal mounting sleeve (45). Remove both snap rings (38) and washer (94) then bump or press bearing (102) and seal journal sleeve (91) rearward from the drive shaft. Bearings (101 & 104) and the spur gear (26) can be pressed off mounting sleeve (45) after removing snap ring (37). See Figs. 0621 & 0624.

145L. **R&R COMPLETE PTO UNIT.** To remove complete pto unit housing, drain lubricant and remove rear platform shown at (RP) in Fig. 0613. Remove clutch release lever (78) and the safety shield. Remove 6 cap screws attaching unit to rear frame. Support unit with hoist then withdraw from tractor as shown in Fig. 0620. Removal will be facilitated by using two guiding studs screwed into cap screw holes in rear frame.

145M. **R&R AND OVERHAUL PTO (EXTERNAL OUTPUT) SHAFT.** To remove the pto shaft (39—Fig. 0619) first remove the complete unit housing as described in paragraph 145L. Procedure for overhauling the shaft when pto unit is off the tractor is as follows: Remove oil pan from bottom of pto housing and bearing covers (10 & 28). Remove snap ring (36) from front end of shaft and the shifter poppet (detent) screw, spring and ball from the housing. Bump pto shaft (39) rearward out of the front bear-

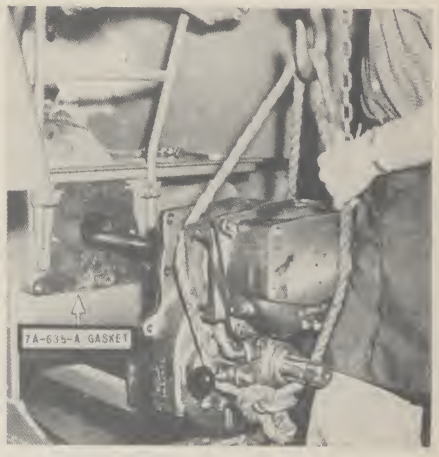


Fig. 0620—Removing pto clutch and belt pulley housing and drive shaft assembly from tractor.

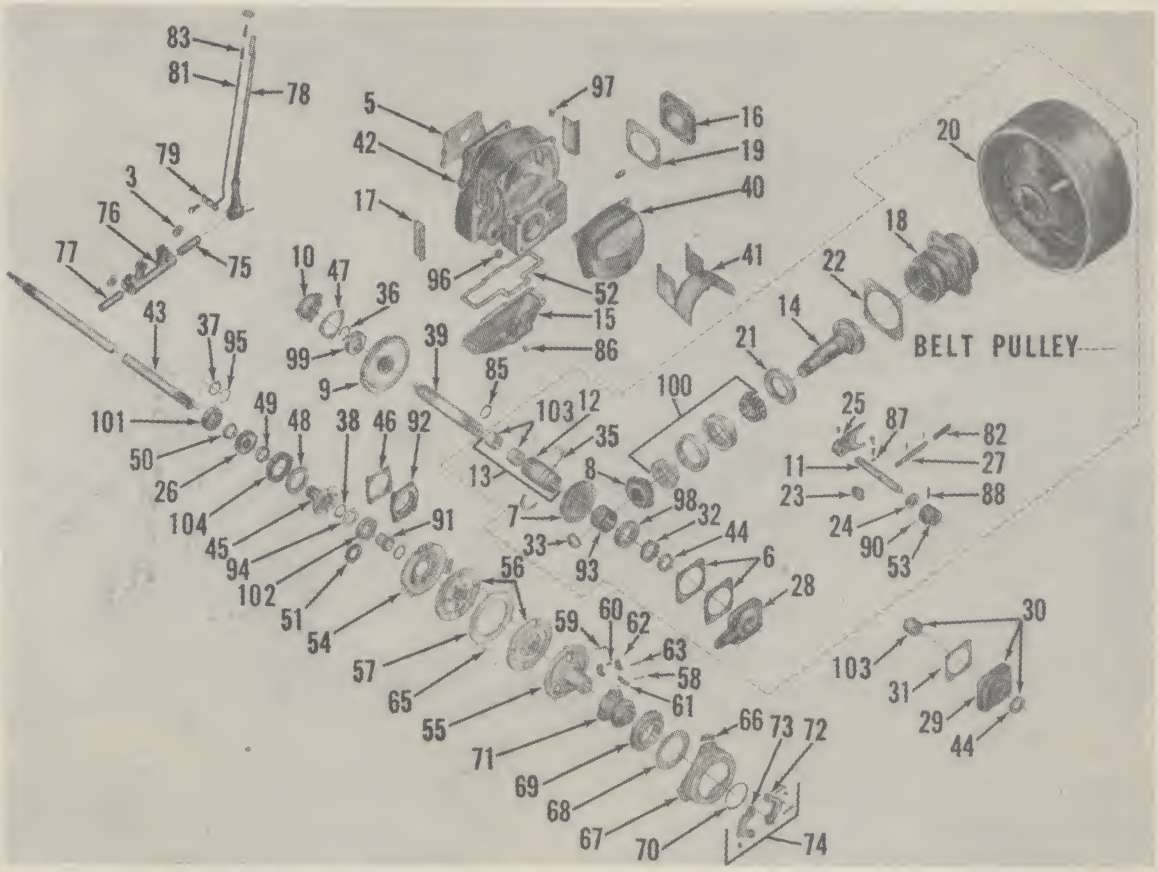


Fig. 0619—Components of the pto and combined belt pulley unit shown in Fig. 0614.

4. Poppet spring
5. PTO housing gasket
6. Shim
7. Pulley drive gear
8. Pulley pinion
9. PTO driven gear
10. Bearing cover
13. Pulley drive shaft
14. Pulley shaft
17. Hand hole cover
18. BP bearing carrier
21. Oil seal
22. Shim
24. Oil seal
25. Shift fork
28. Bearing cover
35. Split ring
36. Snap ring
37. Snap ring
38. Snap ring
39. PTO shaft
40. Clutch housing cover
41. Shield
42. PTO housing
43. PTO drive shaft
44. Oil seal
45. Mounting sleeve
48. Oil seal
49. Spacer
50. Spacer
53. Shift rod collar
54. Clutch housing
55. Pressure plate
56. Driven member
57. Clutch center plate
60. Clutch lever roller
61. Connecting link
66. Shim pack
67. Back plate
68. Pressure washer
69. Washer plate
74. Release bearing
75. Clutch release shaft
76. Clutch release fork
77. Release pivot
78. Release lever
91. Oil seal sleeve
92. Bearing retainer
93. Spacer
95. "O" ring
97. Breather
98. Bearing
100. Bearing
101. Bearing
102. Bearing
103. Needle bearing

ing (99), large spur gear (9) and needle bearings (103). Lift spur gear and shaft from the housing.

Remove lock screw from shifter fork (25) and withdraw shifter fork and rail, and front bearing (99) from pto housing. Remove nut (32) from rear end of pulley drive shaft (12), bump rear end of shaft forward and extract the split rings (35). Remove bevel gear (7) and spacer (93) from shaft and pulley drive shaft and rear bearing (98) from the pto housing. If the needle bearings (103) are to be renewed use a driver similar to the one shown in Fig. 0623. Outer end of needle bearing at threaded end of shaft should be located ¼ inch in from end; bearing at opposite (front) end should be located ⅝ inch in from front end of shaft. Shaft nut (32) should be locked by staking using a pin punch.

145N. **BACKLASH.** Before installing the various covers to the pto housing make sure that the bevel gear (7) on pulley drive shaft has .005-.010 backlash as shown in Fig. 0622. Obtain specified lash by varying the shims (6) shown in Fig. 0614. Mesh position of bevel pinion (8) is controlled by shims (22).

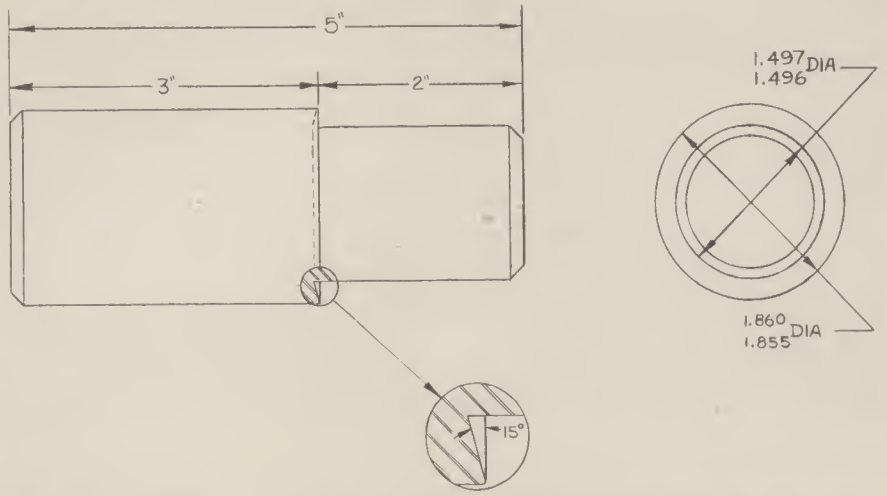


Fig. 0623—Dimensions of a piloted drift designed especially for quick and safe renewal of caged type needle roller bearings. Note 15 degree angle which will concentrate the load on shoulder portion of bearing cage for prevention of distortion.

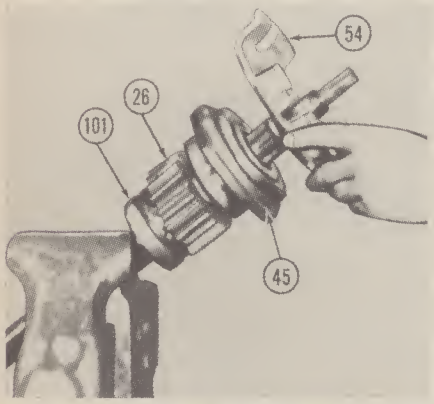


Fig. 0621—Removing pto clutch housing (54) from mounting sleeve (45). Drive gear is (26).

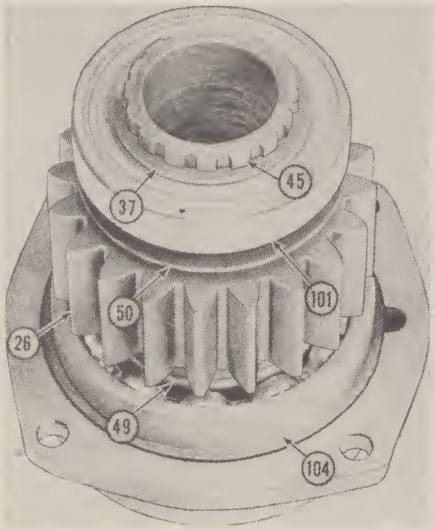


Fig. 0624 — Subassembly containing pto clutch mounting sleeve (45), drive gear (26) spacers (49) and (50).

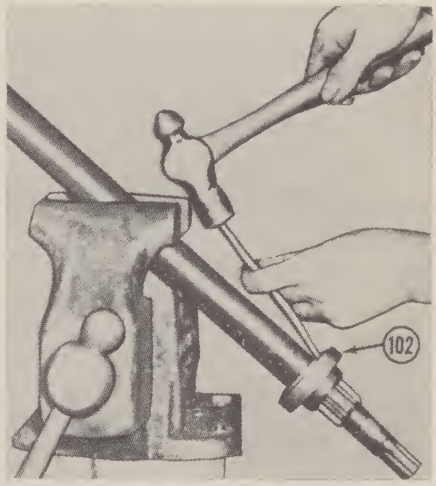


Fig. 0626—Removing bearing (102) and oil seal sleeve (91) from pto drive shaft used with "live" type pto.

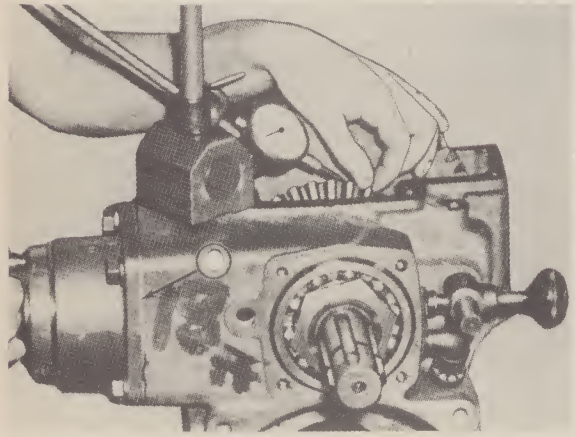


Fig. 0622—Checking backlash of pto belt pulley bevel gears (6 speed tractors) which is controlled by shims.

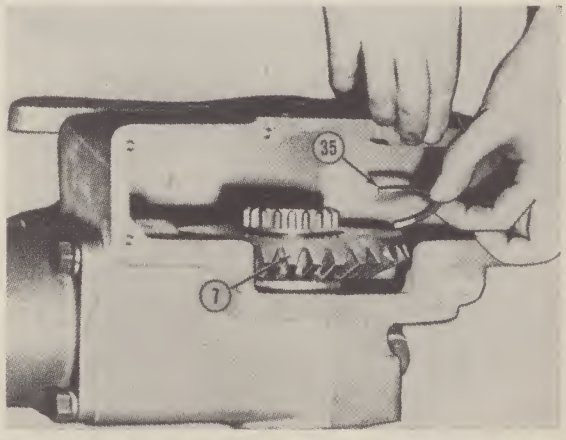


Fig. 0625—Inserting split lock rings (35) used (6 speed tractors) to locate the bevel gear (7) on hollow pulley shaft shown at (12) in Fig. 0614.

BELT PULLEY AND PTO (4 Speed)

(Data for 6 speed tractors begins with paragraph 145.)

BELT PULLEY

146. **PULLEY AND SHAFT.** Refer to Fig. 0627. To remove only the belt pulley and shaft, proceed as follows: Remove nut (10) from end of pulley shaft and pull pulley off the shaft. Remove oil seal retainer from same end of shaft and bearing cage (1) from opposite end. Tie the shims (34) together. Bump the pulley shaft to the left out of the carrier. Procedure for disassembly and overhaul are self-evident. The straight bevel gear (5) can be purchased separately. Adjust backlash of bevel gear teeth by varying the shims (34) under the bearing cage as outlined in paragraph 146C.

146A. **R&R PULLEY CARRIER.** To remove the complete pulley carrier assembly from the tractor proceed as follows: Disconnect battery or batteries from wiring. Remove fuel supply tank and tank support and lay instrument panel on platform or other resting place. Remove clutch front cover (31—Fig. 0457A) and pto drive shaft if so equipped. Remove pulley and steering gear unit from belt pulley carrier housing. Remove locating dowels from front frame also the retaining cap screws and hoist carrier from tractor as shown in Fig. 0594.

146B. **OVERHAUL.** Procedure for overhauling the pulley carrier after it has been removed from the tractor is self-evident after referring to Figs. 0627 and 0628. The straight bevel gears can be purchased separately. After unit is assembled but before installing it to the tractor, check and adjust the mesh position and backlash of the bevel gears as outlined in paragraph 146C.

146C. **MESH AND BACKLASH.** Correct mesh position is with heel (large) end of drive bevel gear flush with toe end of other gear as shown in Fig. 0627. Correct backlash is 0.005-0.010. Obtain flush mesh position by varying the shims (20) and obtain the desired 0.005-0.010 backlash by varying the shims (34) located under the pulley shaft bearing cage. Bearings are non-adjustable ball type.

PTO UNIT

146D. The power take-off is of the same general design as used on the series 70 tractors except that the pto external shaft is spline coupled to the rear end of the pulley drive shaft (DS) shown in Fig. 0627. The service and overhaul procedures are self-evident.

1. Bearing cage
2. Retainer
4. Spacer
5. Pulley drive pinion
6. Pulley shaft
9. Oil seal
13. Bevel gear and shaft
17. Pulley drive gear
18. Thrust washer
20. Shims
21. Bearing cage
25. Retainer
26. Shifter fork
27. Shifter arm
28. Shifter shaft
29. Shifter stop
31. Shifter lever
32. Pulley carrier
33. Carrier cover
34. Shims

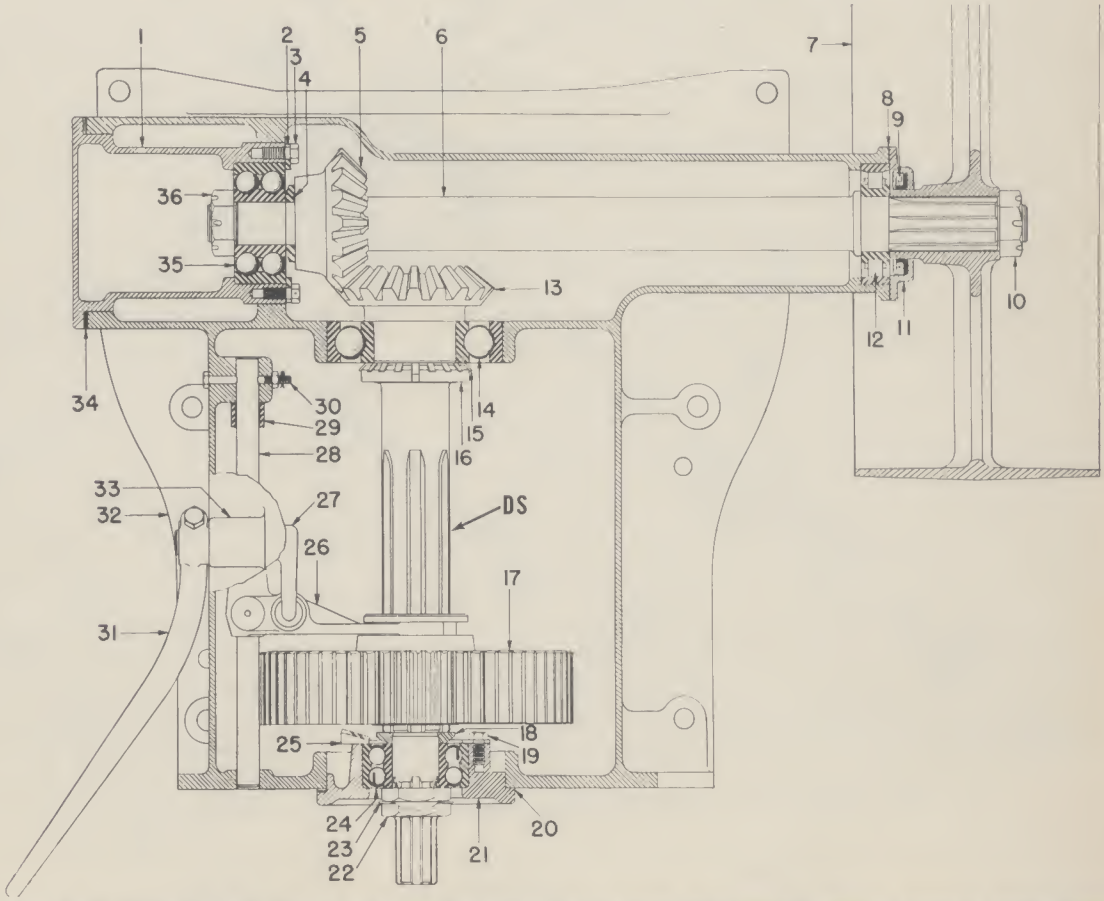


Fig. 0627—Sectional top view of belt pulley carrier and pto drive unit used on models having 4 speed transmission. This unit forms the front top cover of the transmission.

HYDRAULIC SYSTEMS

BRIEF DESCRIPTION

147. Two types of hydraulic systems are available for the Super 99 tractors. The non-depth control system comprises an engine mounted, engine driven, Vickers pump, a fluid reservoir mounted on the side of the chassis, 4 way control valve mounted on the reservoir and a remote double acting two hose work cylinder conforming to ASAE standards.

In the depth control system, one assembly comprising the Vickers pump, control valve and reservoir is mounted on the rear face of the transmission or rear face of continuous pto clutch housing. On tractors without pto, the pump is driven by a long drive shaft splined into the engine flywheel. On pto equipped tractors the pump is joined to the pto clutch shaft by a conventional drive coupling. The work cylinder used in depth control systems is called the "Hydro-Stop" type and is fitted with three hoses to provide hydraulic (non-manual) depth control.

Both systems use SAE 10W engine oil as the operating fluid. Reservoir capacity is 1¾ gallons for the depth control system; 4.3 gallons for the non-depth control system which has the engine mounted pump. Operating pressure is 1250 psi maximum for both systems.

148. **TROUBLE SHOOTING.** Internal leakage arising from leaking valves, seals or gaskets is manifested by failure of the unit to control the ground engaging implement. Under such conditions the implement will either settle to the ground from the raised position or the soil penetration depth will slowly increase from a fixed position due to the natural ground suction of the tool.

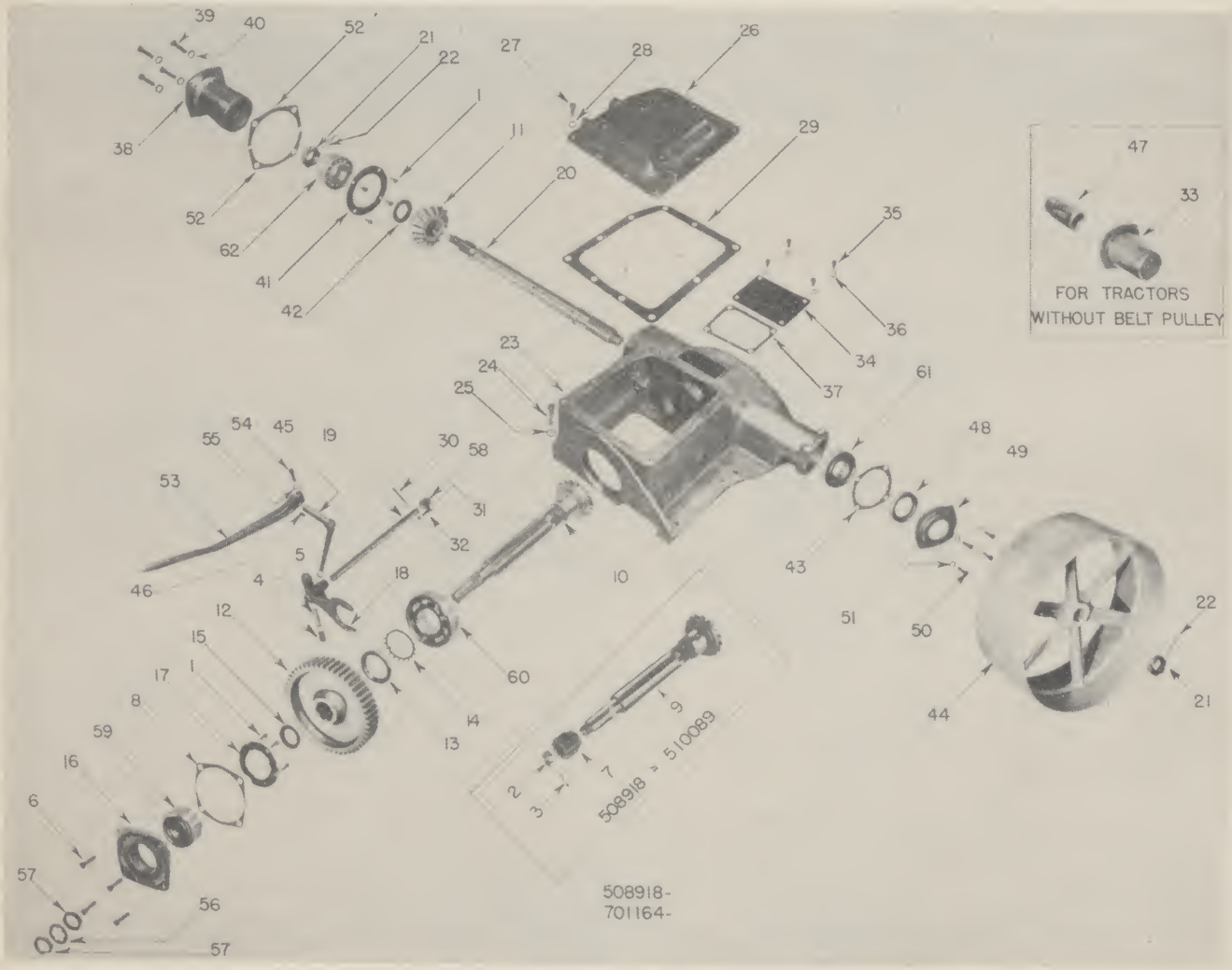


Fig. 0628—Components of belt pulley carrier assembly used on tractors equipped with 4 speed transmission.

4. Poppet
5. Poppet spring
7. Coupling
8. Shim
9. Pulley gear
10. Pulley gear
11. Pinion
15. Thrust washer
12. Drive gear
20. Pulley shaft
23. Carrier
26. Carrier cover
38. Bearing cage
41. Bearing retainer
42. Spacer
45. Shifter arm
47. Spacer
48. Oil seal
49. Bearing cover
52. Shim
58. Shifter stop
59. Ball bearing
60. Ball bearing, front
61. Ball bearing, right
62. Ball bearing, left

A check of the pressure relief valve unseating pressure can be made by connecting a high reading pressure gauge anywhere into the outlet (pressure) side of the system. If valve (33—Fig. 0634 does not unseat in the range of 1235-1270 psi remove it for inspection. Renew any ridged, grooved, worn or otherwise damaged parts. Valve is not adjustable.

DEPTH CONTROL SYSTEM

(Non-depth system begins with paragraph 150.)

149. **HYDRO-STOP WORK CYLINDER.** Two sizes of cylinder are available. Bore diameter for both sizes is 4 inches, stroke is 8 inches or 16 inches.

To overhaul a removed cylinder refer to Fig. 0629 and proceed as follows: Remove rod clevis (4) and gland retainer (12) by unscrewing. Remove Tru-Arc snap ring (6). Gland (2) and piston and rod assembly can now be withdrawn from the cylinder. Access to the piston rod chevron packing (14) is obtained by unscrewing the holder (9). Quill (10) is removed from cylinder base by unscrewing the Allen head screw (18). Install all new "O" rings and other seals.

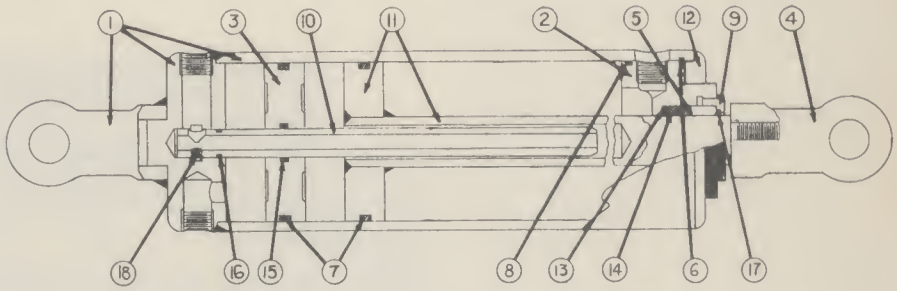


Fig. 0629—Hydro-Stop hydraulic work cylinder used on some Super 99 tractors has 4 inch bore and is available with stroke of 8 inches or 16 inches. Depth stop is hydraulically controlled.

1. Base and clevis
2. Gland
3. Piston stop
4. Clevis rod
5. Bearing
6. Snap ring
7. "O" ring
8. "O" ring
9. Packing holder
10. Quill
11. Piston and rod
12. Gland retainer
13. Backer packing
14. Packing
15. "O" ring
16. "O" ring
17. Wiper
18. Allen screw

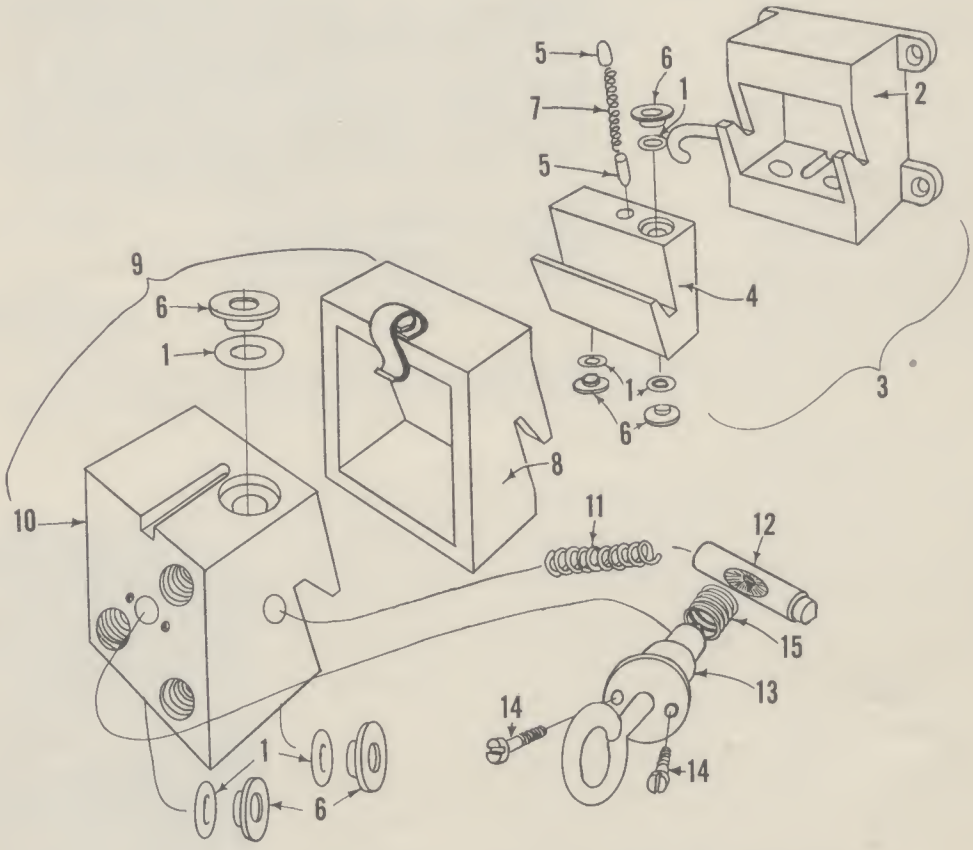


Fig. 0630—Multiple disconnect coupling for hydraulic system hose.

1. "O" ring
2. Housing
3. Coupling half
4. Slide
5. Slide stop pin
6. Seal washer
7. Stop pin spring
8. Housing assembly
9. Half assembly
10. Slide
11. Lock pin spring
12. Lock pin
13. Cam assembly
14. Screw 6-32
15. Cam spring

149A. **CONTROL VALVE.** Valve body assembly (28—Fig. 0634) can be removed from the pump by removing the wire locked attaching screws.

Overhaul a removed valve as follows: Remove the screws which attach the two plates (47) to valve body. Withdraw from bores the control spool caps (45) and stop spool cap (53). Seals and wipers (35, 44, 46 and 52) can be renewed at this time.

Spool valves (43 & 49) are marked with the letter "T" on a flat adjacent to one of the spool collars. Carefully note the installed position of spools then lift them from the valve body bores.

Springs and retainers (50 and 51) can now be removed. Lock valves (41) and springs and balls for same can be removed after unscrewing the plugs (42). High pressure relief valve (33) and its seals and spring will drop out when plug (38) is removed.

Wash all parts except seals in solvent. If body bores show scoring or other damage discard the body. Discard any spool valves or lock valves which are scored, pitted or worn. Pitted or ridged check balls should be renewed. Discard all of the original gaskets, "O" rings and other seals.

149B. Observe these points when reassembling: Install all new gaskets, "O" rings and other seals. Coat all parts with engine oil when assembling. After spools are assembled to body, position them as noted at disassembly. Letter "T" on flat of spool (49) should face upward when viewed from top of valve body. Spool flats should be approximately perpendicular to the perpendicular center line of the bores in body.

149C. **PUMP.** To disassemble a removed pump unit refer to Fig. 0634 and proceed as follows: Remove the screws (2) and pump cover (3), seal (6), pressure plate (5) and plate spring (4). The normal pressure control (relief) valve (21) is removed by pulling pin (20) and removing plug (23).

Before removing the rotor (8), carefully note position of embossed arrow on outer surface of ring (7) in relation to the pump body, also the relative position of the locating pins (10). Remove pins (10) and ring (7) then pull rotor from splined end of shaft (14).

To inspect pump shaft and bearings, remove snap ring (15) and pull shaft (14) and bearing (63) as a unit from pump body. Bearing (62) will remain in body. Wash bearings and check for "lumpiness". To remove inner bearing (62) from body, first extract the seal (13) and spacer (12) then working from rotor end of body, engage outer race of bearing with a drift and bump it out.

After washing all parts inspect rubbing surfaces of same for scoring or pitting. All vanes should slide freely in their rotor slots. Discard all seals. Discard any ridged, scored or pitted rubbing parts.

149D. Observe the following points when reassembling the pump: Coat all parts with engine oil just prior to reassembly. Refer to Fig. 0633 and install new shaft seal into housing counterbore squarely against spacer, keeping the installing sleeve (IS) in place. Assemble shaft through seal, being careful not to push out the installing sleeve until sealing lip of seal is riding on polished surface of shaft then remove sleeve.

Assemble vanes to rotor and ring with rounded surface of vane contacting the race of the elliptical ring. If pressure plate dowel pin (17) has been removed it should be inserted before assembling the valve (21) to pressure plate. Pump cover screws (2) should be torqued to 65-75 foot pounds.

149E. **PUMP TEST SPECIFICATIONS.** Required for a capacity test of the pump are means for maintaining oil temperature at 90—110F, a shut off valve for pressure side of circuit, means for driving the pump and a gauge capable of reading pressures to 1500 psi. With such a set up the pump should deliver 12.5 gallons per minute at 1725 pump rpm when shut off valve is turned to position where 1000 psi pressure is registered. At zero gauge pressure (head) and same rpm the delivery should be at least 16 gallons per minute.

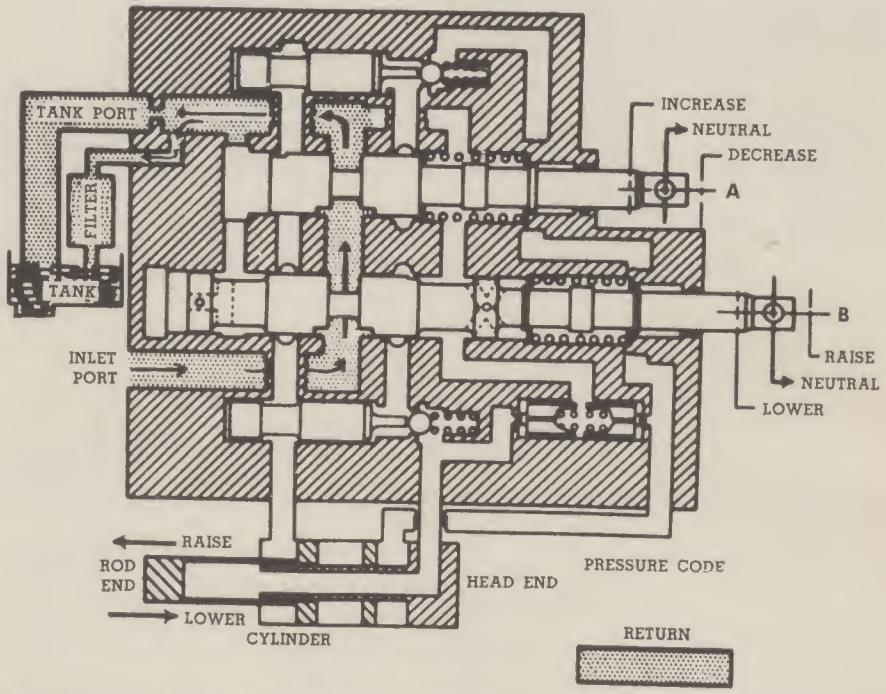


Fig. 0632—Circuit diagram of oil flow in depth control type hydraulic system when control valves "A" and "B" are in neutral position, pump by-passing to reservoir.

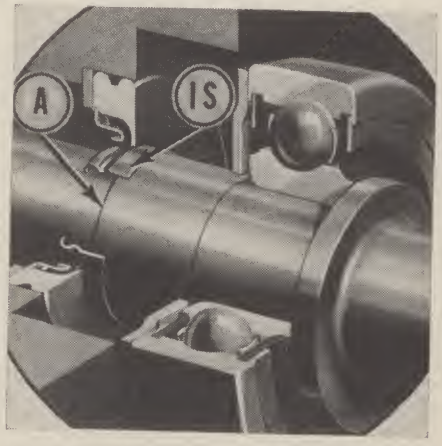


Fig. 0633—Details of shaft seal used on Vickers hydraulic pump. Seal installing sleeve (15) is furnished with each new seal and must be removed after seal is installed.

NON-DEPTH CONTROL SYSTEM

(Depth control type begins with paragraph 149.)

150. **WORK CYLINDER.** A double acting cylinder of 4 inch bore, 8 inch stroke is furnished as standard equipment with the system, but a cylinder of similar bore having 16 inch stroke is optional at extra cost. Both cylinders conform to ASAE Standards.

150A. **CONTROL VALVE.** Procedure for removal of this valve which is mounted on top of the fluid reservoir is conventional and self-evident.

To disassemble and overhaul the removed valve refer to Fig. 0635 and proceed as follows: Remove valve bonnet (2) and cap screw (3) washer, center spring (5) and collar (6) from end of valve spool. Remove control handle and valve spool from housing. Be careful when removing "U" cup seals (16) to prevent damaging collar surfaces of spool.

Light pitting and scoring can be removed from housing bore by honing if smooth surface can be restored without enlarging bore diameter more than 0.005. If valve housing requires oversizing beyond 0.005 reject it and install a new one.

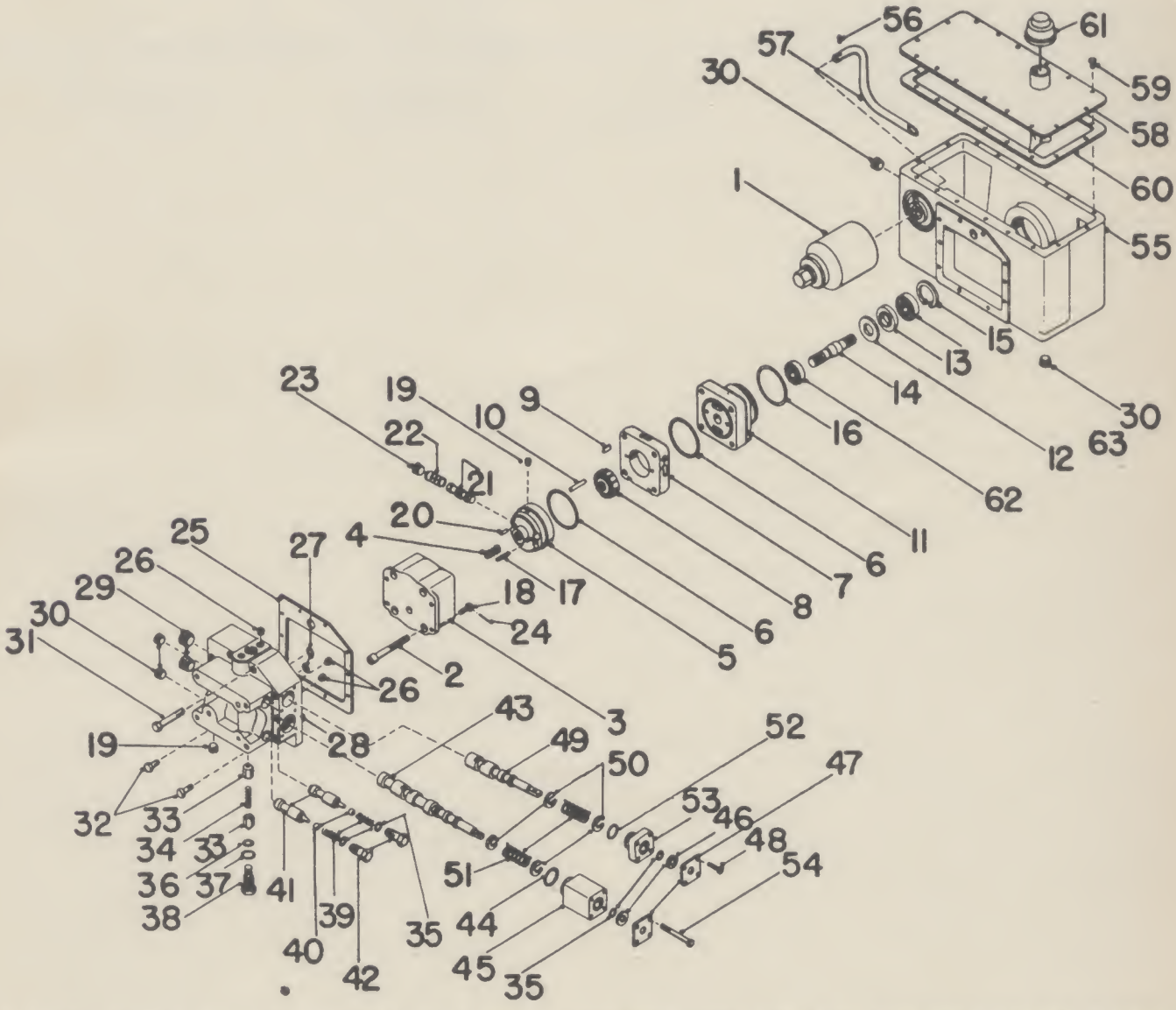


Fig. 0634—Exploded view of the Oliver 7AS-2043-A hydraulic system depth control type. Pump shown here is also used on non-depth control system, the control valve for which is shown in Fig. 0635.

1. Oil filter
2. Pump cover screw
3. Pump cover
4. Spring for plate 5
5. Pressure plate
6. "O" ring
7. Pump ring
8. Pump rotor
9. Vane for rotor 8
10. Dowel pin
11. Pump body
12. Shaft spacer
13. Seal for shaft 14
14. Pump shaft
15. Snap ring
16. "O" ring
17. Plate dowel pin
18. Lock screw
19. Plug
20. Dowel pin
21. Pump control valve
22. Valve spring
25. Gasket
27. "O" ring
28. Valve body
33. Relief valve poppet
34. Relief valve spring
35. "O" ring
36. "O" ring
37. "O" ring
39. Plunger spring
40. Plunger ball
41. Valve plunger
43. Implement control spool
44. "O" ring
45. Control spool cap
46. Spool wiper
47. Spool plate
49. Stop adjustment spool
50. Spring retainer
51. Spool spring
52. "O" ring
53. Stop spool cap
55. Reservoir
56. Groov-pin
57. Drain tube
60. Gasket
62. Pump bearing, inner
63. Pump bearing, outer

Install all new seals. Recommended method for installation of seals (16) is to enter spool until only the groove (A) at bonnet end extends out of body bore. Install seal ring into groove, coat outer surface of seal with engine oil then push spool and seal into bore until groove (B) is exposed at opposite end of valve housing. Install seal ring to groove (B) in a similar manner. Be careful to avoid putting a twist into seal rings when they enter the valve bore.

150B. **PUMP.** This Vickers unit is basically the same as the pump used on depth control system. Procedure for disassembly overhaul and test of pump is contained in paragraphs 149C through 149E.

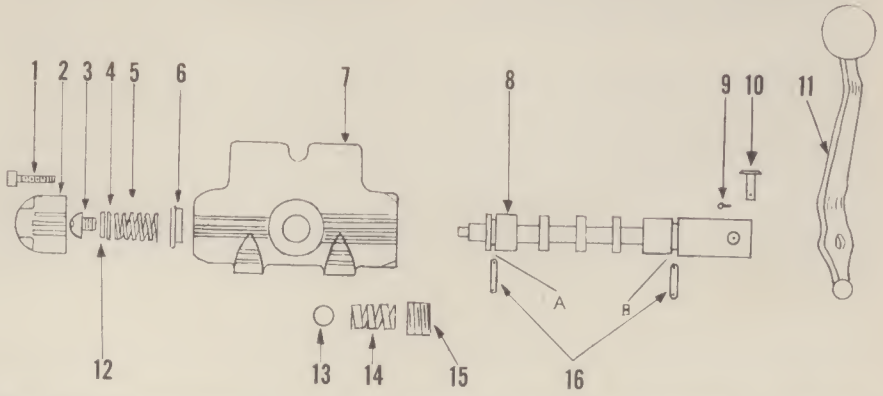


Fig. 0635—Components of control valve used on non-depth control type hydraulic system.

2. Spring bonnet
4. Spring washer
5. Center spring
6. Spool collar
7. Valve housing
8. Control valve
11. Handle
12. Lock washer
13. Relief valve ball
14. Relief valve spring
15. Relief valve plug
16. Seals for grooves A and B

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