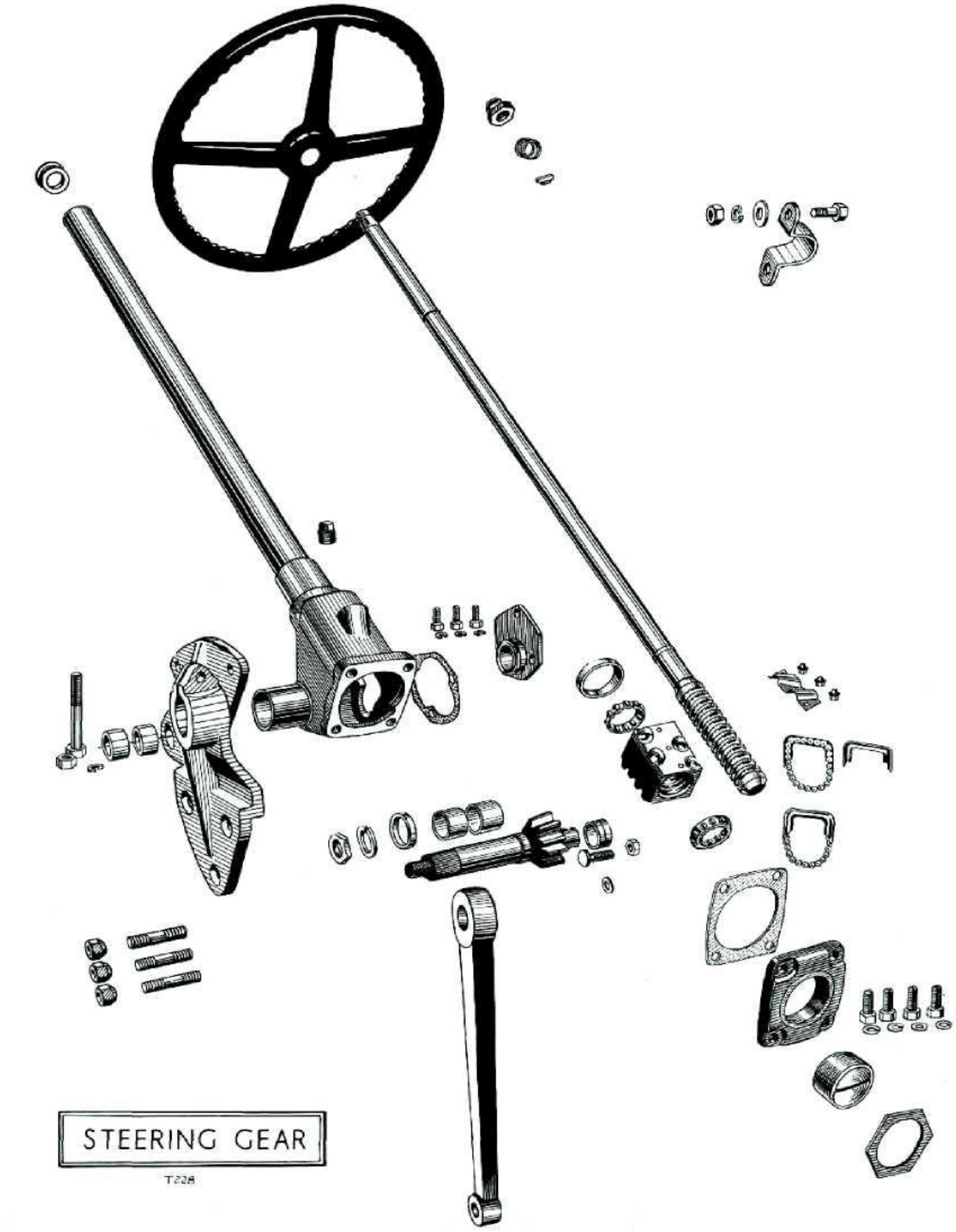
STEERING GEAR
T228

# STEERING GEAR ASSEMBLY (TYPE A)

## DESCRIPTION

The steering gear is of the re-circulating ball type, the ball bearings acting as contact between the worm and the worm nut. The worm, welded to a tubular worm shaft, is mounted between barrel type roller bearings. The worm nut is bored to fit over the worm, and both are threaded with corresponding helical grooves. Two circuits in the nut contain the steel balls so that the balls run between the nut and worm to form the only contact between these two parts. The balls are returned through two pressed metal guides to complete their circuits through the nut.

When the wormshaft is turned, the nut moves along the worm as it would with a normal screw thread. However, the movement of the nut is accomplished by balls rolling between the worm and nut instead of by sliding contact between the parts. This system reduces to a minimum the friction losses of the steering gear.

Teeth on the worm nut engage teeth on a sector on the pitman shaft. The teeth on the pitman shaft are cut on a taper, so that adjustment of the shaft in a lateral direction by means of the adjusting screw "B" will control the segment backlash with the worm nut. The gears are also cut so that if they are adjusted to give no backlash in the straight ahead position, they will have a slight backlash if the wheels are turned to either side. This arrangement allows adjustment to be made for wear in the straight-ahead position without causing binding in the less used turning positions. The pitman shaft is supported in three bushes and an oil seal is fitted at the outside of the housing. Adjustment of the worm bearings is provided by having the lower outer race screwed into the end cover and fitted with a locknut.

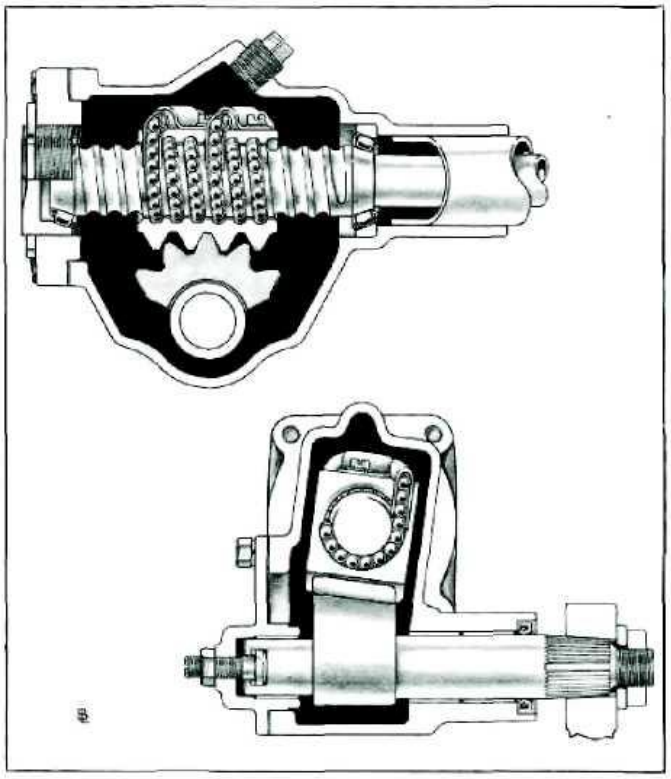

Fig. A.2 — Section through Steering Box

## MAINTENANCE

Check the oil level (up to the level plug) every 500 hours. Top-up as necessary. If the unit appears to be leaking excessively, repairs should be carried out.

## SPECIFICATIONS

| | |
|---|---|
| Type | — Re-circulating ball. |
| Make | — Saginaw. |
| Gear Ratio | — 23.6 : 1. |
| Model | — 548 - E - 48. |
| Bearings | — Worm — Barrel roller.<br>Pitman shaft — Bronze bushings. |
| Quantity of Balls | — 106. |
| Clearances | — Pitman shaft in cover bush, .0015" - .0025".<br>Pitman shaft in housing bushes, .0035" - .0045". |
| End Float | — Worm bearings — .000.<br>Pitman shaft — .002" - .004". |
| Steering Wheel | — 17" diameter. |
| Lubrication | — S.A.E. 140 E.P. gear oil. |

## INSPECTION

The condition of the internal mechanism may be checked by proceeding as follows:

1. Disconnect the draglink and check the adjustment as detailed under "adjustment".

2. Turn the steering wheel slowly and carefully with the drag link disconnected to determine if the operation is rough or lumpy.

Rough or lumpy action indicates worn or damaged bearings. In order to service these, it will be necessary to remove and dismantle the assembly.

**Caution:** Do not turn the wheel hard against the stops, otherwise the worm nut may be damaged when it bottoms in the gear housing.

**To Remove the Steering Gear Assembly: (On tractors with original type handbrake)**

1. Remove the nut and spring washer from the pitman shaft and, with the aid of a suitable puller, remove the pitman arm (Fig. A.4).

2. Remove the domed nut from the steering column and remove the steering wheel. The use of tool No. 22756 or some suitable puller may be found necessary (Fig. A.3). Remove the spring and key.

3. Raise the top engine cowling and remove the upper side cowl. Uncouple the three control rods from the governor control bellcrank and remove the lever from the hand brake spindle. Remove the bolts coupling the offside footplate and rear cowl support to the chassis, coupling shaft cover, fuel tank shield, mudguard, top cowl frame, bulkhead and steering column. Remove the footplate, support and lower side cowl as a unit.

4. Remove the two bolts coupling the governor hand control bracket plate to the instrument panel and remove the three chamfered nuts which retain the steering column bracket to the chassis. Remove the steering assembly and hand brake as a unit.

---

**To Remove the Steering Gear Assembly: (On tractors with later type handbrake)**

1. Remove the nut and spring washer from the pitman shaft and, with the aid of a suitable puller, remove the pitman arm (Fig. A.4).

2. Remove the domed nut from the steering column and remove the steering wheel. The use of tool No. 22756 or some suitable puller may be found necessary (Fig. A.3). Remove the spring and key.

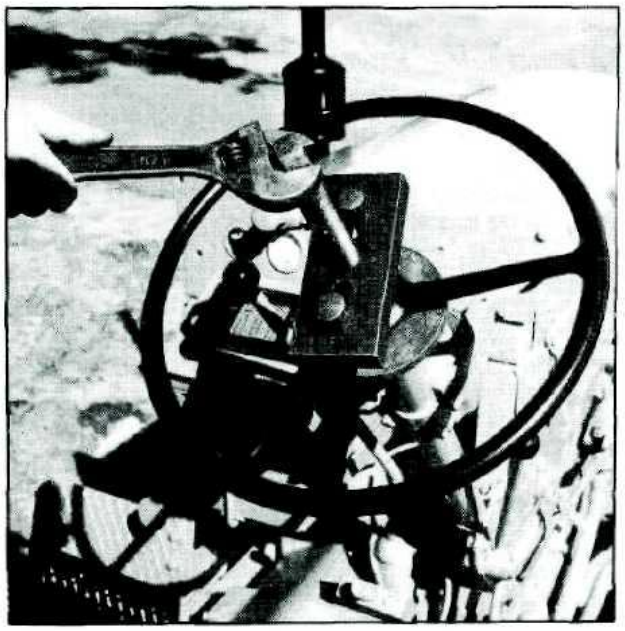

Fig. A.3 — Removing Steering Wheel

3. Raise the top engine cowling and remove the upper and lower side cowls. Disconnect foot pedal to bellcrank rod and remove column clamps.

4. Remove the three chamfered nuts which retain the steering column bracket to chassis and slacken the bracket clamp bolt.

5. Manipulate the column off the studs and free of the tractor.

---

**To Dismantle the Steering Gear Assembly:**

All work must be carried out on a clean bench with clean tools.

1. Unlock and slacken the lash control screw (B).

2. Remove the three bolts from the side cover, and drain the oil from the assembly.

3. Remove the side cover together with the lash control screw and the pitman shaft, from the housing. If the sector will not clear the housing opening, turn the worm by hand until the sector is aligned.

4. Slacken the worm bearing screw locknut (C) and back off the screw (D) a few turns.

5. Clamp (not too tightly) the steering gear housing in a bench vice with the column horizontal and remove the end cover bolts. Remove the end cover, adjusting screw, thrust bearing and gasket.

6. Withdraw the ball nut and the worm shaft through the end cover opening. Hold both parts to prevent the nut turning on the worm. Place the assembly flat on the bench. If the nut is allowed to rotate so that it strikes either end of the worm, the ball guides may be damaged. Inspect the upper thrust bearing race and if damaged or worn, remove it from the housing with the aid of a puller.

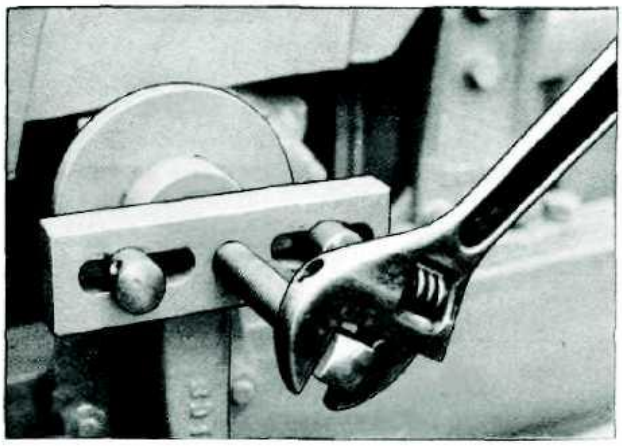

Fig. A.4 — Removing Pitman Arm

7. Inspect the steering shaft upper bearing, and, if faulty, remove from the steering column jacket.

8. Remove the lash adjustment locknut (A), then, with a screwdriver, screw the adjusting screw out of the cover. Slide the lash adjusting screw and washer from the slot in the pitman shaft.

9. Check the fit of the pitman shaft in all three bushes and, if the clearances are greater than those specified, press the bushes from the housing and the side cover. The oil seal will be removed at the same time.

10. If the nut rotates smoothly on the worm shaft without binding or roughness, it is not necessary to dismantle the assembly. If binding or roughness is found, however, it will be necessary to remove the guide races and balls to separate the parts. If one or more balls are found to be faulty, it will be necessary to replace all 106 balls and closely inspect the surfaces of the worm and nut.

When dismantling, check the arrangement of the guides, etc., in order to facilitate re-assembly.

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**Re-assembly and Adjustment:**

It is presumed that the pitman shaft bushes and seal, and upper thrust bearing are in place.

1. Install the worm shaft and nut assembly through the lower end of the housing.

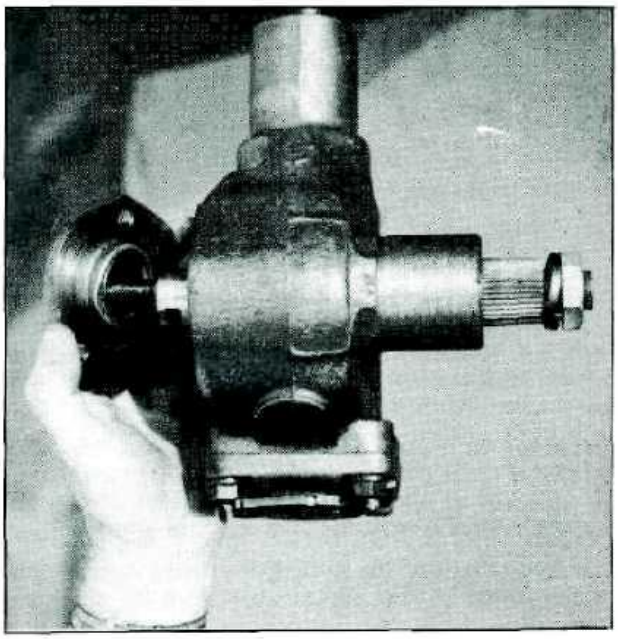

**Fig. A.5 — Removing Pitman Shaft Cover**

2. Replace the end cover assembly, making certain that the lower thrust bearing is in place on the end of the worm shaft. If necessary, use heavy grease to hold it in place. The use of a new gasket is recommended.

3. Grease and fit the steering column upper bearing. Tap it firmly onto its seating in the column jacket.

4. Fit the steering wheel, with spring, key and nut. The fitment of a greased felt washer (31135) under the steering wheel will prevent corrosion of the column upper bearing.

5. Screw in the worm thrust bearing adjustment screw until all end play has been eliminated then tighten until a force of 1½ lbs. must be applied to the outer end of one of the steering wheel spokes to turn the wheel. This may be checked with the aid of a spring balance. Lock the adjusting screw.

6. Push the assembled pitman shaft, side cover and adjustment screw into position. Make sure that the centre tooth on the sector engages in the centre slot in the worm nut. Fit and tighten the cover bolts.

7. Adjust the lash screw with the mechanism positioned in centre of its travel (straight ahead position) to give an extra pre-load on the steering wheel of one pound (a total of 2½ lbs.). Lock the adjusting screw.

8. Re-assemble the unit, together with the other parts removed, to the tractor. Care must be exercised to prevent a bending stress being imposed on the column. Refill to the level of the filler plug with S.A.E. 140 E.P. gear oil.

9. Reconnect the drag link and check that the governor controls are correctly adjusted.

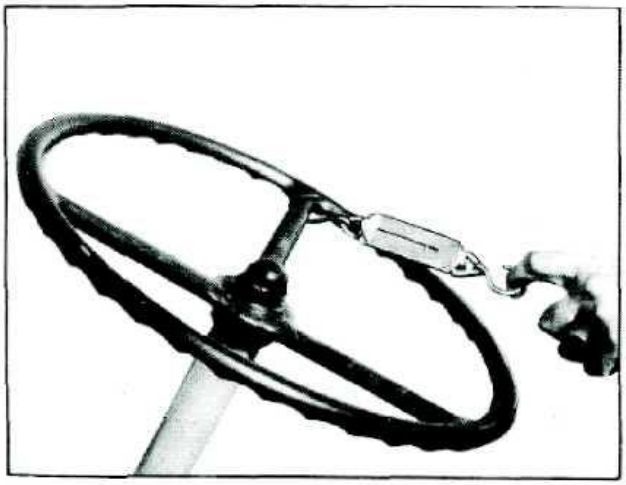

**Fig. A.6 — Checking Bearing Pre-Load**

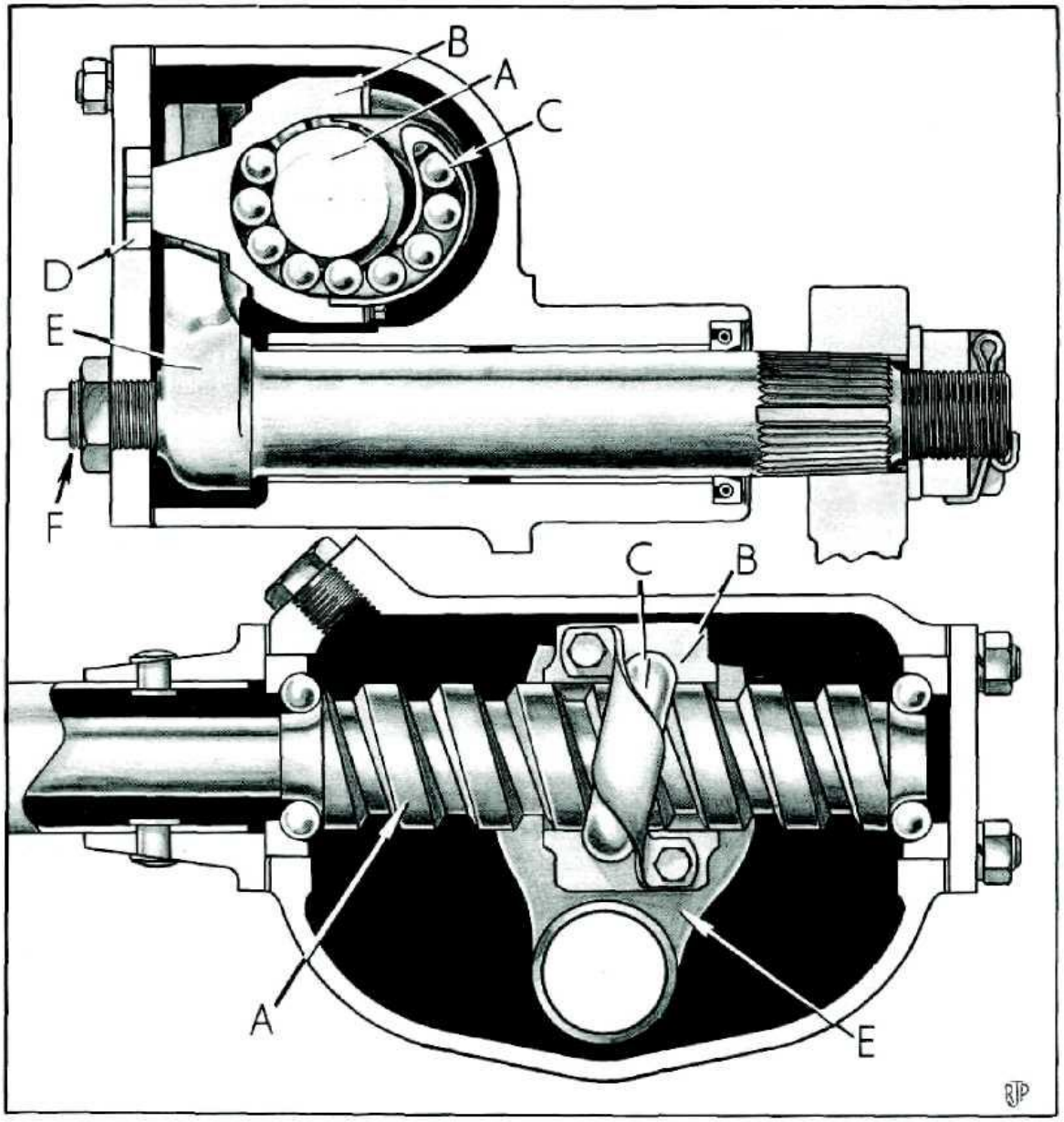


Fig. A.7 — Sectional Diagrams of Model B Steering Box

# STEERING GEAR (TYPE B)

## DESCRIPTION

This unit operates on the re-circulating ball principle, the balls acting as contact between a worm and nut. The nut operates on a fork integral with the pitman shaft.

The steering wheel is connected by a shaft to the worm (A) which is supported by angular contact ball bearings. The bearings are adjusted by shims under the flange of the end cover.

The nut (B) has a spiral groove cut in its internal face to coincide with the spiral groove of the worm, and ball bearings occupy the cavity thus provided. When the worm is rotated by the steering wheel the nut is moved by the ball bearings along the length of the worm. The balls are collected, when discharged from the nut, by a pressed metal guide (C) and returned to the other end of the groove. A smooth, low friction drive is thus obtained.

The nut (B) is provided with an extension on which is fitted a roller (D). This roller runs in a groove cut in the side cover, allowing free side travel of the nut, but preventing it from turning with the worm.

A conical face on the nut engages with tapered faces on the inside of the pitman shaft fork (E), the clearance between the two faces being adjustable by the screw (F). The pitman shaft is supported by two bushes and is provided with a spring loaded type oil seal.

## SPECIFICATION

| | |
|---|---|
| Type | — Re-circulating ball. |
| Make | — Burman. |
| Gear Ratio | — 22.3 : 1. |
| Turns, Lock to Lock | — 5.33. |
| Bearings | — Worm – Angular Ball.<br>— Shafts – Bronze Bushes. |
| Steering Wheel | — 17" diameter. Keyed on taper. |
| Lubrication | — S.A.E. 140 E.P. oil. |

## MAINTENANCE

Check the oil level (up to the level plug) every 500 hours. Top-up as necessary. If the unit appears to be leaking excessively, repairs should be carried out.

## CHECKING

The condition of the internal mechanism may be checked by proceeding as follows:

1. Disconnect the draglink and check the adjustment as detailed under "adjustment".

2. Turn the steering wheel slowly and carefully with the drag link disconnected to determine if the operation is rough or lumpy.

Rough or lumpy action indicates worn or damaged bearings. In order to service these, it will be necessary to remove and dismantle the assembly.

**Caution:** Do not turn the wheel hard against the stops, otherwise the worm nut may be damaged when it bottoms in the gear housing.

## TO REMOVE

1. Remove the splitpin, nut and washer from the pitman shaft and, using a suitable puller, remove the pitman arm (see Fig. A.4).

2. Remove the domed nut from the steering wheel and remove the steering wheel. It may be necessary to use tool No. 22756 or some suitable puller (Fig. A.3). Remove the key.

3. Raise the top engine cowling and remove the upper and lower side cowls. Disconnect foot pedal to bellcrank rod and remove column clamps.

4. Remove the three chamfered nuts which retain the steering column bracket to chassis and slacken the bracket clamp bolt.

5. Manipulate the column off the studs and free of the tractor.

## TO DISMANTLE

Use a clean bench and clean tools.

1. Unlock and slacken the adjusting screw (F).

2. Remove the three nuts and allen head screw from the side cover, remove the side cover and the nut roller. Drain oil.

3. Remove the pitman shaft through the side opening.

4. Remove the four nuts securing the end cover to the housing. Remove the cover.

5. Support the nut by hand and screw the worm out from the housing and nut. Collect the nut, ball bearings and end race.

The upper race may be removed by uncoupling the column jacket from the housing.

## INSPECTION

Inspect the steel balls for any sign of pitting. If any are found to be faulty it is necessary to replace the complete set.

Check the two surfaces of the worm, nut and races for wear or pitting. Replace if necessary. Inspect the nut roller and the side cover slot.

Check the fit of the pitman shaft in its bushes and the column shaft in the upper column bush. Replace the bushes if worn excessively.

## RE-ASSEMBLY

Re-assembly is a reversal of the dismantling procedure. The use of heavy grease to hold the ball bearings in place will facilitate re-assembly of the worm and nut. Refer to the adjustment section before re-fitting the assembly to the tractor.

## ADJUSTMENT

**Worm Bearings:** These bearings are adjusted by adding or removing shims from the flange of the end cover. Adjust to remove all end float without allowing the pre-load on the bearings to exceed 10 lbs./inches. (A spring balance attached as shown in Fig. A.6 should not read more than 1½ lbs. when the steering wheel is being slowly turned by the balance). Firmly tighten the cover nuts before taking readings. (A gasket should be placed between housing and shim to prevent oil leaks. The use of gasket cement is also recommended).

**Pitman Shaft:** Backlash between the pitman shaft fork and the worm nut is decreased by screwing in the adjusting screw (F). Adjust to remove all backlash at the centre of travel.

Check that the force required to turn the steering wheel does not exceed 2½ lbs. after adjusting the backlash. Check through the full travel of the box.

# FRONT SUSPENSION
## (AGRICULTURAL CHAMPION)

### DESCRIPTION

The front axle and radius rod are a welded unit of high clearance design, supported under the chassis by a transverse semi-elliptic spring swung in front of the axle. The radius rod is free to oscillate in a ball joint housing welded to a chassis cross-member under the flywheel housing. The front spring is coupled by "U" bolts to a block which is able to rock on a pin through a swivel block bolted to the underside of the chassis front cross-member. The spring eye ends, the spring shackle and the axle bearings for the kingpins are fitted with replaceable bushes, felt washers and grease nipples. The spring is a bolted assembly, so that individual leaves may be readily replaced.

Early tractors were fitted with pressed steel deep well wheels attached by studs and chamfered nuts to cast hubs. These were replaced at S/No. 1105 by one piece cast deep well wheels. Taper roller bearings are used in both types.

Original stub axles were a one piece forging incorporating the 1½" dia. kingpins. At S/No. 1984 these were replaced by a forged stub axle with a removable 1⅝" dia. kingpin. The kingpin is secured to the stub axle by a taper, key and nut. A removable 1½" dia. kingpin is available for earlier tractors.

At S/No. 3102 the thread for the wheel bearing retaining nut was changed from N.F. (14 t.p.i.) to U.N.F. (12 t.p.i.) to standardise production.

The kingpins are supported in bronze bushes fitted in the front axle. Roller thrust bearings support the axle.

Steering arms which are fitted to the upper ends of the stub axles are connected by an adjustable, ball jointed track rod. A drag link couples the off-side arm to a fork on the steering box pitman arm. At S/No. 1504 a modified type of drag link was introduced. This link is machined from solid bar and has the balljoint located with a locknut.

### TYRES

The front tyres are 7.50 x 18 x 6 ply and their inflation depends to some extent on the conditions of service, but pressures should always be between 25 and 30 p.s.i.

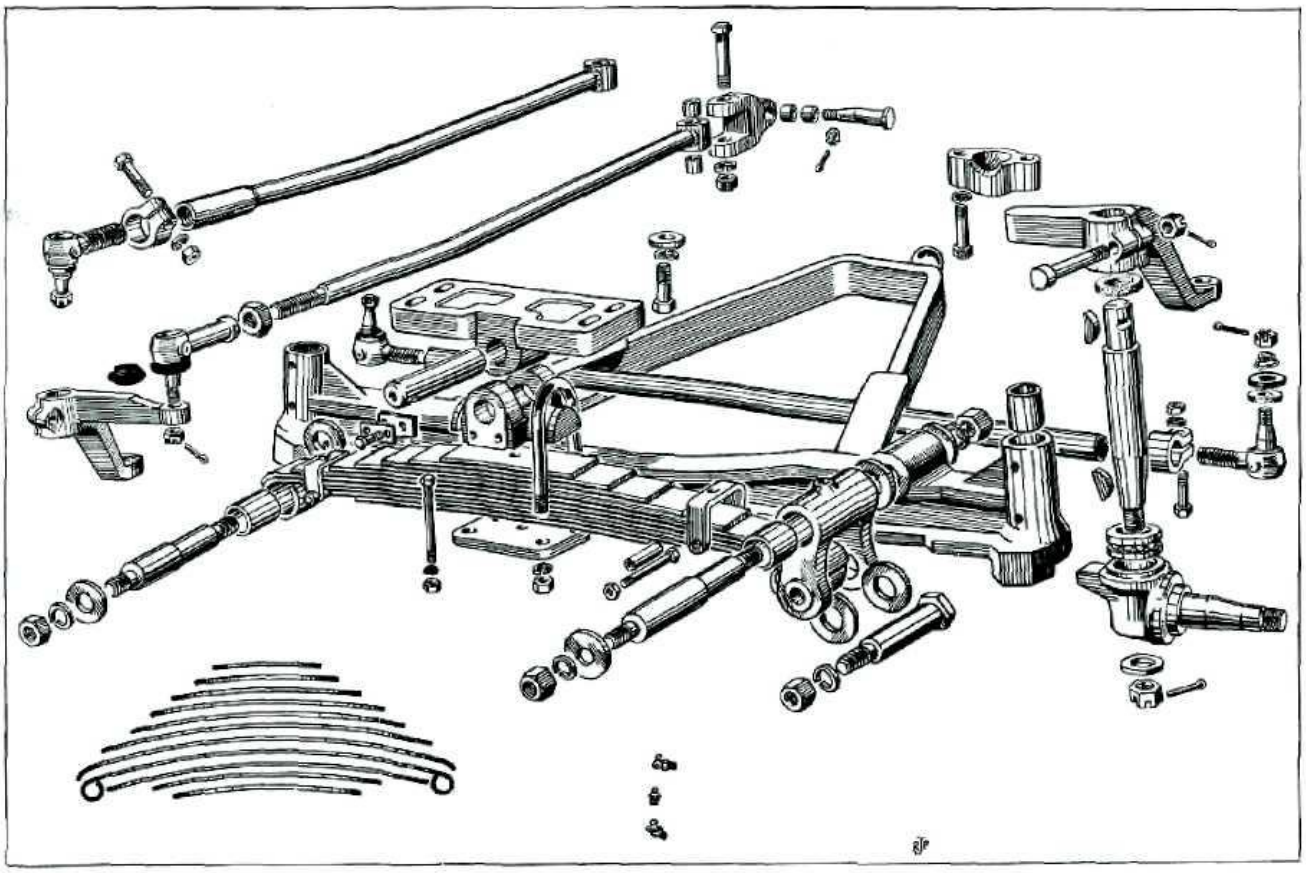

Fig. A.8 — Exploded view of Front Suspension

# FRONT SUSPENSION

## (INDUSTRIAL CHAMPION)

### DESCRIPTION

The front axle and radius rod are a welded unit connected at the front to the underside of the chassis cross-member by a bolted swivel block and pivot pin, and at the rear, in a ball joint housing welded to the chassis cross-member under the flywheel housing. Various methods of retaining the pivot pin have been used culminating with the use of a $\frac{3}{8}$" lockplate, two set screws and a lock tab. Later type pivot pins have machined grease grooves. To prevent the radius rod contacting the chassis while the axle is still free to move, the packing piece originally fitted under the swivel block has been removed. Steering stop set-screws were increased from $\frac{1}{2}$" to $\frac{3}{4}$" dia. at S/N IND 604.

Forged integral with the stub axles are the kingpin supports, lined with bronze bushes. Original bushes fitted on units S/N IND840 onwards and all replacement bushes now have grease grooves machined to facilitate lubrication.

Steering arms fitted by a taper, keys and nut to the lower section of the stub axle, are connected by an adjustable, ball jointed track rod. At S/N IND 850, the steering arms which had two keyways, allowing N.S. or O.S. application, were replaced by arms having only one keyway. Coinciding with this change, the threads were changed from N.F. (14 t.p.i.) to U.N.F. (12 t.p.i.). A re-designed tie-rod, completely interchangeable as an assembly with the previous type, was fitted as from S/N IND 1114.

A drag link couples the offside drag link arm to the steering box pitman arm. At S/N IND 842, the O.S. stub axle and welded drag link arm was replaced by a unit having the arm fitting into a taper, keyed and retained by a spring washer and nut. Heavier ball joints, located with locknuts on a drag link machined from solid bar are fitted on tractors after S/N IND 1051.

### TYRES

The front tyres are 8.25 x 20 x 8 ply and their inflation depends to some extent on the conditions of service, but pressures should always be between 40 and 45 p.s.i. Removal from the tyre of kerosine and oil spillage will assist to lengthen the tyre life.

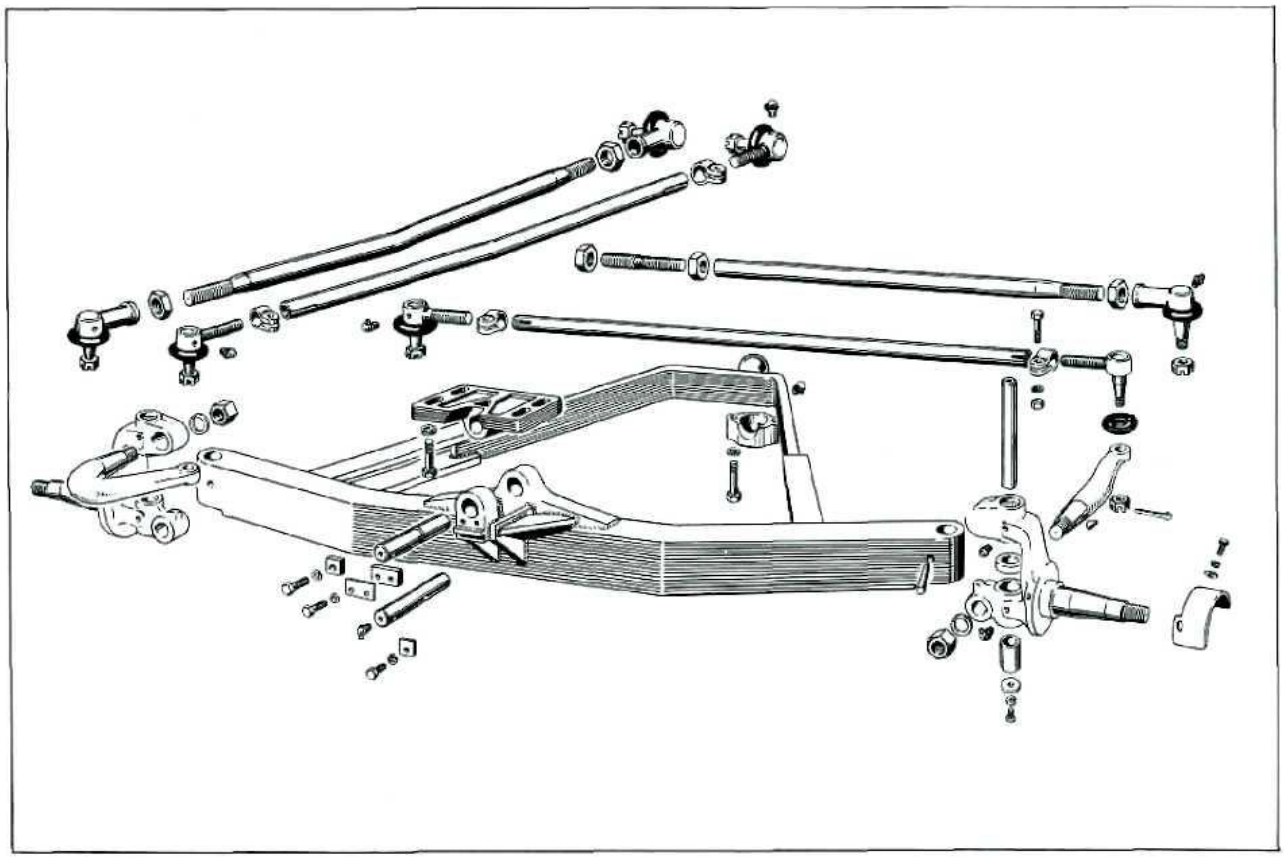

**Fig. A.9 — Exploded view of Front Suspension**

# FRONT SUSPENSION

## (CRUSADER)

### DESCRIPTION

The front axle and radius rod are a welded unit, connected at the front to the underside of the chassis cross-member by a bolted swivel block and pivot pin, and at the rear in a ball joint housing welded to the chassis cross-member under the flywheel housing.

The front wheels are of cast deep well construction and are mounted directly onto the stub axle with taper roller bearings, retained and adjusted by a locknut and split pin.

A forged stub axle with a removable kingpin is fitted, the kingpin being secured by a taper, key and nut. Bronze bushes are fitted to the front axle as kingpin supports and roller thrust bearings support the axle. At S/N CR 172, the thread for the wheel bearing retaining nut was changed from N.F. (14 t.p.i.) to U.N.F. (12 t.p.i.) to standardise production.

Steering arms which are fitted to the upper ends of the stub axles are connected by an adjustable ball jointed track rod. A drag link couples the off-side arm to a fork on the steering box pitman arm.

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### TYRES

The front tyres are 7.50 x 18 x 6 ply and their inflation depends to some extent on the conditions of service, but pressures should always be between 25 and 30 p.s.i.

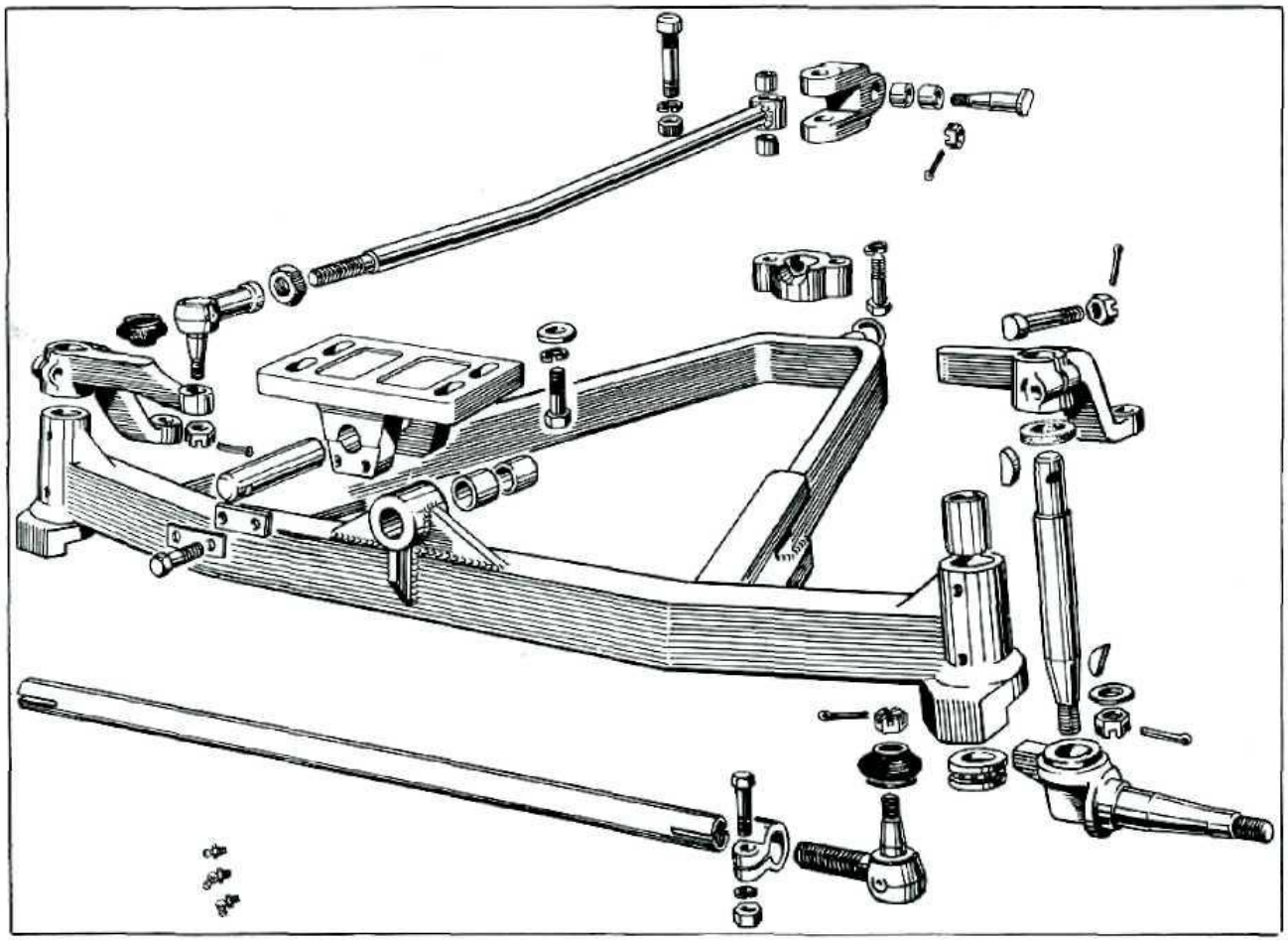

**Fig. A.10 — Exploded view of Front Suspension**

# FRONT SUSPENSION

## (CANELANDER)

### DESCRIPTION

**CANELANDER (Type 1):**

An exceptional high ground clearance is incorporated in this all welded front axle and radius rod unit. The assembly is connected by means of a swivel block and pin, to the underside of the chassis front cross-member and the radius rod ball joint oscillates in a housing welded to a chassis cross-member under the flywheel housing.

**CANELANDER (Type 2):**

This assembly maintains the high ground clearance and pivot points of the previous model. The unit consists of a main beam and radius rod assembly and two kingpin housing and axle extensions. Various widths of front wheel track can be obtained by extending or contracting the extensions within the limits of the holes provided.

The front wheels are of cast deep well construction and are mounted directly on to the stub axle with taper roller bearings, retained and adjusted by a locknut and split pin.

Forged stub axles with removable kingpins are fitted and these kingpins are secured to the stub axle by a taper, key and nut. On units with adjustable front axle, the kingpin has a different part number due to the 2" difference in length. At S/N HC 183, the thread for the wheel bearing retaining nut was changed from N.F. (14 t.p.i.) to U.N.F. (12 t.p.i.) to standardise production.

The kingpins are supported in bronze bushes fitted in the front axle. Roller thrust bearings support the axle.

Steering arms which are fitted to the upper ends of the stub axles are connected by an adjustable, ball jointed track rod. A drag link couples the off-side arm to the steering box pitman arm.

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### TYRES

The front tyres are 7.50 x 18 x 6 ply and their inflation depends to some extent on the conditions of service but pressures should always be between 25 and 30 p.s.i.

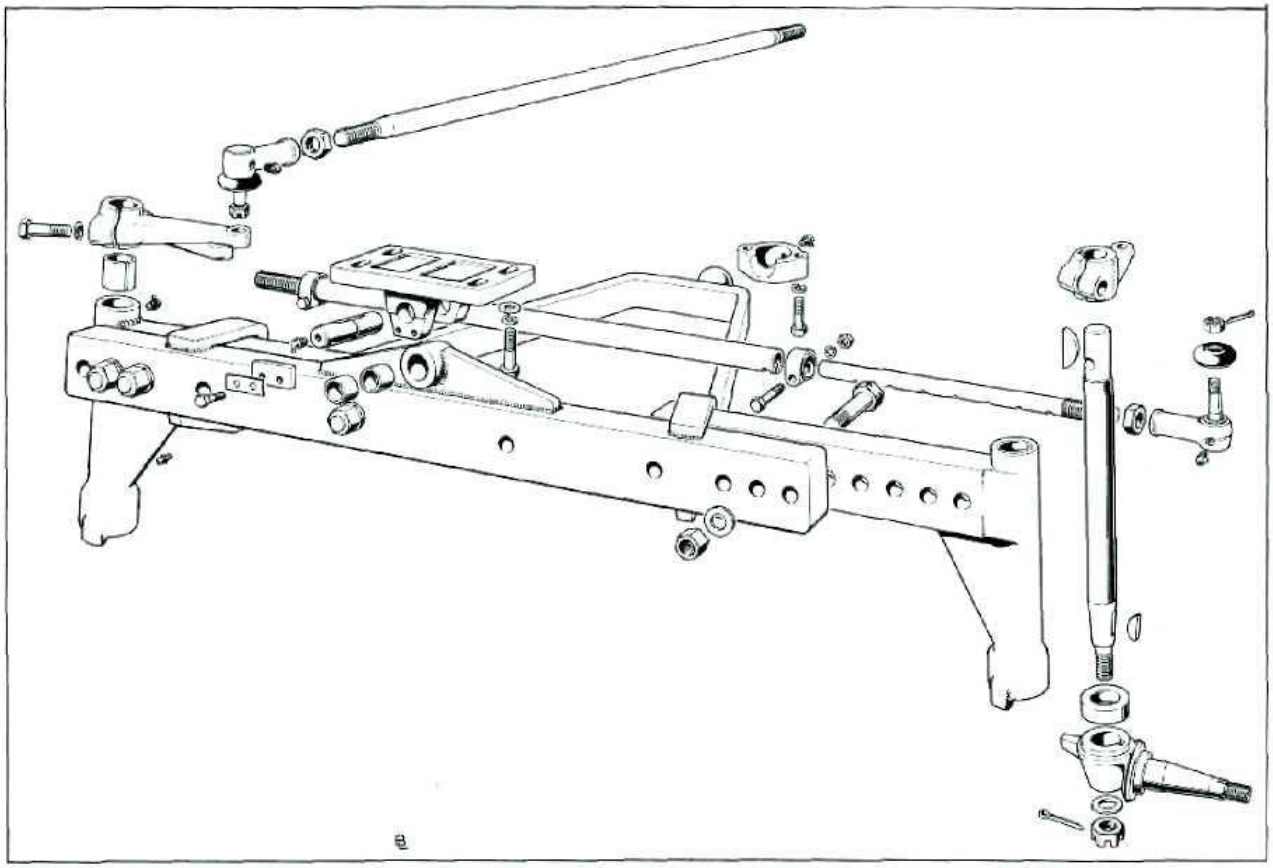


Fig. A.11 — Exploded view of Front Suspension

## MAINTENANCE

Every 10 operating hours lubricate the grease nipples with chassis grease. Do not over-lubricate. Check the tyres for faults and pressure.

Every 1000 hours, or once per annum, dismantle, clean and regrease the wheel bearings. Proceed as follows:

1. Jack the wheel until it is just resting on the ground.

2. Remove the hub cap.

3. Unpin and remove the axle nut.

4. Thoroughly clean the hub, bearings and axle with kerosine or petrol and inspect the bearings and seal for wear. The presence of dirt in the hub grease is an indication of a faulty seal in need of replacement.

5. Repack the bearings with wheel bearing grease and re-assemble. Half fill hub cavity with wheel bearing grease. Do not pack tight, otherwise heating with decomposition of the grease and bursting of the oil seal may result. Tighten the nut, whilst turning the wheel by hand, until the bearings start to bind, then back off the nut sufficiently to allow the wheel to spin freely, but without perceptible side play (about 1/6 of a turn), then repin the axle nut.

6. Replace the hub cap, preferably with a new gasket.

A periodical check on suspension nut tensions is advisable, particularly those nuts securing parts in tapers, such as ball joints and king pins.

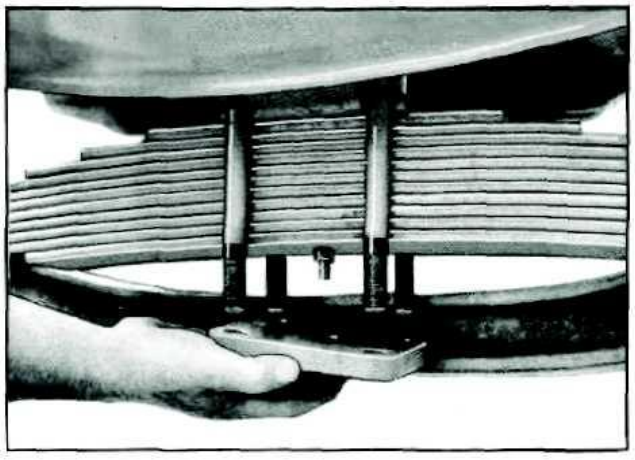


Fig. A.12 —Removing Spring U Bolt Plate

## SERVICE

**To Remove the Assembly:**

1. Remove the drag link from the pitman arm.

2. Jack under the radius rod ball joint cross-member to relieve the load on the front wheels.

3. Remove the four bolts holding the front axle swivel block to the front cross-member.

4. Remove the two bolts and the ball joint cap and raise the tractor to clear the swivel block.

5. The assembly may now be wheeled forward from the tractor.

---

Re-assembly is a reversal of this procedure. Three points need care:

(a) Locate the ball joint in its housing before tightening the swivel block bolts.

(b) Lower the tractor and tighten all nuts and bolts firmly.

(c) If the drag link adjustment has been disturbed, it will be necessary to re-centralise the steering. Turn the wheels to the straight ahead position and, by turning the steering wheel through the steering gear full travel and then halving this travel, centralise the steering gear. Offer up the drag link to the pitman arm. Turn the drag link on its threads as necessary to align the holes. Before securing the drag link, check that the steering box has at least ½ turn of steering wheel travel remaining when the stub axle contacts its stop on either wheel. It may be necessary to slightly offset the box to provide this free travel.

**Caution:** When turning the steering wheel to determine the extent of the steering gear travel, do not allow it to swing hard against the end stops, otherwise the internal mechanism may be damaged.

---

**To Remove the Front Spring (Agricultural Champion):**

1. Jack under the front of the chassis until the spring is unloaded.

2. Remove the nuts and spring washers from the spring 'U' bolts. Remove the plate from the 'U' bolts.

3. Remove the nuts and spring washers from the front ends of the pins securing the offside end of the spring and the nearside shackle to the axle and remove the spring, jacking the tractor to clear the "U" bolts.

4. Withdraw the shackle pin and remove the shackle.

Re-assembly is a reversal of this procedure. Re-tighten all nuts firmly. Shackle and spring bushes will not require reaming if fitted with care.

## KING PIN BUSHES

**To Renew:**

**(Champion Agricultural, Crusader and Canelander)**

1. Jack under the axle until the tyre is just resting on the ground.

2. Remove the clamp bolt from the steering arm and prise the lever from the kingpin. Remove the key. The stub axle assembly may now be removed. If the tractor cannot be jacked high enough, it will be necessary to remove the wheel.

3. Drift the bushes from the axle.

4. Press the replacement bushes into position, carefully aligning the grease hole. Line ream to fit the stub axle kingpin.

5. Clean and examine the kingpin and the roller thrust bearing.

To re-assemble, reverse the procedure, tightening all bolts firmly.

**(Champion Industrial)**

1. Jack under the axle until the tyre is just resting on the ground.

2. Remove the tapered cotter pin locking the kingpin in the front axle.

3. Remove the splitpin and nut from the tie rod end and loosen the tie rod in the steering arm. This should be accomplished by striking the steering arm on the outside, in the immediate vicinity of the mating tapered parts, not on the threaded tie rod end.

4. Remove the stub axle plugs, then remove the kingpin.

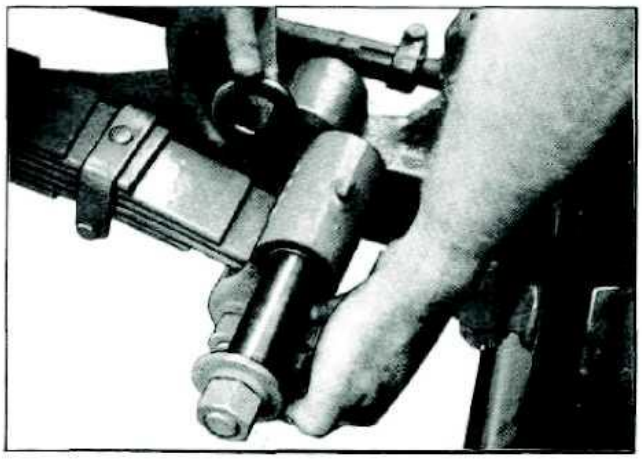


Fig. A.13 — Removing Spring Shackle Pin

5. Drift the bushes from the stub axle.

6. Press the replacement bushes into position, carefully aligning the grease hole. Line ream to fit the kingpin.

7. Clean and examine the kingpin, tapered cotter pin, front axle eye and the roller thrust bearing.

To re-assemble, reverse the procedure, tightening all bolts firmly.

## WHEEL ALIGNMENT

1. Make a chalk mark on the inside of each wheel rim in front of, and level with the centre of the wheel.

2. Measure the distance between the marks. The use of a telescopic rod is the most convenient method, but a rule used in conjunction with a straight length of rod can, if used with care, give satisfactory results.

3. Roll the tractor forward until the two marks are behind, and level with, the wheel centre. Compare the distance between the marks in this position with the original distance. It should be $\frac{1}{8}$" to 3/16" greater.

4. Repeat the procedure with two more chalk marks opposite the original marks to check the accuracy of the previous measurement. A mark on the road surface of the tyre may be used to check toe-in, but in this case the correct tow-in measurement is 1/4" to 3/8".

5. Adjust as necessary by slackening the clamps on the track rod and turning the rod on ball end threads, to suit.

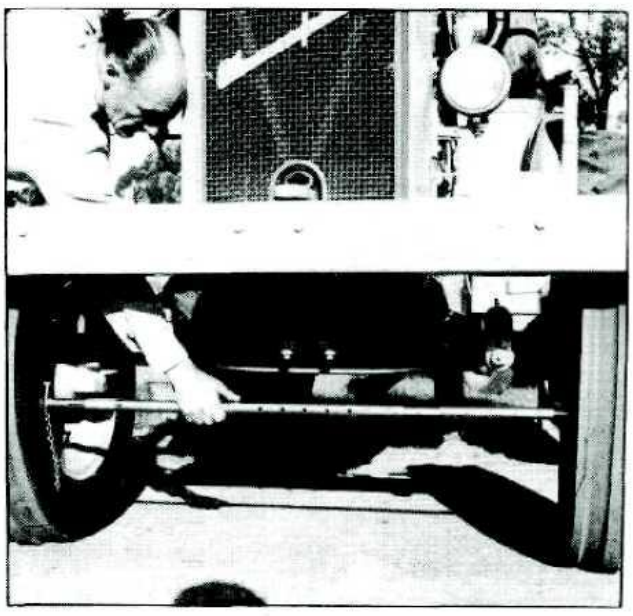


Fig. A.14 — Checking Wheel Alignment

## SPECIFICATIONS

| | Champion (Agricultural) | Champion (Industrial) | Crusader | Canelander |
|---|---|---|---|---|
| Track (front) | 55¾" | 63½" | 55¾" | Type (1) 57"<br>Type (2) 56" to 80" |
| Track (rear) | 64½" | 74" | 61" | Type (1) 55" to 61½"<br>Type (2) 54" to 75" |
| Camber<br>Caster<br>Toe-in<br>Kingpin inclination | 2°<br>Nil<br>1/8" to 3/16"<br>4° | 2°<br>Nil<br>1/8" to 3/16"<br>4° | 2°<br>Nil<br>1/8" to 3/16"<br>4° | 2°<br>Nil<br>1/8" to 3/16"<br>4° |
| Clearance Turning circle | 31' 0" without brakes | 32' 0" without brakes | 31' 0" without brakes | 32' 6" without brakes |
| Wheel Base | 96½" | 95" | 95" | 95" |
| Axle Ground Clearance | 16¾" | 18¾" | 16¾" | 26" |
| Spring | Semi-elliptic transverse with one main leaf, 7 helping and 3 rebound leaves | Not fitted | Not fitted | Not fitted |
| Tyres (front)<br>(rear) | 7.50 x 18 x 6 ply<br>15 x 28 x 6 ply | 8.25 x 20 x 8 ply<br>15 x 28 x 8 ply (mutton leg) | 7.50 x 18 x 6 ply<br>14 x 28 x 6 ply | 7.50 x 18 x 6 ply<br>13 x 38 x 6 ply |
| Wheel Bearings | Sealed H.D. taper roller bearings | Sealed H.D. taper roller bearings | Sealed H.D. taper roller bearings | Sealed H.D. taper roller bearings |
| Stub Axles | Forged Steel, 6° angle | Forged steel, 6° angle | Forged steel, 6° angle | Forged steel, 6° angle |
| Lubrication | See Chart | See Chart | See Chart | See Chart |

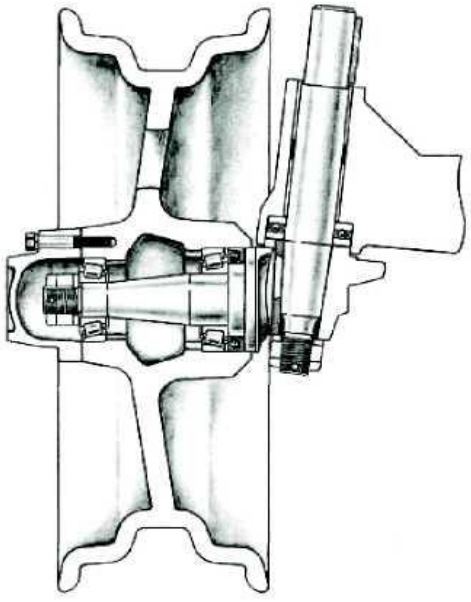


Fig. A.15 — Section of Agricultural Front Wheel.

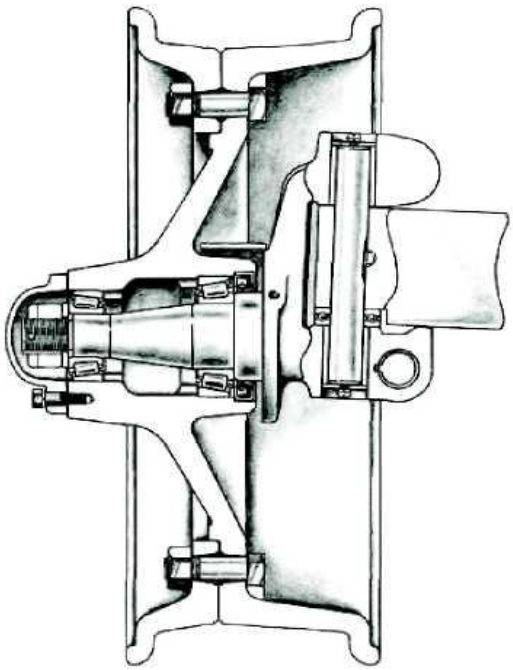
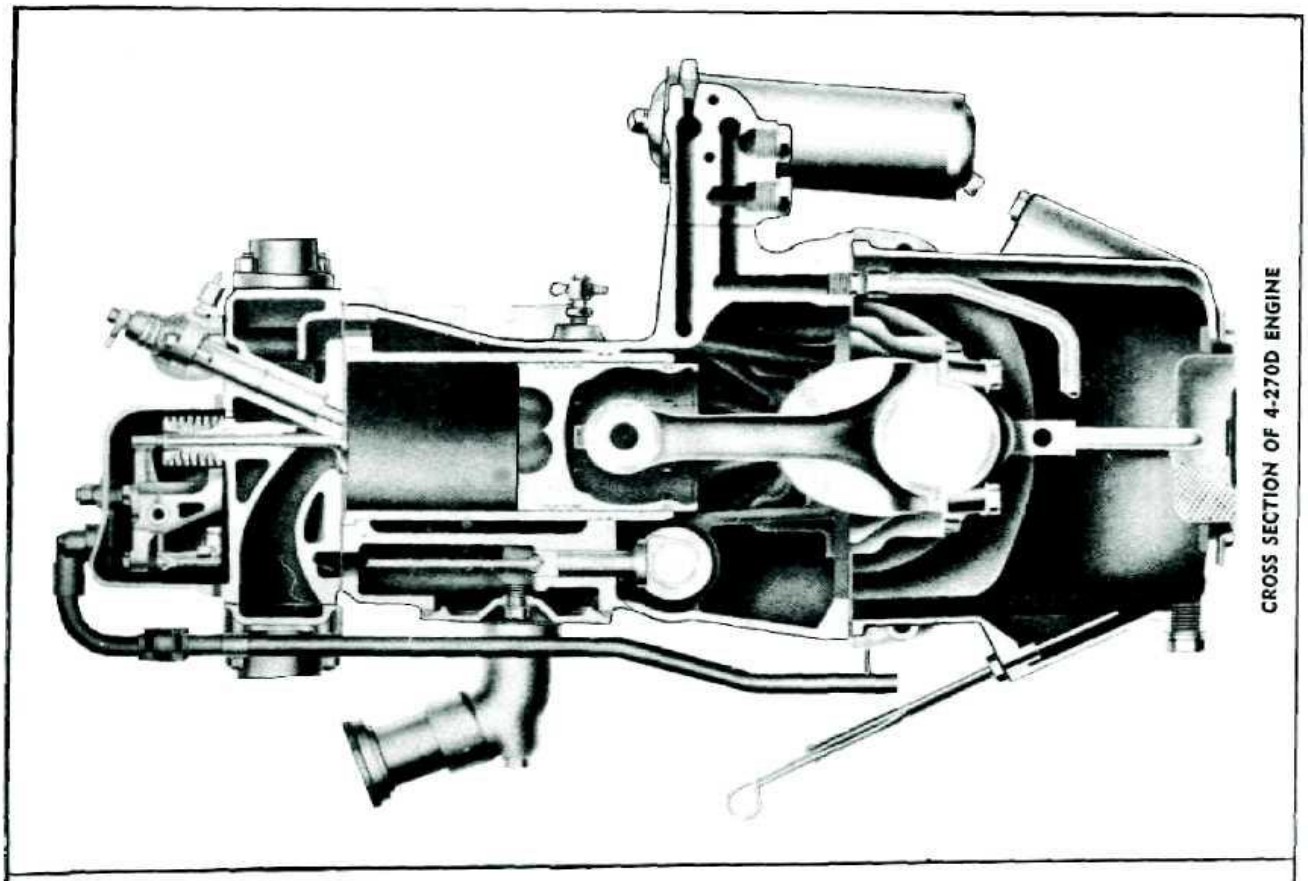
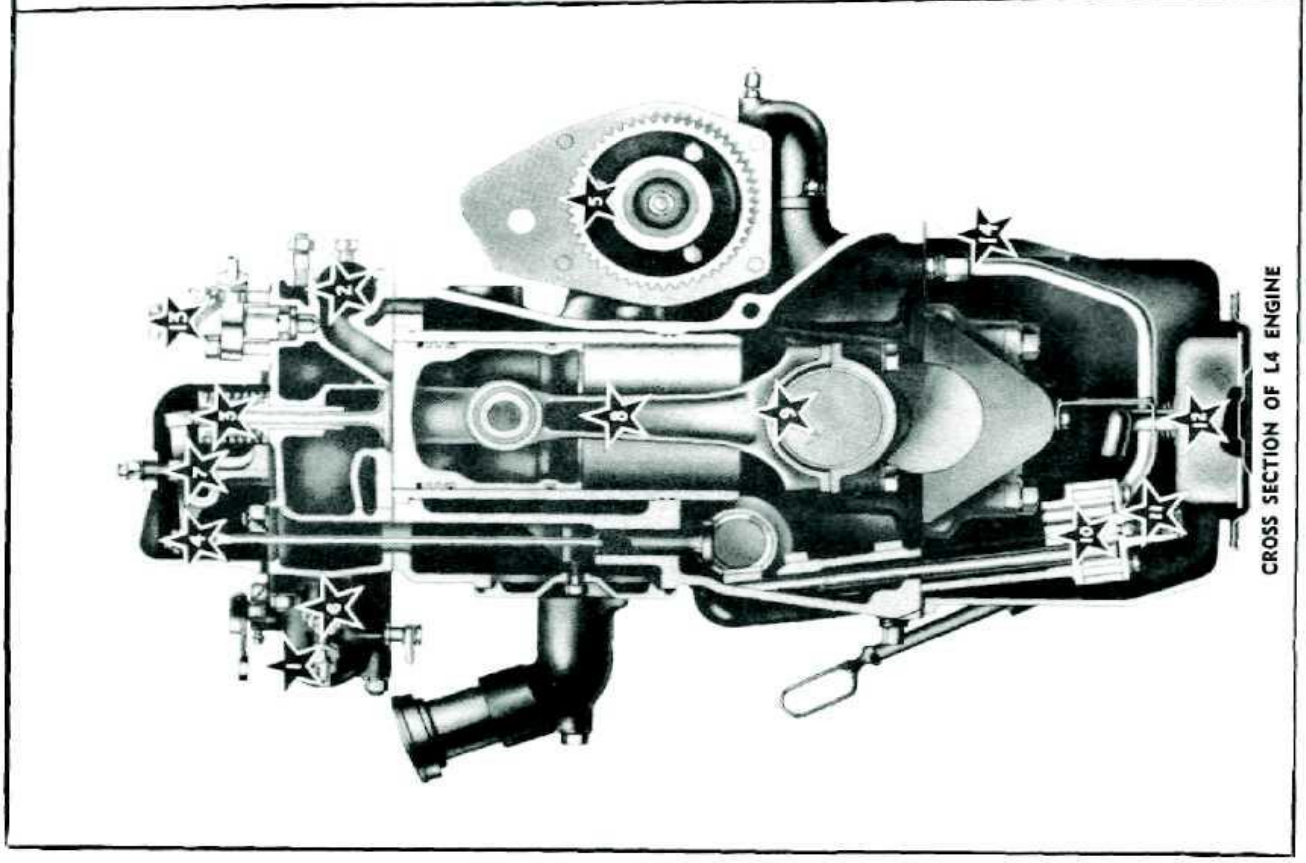


Fig. A.16 — Section of Industrial Front Wheel.



CROSS SECTION OF 4-270D ENGINE



CROSS SECTION OF L4 ENGINE

**Fuel Injection Equipment:**

The L4 engine has a unit 'In Line' type fuel pump flange mounted on the timing case. The Four-270D has a distributor type pump mounted in the same position.

With the L4 unit the governor is pneumatic, the fuel pump rack being operated by a diaphragm which is controlled by a spring and pressure difference imposed by a butterfly in the intake manifold. Fuel is supplied to the injection pump by a plunger pump operated by a cam in the fuel injection pump. Injectors are of the two hole type, one spray being directed into the combustion chamber whilst the other is directed into the cylinder, ensuring easy starting.

The Four-270D distributor type pump has a mechanical governor incorporated in the fuel pump body. Fuel is supplied to the pump by a diaphragm type pump which is push rod operated from an eccentric on the fuel pump gear hub. A vane type transfer pump is also built into the injection pump circulating fuel through the pump body, feeding the operating plungers. Surplus fuel from this pump is bypassed back to the fuel filter. Injectors are of the multi-hole type with a spray, conical in form, directed into the toroidal combustion chambers in the piston crowns.

**Cooling:**

The cooling water is pump circulated by a centrifugal pump which is mounted on the front end of the cylinder block. It is driven, together with the dynamo, by a Vee belt from the engine crankshaft.

The internal water passages are arranged to give a brisk circulation of water around the cylinder block, head and atomiser seating. The fan is mounted on the forward end of the water pump.

**Air Intake:**

A large air cleaner is fitted through which must pass all air drawn into the engine. Harmful dust is thus excluded and the life of the cylinders correspondingly prolonged. The air cleaner is fitted with a centrifugal type pre-cleaner.

**Cold Starting Equipment:**

An electrically operated cold starting aid is fitted horizontally in the induction manifold: the starting fluid is expressly fuel oil. Operation on the L4 is by hand pump and heater switch and on the Four-270D by a four position starting switch.

## SPECIFICATIONS

| | |
|---|---|
| Bore and Stroke | — 4¼ ins. and 4¾ ins. |
| No. of Cylinders | — 4 |
| Swept Volume | — 4.42 litres. |
| Compression Ratio | — 17.5 : 1 – L4 engine.<br>16.0 : 1 – Four-270D engine. |
| Firing Order | — 1, 3, 4, 2. |
| Oil Pressure (Hot) | — 25/35 lbs. per sq. in. |
| Spill Timing | — 21° B.T.D.C. – L4 engine.<br>16° B.T.D.C. – Four-270D. |
| Injection Pressure | — 120 Atmos. – L4 engine.<br>170 Atmos. – Four-270D. |
| Tappet Cl. (Hot) | — .010 in. |
| Valve Seat Angle | — 45°. |
| Valve Lift | — .465". |
| Maximum Torque | — 189 lbs./ft. at 1,000 r.p.m. |

| **Recommended Torque Tensions:** | **lbs./ft.** |
|---|---|
| Cylinder Head Nuts ... ... ... ... ... | 80/85 |
| Con. Rod Setscrews ... ... ... ... ... | 100/105 |
| Main Bearing Setscrews ... .. .... ... | 125/130 |
| Flywheel Setscrews ... ... ... ... ... | 90 |

With reference to the Cylinder Head Nuts, these should be rechecked with the engine hot.

It will be appreciated that after overhaul or rectification work has been carried out, there will be a settling period which will allow a slight variation on the figures quoted. This is not detrimental to the performance of the engine and there is no necessity to interfere with the settings.

On no account should attempts be made to increase the torque already quoted by re-tightening with a torque spanner.

**Performance:**

Maximum noted output (gross)
L4 engine at 2000 R.P.M. – 59 B.H.P.
Four-270D engine at 2000 R.P.M. – 62 B.H.P.

## OPERATION

**Starting the Engine—L4 Engine:**

Before starting the tractor carry out a 10-hour maintenance schedule as shown on the maintenance chart, Section Q.

Set the front gearbox in neutral, set the governor control open and unless the engine has been stopped for a long period in cold weather, the engine should start when the starter control is pressed. Should conditions be too cold to enable a start by this method, turn on the tap on the heater fuel tank and give the pump a stroke of about ½". Press the heater switch and hold for about thirty seconds. Press the Starter control and give short strokes on the hand pump, with the heater button still pressed.

Always be sure the starter motor has come to rest before re-pressing the control, otherwise the ring gear teeth may be damaged.

Always screw down the plunger on the hand pump after use and turn off the tap on the tank.

If the engine fails to start refer to Page B-7.

The engine may be stopped by pulling the wire ring control connected to the fuel pump governor.

**Four-270D Engine:**

As for the L4 engine other than for the operation of the cold starting equipment. Check that the tap on the heater is turned on. Turn the key to 'H' for 10 to 15 seconds, then turn to 'H.S'.

**10 hours:** Check the sump oil level and top-up as necessary. Check the cleanliness of the air cleaner oil.

**50 hours:** Check the tension of the fan belt.

**100 hours:** Drain the engine oil, remove and clean the sump strainer, remove and discard the oil filter element. Fit a new element and refill with new oil. Oil Recommendations as shown in Section Q. The paper element introduced in the Four-270D is not washable and the washing of the felt type elements, as previously recommended has been found to be unsatisfactory.

**500 hours:** Remove, clean and check the injectors. Clean oil filler strainer.

**1,000 hours:** Check the valve condition and clearance.

These maintenance routines are covered on the following pages and are also quoted, in conjunction with maintenance for the remainder of the tractor, in Section Q.

## KEEP THE ENGINE CLEAN

### THE AIR CLEANER

The air cleaner fitted is an oil bath type with a centrifugal pre-cleaner. These units are mounted side by side behind the engine bulkhead. There is no provision for maintenance of the pre-cleaner as this unit is self-emptying. The regularity of maintenance to the oil bath depends entirely on the conditions under which the tractor is operating. The importance of preventing this unit from becoming inefficient cannot be over-emphasised, as the economical life of the engine is largely dependent on its correct maintenance.

To service the air cleaner, release the latches on the offside of the top cowling. Raise the top cowl and allow it to be supported by its stay. Release the latch on the side cowl and slide the cowl forward and free of the locating pins. The clips retaining the air cleaner bowl are now accessible and the bowl may be released, lowered and moved sideways clear of the tractor. Clean out the oil and dirt in the bowl, refill with engine oil to the marked level and refit to the body of the air cleaner. Under some conditions once every 50 hours will be sufficient for this service but when working in very dusty conditions, it may be necessary to clean the bowl every ten hours.

**Inspect cleanliness of oil at least every 10 hours.**

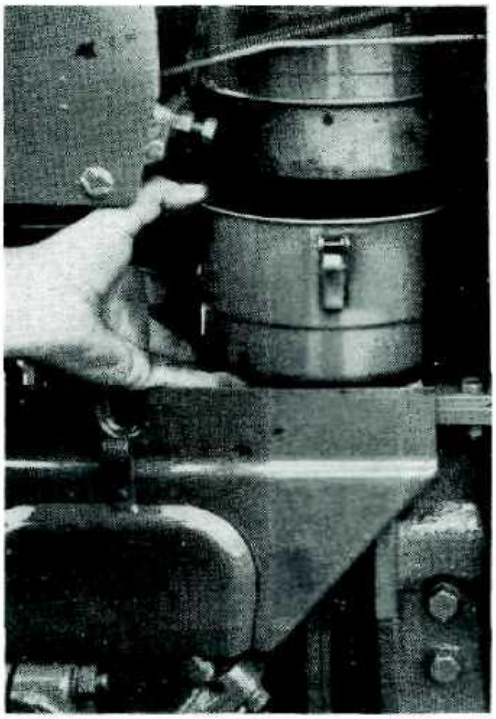


Fig. B.2 — Removing Air Cleaner Bowl.

### THE OIL FILTERS

There are three filters for lubricating oil on or about the engine.

**The first filter** is a gauze strainer in the oil filler. Do not on any account remove this when pouring oil into the engine. It is your first line of protection against dirt in the oil.

Take this gauze strainer out and clean it every 500 hours. Wash it in fuel oil before putting it back. This strainer is at the bottom of the oil filler tube.

**The second filter** is in the sump. This also is a gauze strainer. All the oil must pass through this before it reaches the oil pump and is delivered to the bearings.

Remove it and clean every 100 hours. Wash it in fuel oil before replacing it.

**The third filter** is on the side of the engine below the fuel pump. The oil passes through it after it has left the pump, before it reaches the bearings. This was a felt element type filter but the felt element has now been replaced by a paper element.

**l Filters—Continued**

The oil in the sump must be drained every 100 urs and replaced by clean, new oil.

(When checking oil level in sump make sure that s is carried out on level ground).

Make a regular habit, once a week, of wiping the gine over, paying particular attention while doing to the joints in the crankcase, etc., to check for ıkages.

If oil is leaking at any point, take immediate steps remedy it.

**Remove Oil Filter Element:**

(a) Unscrew nut on cover and remove cover.

(b) Remove by-pass valve assembly.

(c) Remove element.

(d) Remove plug at base of filter casing and clean filter casing with paraffin.

(e) Inspect the condition of the cover and by-pass valve seals. Replace if necessary.

(f) Install the replacement element, by-pass valve and cover.

If the filter element is not replaced as recommended, the flow of oil through the filter is restricted. This does not, however, prevent oil passing to the engine, for when restriction takes place, the by-pass valve opens and permits unfiltered oil to continue to flow round the engine. The consequence of this need not be described. Do not, therefore, omit to clean the element as described.

There are two joints in the lubricating oil filter.

The first is a rubber joint between the filter cover and the filter bowl; it fits in a recess in the filter cover.

The second is a rubber seal fitted in the top groove of the by-pass valve assembly piston. Earlier engines used a felt seal in this location.

When dismantling the filter for cleaning purposes, care should be taken not to damage these joints. If it is found that either of these joints is damaged it should be replaced by a new joint.

**Atomisers:** The removal, inspection, cleaning and replacement of these units is covered in Section D.

**Valves:** The adjustment of the valves is covered under "Cylinder Head", Page B-10. Clearances are .010" for both inlet and exhaust.

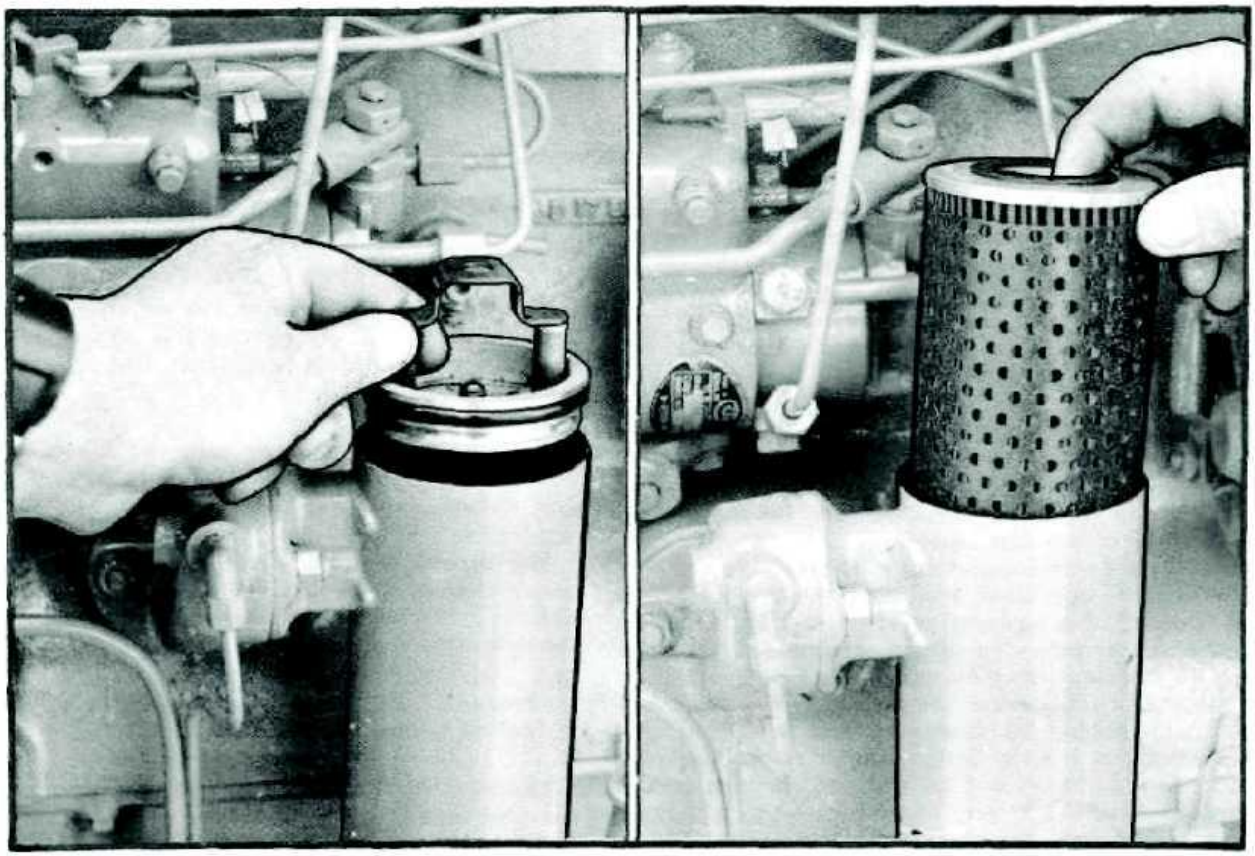


Fig. B.3 — Removing Oil Filter Element.

## DIFFICULTY IN STARTING

**No Fuel at Atomisers:**

(a) No fuel in tank.

(b) Fuel lift pump not working.

(c) Slack connections in the fuel system.

(d) Air in the fuel system (trace from suction side).

Go over the whole of the above and make sure that the atomisers are fully primed and that the "pinging" or "squeaking" noise is heard from each atomiser when the engine is turned over.

**Engine not being turned over quickly enough** (particularly in cold weather):

(a) Lubricating oil too thick. (See Section Q).

(b) Battery not fully charged. Fit fully charged battery.

(c) Engine "gummy" due to standing in the cold.

Use the cold starting equipment.

**Low Compression:**

This may be due to dry cylinders and piston rings, worn piston rings, worn cylinders, or leaky valves.

**Dirt between Valve and Seat:**

Remove cylinder head cover and turn the engine. Note which valves leak. Bring corresponding piston to beginning of compression stroke, turn engine over compression at the same time bouncing valve open by hitting valve rocker end down with a block of hard wood or the like. Repeat until dirt is blown out and valve holds compression.

**Atomisers Faulty:**

Test atomisers for "ping" or "squeak" as already mentioned. If any atomiser fails to give this "pinging" or "squeaking" noise when that cylinder is pulled smartly over compression and it has been made certain that the atomiser is fully primed, then the atomiser should be tested by removing it from the cylinder head. (See Section D).

Disconnect pipes on other atomisers while making this test.

**Sticking Valves:**

Trouble with sticking valves may be due to overheating, the result of choked atomisers, or the use of unsuitable lubricating oil.

Test the atomisers as recommended in Section D. and clean them if necessary.

The lubricating oil used should be of an approved type. (See Section Q.). To free a valve, squirt a small quantity of kerosine down the valve guide and allow it to seep right through. The valve may then be given a sharp tap. This process will invariably free the valve. A quantity of clean oil should then be poured down the guide to lubricate the valve stem before again starting up the engine.

**Sticking Rocker:**

If the rockers stick the cause may be: the use of unsuitable oil, shortage of oil, or sludging. If there is a shortage of lubricant, the passages and pipes to the rockers should be checked.

To free the rocker, squirt a little kerosine into the bearings, allow it to seep through, then gently tap the rocker arm. This will free the rocker. Thoroughly lubricate with oil, and the engine may be restarted.

**Fuel Oil:**

It is essential to use clean fuel oil free from water, dirt or sand. Providing clean fuel is used, no trouble should be experienced with the fuel system but dirty oil will lead to trouble due to choked filters, damaged fuel pump and atomisers. If the engine tends to run well for a short period and then to die away or stop altogether, the fuel system should immediately be suspected. The trouble may be due to the lift pump not working properly, to a loose pipe joint allowing air to get into the fuel system, to a dirty fuel filter, or to a choked fuel pipe. The pre-filter in the fuel feed pump (when fitted) should be cleaned by washing in clean fuel oil, but the final filter should not need attention more than once in 500 hours, when a completely new filter element should be fitted. If the conditions lead to dust or contamination of the fuel, decrease the maintenance interval.

# CYLINDER HEAD

The Diesel engine rarely, if ever, needs the periodical decarbonising that is accepted as a matter of course with the petrol engine, insofar that in an engine operating on the diesel cycle, carbon, beyond a superficial coating, does not form and accumulate in the combustion chamber and on the pistons as in the case of the petrol engine.

Owing to its higher thermal efficiency, the valves of the Diesel engine are also much more free from trouble due to overheating; that is, of course, providing the engine is reasonably maintained.

After a period, depending upon the conditions under which the engine is operated, the valves may need attention. This will become apparent by loss of compression, in which case a top overhaul may be necessary.

## TO DISMANTLE

Begin by assembling all the joints and other parts required, as called for in the spare parts list.

1. Drain all water from the radiator and cylinder block. The drain cock for the cylinder block is on the left hand side of the engine.

2. Remove the spark arrestor and the exhaust manifold.

3. On the Four-270D, remove the fuel filter bracket bolts.

4. Slacken the hose clips on the air cleaner pipe and remove the pipe.

5. On the L4, uncouple the governor control rod, the cold starting pipe and cable and the venturi vacuum pipe and remove the venturi body.

On the Four-270D, uncouple the Therma-start container to heater plug pipe and remove the air intake body. Remove the bolts holding the wiring clip.

6. Remove the thermostat and slacken the hose clips on the pipe connecting the thermostat housing to the water pump.

7. Remove the retaining nuts and in the case of the Four-270D, slacken the breather hose clips and remove the cylinder head cover.

8. Uncouple the union on the oil pipe to the rocker shaft.

9. Remove the four nuts, lock washers and plates (if fitted) from the rocker shaft brackets, and remove the rocker assembly as a unit, complete with the oil pipe.

10. Remove the push rods.

11. Remove the four atomiser pressure pipes. Protect the exposed ports on the fuel pump and the atomisers against the ingress of dirt.

12. Remove the atomiser fuel return connections on the Four-270D and the atomiser overflow pipe on the L4.

13. Remove the flange nuts from the atomisers and remove the atomisers.

14. Remove the cylinder head nuts and lift the cylinder head clear of the engine.

### To Remove the Valves:

All the valves are numbered consecutively from 1 to 8, commencing at the front of the engine. The cylinder head is marked with corresponding numbers opposite the valve seats.

Compress the valve springs and caps with a valve spring compressing tool and remove the split-cone cotters. Remove the spring caps and springs and the valves may be withdrawn through the head.

## INSPECTION OF CYLINDER HEAD COMPONENTS

### Valve Springs:

Valve springs deteriorate because of fatigue resulting from the combined effect of heat and the working of the valve. After a period the spring becomes weaker and is then prone to failure.

Arrange the springs in a line and compare their lengths. If there is any appreciable variation in their lengths, replacement of the complete set is advisable.

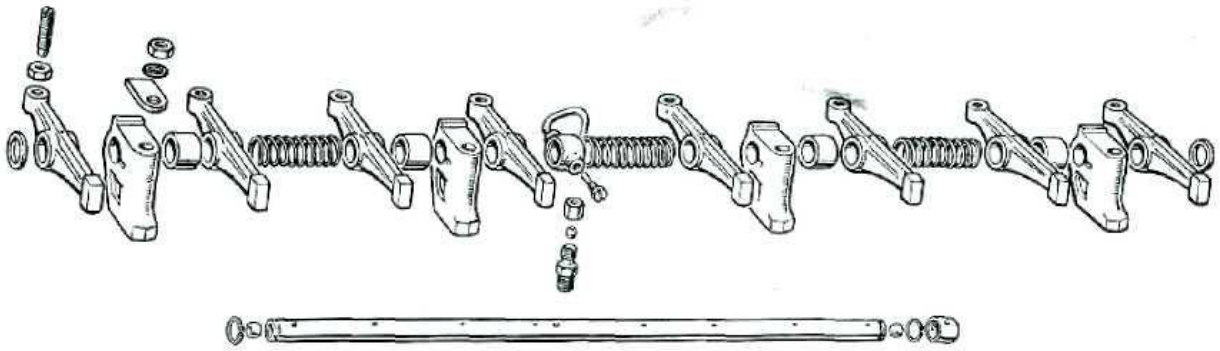


Fig. B.4 — Arrangement of Rocker Components.

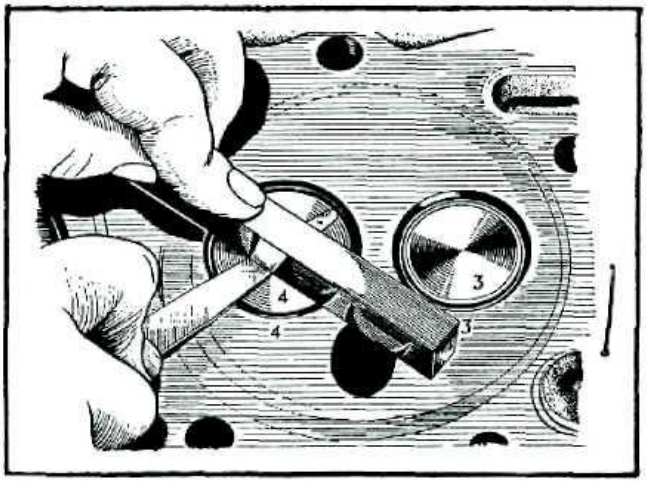



Fig. B.5 — Checking Valve Head Clearance.

**Rocker Levers and Bushes:**

Wash the assembly thoroughly in kerosine. Examine the rocker lever bushes for wear. The rockers should be an easy fit on the shaft without excessive side play. If, as a result of inadequate lubrication, any rocker bushes have seized on the shaft, the rockers may have worked loose on the bushes. Should this have occurred, it will be necessary to replace the bush and possibly the rocker. Examine the four rocker brackets. Some early L4 engines may be fitted with a plain bracket without the separate steel plate as illustrated in the parts book. Should this type of bracket be fitted, examine closely for signs of failure. Should replacement be necessary, a new type bracket and plate (P/NS.21139 and 21336) may be fitted. If a new bracket is fitted on either of the two centre positions it will also be necessary to fit a longer stud (P/N21275).

The rocker mechanism may be dismantled by removing the circlips from the ends of the shaft, and sliding the components free.

**Valves and Valve Seats:**

There will be little wear of the valve stems or their guides provided that the lubrication of these parts has always been adequate.

Examine the valves for cracks. Check wear of valve stems and their fit in guides. If the stems are worn fit new valves.

Number all new valves to correspond with the numbering of the old valves.

When fitting new valves take care that the clearance between the valve head and the cylinder head bottom face is not less than .075 ins. inlet and .053 ins. exhaust. Maximum clearance should not exceed .140 ins. inlet and exhaust. Check this by putting a straight edge across the bottom face of the cylinder head and measuring the distance between the straight edge and the valve head as illustrated in Fig. B.5.

The efficiency of a diesel engine depends largely on the maintenance of good compression, therefore, when grinding in valves, make certain that no signs of pitting are left on the seatings. Valves should be ground in until a continuous "high mark" is present the full way round the seating, both on the valve and on the valve seating in the head. At the same time care should be taken to avoid unnecessary grinding away of the seat.

**Valve Guides:**

Examine the guides for wear, if necessary replace with new guides.

To remove old guides: press out, or use a suitable drift.

To fit new guides: clean and remove any burrs.

Smear the outer surface with clean oil, and, using a suitable press, drive home hard up to the collar. Care should be exercised as the collar approaches the cylinder head as the guides are made of cast iron and therefore comparatively brittle.

**Cylinder Head:**

Remove exhaust manifold and clean off any carbon deposit formed in the cylinder head.

Wash out and thoroughly clean the water passages in the head, subsequently drying out and finally cleaning with compressed air.

If the water jacket of the cylinder head shows signs of excessive scale, a proprietary brand of descaling solution should be used.

**Combustion Chamber Joints—L4 Engine:**

It is not, as a rule, necessary to remove the covers of the combustion chambers during a top overhaul, as carbon rarely forms in these chambers.

Should it be necessary to remove these covers, new copper joints should be fitted when they are replaced.

If new copper joints are not available, the old ones may be used provided they are softened before being re-fitted.

To soften the joints heat them to a dull red heat and quench in cold water.

Special care is necessary when refitting these covers to ensure that there are no leaks at the joints otherwise there will be a loss of compression and the efficiency of the engine will be impaired.

**RE-ASSEMBLY OF CYLINDER HEAD**

1. Replace valves, valve springs, collars and cotters.

2. Replace combustion chamber caps and joints on L4 head.

3. Before replacing cylinder head, it is extremely important to ensure that the cylinder block and cylinder head faces are perfectly clean.

**Re-assembly—Continued**

When replacing the cylinder head a new gasket should be used. Cover both sides with a thin coating of good jointing compound and before placing over the cylinder head studs, ensure that the gasket is correctly positioned. The gasket is marked to indicate how it should be replaced. The correct gasket has 4-5/8" cylinder bores and a copper top and steel bottom plate. An earlier L4 gasket with copper and steel plates had $4\frac{3}{4}$" cylinder bores. This gasket is unsuitable. Four-270D gaskets are similar to L4 gaskets other than that the side water passages have been considerably enlarged. L4 gaskets must not be used on Four-270D engines.

4. *Tighten the head nuts evenly and tension with* a tension wrench to 80-85 lbs./ft. Follow the sequence shown below.

5. Replace the push rods.

6. Replace the rocker shaft assembly. Guide the push rods and the oil pipe into position. Tighten the four bracket nuts and the oil pipe union.

7. Adjust the valve clearances. The clearance for both valves is .010".

When adjusting valve clearances the engine should be turned to bring the respective pistons to T.D.C. on compression.

To adjust: Slacken the lock nut and with a .010 feeler gauge between the top of the valve stem and the rocker lever face, turn the adjusting screw by means of a screwdriver until the correct clearance is obtained. Tighten lock nut.

8. Replace the atomisers and atomiser pipes. This procedure is detailed in Section D.

9. Replace the exhaust manifold, the air intake body, the air cleaner hose, the thermostat and the governor control rod (L4 engines only). Re-connect all fittings previously disconnected including water hoses.

10. *Refill the radiator with clean water.*

11. Start and run the engine. Check that oil is oozing from the joints of the rockers. Keep the engine running until it is thoroughly warmed up and normalised. Do not mask the radiator to speed up the heating as it is important that the lubricating oil also is correctly heated.

12. Stop the engine, recheck the tension of the cylinder head nuts and the valve clearances.

13. Replace the valve cover and cowlings. Ensure that the breather connection on the Four-270D valve cover is tightened.

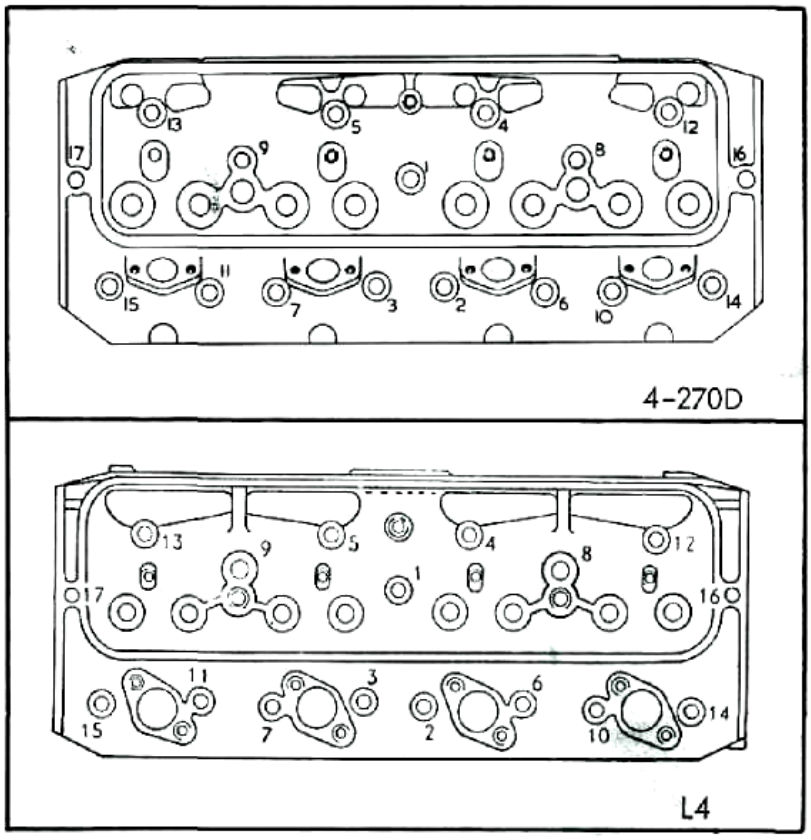



**Fig. B.6—Cylinder Head Nut Tightening Sequence.**

# PISTONS AND CONNECTING RODS

The pistons are of light alloy, with fully floating gudgeon pins, which work in the bush fitted to the connecting rod small end. The gudgeon pins are held in position by means of circlips.

The pistons are fitted with three compression rings, and two oil control or scraper rings.

Four-270D pistons have the chrome ring fitted to the top groove. Early L4 information stipulated that the chrome ring was to be fitted in the top groove but this was later altered to the second groove. The type and arrangement of piston rings for both engines are as shown in Fig. B.7.

Pistons are numbered from 1 to 4, commencing with No. 1 at the front of the engine.

Each connecting rod and cap are also numbered 1 and 1, 2 and 2, etc.

The connecting rod and cap mating faces are serrated to ensure correct positioning and should on no account be filed.

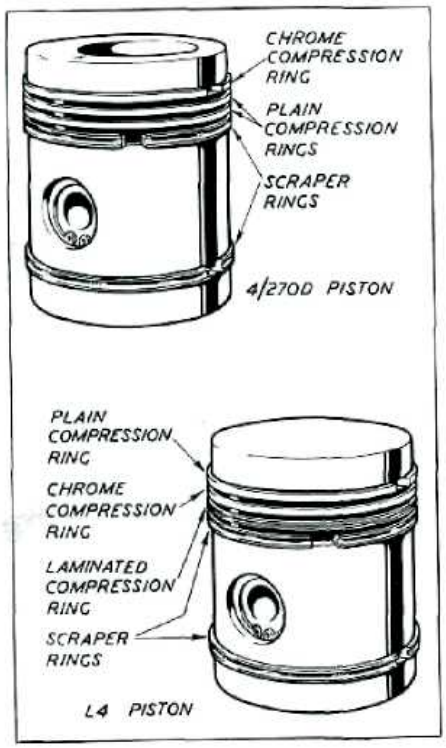



**Fig. B.7 – L4 and 4-270D Pistons.**

### TO DISMANTLE

1. Remove cylinder head assembly (See page B-8).

2. Remove sump (See page B-23).

3. Remove lubricating oil pump (See page B-23).

4. Turn engine until two connecting rods are at bottom centre, then remove setscrews and locking washers.

5. Remove caps and bearing shells.

6. Push piston and connecting rod out of the top of the cylinders, ensuring that the liner does not move.

7. Turn engine until remaining connecting rods are at bottom centre, then repeat removal operations.

Should there be carbon ridges in the cylinder bores, remove them, using a scraper for the purpose.

Keep each piston and connecting rod assembly separate, each to each as marked.

**To Remove Gudgeon Pins:**

1. Remove circlips from the piston, using long nosed pliers.

2. To remove the gudgeon pins, warm the pistons in liquid to a temperature of 100°F. - 120°F. The pins can then be pushed out.

### INSPECTION

Thoroughly clean all parts and examine for wear. Dimensions and permissible clearances for rings, small-end bushes and big-end bearing shells are given on Page B-31.

Early tractors had cap bearings lined with white metal. This bearing metal was later replaced with lead bronze similar to the con-rod shell bearing. Subsequently the engine manufacturers have introduced thick aluminium tin bearings. This latest bearing is interchangeable with both earlier types, but it is recommended that they be fitted as pairs only.

When fitting new rings to original pistons, clean out piston ring grooves using the old ring from the appropriate groove for this.

Examine the piston skirt and if there is any scoring the piston must not be used again.

**Inspection—Continued**

No clearances are stipulated by the engine manufacturers for the piston as these parts are cam and barrel ground. The pistons do not need to be replaced unless:

(a) new rings have excessive side clearance;
(b) the piston skirt shows signs of scoring;
(c) the cylinder liners are excessively worn and are to be replaced.

**To Fit Small End Bushes:**

1. Remove piston and connecting rod from engine.
2. Remove gudgeon pins (see previous page).
3. The small end bushes are a press fit into the connecting rods.
4. Press out old bush with suitable press.
5. Remove any sharp edges around small end parent bore.
6. Press in new bush, ensure that oil hole in bush coincides with hole in top of connecting rod. Ream out new bush to suit gudgeon pin (see Page B-30) and check for parallelism.

**RE-ASSEMBLY**

If original pistons are being used they must be reassembled to the same connecting rods, e.g., piston stamped 1 must go with connecting rod stamped with the figure 1.

**To Assemble Piston and Connecting Rod:**

1. Insert gudgeon pin into position, to do this it may be necessary to heat piston in liquid to a temperature of 100° – 120°F. The gudgeon pin can then be pushed easily into position.

On Four-270D engines, before inserting the gudgeon pin, ensure that the letter "F" on the piston crown is facing the front of the engine.

2. Fit circlips, check to ensure that they fit correctly into the grooves in the piston. It is advisable to fit new circlips even if the old ones do not appear to be damaged or strained.

3. Fit the rings to the piston in the order shown in Fig. B-7. The gaps of the two compression and scraper rings must be arranged so that they are equally spaced around the piston and not in line with one another.

On Four-270D engines, the chrome plated ring is fitted to the top ring groove and the two taper faced compression rings, with the letter "T" facing the top, are fitted to the next two ring grooves.

On L4 engines, when fitting the third, laminated compression ring, care should be taken that the four laminations are correctly assembled to the piston.

To assemble the laminated ring proceed as follows:

(a) Examine the laminations and it will be observed that the free ends of the ring are not cut square to the circumference but slope away either to the right or left, depending on which way up the ring is turned.

(b) Fit the first lamination to the piston with the ring ends going off to the left. Place this ring in the bottom of the ring groove and with the gap over the gudgeon pin.

(c) Place the second lamination on top of the first with the gap at 180° to the first lamination gap, but with the ring ends leading off to the right.

(d) Assemble the third lamination to the piston with the ring ends leading off to the left and on top of the second lamination fitted. The gap of this lamination should be immediately above the lamination fitted first.

(e) To fit the fourth lamination the ring ends should go off to the right with the gap immediately above the second lamination.

(f) When the four laminations are fitted to the piston check that they are fitted correctly. If fitted correctly there will appear a circumferential gap between the bottom two laminations and the top two laminations as illustrated in Fig. B.8.

(g) The piston should be examined carefully for bruising of the ring grooves and ensure that the rings move freely in their grooves.

**Note:** When fitting new rings to worn cylinder liners, the ring gaps should be checked at a bore diameter of 4.250 ins.

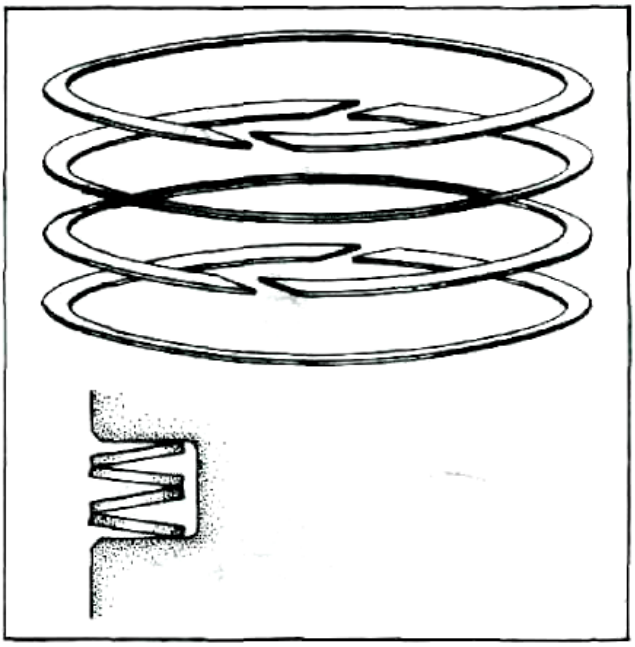


Fig. B.8 — Laminated Ring Arrangement on L4 Piston.

**To Fit Piston and Connecting Rod to Cylinder Block:**

All connecting rods and caps are plainly marked with a number corresponding to their position in the engine. These numbers are stamped on that side of the connecting rods and caps which is machined to take the locating lips of the bearings.

When fitting pistons and connecting rods to cylinder block and crankshaft, ensure that the side of the connecting rod which is stamped with the number goes to the camshaft side of the engine. Four-270 D engines also have the marking "F" to indicate the front of the piston.

1. Insert the pistons and connecting rods into the cylinder bores from the top, ensuring that piston and rod stamped No. 1 are fitted into No. 1 cylinder bore and No. 2 into No. 2 cylinder bore and so on counting from the front of the engine.

When fitting assemblies, deal with them in the order 1 and 4 then 2 and 3. Turn the crankshaft until the appropriate crankpins are at B.D.C.

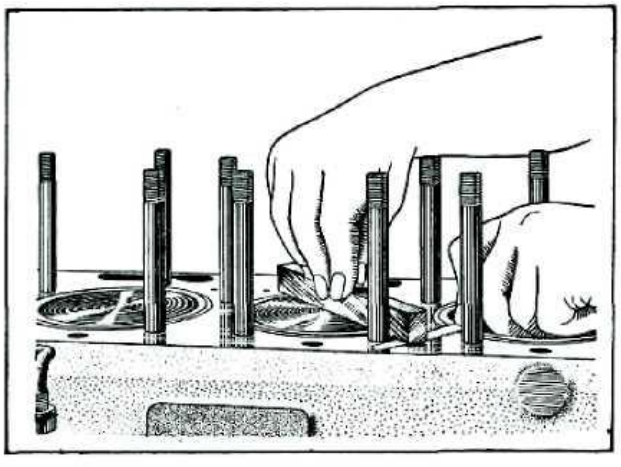


Fig. B.9 — Checking Piston Crown Clearance on an L4 Engine.

2. To minimise the possibility of breaking piston rings, it is advisable to use a piston ring guide. Take care not to damage the rings. Should the piston accidentally drop partly into the bore and is held suspended by a piston ring, it must be taken out again and the ring examined to see if it is cracked or broken.

3. Pull the connecting rod to the crankpin and insert the half bearing.

4. Fit cap and cap half bearing.

**Note:** When replacing connecting rod setscrews new locking washers must always be used.

5. Tighten connecting rod setscrews, using a torque wrench set to a tension of 100-105 lbs./ft.

**Fitting New Pistons:**

It is important, when fitting new pistons, to check the distance from the crown of the piston to the face of the cylinder block.

When the crank is at top dead centre the crown of the piston must be .007 to .012 ins. above the face of the cylinder block (L4 engine) and between .011 ins. above and .003 ins. below for the Four-270D engine.

With the L4 engine, if the piston stands higher than this then the crown must be reduced by taking the necessary amount off in a lathe. If lower, that piston must be rejected, if a first class performance is required.

With the Four-270D engine no topping allowance is provided on the replacement pistons due to the design of the piston crown. If genuine replacement parts are used, the stipulated tolerance will be met without machining.

To take this measurement the piston assembly and connecting rod must be fitted to the cylinder block and crankshaft as previously described.

When assembled turn crankshaft to bring piston to T.D.C. and place a straight edge across the top of the piston and with a set of feeler gauges, measure the distance between the bottom of the straight edge and the top face of the cylinder block (See Fig. B.9).

**Connecting Rod Weights:**

The finished weight of connecting rods in engine sets should balance within two ounces.

# CYLINDER LINERS

The liners fitted to the engine are centrifugal cast iron wet liners. They are flanged at the top and rubber type sealing rings are fitted at the bottom. (See Fig. B.10).

Under normal circumstances the liner would only need to be renewed during a major overhaul, but should it be necessary to remove the liner for any other reason this can be carried out without removal of the crankshaft.

Should, at any time, the liner be removed and later replaced for further service, it is essential the liner be marked to show which parent bore it belongs and also to show its original position in the parent bore, so that it may be replaced in its original position in its orignal bore.

**To Remove Liners:**

Remove cylinder head. (See Page B-8).

Remove sump. (See Page B-23).

Remove oil pump. (See Page B-23).

Disconnect connecting rods and remove pistons. (See Page B-11).

Mark liner and block (see above). Remove liner using a suitable liner removing tool.

When the rubber sealing rings have cleared the bottom landing, the liner can be removed by hand.

**To Fit New Liners:**

When fitting new liners it is essential that new pistons and rings are also fitted. On no account should old pistons be fitted to new liners. For fitting of new pistons see Page B-13.

Over a period of service, corrosion may have taken place at the inner ends of the landings. This corrosion, and any burrs which may be present should be removed with a scraper or emery cloth.

Fit the rubber sealing rings in the grooves provided in the lower diameter of the liner. Care should be taken not to stretch these rings as they are not elastic and if stretched will not return to their former size.

In order to facilitate the fitting of the liners when the two rings have been placed in position on the liner, smear them with soft soap or soapy water.

On the fuel pump side of the Four-270D cylinder block will be seen four 3/32" holes. With the cylinder liners correctly fitted, each hole breaks through on its respective cylinder liner between the two sealing rings. The holes are to allow any coolant leaking past the first sealing ring to escape to the atmosphere. Oil present at this point indicates that the lower seal ring is leaking.

To prevent damage to the lower sealing ring wh assembling this engine, a suitable tool may be co structed with a length of 3/32" diameter wire p truding 1½" from a handle. The end of the w must be dressed to remove all sharp edges.

Place the liner in position and press down by ha ensuring that the rubber sealing rings remain in th respective grooves until the lower sealing ri touches the lower landing of the cylinder block, wh a resistance will be felt. Insert the above mention tool through the drain hole in the cylinder blo until it is arrested by the cylinder liner wall. Ho the tool exactly in this position and press home t liner. Take care not to push the tool inwards at while the liner is being pressed home.

The L4 engine has no drain holes in the block.

After fitting the liners, the cylinder block shou be water tested to a pressure of 20-25 lbs., per s inch. If no pressure facilities are available, the c inder block should be filled. with water and view from below for seal leakage before replacing t sump.

Re-assemble engine as required and to instructio given for the various components.

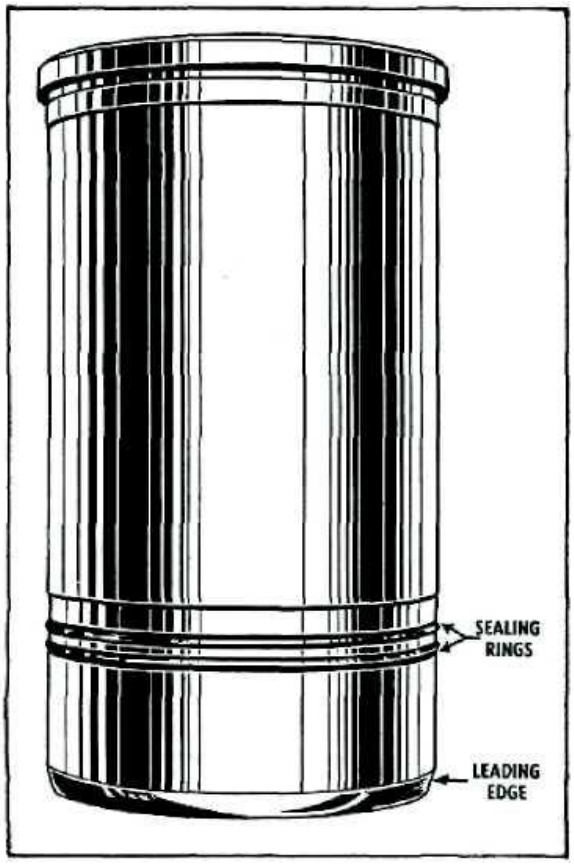



Fig. B.10 — Cylinder Liner and Sealing Rings.

# CRANKSHAFT AND MAIN BEARINGS

The crankshaft runs in three pre-finished, replaceable shell bearings, the end thrust being taken by thrust washers on the rear main bearing.

## CRANKSHAFT MODIFICATIONS

As mentioned under "Pistons and Connecting Rods," the big-end cap bearings have been changed from white metal, to lead bronze, to thick aluminium tin and this also applies to the main bearings. The latest type bearings are fitted to Four-270D engines from serial number 6230201. The new main bearings are not interchangeable with previous types but, the big end bearings are providing they are fitted in pairs.

Apart from the bearing changes, modifications have also been introduced in the crankshaft arrangement.

(1) L4 engines after, and possibly some earlier than serial number 6030431, were fitted with a new type seal. This involved the introduction of a new crankshaft, seal housing, gaskets, bolts, etc. The arrangement is shown in diagram B, below. The seal was of rubber cored asbestos composition, the seal gasket and housing being in two halves with two clamping through bolts.

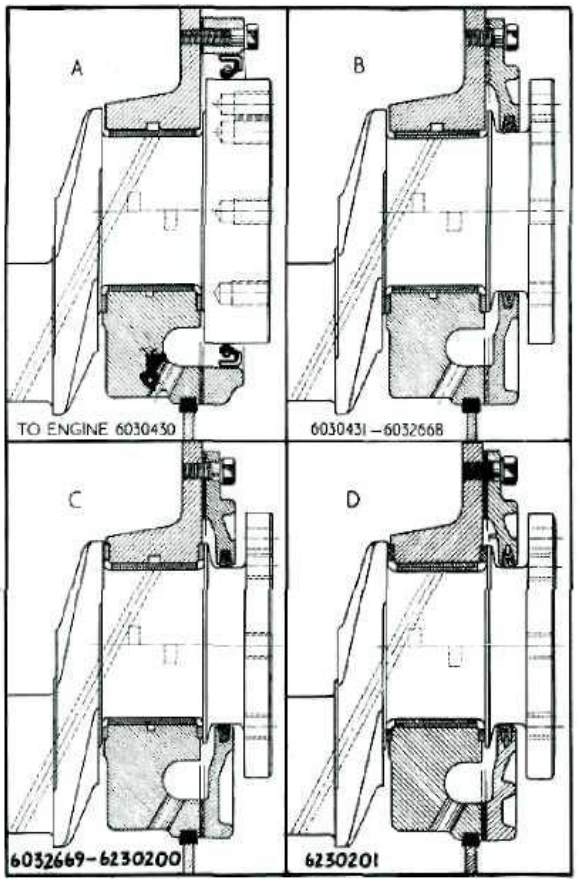



Fig. B.11 – Engine Rear Seal and Crankshaft Arrangements.

(2) At, or before L4 engine serial number 6032669, the crankshaft thrust was increased from 180° to 360°. Earlier engines had thrust washers in both sides of the rear main bearing cap as in diagrams A and B in Fig. B11. The change consisted of moving these thrust washers into new recesses provided in the cylinder block and providing two new thrust washers for the rear main bearing cap as in diagrams C and D Fig. B11.

(3) At, or before Four-270D engine serial number 6230201, a new crankshaft was introduced. Providing the thick aluminium tin main bearings are also used, this crankshaft can be fitted to earlier Four-270D and L4 engines. In the event of this crankshaft being used to replace the type used in L4 engines prior to engine number 6030430, shown in diagram A Fig. B11, it will be necessary to also replace the rear oil seal assembly.

4. At Four-270D engine serial number 6212604, an improved type rear engine oil seal was introduced incorporating—

(a) A deflector shroud in the upper half of the housing to deflect splashed oil away from the rope seal.

(b) An extra stiffening rib in the lower half of the housing.

(c) Four small pegs (2 in each half) in the oil seal groove to prevent the oil seal from being turned in service.

It is recommended that this new seal assembly, shown in diagram D. Fig. B11, be fitted when a replacement is necessary to any Four-270D or L4 engine from serial number 6030431.

Various types of rear engine oil seal material has been used since the introduction of the split type seal.

The first was of light grey colour with a small black core. This was replaced by a black material, then finally a light grey material with a large black core was introduced. All these seals are covered by the same part number (22635) as they are interchangeable, but it is essential that the latest type be used if satisfactory operation is to be expected. The core in the latest type is approximately 3/32" diameter. The fitting procedure for both types of seal is covered on page B-18.

## MAIN BEARING REPLACEMENT

Under normal circumstances by the time the main bearings require to be renewed, the crankshaft will need to be removed for regrinding. However, if for any reason one or more of the bearings should have to be renewed or removed for inspection, this can be carried out on Nos. 1 and 2 bearings without the necessity of removing the crankshaft from the engine, but it will be necessary to remove the front gearbox, clutch, flywheel and rear oil seal before the rear main bearing cap may be lowered.

Proceeds as follows:

1. Remove sump. (See Page B-23).

2. Take off the cap of the bearing in question.

3. Slacken remaining bearing cap setscrews one or two turns.

4. Remove the lower half of the bearing from the bearing cap.

5. With a suitable tool push out the top half of the bearing by rotating it on the crankshaft, applying the tool to the side opposite the locating lip. The locating lips are on the camshaft side of the engine.

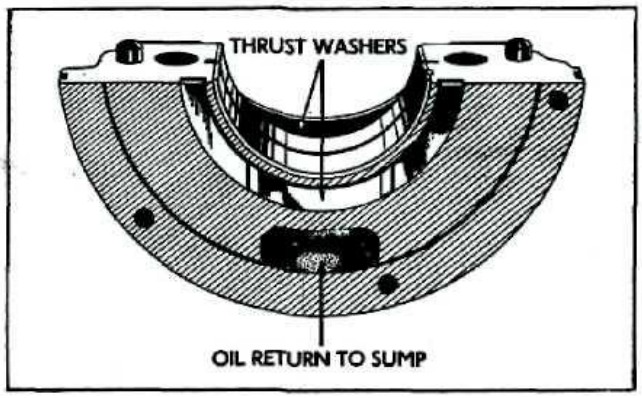



Fig. B.12 — Rear Main Bearing Cap.

6. Inspect the bearing shells and if they require renewing, insert a new half bearing in the top, inserting plain end first. Fit new half bearing to cap. Do not remove more than one bearing at a time.

7. Replace cap and tighten setscrews lightly before proceeding to next bearing.

8. Having replaced the bearings and caps pull down the setscrews with a torque wrench set to 125/130 lbs./ft.

The thrust washers fit in the recesses provided on either side of the rear main bearing cap and should be assembled with the flat steel side to the bearing cap. The end float of the crankshaft is measured between the crank cheek and the thrust washers. This measurement should be between .0045 ins. and .0115 ins. for the L4 engine and between .001 ins. and .008 ins for the Four-270D engine. If greater or smaller than this amount, fit new thrust washers.

## CRANKSHAFT REGRINDING

Under normal service conditions the crankshaft will not require removal for grinding until a complete engine overhaul is advisable. To carry out this operation conveniently, it is advisable to remove the engine and work on it on a bench or, preferably, on a suitable "turn-over" stand.

Before attempting to re-grind the Four-270D crankshaft, facilities must be available for cold rolling the crankshaft after regrinding.

The fillet radii of the crankshaft has been cold rolled by the manufacturer to add strength and regrinding of the crankshaft will practically remove the beneficial effects of the cold rolling.

### To Remove the Engine from the Tractor:

This may be accomplished by either lifting the engine and front gearbox as a unit, or by uncoupling and moving back the front gearbox, removing the clutch and flywheel then lifting the bare engine. To use the first method proceed as follows:

1. Remove the radiator and cowling as a unit. (See Section C).

2. Disconnect and remove the batteries.

3. Uncouple all wiring, controls and piping from the engine.

4. Uncouple the rear light cable from the instrument panel and the tractometer cable when fitted.

5. Uncouple and remove the top cowl frame, bulkhead, nearside rear support, air cleaner and instruments, etc., as a unit.

6. Uncouple and remove the two coupling shafts. (See Section H).

7. Disconnect the clutch link from the cross-shaft lever.

8. Remove the bolts coupling the offside rear support to the footplate and the three conical nuts on the steering assembly bracket, then move the assembly outwards until the steering assembly lash adjusment screw is clear of the gear box cover plate.

9. Remove the bolts coupling the engine rear mounts and front plate to the chassis and the engine and gearbox may be hoisted from the tractor using the lifting lugs provided on the cylinder head.

10. Remove the front gearbox and clutch. (See Section F).

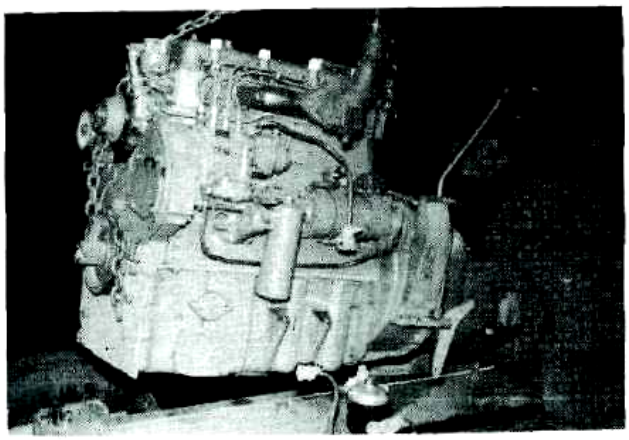


**Fig. B.13 — Removing Engine. (L4 Engine Illustrated)**

**To Remove the Crankshaft:**

1. Remove the cylinder head. (See Page B-8).

2. Remove the sump. (See Page B-23).

3. Remove the lubricating oil pump. (See Page B-23).

4. Remove the pistons and connecting rods. (See Page B-11).

5. Remove the starting dog.

6. Remove the crankshaft pulley.

7. Remove the timing case front cover. Handle the cover with care to prevent damage to the front oil seal.

8. Remove the idler gear.

9. Remove the timing case bottom cover.

10. Remove the starter motor.

11. Remove the flywheel and housing. (See page B-26).

12. Remove the rear crankshaft seal. On type A crankshafts, remove the six setscrews and withdraw the housing and seal. On B, C and D crankshafts, remove the two clamp bolts, remove the six setscrews and remove the two halves of the seal and housing.

13. Remove the main bearing caps and half bearings.

14. Remove the crankshaft.

**Crankshaft Regrinding:**

Inspect and measure the crankshaft journals and crank pins for scoring, ovality and wear. Permissible dimensions are given on Page B-29. If regrinding is necessary, a crack detection test before grinding is advisable, if suitable equipment is available.

Determine the amount of regrinding necessary. (Undersize bearings are available in —.010", —.020" and —.030").

When regrinding it is important that the radii on the main journals and crankpins are maintained. If these are neglected a fatigue fracture may occur.

Crankshaft dimensions are as follows:

| Description | Dimensions | Remarks |
|---|---|---|
| Main Journal Diameter<br>Std.<br>—.010"<br>—.020"<br>—.030" | <br>2.99825/2.9985"<br>2.98825/2.9885"<br>2.97825/2.9785"<br>2.96825/2.9685" | Surface finish not to exceed 16 micro ins. |
| Main Journal Radii | $\frac{1}{8}'' \; ^{-\ 0}_{+\ .015''}$ | Must be maintained |
| Rear Main Journal Width | 2.0625/2.0635" | Not to exceed 2.0785" after regrinding |
| Crankpin Diameter<br>Std.<br>— 010"<br>— 020"<br>—.030" | 2.74825/2.749"<br><br>2.73825/2.739"<br>2.72825/2.729"<br>2.71825/2.719" | <br><br>Surface finish not to exceed 16 micro ins. |
| Crankpin Radii | $3/16'' \; ^{+\ .015''}_{-\ 0}$ | Must be maintained |
| Crankpin Width | 1.780/1.785" | Not to exceed 1.8" after regrind |

Due to the action of the original rubber rear oil seal, the rear flange may on occasion need regrinding. In such cases, the rear 3/8" of the flange must not be ground. The remaining portion of the flange width may be ground to a minimum diameter of 5.238 ins. After regrinding, the sharp corners of the oilways must be removed, the oilways thoroughly cleaned out and all the bearing surfaces closely inspected for imperfections.

**To Replace the Crankshaft:**

1. Ensure that all oilways are clear.

2. Check main bearing setscrews for stretch or damage to threads. Affected setscrews must be scrapped.

In no case should setscrews, other than those supplied by the engine manufacturer be used, as they are of special heat treated high-grade steel.

3. Clean bearing housings and place top half bearings in position. Liberally oil with engine oil.

**Replacement of Crankshaft—Continued**

4. Place crankshaft in position.

5. Fit lower halves of bearings to bearing caps and place in position, ensuring that the thrust washers on No. 3 bearing cap are fitted correctly.

6. Place new tab washers in position and tighten setscrews.

7. For final tightening of the setscrews, a torque wrench should be used, set to 125/130 lbs./ft.

8. Lock setscrews in position by means of the tab washers.

9. Fit the rear end oil seal. (See below).

10. Fit the flywheel. (See Page B-26).

11. Re-assemble the idler gear, timing case covers, pulley and crank dog. (See Page B-20).

12. Replace the starter motor.

13. Replace the pistons and connecting rods. (See Page B-12).

14. Replace the lubricating oil pump. (See Page B.23).

15. Replace the sump. (See Page B23).

16. Replace the cylinder head. (See Page B-9).

Two types of oil seal have been fitted. To service either type it is necessary to uncouple the front gearbox and remove the clutch and flywheel. (See Section F.).

**Note:** Before replacing the crankshaft oil seal, check the possibility of oil leakage from the rear sump seal and the plug at the rear of the engine oil pressure gallery.

**Seal for Model A Crankshafts:**

This seal was fitted prior to engine number 6030431 and consists of the housing and a rubber seal.

When removed it should be inspected for cracks or scratches on the bearing surface. If this surface is damaged in any way a new seal should be fitted.

At the time of replacement of the seal, a 1/8" hole should be drilled through the crankcase casting at a point opposite the top face of the oil seal, taking care to avoid contact with the oil gallery. This modification will eliminate the possibility of a pressure build up behind the oil seal.

To fit a new seal proceed as follows:

Remove oil seal by pressing it out of the housing.

Lightly smear the outer edge of the new seal with soft soap.

Place seal in position and press in by hand as far as it will go, this should be approximately half way in. Pressing in halfway by hand ensures that the seal is centralised.

Press in with a press until the bevelled edge of the seal is level with the outer face of the housing.

Lightly smear the crankshaft rear end oil seal joint with jointing compound and place in position.

Place crankshaft rear end oil seal in position and tighten setscrews.

**Seal for Model B and C Crankshafts:**

As from Engine No. 6030431 all engines incorporate a modified crankshaft and rear oil seal.

The modification to the crankshaft affects that part of the shaft around which the rear oil seal is fitted. Whereas previously this portion of the shaft had a nominal diameter of 5¼", the equivalent nominal dimension in the case of the modified shaft is 3-1/8". Furthermore, the modified crankshaft has a shallow oil groove machined to a depth of .004/.008 ins. in that section upon which the rear seal bears.

With the advent of this crankshaft, the bore of the modified rear oil seal is machined to accommodate a rubber cored asbestos strip. This strip consists of two sections, one for each of the two half-housings which now compose the seal cover. The strip itself forms a positive seal with the rear end of the crankshaft.

**Model D arrangement:**

This oil seal, introduced at engine number 621-2604 employs the same principle as B and C arrangements, with modifications to the seal housing itself. These modifications consist of:—

(a) A deflector shroud in the upper half of the housing to deflect splashed oil away from the rope seal.

(b) An extra stiffening rib in the lower half of the housing.

(c) Four small pegs (2 in each half) in the oil seal groove to prevent the oil seal from turning in service.

Model B, C and D arrangements are completely interchangeable with each other but cannot be fitted to engines prior to 6030431 unless a modified crankshaft is also fitted.

When fitting the seal with the crankshaft in position, the following procedure should be adopted:

1. Separate the half covers and press the strips into the grooves. The strips should project .010/.020 ins. beyond the faces of the respective half housings and under no circumstances should the ends be cut.

2. Spread a film of graphite oil mixture over the exposed inside diameter surface of the rope seal, and rub thoroughly into the surface.

3. Lightly paint the butt surfaces of the covers with a suitable jointing compound.

4. Oil the crankshaft rear end around the oil return groove.

5. Assemble the half covers around the crankshaft, over the oil return groove, and fasten together by the two setscrews.

6. Swivel the complete seal cover on the shaft to bed in the strips, and to establish that the assembly turns easily on the shaft.

7. Lightly bolt the seal cover in position on the block and main bearing cap.

8. Slacken the two setscrews securing the two half covers and tighten the six setscrews securing the seal cover in position, ensuring that a good joint is made between the seal cover and its mating faces.

9. Re-tighten the two setscrews securing the two half covers.

# TIMING

The camshaft gear and fuel pump gear mesh with an idler gear, which, in turn, meshes with a gear on the crankshaft. A cover on the offside of the timing case may be removed to allow the fitting of a hydraulic pump or pump drive.

**To Check Valve Timing:**

Remove valve cover.

Set valve clearance of No. 4 cylinder to .025 ins. with No. 4 piston at T.D.C. on compression.

Remove injectors.

Turn engine in the normal direction of rotation until the inlet push rod of No. 4 cylinder just begins to tighten. This is point at which the inlet valve begins to open.

Check through the inspection hole in the flywheel housing that the flywheel T.D.C. mark is central within the inspection hole. If the T.D.C. mark on the flywheel is within plus or minus 3° of T.D.C. position, then the valve timing is correct.

Having checked the valve timing, the valve clearances should be re-set to .010 ins. with engine warm. When checking and adjusting valve clearances, the engine should be turned to bring the respective pistions to T.D.C. on compression.

**To Check Fuel Pump Timing—L4 Engine:**

Remove atomisers.

Remove valve cover.

Remove the inspection plate on the side of the timing case.

Turn the engine in the normal direction of rotation and bring Nos. 1 and 4 pistons to the top, No. 1 piston being on the compression stroke, the rockers of No. 4 cylinder being just rocking.

Check that Nos. 1 and 4 pistons are at T.D.C. by examining the flywheel.

Check through the inspection hole that the scribed line marked "S" on the fuel pump adaptor is in line with the scribed line on the pointer of the fuel pump.

Should the scribed lines mentioned above not coincide, adjustment can be made by slackening the three setscrews in the centre of the fuel pump gear, then turning the fuel pump adaptor in the direction required.

To obtain access to the setscrews, remove the plate on the front of the timing case cover.

**To Check Fuel Pump Timing—Four-270D Engine:**

Two adjustments are provided. The driving gear has slotted holes and the pump flange is also slotted.

Check that the scribed lines on the fuel pump flange and the carrier flange (adjacent to the timing case) are in line. The three setscrews retaining the pump may be slackened to allow correction if necessary.

If the front cover is removed from the timing case, the mating of the scribed lines on the flange of the driving plate and the driving gear may be checked. Slacken the three setscrews to adjust if necessary.

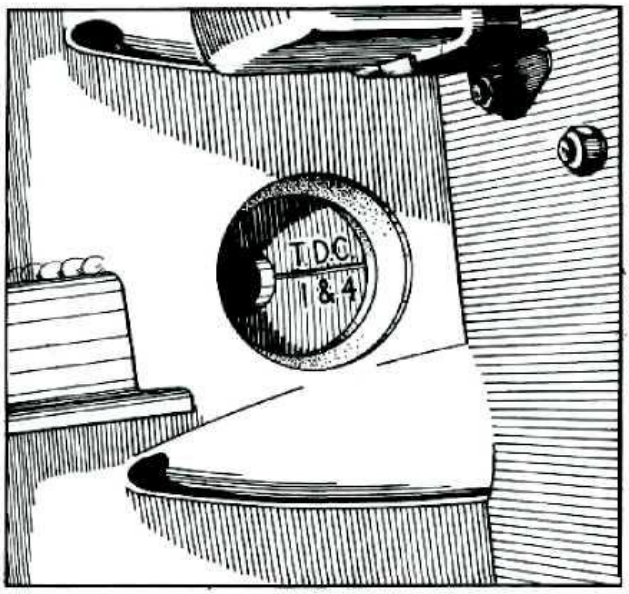



Fig. B.14 — Flywheel Timing Marking.

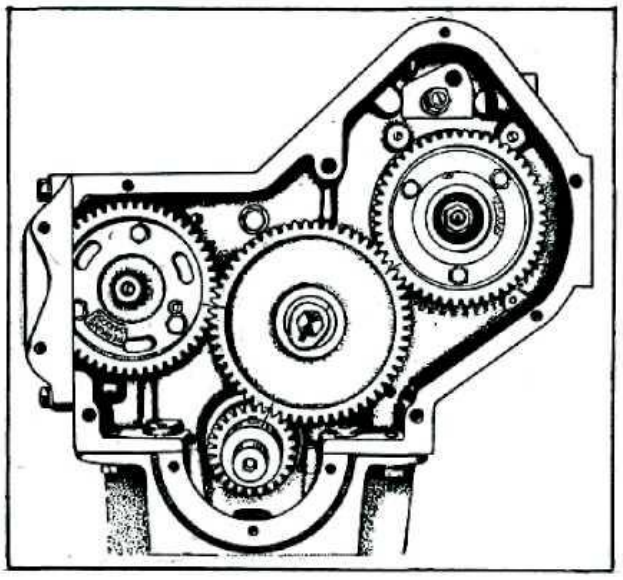


Fig. B.15 — Timing Gear Markings.

# TIMING GEARS

**To Remove the Timing Gears:**

1. Remove the radiator and cowlings. (See Section C).

2. Support the front of the engine either with tools No. 22750 or by using a hydraulic jack with a block of wood under the front of the sump.

3. Remove the bolts coupling the front mounting plate to the chassis, the rear mounts to the chassis and those retaining the two rear cowl supports.

4. Raise the front of the engine sufficiently to clear the crankshaft pulley. Exercise care to prevent fouling the clutch cross-shaft grease nipples on the chassis. If necessary, block under the rear engine mounts.

5. Unlock and remove the crank dog.

6. Remove the crankshaft pulley.

7. Remove the timing case cover. Exercise care to prevent damage to the front oil seal.

Note the timing marks.

8. The idler gear may be removed by unlocking and removing the idler gear setscrew.

9. The L4 engine fuel pump gear may be removed by removing the three setscrews and plate. Note that the setscrews pass through the slots in the gear.

The four-270D fuel pump gear is retained behind the triangular shaped driving plate. Check that the scribed lines on the gear and plate are in line, before removing the gear.

10. To remove the camshaft gear, remove the P.T.O. side cover and remove the three centre setscrews.

11. If necessary, the crankshaft gear may be withdrawn over the front of the crankshaft. The use of a puller may be necessary to move the gear from its key.

**To Replace the Timing Gears—L4 Engine:**

1. Camshaft Gear.

The three clearance holes drilled at equal angles are the holes for attaching the gear to the camshaft. The three slotted holes are for use with the fuel pump.

When fitting a replacement gear, turn the camshaft until No. 1 cam is upright. It will be observed that a tapped hole on the camshaft hub is also at the top, in line with No. 1 cam. Look at the gear and it will be noticed that one of the holes in the gear has the letter "D" adjacent to it.

Place the gear on the hub with these two holes in line.

Replace setscrews and plain washers, finally lock setscrews with locking wire.

2. Fuel Pump Gear:

Turn the fuel pump shaft until the line on the adaptor plate marked "S" approximately lines up with the pointer on the fuel pump housing. Mount the gear on the adaptor with the adaptor plate in position. The setscrews pass through the three slots in the gears and the scribed line on the front of the gear must be towards the crankshaft as shown in Fig. B.15.

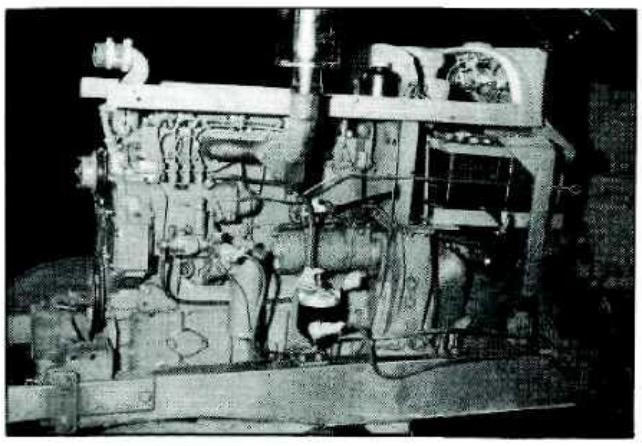


Fig. B.16 — Front of Engine Raised.
(L4 Engine Illustrated)

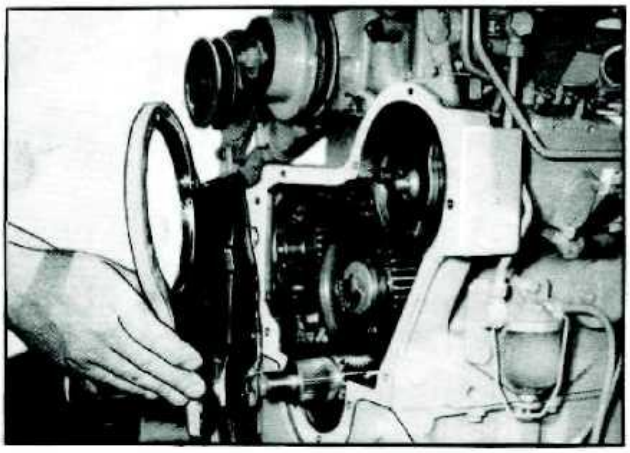


Fig. B.17 — Removing Timing Case Cover.
(Four-270D Engine Illustrated)

3. Turn the crankshaft until Nos. 1 and 4 pistons are at T.D.C. This may be checked by viewing the flywheel through the inspection hole in the top of the flywheel housing. The crankshaft key should also be at the top of its periphery.

4. Place the idler gear in position with the markings aligned as shown in Fig. B.15. Turn the camshaft and fuel pump gears as necessary to align the markings. Check that the tappets of No. 4 cylinder are in the rocking position.

5. Slacken the fuel pump gear setscrews and accurately align the adaptor line "S" with the fuel pump body pointer. Retighten the gear setscrews.

6. Turn the crankshaft through two full revolutions. Align the T.D.C. mark on the flywheel with the centre of the inspection hole and check that the fuel pump "S" line is once more aligned with the housing pointer, and that No. 4 cylinder tappets are just rocking.

7. Tighten and lock the idler gear centre bolt.

**To Replace Timing Gears—Four 270D Engine.**

1. Set crankshaft to T.D.C. Nos. 1 and 4 pistons as indicated by the flywheel markings, and by the key in the crankshaft gear, which should be at the top

2. Fit the Camshaft gear to the camshaft, taking care that the letter "D" on the gear coincides with the letter "D" on the camshaft hub. Note that the bolts pass through the plain holes, not the slots.

If the fuel pump driving gear hub and circlip have for any reason been removed, it is advisable to remove the fuel lift pump and its push rod. Having replaced the fuel pump driving gear hub and circlip, replace the push rod and lift pump.

3. Offer up the fuel injection pump driving gear to the hub, but first ensure it will locate in the one position to the hub where the fixing bolts will be in a central position within the elongated slots.

4. Fit the triangular shaped adaptor or driving plate and fixing bolts to the fuel pump gear and hub, taking care to engage the master spline of the quill shaft and the driving plate.

5. Replace the circlip inside the driving plate.

6. Turn the driving plate in relation to the fuel pump driving gear until the scribed lines on the gear and driving plate coincide. Tighten the securing bolts.

7. With the camshaft and fuel pump gears fitted, replace the idler gear ensuring all the timing marks coincide.

If the fuel pump driving gear has been renewed, it will be necessary to time the pump as detailed in Section D, and to mark the gear for future reference.

# CAMSHAFT

Normally, it will not be necessary to remove the camshaft other than when completely overhauling the engine, in which case the engine will be removed from the tractor.

**To Remove the Camshaft:**

1. Remove cylinder head. (See Page B-8).
2. Remove timing case front cover.
3. Remove sump. (See Page B-23).
4. Remove lubricating oil pump. (See Page B-23).
5. Remove timing case 'Power Take Off' facing cover.

Note timing marks. (See Fig. B.15).

6. Remove idler gear.
7. If engine is in a swivel stand, turn engine completely over. If not, lay engine over at an angle. This will prevent the tappets dropping out when the camshaft is removed.
8. Remove camshaft.

If for any reason it is required to remove the camshaft before a cylinder head overhaul is necessary, proceed as follows:

1. Remove cylinder head valve cover.
2. Remove rocker shaft assembly and push rods.
3. Remove atomisers.
4. Remove timing case cover and then proceed as before.

**To Replace Camshaft:**

See that tappets are in position.

Replace camshaft.

Replace idler gear but do not lock idler gear retaining setscrew.

Check backlash between idler gear and camshaft gear which should be .003 in. to .009 in.

Reset timing.

Re-assemble engine as required and to the instructions given for the various operations.

# LUBRICATING SYSTEM

The importance of correct and clean lubrication cannot be too highly stressed. Only high grade heavy duty diesel lubricating oil should be used. When working in temperatures between 30° and 70°F., oil of S.A.E. 20 rating should be used. At temperatures over 70°F., use S.A.E. 30 oil. The engine manufacturers recommend that S.A.E. 20 oil should be used for the first 50 hours of operation, regardless of temperature, for running-in purposes.

Routine maintenance procedures for the strainers and filters are covered on Page B-5.

The sump should be filled with suitable lubricant to the correct level, but do not attempt to overfill above the full mark. Before filling, or checking the dipstick, ensure that the engine is level.

**Oil Circulation:**

The system of lubrication is pressure feed to main and big end bearings, to camshaft bearings and to valve rocker assembly.

The pump draws oil through the strainer from the sump and delivers it by an external pipe inside the crankcase through a drilling in the side of the cylinder block; thence through the lubricating oil filter bracket to the lubricating oil filter.

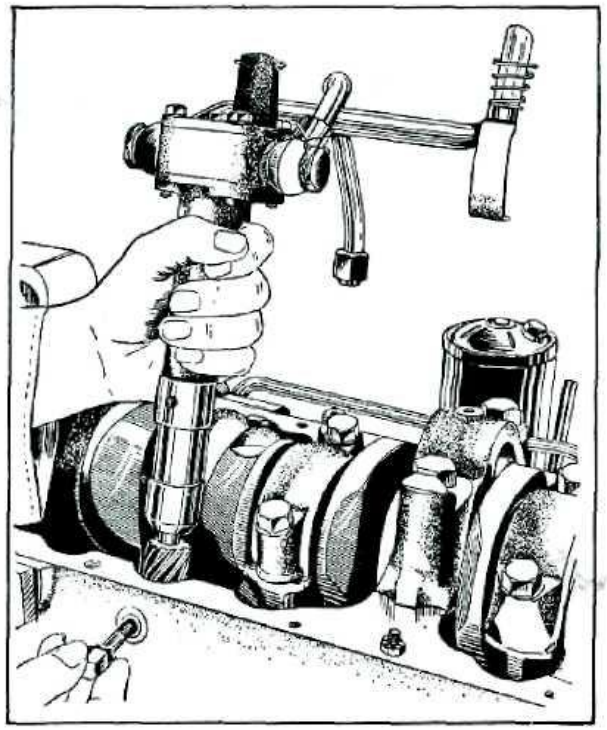


Fig. B.18 — Removing Oil Pump.

From the filter it is delivered through a second drilling in the lubricating oil filter bracket and cylinder block to the pressure rail which is an internal passage within the crankcase; holes are drilled which lead from the pressure rail to the crankshaft main bearings and holes drilled in the crankshaft carry oil to the big end bearings. Surplus oil returns to the sump.

A seal prevents oil leaking from the rear end of the crankshaft.

The small end bushes are lubricated by splash and lubricating oil mist.

A passage from the centre main bearings brings oil to the centre camshaft bearing, this bearing also has a vertical drilling leading to the top face of the cylinder block. The camshaft journal has two passages drilled in it which act as an oil pressure reducer for the oil feed to the rocker assembly.

When the drillings in the camshaft journal are in line with those in the camshaft bearing, oil flows up to the top face of the cylinder block. Owing to the short time that these drillings are in line only a reduced quantity of oil is supplied to the passage leading to the top face of the cylinder block.

The drilling in the top face of the cylinder block matches up with the vertical drilling in the cylinder head which emerges on the top face of the cylinder head, oil is then taken by an external pipe to the hollow rocker shaft and thence to the rockers. The overflow of oil from the rocker assembly flows from the head into the push rod chamber and the sump.

Oil flows from the front main bearing bracket via a hole drilled in the front of the cylinder block to the idler gear spigot from which it escapes through a drilling in the boss of the idler gear thus lubricating the timing gears.

A further drilling from No. 1 Main Bearing Housing conveys oil to the front camshaft bearing, surplus oil returning to the sump.

**Oil Pressure:**

See that oil pressure is registered on the gauge. The actual pressure may vary with individual engines and under different operating conditions but should be 25/35 lbs. per sq. in. at working temperature and normal running speed.

If the oil pressure, as registered on the gauge, is below normal, check the following in the order given below:

1. Dipstick: Ensure that there is sufficient oil in the sump.

2. Oil pressure gauge: Check for accuracy with master gauge.

3. Lubricating oil filter: May be choked, re-new element.

4. Sump strainer: This may be choked, remove, clean and replace.

5. Lubricating oil pump: Ensure that suction and delivery pipe unions are tight.

6. Oil pressure relief valve: Foreign matter may be preventing the valve from closing.

**To Remove, Clean and Replace Sump Strainer:**

1. Drain oil into a suitable receptacle after removing the drain plug. Remove setscrews holding sump strainer cover. This cover is situated near the drain plug.

2. Remove cover and strainer will come away with cover.

3. Wash and clean strainer in clean fuel oil or kerosine.

4. To re-assemble, reverse the order of operations. Ensure that the oil pump suction pipe enters the hole provided in the strainer.

If reasonable care is taken when removing and replacing sump strainer cover, the joint will not require renewing every time the strainer is removed.

**To Remove the Sump:**

1. Remove the front suspension as a unit. (See Section A).

2. Support the front of the engine using tools No. 22750.

3. Remove the rear engine mount to chassis bolts.

4. Slacken the rear cowling support bolts.

5. Remove the bolts coupling the front mounting plate to the engine and chassis.

6. Drain the oil, remove the sump strainer and the dipstick.

7. Remove the sump setscrews. The two setscrews, situated at the forward end of the sump can be removed with a normal size socket providing the obstructing webs are first removed.

8. Support the sump from below. Prise the engine back along the chassis approximately 1/4" allowing removal of the sump.

**To Replace Sump:**

Assemble new joints and cork strips.

Lightly smear crankcase faces with a thin coating of jointing compound and place joints in position ensuring all holes line up.

When placing joints in position it is important that the mitred ends go right up into the recesses of the timing case bottom cover and rear main bearing cap.

Lightly coat one face and the two sides of the cork with jointing compound and place in position.

To facilitate assembly of the sump, screw two guide studs into the crankcase, one on each side.

The studs will position the sump accurately and prevent displacement of the joints.

Place the sump in position and insert the screws.

Remove guide studs.

When all the setscrews have been inserted, tighten evenly all round. Do not overtighten setscrews.

Replace sump strainer and cover plate as previously described.

**To Remove and Refit Oil Pump:**

1. Remove sump and sump strainer. (See previous headings).

2. Disconnect oil pump delivery pipe from the crankcase union.

3. Remove setscrew from centre main bearing cap thus releasing the oil suction pipe.

4. Unscrew the lubricating oil pump locating setscrew. This screw is situated outside the cylinder block. (See Fig. B.18).

5. The oil pump may now be removed. (See Fig. B.18).

To refit, reverse the above order of operations.

**To Dismantle the Oil Pump:**

1. Remove pump from engine. (See above).

2. Remove locking wire from suction and delivery pipe banjo bolts and remove pipes. On oil pumps having the oil pressure relief valve P/N 22668 fitted, it will be necessary to remove the relief valve in order to release the delivery or outlet pipe.

3. Remove the setscrews securing the bottom cover and gear housing.

4. The idler gear can now be removed.

5. Press off spiral driving gear.

6. The drive shaft and gear can now be removed. To remove gear from shaft, use suitable press.

7. Press the idler gear shaft from the housing. If the shaft is fitted with a split pin, remove the pin before pressing the shaft. Unless a replacement shaft is to be fitted, it is not necessary to remove this shaft.

The cleaning of the pressure relief valve is dealt with on Page B-25.

**Inspection:**

All the parts of the pump should be cleaned and inspected for wear. The fit of the shaft in the pump body should be carefully checked. The shaft should work easily without lateral movement in the bushes fitted in the body. If the bushes are worn, they should be replaced.

If the oil pump gears show signs of wear, they should be renewed.

**To Re-assemble the Oil Pump:**

1. Press drive shaft gear on to shaft, the end of the shaft should be flush with the bottom face of the gear.

2. Assemble gear and shaft to pump body.

3. Assemble idler gear, pump housing and joint to body; secure by using setscrews with suitable distance pieces.

4. Check that there is clearance between housing and gears.

5. Place bottom cover joint on bottom face of housing and with a straight edge and feeler gauge, check the clearance between the straight edge and face of gears. This clearance should be .002 in. to .006 in. It is important that this clearance does not exceed .006 in. otherwise the pump output will be insufficient and the lubricating system adversely affected.

New joints should be used when carrying out the above test.

6. Remove setscrews, pump housing and idler gear.

7. Using a suitable press, press the spiral driving gear on to the shaft. The shaft end should be just level with the top face of the spiral gear.

8. Assemble housing, joints, idler gear and bottom cover to pump body, using new Shakeproof washers for the securing setscrews.

**WARNING:** WHEN RE-ASSEMBLING THE P/N21299 OIL PUMP COVER ON EARLY L4 ENGINES, CARE MUST BE TAKEN TO ENSURE THAT THE OIL RELIFE VALVE IS ASSEMBLED ON THE DELIVERY SIDE OF THE PUMP.

9. Re-assemble pump to engine.

10. Replace suction and delivery pipes and lock banjo bolts with lock wire.

**Pump Models:**

Three types of pumps have been used. Early L4 engines used oil pump assembly P/N 21244. This assembly had an oil pressure relief valve fitted to the bottom cover plate. At, or before engine number 6032453, a larger capacty pump P/N 22662 was introduced. Besides the increased capacity, the pump also incorporated a modified relief valve in the enlarged head of the delivery banjo bolt. The suction banjo was replaced by a nut and sleeve type fitting.

The modified relief valve P/N 22668 may be fitted to oil pump assembly P/N 21244 providing the bottom cover P/N 21299 is replaced by cover P/N22666. The relief valve can be assembled to the engine through the sump oil strainer cover without removing the sump. Care should be taken to ensure that the oil pump cover plate gasket P/N 21197 is correctly fitted.

The modified oil pump P/N 22662 was used until the introduction of the Four-270D engine commencing at engine number 6200733. This engine included a new oil pump assembly P/N 25768. This assembly has an improved driver gear, but may be fitted to later L4 engines and to engines prior to number 6032453, providing modified suction and delivery pipes are fitted and the sump off-side web is modified as shown in Fig. B.19.

Interchangeability of component parts can be taken from the table shown overleaf.

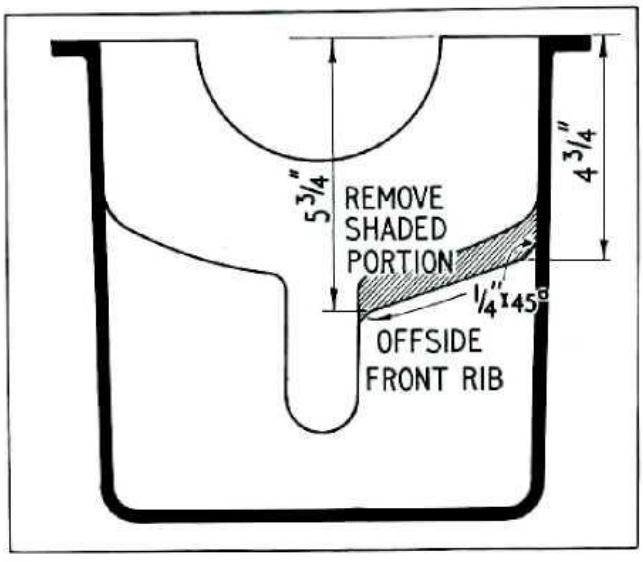
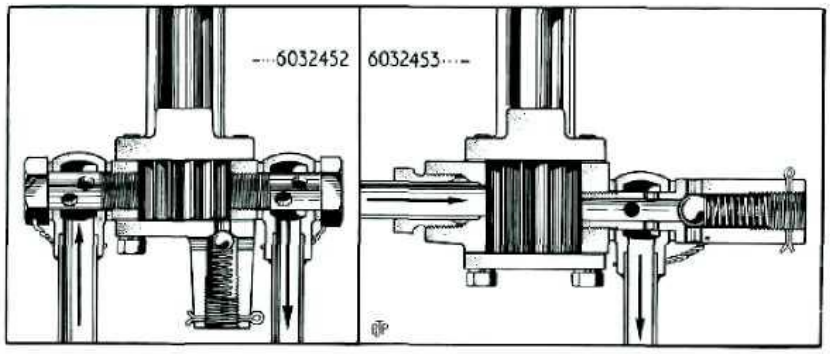



**Fig. B.19 — Sump Modification.**

| Description | To Eng. 6032452 | | To Eng. 6052779 | | From Eng. 6200733 | |
|---|---|---|---|---|---|---|
| PUMP, LUB. OIL, ASSEMBLY | 21244 | 1 | 22662 | 1 | 25768 | 1 |
| GEAR, lub. oil pump | 21183 | 1 | 22663 | 1 | 22663 | 1 |
| GEAR, lub. oil pump idler | 21183 | 1 | 22663 | 1 | 22663 | 1 |
| SPLITPIN, idler shaft retaining | 10011 | 1 | 10011 | 1 | 10009 | 1 |
| HOUSING, lub. oil pump gears | 21189 | 1 | 22664 | 1 | 22664 | 1 |
| DOWEL, lub. oil pump housing | 21372 | 2 | 21372 | 2 | 21372 | 2 |
| DOWEL, lub. oil pump bottom cover | — | – | 22665 | 2 | 22665 | 2 |
| GASKET, lub. oil pump housing | 21197 | 2 | 21197 | 2 | 21197 | 2 |
| COVER, lub. oil pump housing | 21299 | 1 | 22666 | 1 | 22666 | 1 |
| SETSCREW, bottom cover to body | 4227 | 4 | 22667 | 4 | 22667 | 4 |
| WASHER, bottom cover setscrews | 22675 | 4 | 22675 | 4 | 22675 | 4 |
| ASSEMBLY, VALVE, lub. oil relief | — | – | 22668 | 1 | 22668 | 1 |
| BALL, lub. oil relief valve | 22514 | 1 | 22669 | 1 | 22669 | 1 |
| SPRING, lub. oil relief valve | 22515 | 1 | 22670 | 1 | 22670 | 1 |
| PLUG, lub. oil relief valve | 22516 | 1 | 22671 | 1 | 22671 | 1 |
| SPLITPIN, lub. oil relief valve | 14276 | 1 | 14276 | 1 | 14276 | 1 |
| PIPE, lub. oil suction | 22518 | 1 | 22672 | 1 | 22672 | 1 |
| NIPPLE, lub. oil suction pipe | — | – | 22673 | 1 | 22673 | 1 |
| UNION, lub. oil suction pipe | — | – | 22674 | 1 | 22674 | 1 |
| PIPE, lub. oil delivery | 22517 | 1 | 22676 | 1 | 22676 | 1 |
| NIPPLE, lub. oil delivery pipe | 22586 | 1 | 22586 | 1 | 22586 | 1 |
| NUT, lub. oil delivery pipe | 22587 | 1 | 22587 | 1 | 22587 | 1 |
| UNION, lub. oil delivery pipe | 22519 | 1 | 22519 | 1 | 22519 | 1 |
| BOLT, suction and del. pipe banjo | 22520 | 2 | — | – | — | – |
| WASHER, suction and del. pipe banjo bolt | 22599 | 4 | 22599 | 2 | 22599 | 2 |
| SUMP, lub. oil, bare | 22521 | 1 | 22677 | 1 | 22677 | 1 |
| BODY, lub. oil pump c/w. bushes | 22513 | 1 | 22513 | 1 | 25770 | 1 |
| BUSH, lub. oil pump body | 21145 | 2 | 21145 | 2 | 21145 | 2 |
| SHAFT, lub. oil pump driver | 21263 | 1 | 22678 | 1 | 22678 | 1 |
| GEAR, lub. oil pump driver | 21182 | 1 | 21182 | 1 | 25700 | 1 |
| SHAFT, lub. oil pump idler | 21264 | 1 | 22679 | 1 | 25717 | 1 |




L4 Engines to 6032452

**To Remove and Clean Oil Pressure Relief Valve:**

The oil pressure relief valve forms part of the oil pump bottom cover in original pumps, and is incorporated in the delivery banjo bolt on later pumps. The breaking pressure is set and adjusted at the factory and unless special test equipment is available, no attempt should be made to dismantle the oil pressure relief valve.

To obtain access to the relief valve for cleaning, proceed as follows:

Original Pumps:

1. Remove the sump strainer cover and the strainer.
2. Remove the setscrews securing the bottom cover and remove bottom cover.

Later L4 and four-270D Engines

3. Wash the valve in clean fuel oil and blow the valve dry with compressed air.
4. See that the ball and ball seat are perfectly clean and bedding correctly.
5. Re-assemble bottom cover to pump using a new bottom cover joint.

When re-assembling bottom cover to pump, ensure that the valve is towards the delivery side of the pump.

Later Pumps:

1. Remove the sump strainer cover and the strainer.
2. Unlock and remove the relief valve assembly.
3. Clean and check as above.

# FLYWHEEL AND FLYWHEEL HOUSING

It is most important that the flywheel housing be correctly aligned with the crankshaft, therefore, if a housing has been removed, the greatest care must be taken on replacement to ensure accuracy of alignment.

For convenience in turning the engine, it is advisable to release (but not remove) the nuts holding the atomisers in place when carrying out alignment of flywheel and flywheel housing.

**To Remove Flywheel:**

1. Remove the locking wire from the setscrews which secure the flywheel to the crankshaft flange.
2. Turn the engine to bring one setscrew to the top.
3. Remove this setscrew and screw in a stud in its place as a temporary measure, to prevent the flywheel from dropping.
4. Remove the remainder of setscrews.
5. Remove the flywheel.

**To Remove Flywheel Housing:**

1. Remove the flywheel.
2. Removal of the nuts and spring washers from the studs securing the flywheel housing to the cylinder block, will enable the flywheel housing to be removed.

**To Refit Flywheel Housing:**

Before fitting or refitting the flywheel housing, ensure that the mating faces of the cylinder block and housing are perfectly clean and free from burrs.

Put the housing on to the studs, replace spring washers and nuts. Tighten the nuts evenly, do not overtighten so as to allow adjustment.

**Alignment of Flywheel Housing Bore:**

Secure the base of an indicator stand to the flange of the crankshaft.

Set the needle of the gauge to the interior of the bored hole in the flywheel housing. (See Fig. B.20).

Turn the crankshaft and check that this hole is central. The housing is adjusted until the bored hole is central with the crankshaft within .008".

**Alignment of Flywheel Housing Face:**

With the base of the indicator stand still secured to the crankshaft flange, adjust to set the needle of the indicator against the vertical machined face on the flywheel housing. (See Fig. B.21).

Turn the crankshaft and check that this face is at right angles to the crankshaft axis. This facing must be within .008" of being at true right angles to the crankshaft.

All adjustments to bring the flywheel housing within the limits specified must be on the flywheel housing and under NO CONDITIONS must the rear of the cylinder block be interfered with.

When the housing is aligned to the above limits, tighten the securing nuts evenly.

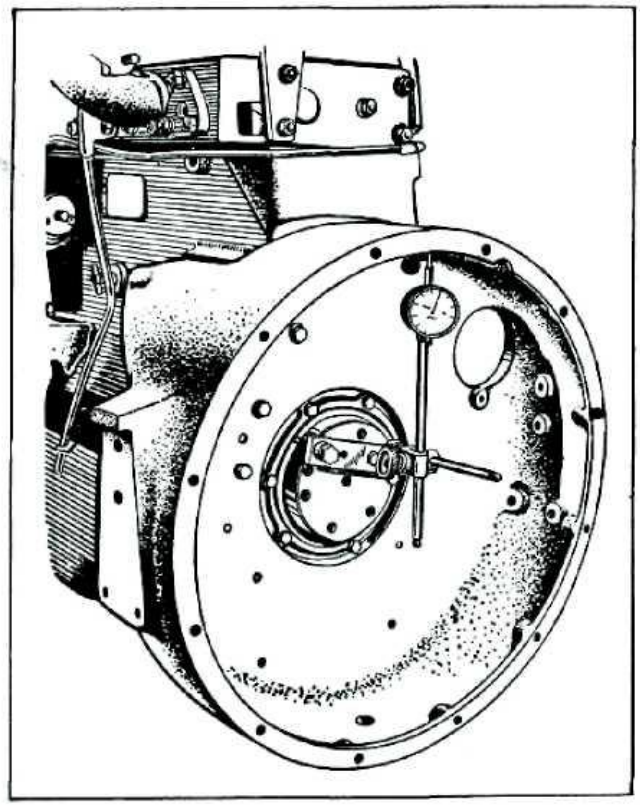


Fig. B.20 — Alignment of Flywheel Housing Bore.

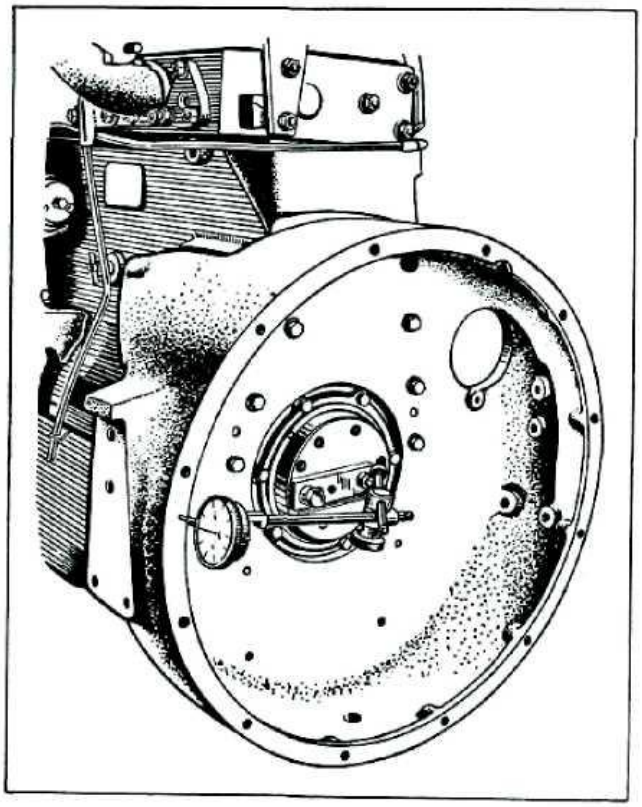


Fig. B.21 — Alignment of Flywheel Housing Face.

Ream the two dowel holes and fit the correct length and size of dowels.

**To Refit Flywheel:**

The flywheel should be replaced in the reverse order to when removing but the following must also be carried out:

See that the flywheel face and crankshaft flange are perfectly clean and free from burrs before fitting the flywheel.

When replacing the setscrews, tighten evenly, and for final tightening, a torque wrench should be used, set to a tension of 90 lbs./ft.

On later flywheels only six setscrews are used. When re-assembling these flywheels, it is important to ensure that the seventh flywheel hole is in line with the plain hole n the crankshaft flange. If the flywheel is mis-placed, the timing marks will be incorrect.

**Checking Alignment of Flywheel:**

When the flywheel has been removed, it is necessary to check the alignment on replacement.

Replace flywheel as mentioned above.

Secure the base of a dial indicator stand to the flywheel housing.

With the flywheel at top centre, set the needle of the indicator on the flywheel periphery at T.D.C. (See Fig. B.22).

Turn the crankshaft and check the clock, the flywheel should run true within .012" (total indicator reading).

With the base of the indicator stand still bolted to the flywheel housing, adjust to bring the indicator needle against the vertical machined face of the flywheel. (See Fig. B.23).

Again turn the crankshaft and check the clock, the flywheel should be within .0005" per inch of diameter (total indicator reading) at right angles to the crankshaft axis.

When the flywheel has been checked for the correct limits, lock the setscrews with wire.

**Flywheel Ring Gear Replacement—L4 Engine:**

1. Remove the flywheel.
2. Remove the ring gear setscrews.
3. Drift the ring gear from the flywheel.
4. Heat the replacement ring gear to approximately 100°c.
5. Check the replacement ring gear and the flywheel for cleanliness then install the ring gear. Fit and tighten the ring gear setscrews.
6. Allow the ring gear to cool, then retighten the setscrews.

**Four-270D Engine:**

1. Remove the flywheel.
2. Drift the ring gear from the flywheel.
3. Heat the replacement ring gear to approximately 130°C. - 140°C.
4. Check the replacement ring gear and the flywheel for cleanliness, then install the ring gear.
5. Allow ring gear to cool. Ensure that the ring gear is seating against the shoulder all around.

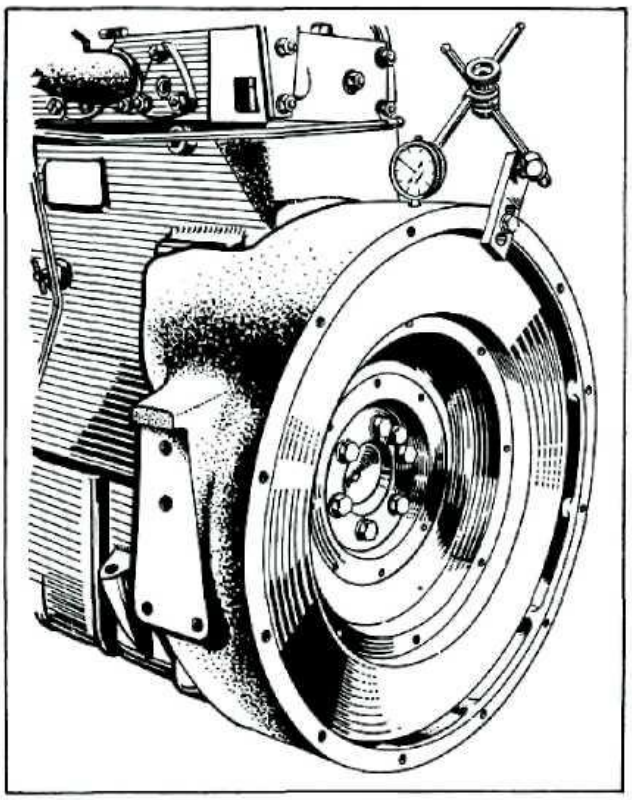


Fig. B.22 — Alignment of Flywheel Periphery.

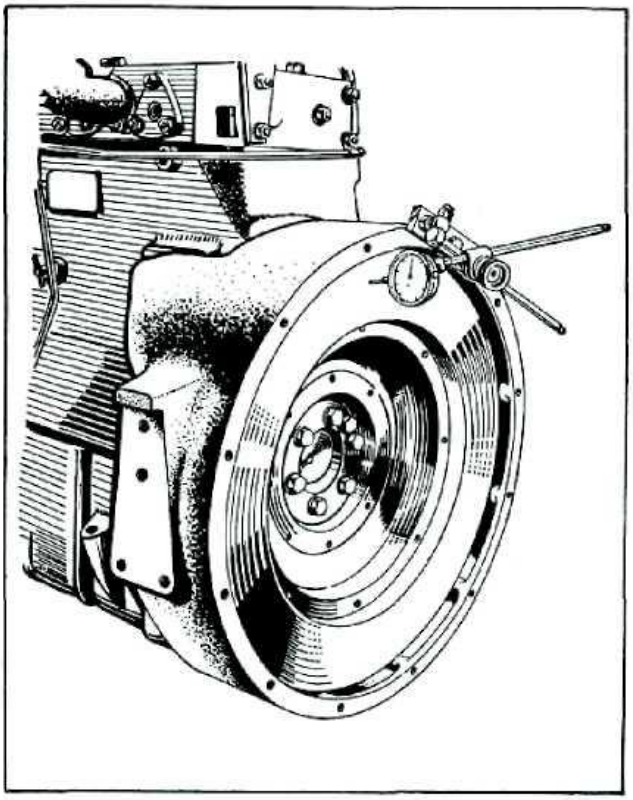


Fig. B.23 — Alignment of Flywheel Face.

# SCHEDULE OF CLEARANCES AND TOLERANCES

1. The data regarding clearances and tolerances are given as a guide for for personnel engaged upon major overhauls.

2. The figures in the column "Permissible Dimensions" are the drawing sizes to which the parts are made. These dimensions are given in limit form and represent the minimum and maximum sizes to which parts may be accepted when new, as, for example, $\frac{.4985}{.499}$ quoted for a shaft diameter.

3. The difference between the minimum and maximum dimensions quoted in para. 2 is known as the manufacturing tolerance. This tolerance is necessary as an aid to manufacture and its numerical value is an expression of the desired quality of workmanship. For the example referred to in para. 2 the tolerance is 0.0005.

4. If when carrying out a major overhaul it is found that a bush and corresponding shaft have worn and that the majority of wear has taken place in the bush it may be necessary to renew the bush only. Similarly if the majority of wear has taken place on the shaft it might only be necessary to renew the shaft.

5. During the overhaul of worn components personal initiative must be exercised at all times. It is obviously uneconomical to return worn parts to service with an expectation of life which may involve labour costs again at an early date.

**IMPORTANT NOTE:** All threads used on the L4 and the Four-270D engines except on proprietary equipment and the crankshaft are Unified Series, and American Pipe Series. The crankshaft and starting dog nut are threaded 1 inch American National Fine of 14 t.p.i.

The new threads are not interchangeable with B.S.F. and although B.S.W. have the same number of threads per inch as the Unified Coarse Series, interchanging is not recommended, due to a difference in thread form.

| DESCRIPTION | PERMISSIBLE DIMENSION L-4 | PERMISSIBLE DIMENSION 4-270D | PERMISSIBLE CLEARANCE L-4 | PERMISSIBLE CLEARANCE 4-270D | REMARKS |
|---|---|---|---|---|---|
| **OIL PUMP** | | | | | |
| Gear Housing (Dia. of pocket) | 1.339 / 1.341 | 1·339 / 1·341 | .006 / .010 | 0·006 / 0·010 | |
| Gears (Internal, Idler and Driver) (Dia. over teeth) | 1.331 / 1.333 | 1·331 / 1·333 | | | |
| Ditto (Length of gears) | .995 / .997 | 1·495 / 1·497 | .001 / .006 | 0·001 / 0·006 | |
| Housing (Depth of Gear Pocket) c/w Joints | .998 / 1.001 | 1·498 / 1·501 | | | |
| Bush, Oil Pump gear (Bore Dia.) | .502 / .503 | 0·502 / 0·503 | .0005 / .002 | 0·0005 / 0.002 | |
| Shaft, Oil Pump gear (Dia.) | .5010 / .5015 | 0·5010 / 0·5015 | | | |
| Shaft (Internal, Idler) (Dia.) | .4985 / .499 | 0·4985 / 0·499 | .00075 / .00175 | 0·00075 / 0·00175 | |
| Gear (Internal, Idler) (Hole Dia.) | .49975 / .50025 | 0·49975 / 0·50025 | | | |
| **CAMSHAFT** | | | | | |
| Camshaft. No. 1 Journal Dia. | 2.0565 / 2.0575 | 2·0565 / 2·0575 | .004 / .007 | 0·002 / 0·005 | |
| No. 1 Hole for Shaft in Cylinder Block | 2.0615 / 2.0635 | 2·0595 / 2·0615 | | | |
| No. 2 Journal Dia. | 2.0465 / 2.0475 | 2·0465 / 2·0475 | .004 / .007 | 0·004 / 0·007 | |
| No. 2 Hole for Shaft in Cylinder Block | 2.0515 / 2.0535 | 2·0515 / 2·0535 | | | |
| No. 3 Journal Dia. | 2.0365 / 2.0375 | 2.0365 / 2·0375 | .004 / .007 | 0·004 / 0·007 | |
| No. 3 Hole for Shaft in Cylinder Block | 2.0415 / 2.0435 | 2·0415 / 2·0435 | | | |
| Spigot, Idler Gear (Dia.) | 1.497 / 1.498 | 1·497 / 1·498 | .001 / .003 | 0·001 / 0·003 | |
| Bush, Idler Gear (Bore) | 1.499 / 1.500 | 1·499 / 1·500 | | | |

ALL DIMENSIONS ARE IN INCHES

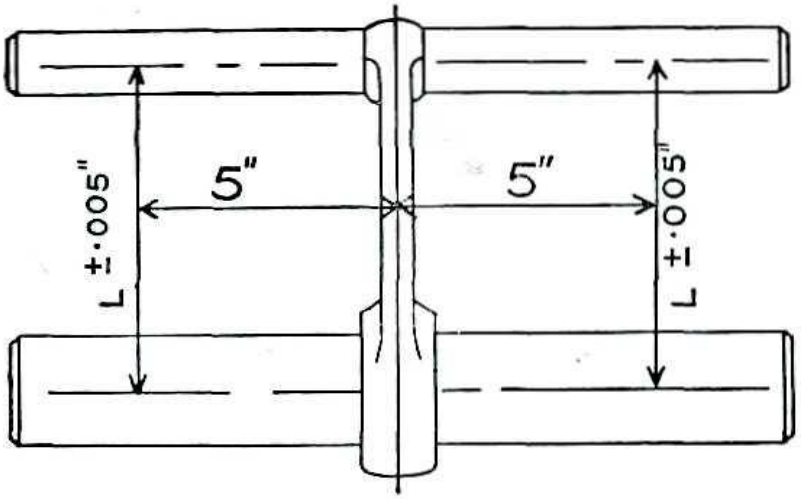
| DESCRIPTION | PERMISSIBLE DIMENSION L-4 | PERMISSIBLE DIMENSION 4-270D | PERMISSIBLE CLEARANCE L-4 | PERMISSIBLE CLEARANCE 4-270D | REMARKS |
|---|---|---|---|---|---|
| **CAMSHAFT (cont.)** | | | | | |
| Cam Lift | .304<br>.312 | 0·304<br>0·312 | | | |
| **CYLINDER BLOCK** | | | | | |
| Cylinder Block (for Camshaft bores see Camshaft Assembly). | 13.772<br>13.777 | 13·773<br>13·776 | | | |
| Height of Block between top and bottom faces | | | | | |
| Bore of Cylinder Liner | 4.250<br>4.251 | 4·250<br>4·251 | | | |
| Piston (Height of Crown above face of cylinder block) | .007<br>.012 | +0·011<br>−0·003 | | | Measured with crank and piston at T.D.C. |
| Comp. Ring Grooves (Width) | .127<br>.128 | 0·127<br>0·128 | .002<br>.004 | 0·002<br>0·004 | |
| Compression Ring (Width) | .124<br>.125 | 0·124<br>0·125 | | | |
| Chrome Plated Compression Ring Gap | | | .017<br>.022 | 0·012<br>0·019 | Gap dimensions are given for a bore diameter of 4.250 ins. |
| Plain Compression Ring Gap | | | .012<br>.017 | 0·012<br>0·019 | |
| Comp. Ring Groove (Width) | .127<br>.128 | 0·127<br>0·128 | | | |
| Comp. Ring—Laminated (Width) (4 per piston) | .026<br>.027 | | | | |
| Piston (Scraper ring groove) (width) | .2525<br>.2535 | 0·2525<br>0·2535 | .0025<br>.0045 | 0·0025<br>0·0045 | |
| Ring, Scraper (width) | .249<br>.250 | 0·249<br>0·250 | | | |
| Gap | | | .012<br>.017 | 0·012<br>0·017 | |
| **CRANKSHAFT AND CONNECTING ROD** | | | | | |
| Weight Connecting Rods (Sets) | See | Remarks | | | Weights of Rods in engine sets must balance within plus or minus one ounce. |
| Rod, Connecting Big End (Bore) | 2.916<br>2.917 | 74.006<br>74.092 | | | |

ALL DIMENSIONS ARE IN INCHES

| DESCRIPTION | PERMISSIBLE DIMENSION L-4 | PERMISSIBLE DIMENSION 4-270D | PERMISSIBLE CLEARANCE L-4 | PERMISSIBLE CLEARANCE 4-270D | REMARKS |
|---|---|---|---|---|---|
| **CRANKSHAFT AND CONNECTING RODS (cont.)** | | | | | |
| Bearing, Connecting Rod Big End (Bore) | 2.7515 / 2.753 | 2·7515 / 2·753 | .0025 / .00475 | 0·0025 / 0·00475 | Measured in position |
| Crankshaft Crankpins (Dia.) | 2.74825 / 2.749 | 2·74825 / 2.749 | | | |
| Bush, Connecting Rod, small end (Bore) | 1.4382 / 1.43925 | 1·4382 / 1·43925 | .0004 / .00175 | 0·0004 / 0·00175 | NOTE : Bushes reamed to suit individual pins. Bushes provided with reaming allowance |
| Pin, Gudgeon (Dia.) | 1.4375 / 1.4378 | 1·4375 / 1·4378 | | | |
| Rod, Connecting, alignment between small and large end bearing bores. (Parallelism) Ditto. (Twist) | | | | | Alignment measured between mandrels through large and small end bores. |
| Housings, Main Bearings (Bore) | 3.166 / 3.167 | 3·16625 / 3·167 | | | |
| Bearings, Main (Bore) | 3.0015 / 3.003 | 3·001 / 3·00225 | .0025 / .00475 | 0·00225 / 0·004 | Measured in position |
| Crankshaft, Main Journals (Dia.) | 2.9983 / 2.999 | 2·99825 / 2·99875 | | | |
| Crankshaft, Main Journal No. 1 (Length) | 1.9225 / 1.9525 | 1·9225 / 1·9525 | | | |
| Crankshaft, Main Journal No. 2 (length) | 2.0313 / 2.0363 | 2·0313 / 2·0363 | | | Standard Crankshafts Only. |
| Crankshaft, Main Journal No. 3 (length) | 2.0625 / 2.0635 | 2·0625 / 2·0635 | | | |
| Crankshaft End Float | .0045 / .0075 (0015) | 0·001 / 0·008 | | | |
| Thrust Washers, Standard (Width) | .091 / .093 | 0·091 / 0·093 | | | |
| Thrust Washers, Oversize (Width) | .0985 / .1005 | 0·098 / 0·100 | | | |
| **CYLINDER HEAD AND VALVE GEAR** | | | | | |
| Bush, Rocker Lever (Bore Dia.) | .6245 / .62575 | 0·6245 / 0·62575 | .00075 / .0035 | 0·00075 / 0·0035 | |
| Shaft, Rocker (Dia.) | .62225 / .62375 | 0·62225 / 0·62375 | | | |

ALL DIMENSIONS ARE IN INCHES

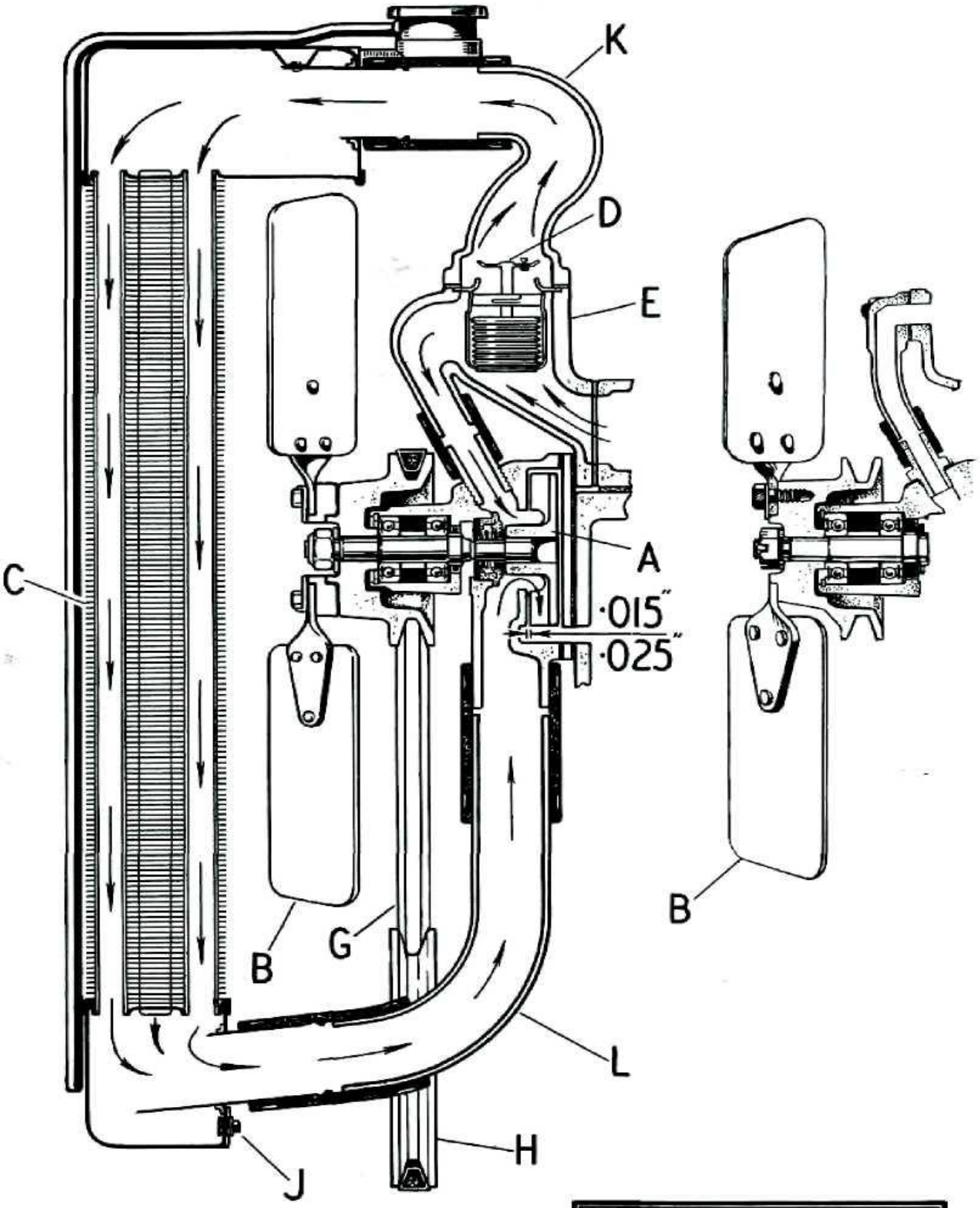
| DESCRIPTION | PERMISSIBLE DIMENSION L-4 | PERMISSIBLE DIMENSION 4-270D | PERMISSIBLE CLEARANCE L-4 | PERMISSIBLE CLEARANCE 4-270D | REMARKS |
|---|---|---|---|---|---|
| **CYLINDER HEAD AND VALVE GEAR (cont.)** | | | | | Clearance of Valve Head (new) below Cyl. Head Face :— Inlet, .057 in. to .070 in. or 1.448 mm. to 1.778 mm. Exhaust, .053 in. to .065 in. or 1.346 mm. to 1.651 mm. |
| Guide, Valve (Bore Dia.) | .376 / .3775 | 0·376 / 0·3775 | .0015 | 0·0015 | |
| Valves, Inlet and Exhaust (Stem Dia.) | .3735 / .3745 | 0·3735 / 0·3745 | .004 | 0·004 | |
| Tappet, Valve (Shank Dia.) | .7475 / .7485 | 0·7475 / 0·7485 | .001 | 0·001 | Seat should not be recut unless essential when clearance should not exceed .140 in. or 3.556 mm. |
| Hole in Cylinder Block for Tappet (Dia.) | .7495 / .75075 | 0·7495 / 0·75075 | .00325 | 0·00325 | |




Large and small end Conn. Rod Bores must be square and parallel with each other within the limits of plus or minus .005 in. measured 5 in. each side of the axis of the rod on test mandrel.

When checking alignment with gudgeon pin bush fitted the limit plus or minus .005 ins. is reduced to plus or minus .0015 ins.

ALL DIMENSIONS ARE IN INCHES




COOLING SYSTEM

# COOLING SYSTEM

## DESCRIPTION

Cooling of the engine is accomplished by means of water circulating through the cylinder block and cylinder head by means of a centrifugal pump mounted on the front of the cylinder block. The water pump (A) works in conjunction with a radiator through which the water passes in the process of cooling.

A cooling fan (B) is mounted on the forward end of the water pump which draws air through the radiator core (C) thus lowering the temperature of the water while passing from the top to the bottom of the core.

The internal water passages of the cylinder head are arranged to give a brisk circulation of water around the combustion chamber and atomiser seating.

The water temperature of the engine is automatically controlled by a by-pass type thermostat (D) which is mounted in the water outlet body (E) attached to the front end plate of the cylinder head.

The thermostat starts opening at approximately 154°F. and is fully open at 170°F. Before the thermostat starts opening water circulation takes place in the cylinder block and cylinder head through the water by-pass tube (F) connecting the water pump to the water outlet body. Water is thus returned from the outlet body to the water pump and then passed once more through the engine without having been cooled by passing through the radiator. In this way the temperature of the engine cooling water is rapidly raised to the operating range when the engine has been started from cold.

When the thermostat is fully open, the water is then circulated right through the whole cooling system.

The water pump is driven, together with the generator, by vee belt (G) from the crankshaft pulley (H). No lubrication is necessary as the bearings are treated with a special grease before assembly.

The pump bearings are sealed, and protected from the ingress of dirt and water by a felt seal at the rear and by the shape of the fan belt pulley at the front.

A drain hole is provided in the under side of the pump body to allow any water which may leak past the pump seal to escape

## SPECIFICATION

| | |
|---|---|
| Radiator Type | — Tubular core – integral with top and bottom tanks with mounting straps attached. Pressurised radiator cap. |
| Circulation | — Centrifugal type water pump mounted on engine block. |
| Heat Regulation | — Thermostatic. By-pass type. |
| Capacity | — 5½ gallons. |
| Fan Type | — 6 steel blades rivetted to pressed steel centre – 17" diameter. Mounted on water pump pulley. |
| Fan Speed | — Approximately 2600 R.P.M. at 1600 engine R.P.M. |
| Fan Drive | — Vee belt from crankshaft in conjunction with generator. |
| Belt Adjustment | — Adjustable stay on the generator |

## MAINTENANCE

In order that the system may function efficiently, it is essential that the water and air passages are free from obstruction and periodic attention should be given to the cooling system to ensure this condition.

It is advisable to service the cooling system every twelve months or after 1000 operating hours, but more frequently if it is not possible to obtain clean water for refilling purposes.

Drain the water from the radiator and engine by removing the drain plug (J) and opening the drain cock on the nearside of the engine block. Reverse flushing of the system is recommended.

Remove the upper and lower connecting pipes (K & L) and remove the thermostat. Apply water

under pressure to the lower radiator connection and the upper engine connection. This has the effect of causing a flow of water in the opposite direction to the normal operating flow which will give a thorough scavenging action to the system. Check that the over-flow pipe (M) is clear, as blockage of this pipe will result in undue pressure being developed in the system with possible damaging effect. If the system is filled until the overflow pipe is submerged, water should be discharged from the pipe's lower end. A blockage may be cleared by applying water pressure at the lower end.

After the cooling system has been cleaned it is good practice to refill with clean water and add a good quality rust inhibitor. If soluble oil is used, caution should be exercised as excessive quantities will cause deterioration of the hose connections.

Cleaning of the air passages can be accomplished by applying a jet of water to the rear of the core.

Keep a close watch at all times of the water level in the top tank and for signs of water leakage. Failure of the cooling system due to lack of water will result in overheating and damage to the engine. A small amount of water seen in the filler elbow is not sufficient indication of the water level.

Early type radiators had the filler elbow mounted on the offside top, whilst later ones have it on the nearside. The radiators are interchangeable.

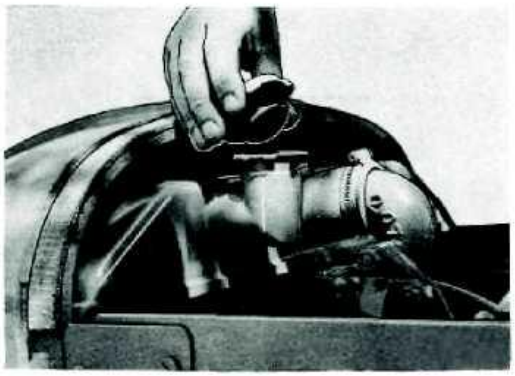


**Fig. C.2 — Checking Radiator Water**

Every 50 operating hours check the tension of the fan belt.

The fan belt may be tensioned by slackening the generator stay and front pivot bolt, the generator swung inwards or outwards till the belt may be moved by the thumb about ¾" midway between the crankshaft and water pump pulleys, then the generator bolts tightened. Overtightening of the belt should be avoided as it causes undue loading of the generator and water pump bearings and tends to cause belt breakage.

## SERVICE

**Overheating:**

Due to (a) Lack of water.

(b) Faulty temperature gauge.

(c) Clogged water passages.

(d) Clogged air passage through core.

(e) Loose fan belt.

(f) Faulty thermostat.

(g) Water pump failure.

(h) Incorrect radiator cap. The correct cap is set at 4 p.s.i. pressure.

**Underheating:**

(a) Temperature gauge faulty.

(b) Faulty thermostat operation.

---

To service the water pump or fan it is necessary to remove the radiator.

---

### TO REMOVE THE RADIATOR

1. Drain the water from the radiator and engine.
2. Remove the top cowl.
3. Remove the grill (four screws).
4. Remove the two bolts coupling the diagonal braces to the front drawbar.

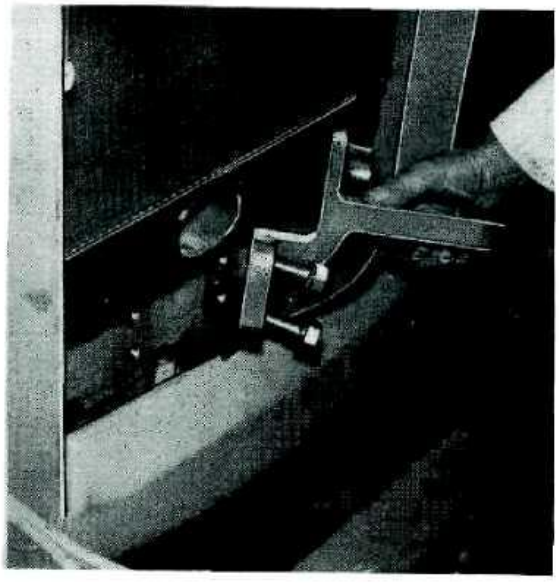


**Fig. C.3 — Removing Front Drawbar**

**Removing Radiator—Continued**

5. Headlight wiring, if fitted, should be disconnected. Disconnect below the generator if the harness is fitted with connectors, otherwise remove the front section of the headlight, slacken the wire retaining screws and withdraw the wiring through the base of the headlight. Particular note should be made of the sequence for the wiring connections. Early tractors may have an earth lead fitted to the offside headlight mounting bracket bolt. This lead should also be removed before the wiring harness is withdrawn from the radiator cowl.

6. Disconnect the hoses from the radiator. A hole is provided in the offside cowling to allow a screwdriver to be used on the lower hose front clip.

7. Remove the front drawbar (four bolts). (See Fig. C.3).

8. Remove the bolts coupling the front cowling and radiator support to the chassis and the top cowl frame angles (six bolts and two screws) and remove the radiator and cowling as a unit.

---

The radiator may be removed from the cowling by removing the side bolts.

**TO REMOVE THE WATER PUMP**

1. Remove the radiator.

2. Unlock and remove the four bolts retaining the fan to the pulley. (Two types of fan are fitted to the engine, but in each case the blades are situated behind the lugs on the pressed steel centre so that the rivets are not in tension when the fan is in operation). Remove the fan.

(Continued over)

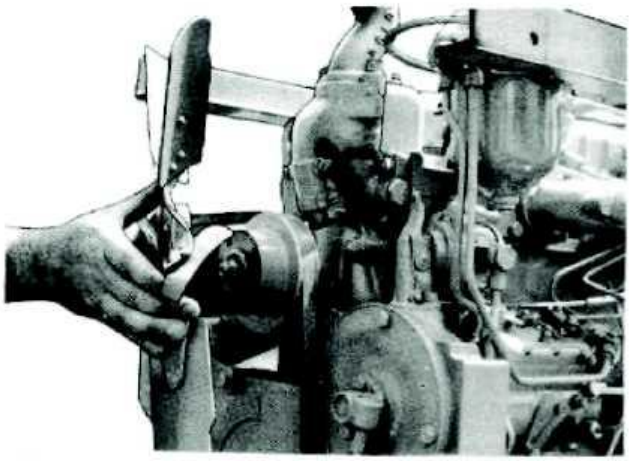


Fig. C.5 — Removing Cooling Fan

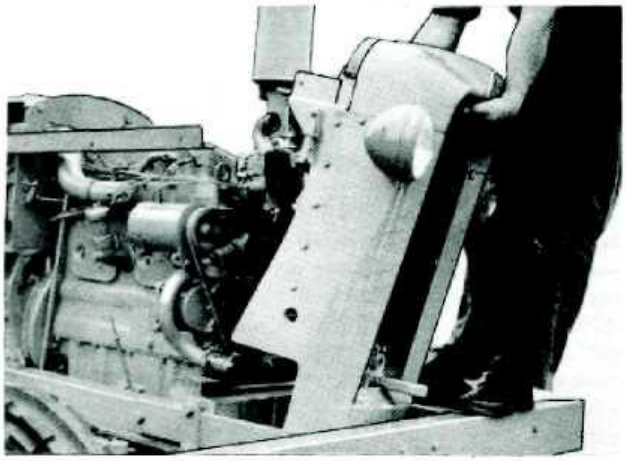


Fig. C.4 — Removing Radiator and Cowls

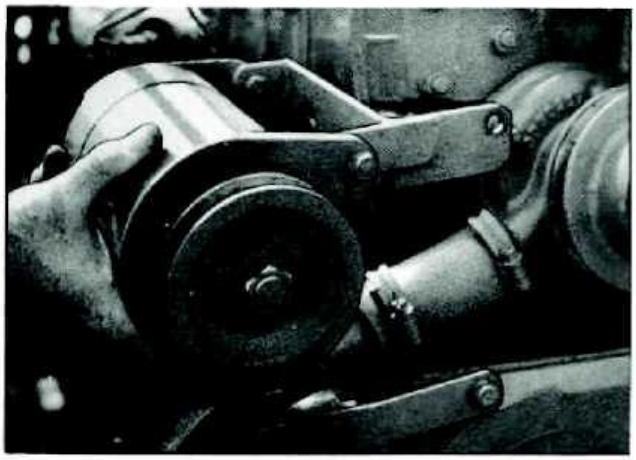


Fig. C.6 — Removing Generator and Bracket

**Removing the Water Pump—Continued**

3. Remove the generator stay bolt and remove the generator belt.

4. Disconnect the generator leads, remove the two bolts and the nut coupling the generator bracket to the engine block and water pump. Remove the generator and bracket. (See Fig. C.6).

5. Remove the remaining nuts from the water pump studs and on L4 engines, move away the venturi pipe clip and remove the two bolts coupling the by-pass pipe flange to the outlet body. The water pump and by-pass pipe may now be removed. On Four-270D engines, the by-pass pipe hose should be moved downward to allow the water pump to be removed.

6. Remove the pump back plate.

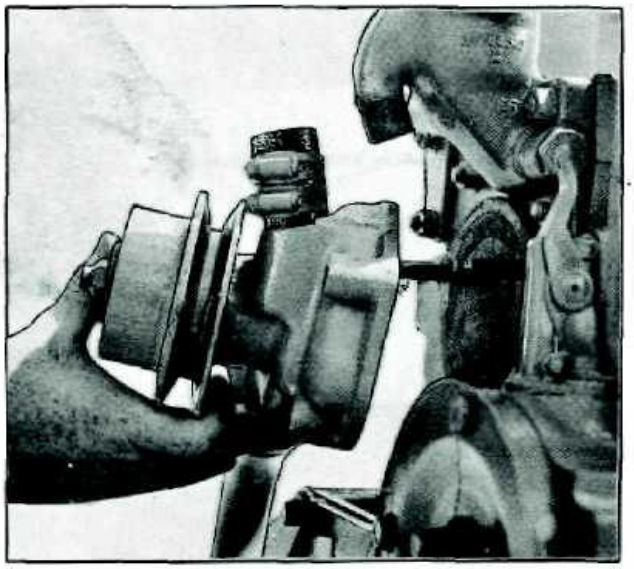


Fig. C.7 — Removing Water Pump

When the pump and back plate are removed from the engine, clean all traces of the face gaskets from the water pump flange, the cylinder block face and from both sides of the back plate.

It is recommended that the cylinder block and head be thoroughly flushed with water whilst the pump is removed.

**TO DISMANTLE THE WATER PUMP**

1. Unpin and remove the slotted nut from the pulley on early model water pumps and the self locking nut on later models.

2. With the aid of a suitable puller, remove the pulley.

3. Remove the impeller.

On some pumps tapped holes are provided, whilst in others the bore is tapped for the application of a puller for the removal of the impeller.

4. Remove the circlip from in front of the bearings with circlip pliers.

5. Remove the rear seal.

6. Using a press, press the shaft from the body from the impeller end. Remove the thrower and locating ring if fitted.

7. The bearings may be removed from the shaft with a suitable press.

**INSPECTION**

1. If the water pump drive shaft shows signs of wear in the region of the bearings, the shaft must be renewed, as a worn shaft in this region will allow the inner race of the bearing to rotate on the shaft.

2. Clean impeller and check for cracks and broken blades.

3. Examine casing for cracks.

4. Wash bearings in thin lubricating oil and examine for pitting, corrosion or wear. If necessary, renew bearings.

**Pump Models:**

At the time of publication of this manual four models of water pump have been fitted to the engine.

At engine serial number 6018880 a new type rear seal was introduced, and at number 6036233 a new pump with larger bearings and a close fitting pulley was introduced. Subsequently, at engine number 6207722, a pump having an increased diameter shaft and pulley bore has been introduced. The serial numbers quoted may be used only as an indication as some engines prior to the official change over numbers may have been reworked if still held in stock when the change was introduced.

Care must be exercised in identifying the pump model as, although the pumps are interchangeable as units, some of the internal parts are not.

**Pump Fans:**

Two models of fans have been used. The first (P/N 21175), being replaced at engine number 6024580 with the second type (P/N. 22630). Part number 22630 may be identified by a step in the tip of each blade and a larger centre plate. When a tractometer is fitted to Four-270D engines, a fan extension P/N 25729 must be fitted behind the fan.

## TO RE-ASSEMBLE WATER PUMP

1. Press rear bearing on to shaft and fit distance piece, then press the front bearing into position. The bearings and the space between the two bearings should be packed with a high melting point grease before assembly to water pump body.

2. The front seal, with front and rear flanges, should now be assembled to water pump body.

3. Press the water pump shaft, complete with bearings, into the water pump body. Place circlip in position ensuring that it seats correctly in recess provided.

4. With the shaft assembled to body, fit the water pump thrower. This is a light press fit, with the flange towards the front of the pump. This part is not used in the latest pumps.

5. Place the seal locating ring in position in the body, and fit the rear water pump seal. The rear seal should be fitted with the carbon face towards the rear of the pump. The locating ring was deleted when the second model pump was introduced.

6. The impeller should now be pressed on to the water pump shaft. When fitting impeller care should be taken to ensure that a clearance of .015"/.025" is maintained between the inner edge of the impeller vanes and water pump body. This clearance can be checked by the use of a feeler gauge, and for preference the lower limit should be maintained.

7. Refit water pump pulley, plain washer and slotted nut or self locking nut on later models. Torque tension is 55-60 lbs./ft.

A new split pin should be used with the slotted nut, and the use of new gaskets is recommended.

## WATER TEMPERATURE GAUGE

The water temperature gauge fitted is a sealed unit, consisting of the bulb, which is screwed into the water outlet housing, the flexible connecting tube and the gauge. No provision is made for adjusting this unit and should it become faulty, will have to be replaced as a unit. Its accuracy may be checked by immersing the bulb in water which is then heated to boiling point. After a reasonable time lag the gauge should register 212°F. (slight variations will occur due to prevailing atmospheric conditions).

## THERMOSTAT

The thermostat may be removed by first removing the top elbow. To test the operation of the unit, immerse it in water with a thermometer of known accuracy. Slowly raise the temperature of the water. The valve should commence to open at about 154°F., and be fully open at a temperature of 170°F. The unit may be adjusted by unsoldering the screw from the valve, adjusting, testing and resoldering.

# L4 FUEL SYSTEM

## GENERAL

The L4 engine is fitted with two fuel pumps, an **injection pump** which delivers fuel oil in regulated quantities and at a pressure of 120 atmospheres (1744 p.s.i.) to the atomisers in each of the four engine cylinders, and a **feed pump** which supplies fuel to the injection pump at a pressure of 22 p.s.i.

The feed pump draws fuel through a coarse strainer in the fuel tank under the driver's seat and through a pre-filter mounted on its inlet port. It then pumps it through a paper element filter to the injection pump. A pressure relief valve is mounted on the element filter which controls the supply pressure and returns surplus fuel to the tank via a second pipe.

Several engine troubles may be traced to some component of the fuel system and the method of diagnosing these faults is covered on pages D-17, 18.

From these pages, the necessity of supplying clean fuel to the pumps and of keeping air out of the system are made obvious.

## FUEL OIL SPECIFICATION

Spec. Gravity, .84 to .87.
Flash point above 150°F. (preferably about: 200°F.).
Viscosity Redwood No. 1 at 100°F. 35/45 secs.
Cold Test. Fuel remains fluid below 20°F.
Gross Calorific Value about 19,000 B.Th.U's. per lb.
Sulphur below 1%.
Water content negligible.
Ash content negligible.
Hard Asphalt content negligible.
The fuel must reach the fuel pump in a perfectly clean state.

Fuel should be filtered before entering the tank.

## THE FILTERS

Of all the factors on which satisfactory operation of a Diesel engine depends, cleanliness of fuel oil is the most important. The efficient operation and length of life of the fuel pump elements and of the atomisers, depends, first, on the use of clean fuel oil; second, the provision of suitable filters; third, attention to these filters.

Protection for the L4 engine is provided by the following filters, reading from the tank to the pump.

1. Water Trap.
2. Pre-filter.
3. Paper element type.

**Water Trap:** The fuel tank has a sump fitted with a drain tap. The tap should be opened every 10 operating hours to drain off any accumulated water or sediment. The suction pipe in the fuel tank is fitted with a coarse gauze strainer which should not normally require any service.

**Pre-filter:** This unit's main purpose is to protect the fuel feed pump. It has a comparatively coarse element.

This element is contained in an easily removable bowl and should be cleaned every 100 operating hours.

To remove the element for cleaning, unscrew the knurled nut at the bottom of the bowl. Swing the stirrup clear and remove the filter bowl. (See Fig. D.1).

Remove the element and wash in kerosine or clean fuel oil. Clean out and wash the filter bowl in clean kerosine or fuel oil.

When re-assembling, take care that a good joint is made between the top of the bowl and the filter body, as any leakage of air here, that is, on the suction side of the fuel pump, may cause air locks in the fuel system.

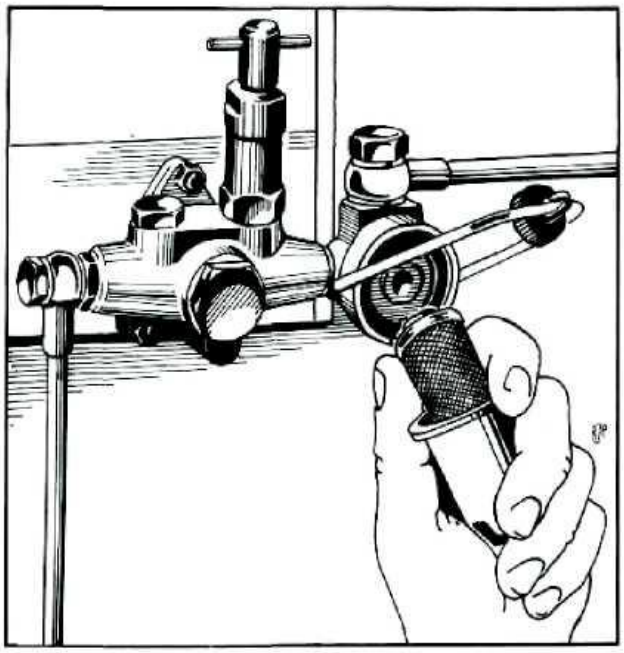


**Fig. D.1—Removing Pre-filter.**

**Paper Filter Element:** It is not possible to clean the paper element in this filter.

It should be renewed every 500 hours. Every 100 hours unscrew the drain plug at the bottom of the filter bowl and allow fuel to flow through until clean fuel oil appears. Replace drain plug.

To remove the element, unscrew the larger nut in the centre of the cover and drop the filter bowl clear. (See Fig. D.3).

Remove the dirty element and throw away.

Before putting new element in position, clean the filter bowl and inspect the relief valve.

Ensure that the rubber joints are in good condition, if not, replace by new.

NOTE.—If either, or both, of the pre-filter or the paper element filter have been disturbed either for cleaning, or for any other reason, it is necessary to bleed any air from the system.

This procedure is covered on page D-5.

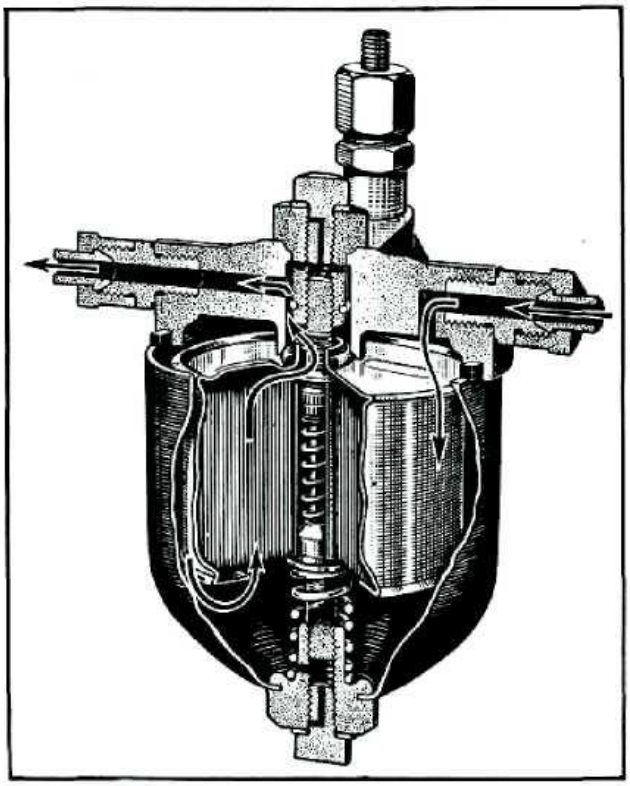


**Fig. D.2—Sectional View of Element Filter.**

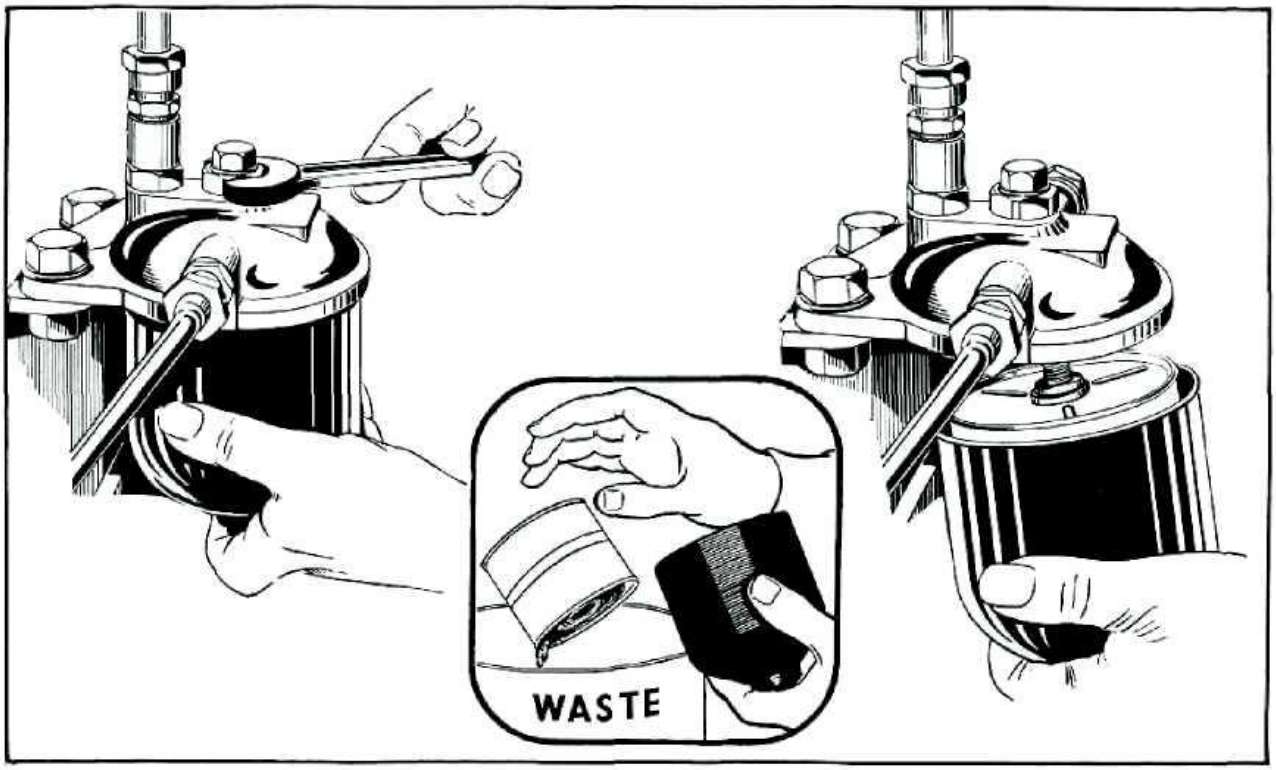



**Fig. D.3—Removal of Filter Element.**

## THE FEED PUMP

**Description:** The feed pump is a simple, spring returned plunger type pump. (See Fig. D.4). The pump is of adequate capacity to draw fuel from the fuel tank through the pre-filter and to pump it through the paper element filter to the injection pump. The pressure of the delivery to the injection pump is limited by a relief valve on the fuel filter to a pressure of 22 p.s.i. Surplus fuel is returned, by a second pipe, to the fuel tank.

The pump plunger (E) is retained against a tappet spindle (D) by a coil spring (F). The other end of the tappet spindle engages a tappet guide (C) which contains a roller (A). The roller operates against the injector pump cam for No. 3 cylinder. The pump is fitted with spring loaded disc inlet and outlet valves (K & G). The inlet valve is located and retained by the hand priming pump (J) whilst a hexagon headed plug (H) locates and retains the outlet valve. The porting of the pump is arranged so that the outer plunger chamber (containing the spring) is connected to the back of the inlet valve, and to the face of the outlet valve. The inner plunger chamber (containing the spindle) is connected to the outlet port of the pump and hence to the back of the outlet valve.

On the outward stroke fuel oil opens the outlet valve and passes to the outlet port from where the majority of it returns to the inner side of the plunger. Examination of the diagram will show that the total volume of fuel between the pump inlet valve and the fuel injection pump has only been reduced by the volume of the tappet spindle now protruding into the inner plunger chamber. This volume represents the quantity pumped. On the return stroke the spring keeps the plunger in contact with the spindle and fuel is drawn in

A—Tappet Roller
B—Tappet Pin
C—Tappet Guide
D—Tappet Spindle
E—Pump Plunger
F—Plunger Spring
G—Outlet Valve
H—Outlet Valve Plug
J—Hand Priming Pump
K—Inlet Valve
L—Priming Pump Handle
M—Priming Pump Plunger
N—Valve Springs
P—Banjo Bolts
Q—Inlet Banjo
R—Pre-filter Strainer
S—Pre-filter Bowl Seal
T—Pre-filter Bowl
U—Pre-filter Bowl Nut
V—Pre-filter Body
W—Feed Pump Body
X—Outlet Banjo
Y—Copper-asbestos Gaskets
Z—Banjo Bolt Bushing

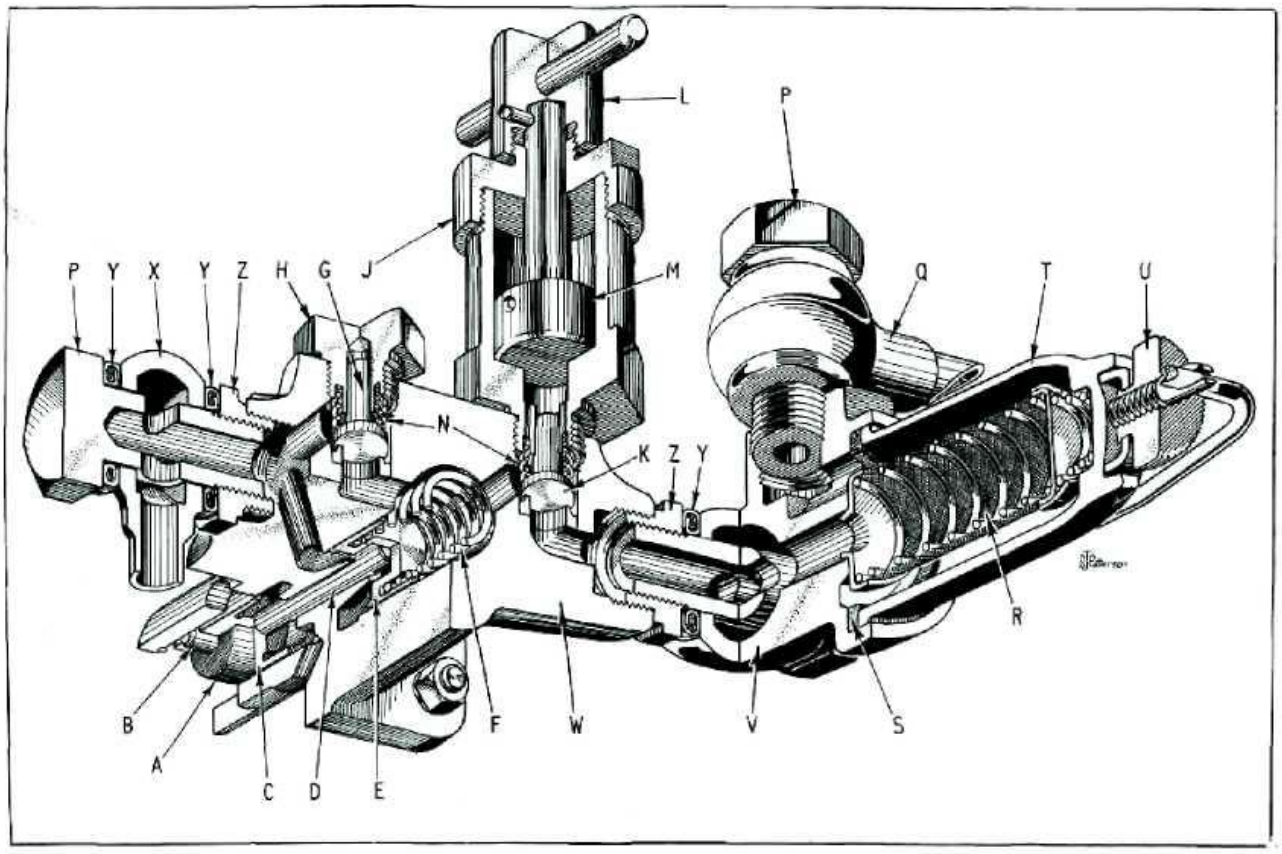



**Fig. D.4—Sectional View of Fuel Feed Pump and Pre-filter.**

through the inlet valve. The suction outside the plunger also holds the outlet valve closed and the fuel behind the plunger (in the inner chamber) is forced out through the outlet banjo connection by the spring-loaded plunger.

In the event of the pressure in the system becoming excessive due to blockage of the relief valve, pipes or porting, the spring will be unable to force the plunger, spindle and tappet against the tappet due to the pressure behind the plunger. The pump will thus cease to operate and overloading of the pump parts will be avoided.

**Feed Pump Service:**

As shown on page D-17, clogging or damage to the feed pump valves, plunger or spindle, or failure of the valve springs or the plunger spring, will result in the fuel injection pump not receiving an adequate supply of fuel. Depending on the extent of the breakdown, the injection pump will either cease to deliver fuel to the atomisers or be unable to deliver the quantity necessary for full power.

The valves may be inspected by unscrewing the hand priming pump and the adjacent hexagon plug, from the feed pump body. Check that the springs are serviceable and that the valves and seats are clean and free of faults. The valves and springs may be replaced if necessary.

The condition of the plunger, plunger spring and spindle may be checked by removing the large hexagon plug from the outside of the feed pump. If the spring is broken, a replacement spring may be fitted. Should the plunger or spindle be badly worn or scored, it will be necessary to have the feed pump repaired by an authorised diesel workshop as it may be necessary to rework the pump body and fit oversize replacement parts.

To remove the feed pump, remove the two pipe banjo studs, remove the nuts and spring washers from the three retaining studs and withdraw the pump.

Whilst the pump is removed, protect the opening in the injection pump and the two uncoupled fuel pipes from the ingress of dirt.

---

**Bleeding the Supply System:** If the fuel system has been opened at any time, say for an overhaul, it is necessary to ensure that all air has been removed before attempting to start the engine. This should be done as follows:

Slacken small plug on the top of final filter and operate the hand primer on the fuel feed pump until fuel, free from air bubbles, issues from the plug hole. Tighten the plug.

Slacken the vent tap on the top of the fuel injection pump.

Again operate the hand primer on the fuel feed pump until fuel issues from the vent tap and all signs of air have disappeared.

Tighten the vent tap securely and give the primer a few more strokes in order to deliver the fuel through the relief valve on the final filter, clearing this part of the system of air.

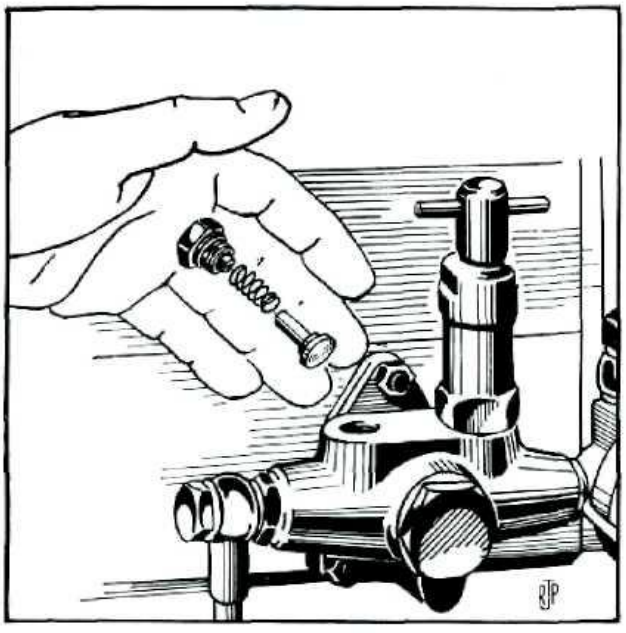


**Fig. D.5—Inspecting Pump Valves.**

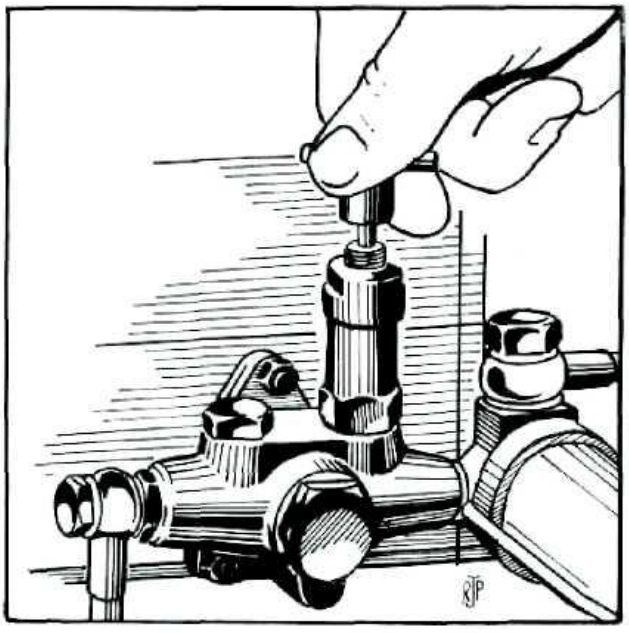


**Fig. D.6—Operating Hand Primer.**

# THE FUEL INJECTION PUMP

## DESCRIPTION

The fuel pump is an instrument of precision. Its working parts are made to extremely fine limits and mishandling in any shape or form, or the entry of the smallest particle of dirt into its working parts, may damage it and diminish its accuracy of operation. Hence the importance of ensuring that the fuel is thoroughly filtered before the pump is reached.

Oil is supplied from the feed pump through the fuel inlet connection (X), and entirely fills the fuel pump gallery (W). This is a tubular passage running the full length of the fuel pump and closed at the end opposite to the inlet by the vent plug. This fuel pump gallery is connected through small ports with all the pump barrels (K).

In the base of the body of the pump is a camshaft. In contact with each cam in a cam roller.

The roller is held in close contact with the cam by the spring (E). The top of this tappet is in close contact with the lower end of the pump plunger (A), contact being maintained between plunger and tappet by the pressure of the oil above the plunger.

As the pump plunger falls, oil flows into the barrel through the port. As the plunger rises it closes the port and propels the oil past the delivery valve (D), into the pipe leading to the atomiser.

Fig. D.9 shows how the upper part of the pump plunger is formed. Observe that an annular groove is cut in the plunger. The lower edge of this groove is level, or horizontal, the upper edge is helical. In addition there is a vertical slot cut right to the top of the plunger and running into the annular groove.

A—Pump Plunger
B—Pump Sleeve
C—Control Rod
D—Del. Valve Holder
E—Plunger Spring
F—Tappet Screw
G—Tappet Guide
H—Tappet Roller
J—Quadrant
K—Pump Barrel
L—Control Rod Stop
M—Locking Pin
N—Camshaft
P—Camshaft Bearing
Q—Camshaft Seal
R—Plug
S—Fuel Pump Gear
T—Fuel Pump Adaptor
U—Gear Plate
V—Feed Pump Mounting
W—Fuel Gallery
X—Fuel Inlet

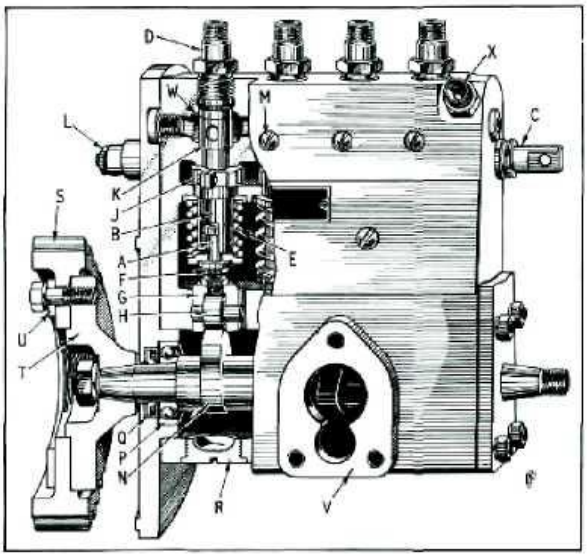



Fig. D.7—Part Section of Injection Pump.

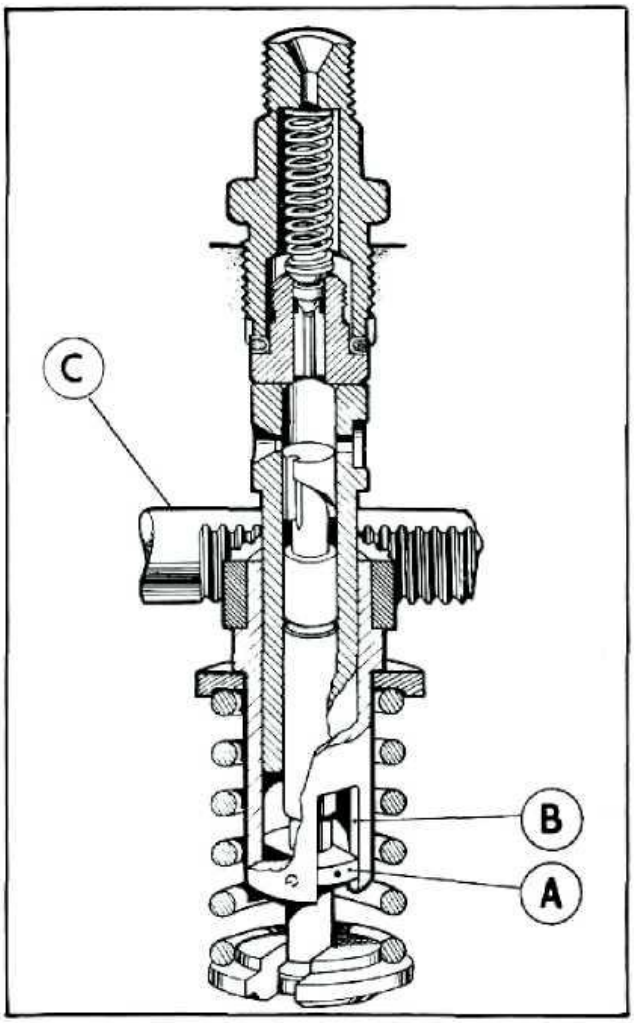



Fig. D.8—Injection Pump Element.

This groove is the means of varying the quantity of fuel delivered per stroke.

The first sketch in Fig. D.9, shows the working end of the plunger and barrel with the fuel port in the latter, which, it should be remembered, is in communication with the fuel gallery (W), of the pump. The plunger is shown at the bottom of its stroke with the cam at its bottom dead centre.

As the camshaft turns the plunger rises, but nothing happens until the top end of the plunger has reached the upper edge of the port in the barrel and closes it. Then the oil is propelled past the delivery valve and injection commences.

The camshaft of the fuel pump is direct driven from the engine timing gear at half engine speed. It is "timed" like the magneto or distributor of a petrol engine, so that the closing of the port and commencing of delivery fuel to the engine, that is, injection, comes at a pre-determined point in the compression stroke. The timing, of course, is precisely the same for each cylinder.

Oil continues to flow until the helical upper edge of the groove in the pump plunger uncovers the port. When that happens communication is established between the oil above the plunger and that in the gallery via (a) the vertical slot, (b) the annular groove, (c) the port in the pump barrel. (See Fig. D.9).

This is the position in the sketch C of Fig. D.9.

The oil then ceases to flow to the atomisers and is merely by-passed through these passages to the fuel pump gallery.

*The upper, and helical edge of the annular* groove thus serves as a valve. The higher that edge is in relation to the top of the plunger the sooner the cut-off and the less quantity of oil supplied to the atomiser per stroke.

By varying the level of that edge the quantity of oil supplied is controlled.

To alter that level, so that it uncovers the port in the pump barrel to vary the quantity of fuel

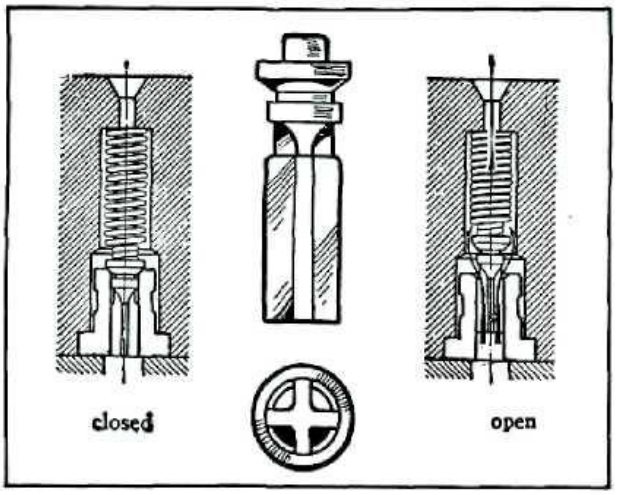



**Fig. D.10—Delivery Valve.**

delivered, the plunger is turned in its barrel by a simple means to be described shortly.

In the sketches A, B and C of Fig. D.9, the plunger is turned to one extreme position with the vertical slot just clear of one of the two port holes in the pump barrel. In that position the helical edge of the circular groove is at its lowest point and, so far as the port in the barrel is concerned the maximum quantity of oil is delivered. That is the setting of the plunger for starting the engine.

In sketches D and E the plunger is shown set for normal running. The precise position is varied by turning the plunger so that a greater or lesser quantity of oil is delivered to conform with the demand for power.

The other extreme position of the plunger is shown in the sketch F. This is the "stop" position: the vertical slot is now in line with the delivery port to the fuel pump gallery, which is thus put into communication with the top of the plunger, and oil therefore, merely passes down this vertical slot as the pump plunger rises. It is not delivered to the atomisers.

Rotation of the plunger into these different

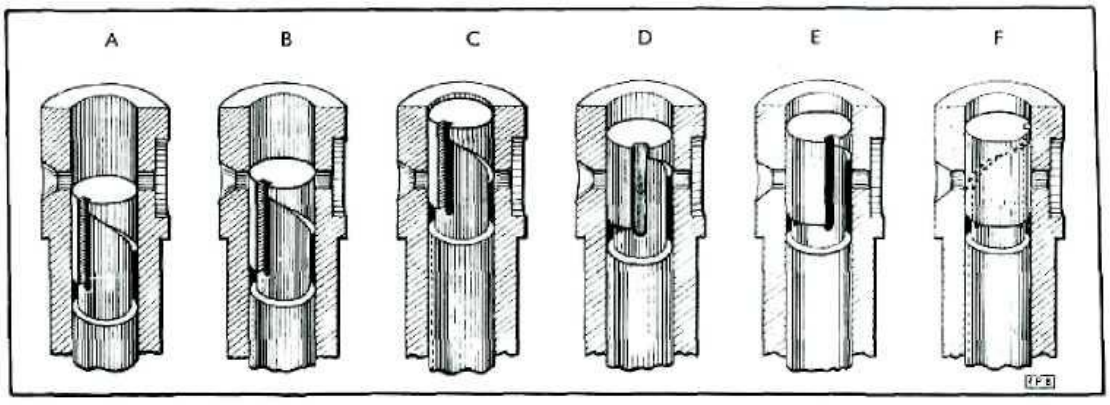



**Fig. D.9—Positions of Plunger in Barrel.**

**INJECTION PUMP DESCRIPTION—Continued**

positions is brought about in this way. Near the lower end of each plunger are two lugs (see Fig. D.8). The lugs are held in a slot on the actuating sleeve which is mounted on the outside of the pump barrel and can be rotated. Clamped to the upper end of each sleeve is a toothed quadrant. The teeth of the quadrant are engaged by a rack on the control rod. To and fro movement of the rack turns the quadrants, the sleeves and the plungers.

Between the fuel pump and the atomisers are delivery valves (D), one to each pump plunger. These serve the important purpose of preventing dribble at the atomisers. They do that by causing a sharp cut off in the oil supply at the end of each injection.

Fig. D.10 shows a delivery valve. It is at one and the same time a poppet valve and a piston valve. The head is poppet valve shaped and below that is a cylindrical portion which serves as a piston valve. In the left-hand sketch of Fig. D.10, the valve is shown closed.

This valve has a high lift, so that, as shown in Fig. D.10, the cylindrical part of the valve rises clear of the valve seat when the valve is fully open.

The way in which this valve operates to prevent dribble at the atomiser is as follows:

So long as the fuel pump is delivering fuel oil the pressure of that oil on the underside of the valve keeps it wide open as in the third sketch of Fig. D.10.

As soon as the helical edge of the annular groove on the pump plunger uncovers the port in the pump barrel the pressure of the oil below the delivery valve falls and that valve is promptly closed by its spring. As it falls the effects of the withdrawal of the piston part of the valve within the seat causes a drop in pressure in the pipe to the atomiser, causing the nozzle valve to snap on to its seat sharply, cutting off the fuel supply, so that there is no dribble.

A steel peg is used to centralise the upper end of the valve spring and also to reduce the capacity of the holder, thereby improving injection control.

## SERVICE

As shown in the fault finding section (page D-17), several engine faults may be traced to the fuel system, but are rarely due to the fuel injection pump itself, due to the protection given to it (if correctly maintained) by the filtering system. It is also not subjected to the harsh cylinder conditions as are the atomisers. For these reasons investigation of the fuel injection pump should be undertaken only as a last resort.

With the exception of the delivery valves and springs, it is not possible to service the injection pump other than in a fully equipped diesel workshop owing to the careful adjustment and synchronisation of the four quadrants and tappets necessary after any dismantling takes place. Examination of the section diagram of the injection pump will show that nothing, other than the feed pump, governor or delivery valves, can be removed from the pump without upsetting either one of these adjustments.

**Delivery Valves:** Should one of these be suspected as faulty, slacken the hexagon nuts which retain the atomiser pipe to the delivery valve housing and uncouple the atomiser pipe. Unscrew the housing and the delivery peg, spring and valve may be withdrawn in that order. Carefully clean and examine these components and check that the valve and seat faces are not damaged. Should replacement of the delivery valve be indicated, it will be necessary to also replace the seat as these two parts are only available in mated pairs. This operation and any further repair work should, as previously mentioned, be carried out only by an authorised diesel workshop, as the fuel output for an element may vary with a change in delivery valves.

**To Remove the Fuel Pump:** If the injection pump is to be removed for service, leave the feed pump, hand primer and pre-filter in place on the pump. Remove the two banjo studs coupling the fuel lines to the feed pump and slacken the nuts on the injection pump fuel inlet pipe, the governor vacuum pipe and both ends of the four atomiser pipes. Move the eight pipes clear of the pump. Uncouple the stopping control from the pump lever.

Remove the pump flange bolts (4 on earlier pumps, and 5 on later pumps) and the pump may be withdrawn from the engine complete with its driving gear. The gear may be removed from the pump adaptor by removing the three bolts from the front of the gear, the shake-proof washers and the circular plate.

Always protect the exposed pipes and the opening into the timing case against the ingress of dirt.

If the fuel injection pump has been removed for service, it is a good policy to service the atomisers at the same time. In any case, these units will need to be removed in order to time the engine when refitting the injection pump.

**To Install the Injection Pump:**

1. Uncouple the atomiser pipes from the atomisers, remove the eight retaining nuts, the four atomisers and the four atomiser joint washers.

2. Remove the two securing nuts from the valve cover (rocker cover) and lift off the cover.

3. Remove the rubber plug in the top of the flywheel housing. This plug is made accessible by a hole provided in the horizontal portion of the engine bulkhead.

4. Turn the engine by hand in the normal direction of rotation until No. 1 cylinder is at T.D.C. on its compression stroke. At this point the rockers of No. 1 cylinder will have their full clearance and the valves of No. 4 cylinder will both be just open, the rockers having no clearance. Check that the line bearing the marking T.D.C. is centralised in the hole in the flywheel housing.

5. Remove the small cover from the nearside of the engine timing case.

6. Fit the gear, plate, lock washers and bolts to the pump adaptor. The bolts should be located approximately midway in the slots in the gear.

It is advisable to fit a new face gasket to the pump.

7. Turn the pump gear until the scribed line on the adaptor marked with the letter "s" is in line with the scribed line on the pump body lug. It will be necessary to hold it in this position otherwise the pump mechanism will move it out of line.

8. Mount the pump onto the timing case flange and hold it correctly in position with two or three of the flange bolts.

9. Turn the engine two complete revolutions, check that the flywheel marking is centralised in its hole, then examine the alignment of the pump adaptor markings. If the markings are not in line, the timing may be adjusted by either:

(a) Removing the cover plate from the front of the timing case, slackening the three gear bolts, adjusting the adaptor position, then retightening the gear bolts and replacing the cover plate.

(b) Estimating the necessary adjustment, removing the pump and adjusting by trial and error.

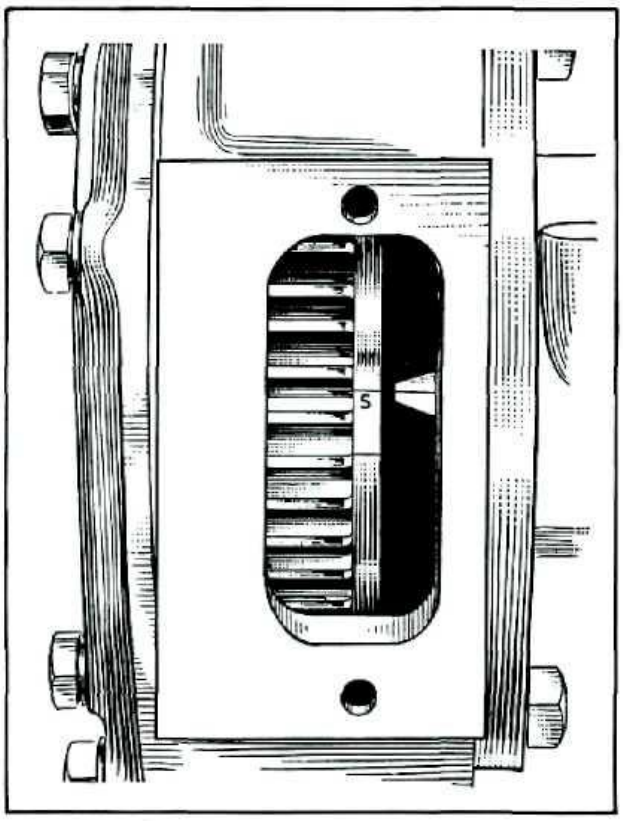



**Fig. D.11—Fuel Pump Timing Marks.**

10. Once the pump is correctly timed, install and tighten the remaining flange bolts.

11. Remove the cover from the side of the injection pump and fill the camshaft compartment with engine oil to the level of drain pipe. Replace the cover.

12. Replace the atomisers and atomiser pipes (see page D-12), the valve cover, the flywheel housing plug, the timing case cover or covers, and couple up the fuel lines and the stopping control.

13. Bleed the air from the supply system by operating the hand primer until all air has been exhausted from the filter vent plug and the fuel injection pump vent.

14. Start the engine and run at slow speed. Air in the vaporiser pipes may cause rough operation and, if this does not correct itself after a few seconds, slacken the pipe nuts on the atomisers one at a time until the air is exhausted.

15. Adjust the idle control screw on the governor. Slacken the locknut and back off the screw several turns. Start the engine and allow to idle. Slowly screw in the idle control screw until the surge or "hunting" is eliminated. If a tachometer is available, check that the engine idles at 450-470 R.P.M. If idling too fast or too slow, alternately adjust the idle stop screw on the venturi butterfly and the governor idle control screw until a satisfactory idle is obtained. Once adjusted, run the engine up to full speed and check that the maximum R.P.M. does not exceed 2200 R.P.M.

The operation of the governor is explained in the following section.

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Do not disturb the sealed venturi screw otherwise the engine manufacturer's warranty will be void.

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# PNEUMATIC GOVERNOR

The position of the control rack, by means of which the quantity of fuel delivered to the engine is regulated as described, is determined by a pneumatic governor. This governor, part of which is in the form of a venturi in the engine induction system, operates the control rack according to the degree of vacuum in the venturi passage.

There is a butterfly valve in the venturi. When that valve is closed, or nearly closed, the suction on the engine side of it is considerable, lessening as the valve is opened.

A pipe connects this venturi passage with a governor casing which is mounted on the fuel pump.

The important element is the flexible leather diaphragm which divides the space inside the governor casing into two compartments, one of which, that on the right, is airtight.

This airtight compartment is in communication with the venturi by means of a pipe. The vacuum in the venturi is thus communicated to the airtight compartment and the right-hand side of the diaphragm.

The chamber, to the left of the diaphragm, is not subject to vacuum.

The diaphragm, therefore, is constantly subject to a pressure tending to move it to the right, against the resistance of the light spring disposed within the right-hand chamber.

It will be appreciated that as the butterfly valve is closed the vacuum increases and the diaphragm moves to the right.

The centre of the diaphragm is coupled to the control rod of the fuel pump. Movement of this rod towards the governor tends to reduce the supply of fuel to the atomisers, as explained on page D-8.

Thus, closing the butterfly valve increases the vacuum in the chamber, moves the diaphragm to the right, and reduces the supply of fuel to the engine.

The butterfly valve is operated by the ordinary throttle valve levers and in that way the speed of the engine is controlled.

Now here is a point of the very greatest importance.

Any leaks in the joints of the pipe, in the pipe itself, or in the diaphragm, will diminish the degree of vacuum and cause the engine to run faster than it should and idle erratically.

Hence the instructions, given later, urging care in ensuring that there are no air leaks in the system.

If the pipe were to become detached, or be left uncoupled, and the engine run, it would race and very serious damage be caused.

Hence the warning, repeated later, that the engine must never be run unless the venturi control unit, pipe and induction manifold are in position and all joints are tight.

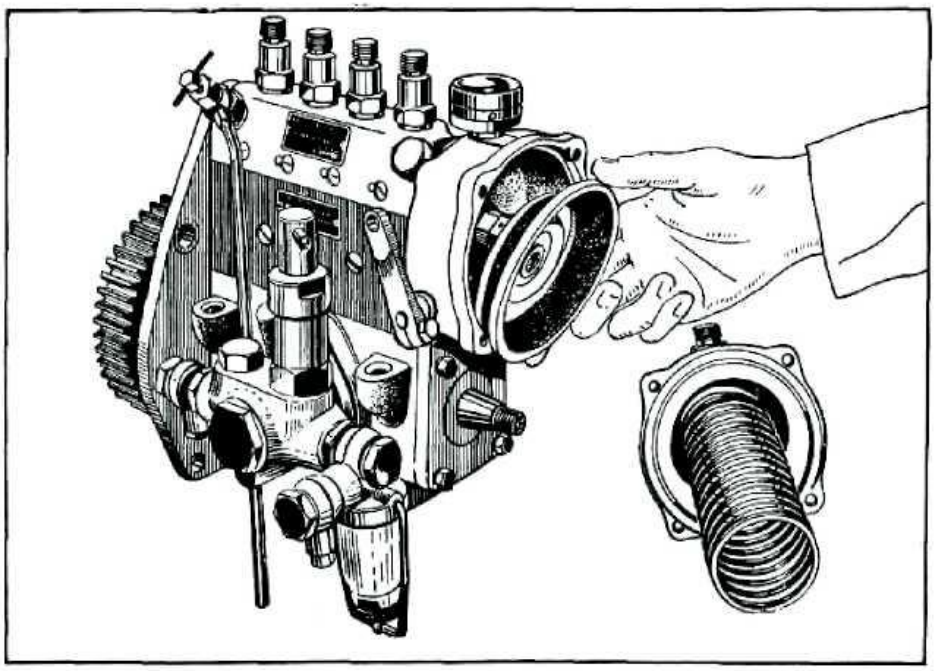

**Fig. D.12—Removing Diaphragm from Governor.**

Adjustment of the pneumatic governor is effected at the works when the engine is erected. It is an operation requiring considerable skill. The idling stop on the butterfly valve and the adjusting screw on the cap of the governor have to be manipulated alternatively until smooth running at the desired idling speed is achieved.

**Controlling the Idling Speed:** An important function of this pneumatic governor is that of controlling the idling speed of the engine.

That is the speed at which it rotates when the butterfly is in its nearly closed position. That position is determined and limited by an adjustable stop mounted on the body of the venturi.

With the butterfly valve control lever in this limiting position the vacuum in the airtight chamber is at a maximum and the diaphragm, together with the fuel pump control rod, is as far to the right as the damping spring, described below, will allow it to go. The minimum quantity of fuel, just sufficient to "idle" the engine, is then being delivered.

Under these conditions there is a tendency for the engine to "hunt," that is, for its speed to fluctuate.

It is to eliminate "hunting" and to ensure a steady idling speed, that the "damping" mechanism on the rear of the pneumatic governor is provided.

The idling control spindle, which is under the control of a small strong spring, contacts the centre of the diaphragm when the latter is in the extreme right or "idling" position and steadies it.

Adjustment is provided for the position of this spindle.

Screwing the adjustment in drives the spindle further in and increases the idling speed, providing a cushioning effect to the pump rack.

The spindle will also contact the diaphragm throughout the speed range when the engine is not under load, so that the maximum speed will increase if the adjustment is screwed in, but the maximum speed of the engine **under load** will not be affected.

The procedure for adjustment of the engine idle speed is covered in Item 15 on page D-9.

**Faulty Governor Operation:** The tiniest pinhole or crack in the leather diaphragm will affect the operation of the governor. If such a fault is suspected, test in this way:

(a) Remove vacuum pipe.
(b) Move the stop lever into "stop" position.
(c) Place a finger over the diaphragm housing union in order to seal it.
(d) Release the stop lever.
(e) The control rod should then slowly return to the maximum speed position after a quick initial movement for a fraction of the distance. If it returns quickly for the whole movement and the housings are clamped firmly together, then the diaphragm is leaking and should be replaced by an authorised agent. Instructions for replacement are given below.

If the diaphragm appears to be sound as indicated by this test, suspect the vacuum pipe and test in a similar way. Replace the union of this pipe on the governor casing and uncouple it at the butterfly end. Repeat the test as before but placing the finger on the uncovered end of the vacuum pipe. The pipe must be clean and airtight.

**To Renew Leather Diaphragm:** To renew the leather diaphragm proceed as follows:

Disconnect the vacuum pipe.

Take out the screws holding the pneumatic governor in place.

The diaphragm will then be accessible. It is held in a light U-section metal rim which must be prised from the casing. (See Fig. D.12).

Great care must be exercised in this operation.

For preference, use a piece of sheet metal about ¾ in. wide, shaped at the end to fit the curve of the rim, and sharpened to an edge similar to that of a screwdriver.

Lift the edge of the rim carefully all round.

When the rim is free, slide the socket at the back of the diaphragm off the pin in the control rod.

Be careful not to mark the face of the fuel pump on to which the governor casing fits.

To replace the diaphragm, first place the socket on the pin in the control rod, and splitpin.

Then press the rim firmly in its place.

Replace the governor casing, being careful to screw the setscrews very tightly and evenly in position.

The pneumatic governor depends for its action upon pressure variations set up in the air intake pipe of the engine by the venturi control valve. If this should be removed either by itself or with the inlet manifold during overhaul, or if the vacuum pipe unions are not always kept perfectly tight, then the governor may fail to operate causing damage to the engine.

**IN NO CIRCUMSTANCES SHOULD THE ENGINE BE RUN WITHOUT VENTURI CONTROL UNIT, VACUUM PIPE OR INLET MANIFOLD.**

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**Engine Speed Control Linkage:** The foot and hand controls for the engine speed control are arranged so that the hand control can be set to the minimum speed and the foot control may be used to override the hand control.

Adjustable stops are provided on the intermediate bell crank to prevent the light operating rod or the butterfly lever being damaged. This latter lever is clamped, but not positively located on the butterfly spindle. After making any adjustments, or removing the cowl supports, check that the spindle stops engage the adjustment screws when the hand lever is in the idle and maximum speed positions.

# ATOMISERS (Injectors)

After leaving the fuel pump the fuel passes through short steel pipes to the atomisers. Atomisers perform the function of injecting the fuel, in the form of fine sprays, into the cylinders, at the moment when the air in the cylinder has been compressed and, as the result of the compression, is at a temperature sufficient to ignite the incoming fuel.

An atomiser comprises two principal parts: the nozzle, 1, with its valve, 2, and the atomiser body, 3.

The atomiser nozzle and nozzle valves are the important parts. They are shown in Fig. D.13.

Fuel is fed to the upper channel in the nozzle from the atomiser body and travels thence along a number of drilled holes to the lower circumferential channel. The outlet from the latter is normally closed by the valve as shown.

The atomiser body, complete with nozzle and nozzle valve, is shown in Fig. D.13. The nozzle is held in place by the nozzle holder cap nut, 4. This holds the upper face of the nozzle in close contact with the corresponding lower face of the atomiser body. A metal to metal joint is made here.

Fuel is supplied through the fuel inlet connection, 5, and passes through the drilled holes down to the channel in the face of the nozzle.

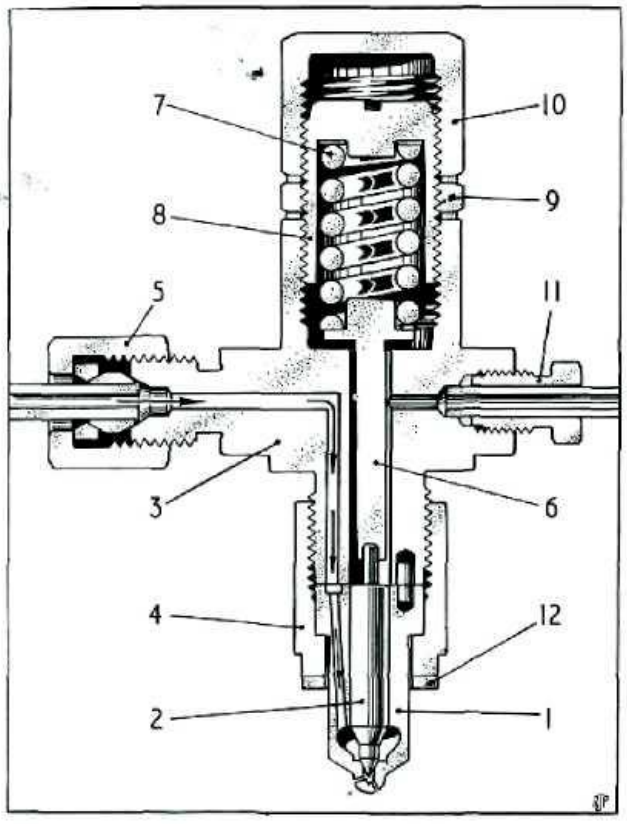



**Fig. D.13—Sectional View of Atomisers.**

In the centre of the atomiser body is the spindle, 6, surmounted by the valve spring, 7, on the top of which bears the spring cap nut, 8. There is a lock nut, 9, on this cap nut. A covering nut, 10, protects the upper part of the atomiser body.

The small quantity of fuel which by-passes the nozzle valve and accumulates within the atomiser body, lubricates the mechanism and is led away by a pipe connected to the leak-off union, 11. At the start of injection the fuel pump delivers fuel at a high pressure into the channel round the lower end of the nozzle. The pressure of this fuel on the end surface of the cone of the valve lifts it against the tension of the spring and fuel passes through two small holes in the end of the nozzle as two fine sprays.

Each atomiser body consists of a steel body held to the cylinder head by means of a flange and two studs.

The joint between the atomiser and cylinder head is made by a special copper washer, 12, between the lower face of the nozzle cap nut and the metal of the cylinder.

When preparing to fit the atomiser into place in the cylinder head, care should be taken that only this special type of copper washer is used to make this joint. The metal of the cylinder head, the faces of the copper joint ring, and the corresponding face on the nozzle holder cap nut should be perfectly clean if a leak-proof joint is to result.

It is advisable to fit a new joint washer or soften the old washer when the atomiser is replaced after having been removed for any reason.

Ensure that the old washer has been removed from atomiser or cylinder head.

This joint washer should be an easy, but not loose fit for the atomiser nozzle, and it is because this is such an important feature that the washers especially made for the purpose should be used and none other. On no account should ordinary sparking plug type washers be used.

The atomiser can now be fitted in place, care being taken to see that it is an easy fit in the cylinder head and on the holding-down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should then be tightened down evenly in order to prevent the atomiser nozzle being canted and so "nipped" in the cylinder head. This is very important, since any unevenness in tightening down may cause distortion of the atomiser nozzle, resulting in its failure, and will most certainly result in blow-by.

**Leak-off Pipes:** The pipes illustrated in the Champion tractor parts book (part number 21233), have been replaced with an inter-changeable pipe which is curved up in a loop to ensure that the atomiser spring is thoroughly lubricated. The new pipe is part number 22645.

**Fuel Pipes:**

No two of the pressure pipes, from fuel pump to atomisers, are alike. Keep this in mind when replacing.

Examine the brass nipples which will be found on each end of these pipes.

If the union nuts have at any time been overtightened there is a risk that the nipples will have cracked or been unduly compressed. If so, leakage will result.

In this connection bear in mind that the working pressure which these joints must sustain is several thousand pounds per sq. in. Only a perfect joint is satisfactory.

It is quite easy to replace these nipples.

Clean up a length of pipe near the end, using a fine cut file for the purpose, until the nipple will slide on to it.

Remove the nipple and replace the union nut and steel washer. The latter must have its countersunk face towards the nipple.

Now press the nipple on to the pipe, leaving 1/64 in. of the latter protruding.

Hold the pipe in the vice so that the nipple rests on the washer and the washer rests on the top of the vice.

Rivet the protruding portion of the pipe over the nipple.

Take care that the hole in the pipe is not closed whilst rivetting.

Clean off with a fine cut file.

When refitting take care that it is the brass nipple which makes the joint and not the actual riveted portion of the pipe.

After fitting new nipples WASH THE FUEL PIPE WITH CLEAN FUEL OIL, using either the atomiser testing pump or the engine fuel pump, thus removing any filings which may be in the pipe.

Offer up the pipe to the delivery valve and atomiser unions to check that the pipe fits square at both ends. Do not fit one and then bend the pipe to square it with the other union.

When fitting the pipe tighten the unions alternately a little at a time, first one end and then the other.

If the nipples have been properly fitted and the pipe is square to the unions at each end as described previously, no force will be needed to make a good joint. No force should be used.

Use only a standard open-ended $\frac{3}{8}$ in. by 7/16 in. spanner.

If the union is tightened excessively the nipple may collapse and split. The same danger exists if the pipe is not square to and central with the union.

When changing an atomiser always remove the pipe entirely. Never undo only one end, leaving the other tight. Never bend the pipe.

**Atomiser Service:**

Atomisers should be taken out for examination at regular intervals. How long this interval should be is difficult to advise, because of the widely different conditions under which engines operate. When combustion conditions in the engine are good and the fuel tank and filtering system are maintained in first class order, it is often sufficient if the atomisers are tested twice yearly.

It is no use taking atomisers out for attention unless the equipment described later is available, or spare atomisers are at hand for substitution.

The nearer the ideal conditions of good fitting with adequate cooling and absolutely clean fuel are realised, the less attention the atomisers will need, and so the longer their efficient life. In this connection, since there is no other item of the equipment upon which the performance of an engine depends so much, it pays the user handsomely to see that the engine never runs with any of its atomisers out of order.

**Troubles in Service:** The first symptoms of atomiser troubles usually fall in one or more of the following headings:—

1. Knocking in one (or more) cylinders.
2. Engine overheating.
3. Loss of power.
4. Smoky exhaust (black).
5. Increased fuel consumption.

Often the particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast "tick-over." This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after slackening a pipe union nut the engine revolutions remain constant, this denotes a faulty atomiser.

The nuts from the flange of the doubtful atomiser should be removed and the complete unit withdrawn from the cylinder head and turned round, atomiser nozzle outwards, away from the engine, and the unions re-tightened. After slackening the unions of the other atomiser pipes (to avoid the possibility of the engine starting), the engine should be turned until the nozzle sprays into the air, when it will be seen at once if the spray is in order. If the spray is unduly "wet" or "streaky" or obviously to one side, or the atomiser nozzle "dribbles," the spray holes should be probed with the special tool ET.120. If after probing the spray holes, the condition of the atomiser is still faulty, remove the complete unit.

A spare atomiser should be carried for this purpose. In which case, in the event of an atomiser becoming faulty, it may be replaced and the tractor kept in operation whilst the faulty unit is serviced. Keep the spare unit well wrapped in grease-proof paper.

**Great care should be taken to prevent the hand from getting into contact with the spray, as the working pressure will cause oil to penetrate the skin with ease.**

**Examination and Testing:** A bench suitable for working with atomisers is preferably linoleum-covered with glass on top. It should be entirely reserved for this work and kept absolutely free from dirt. The use of cotton waste or fluffy rags must be absolutely forbidden.

The bench should have a dust proof drawer for holding the atomiser cleaning tools and equipment described in detail below.

A plate, made up as shown in Fig. D.14, should be secured to the bench. Its purpose is to hold the atomiser securely whilst various maintenance operations are proceeding.

An atomiser testing pump, No. 22759, should be available. This outfit has been specially designed to provide a reliable means of testing and setting the atomisers. It is made up of parts similar to the injection equipment fitted to engines.

The doubtful atomiser should be removed from its wrappings and fitted nozzle downwards to the testing pump.

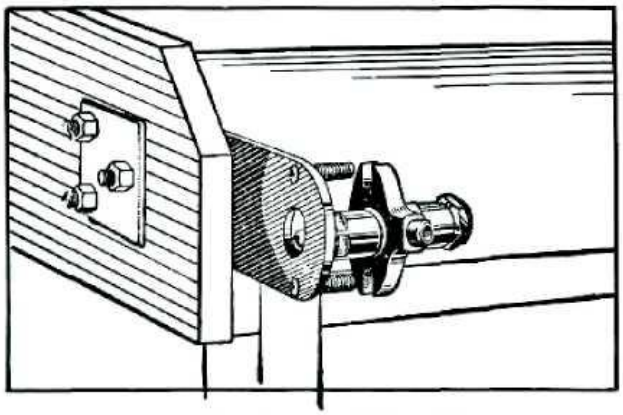


Fig. D.14—Atomiser Holding Plate.

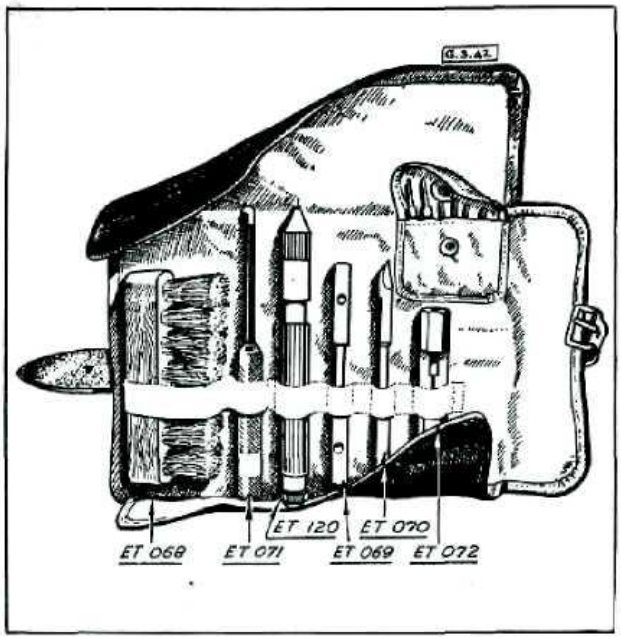



Fig. D.15—Atomiser Cleaning Kit.

No observations should be made until at least ten full strokes of the hand pump have been given to expel all air from the system.

**Atomiser Pressures:** The pressure at which the spray breaks should then be recorded and checked against the recommended pressure which is 120 atmospheres.

The spray should now be observed for uniformity at a rate of pumping of not less than 20 strokes per minute.

Each should be a misty spray spreading to about 3 inches diameter at about one foot away from the atomiser nozzle, then breaking into a very fine mist. There should be two sprays from each atomiser nozzle, one pointing outwards from the top hole, and the other pointing downwards from the lower hole, when the atomiser is in a position corresponding to its working position.

An atomiser is good for service if, when operating the atomiser testing pump at the above speed, it gives two effective sprays as above described.

An atomiser is dirty and requires reconditioning if (a), when proceeding as above it throws out solid wet jets and not broken up spray or (b), if either of the holes are choked or partially choked so that spray issues from one hole in the atomiser only or appreciably more spray issues from one hole than the other.

In this connection, as the engine idles at about 450 r.p.m. the atomiser is never called upon to work in the engine more slowly than 225 injections per minute. Thus by taking the atomiser spray at 20 strokes per minute, ample margin is allowed.

When removing an atomiser from the testing pump, close valve by rotating the hand-wheel and screw off the union nut a little at a time so that the pressure falls gradually.

Atomisers are set to operate at the pressure described above before leaving the works. If a

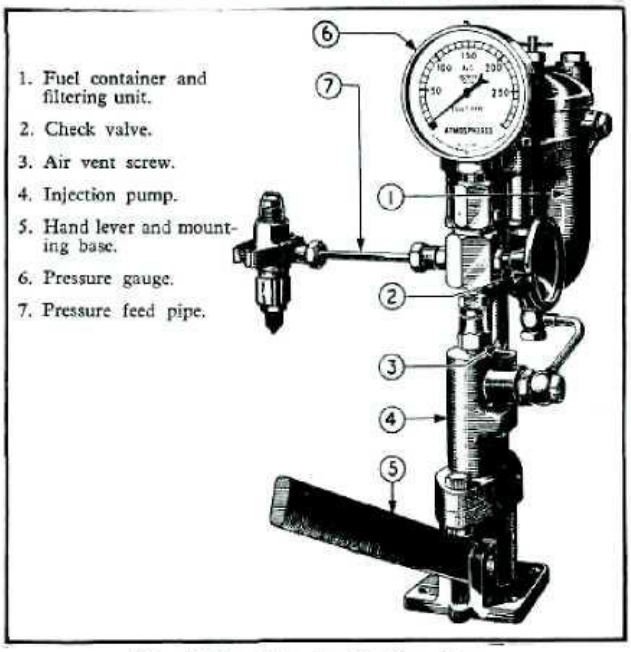



Fig. D.16—Atomiser Testing Pump.

new atomiser nozzle is fitted to an atomiser body, it is necessary to reset the pressure. After the atomiser has been in serivce for some time, the opening pressure tends to fall, but provided that the atomiser nozzle holes do not choke up, there is no need to adjust the pressure.

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT A PROPER TESTING PUMP AND PRESSURE GAUGE AS DESCRIBED AND ILLUSTRATED. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF ATOMISERS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT.

If the atomisers are interfered with, on the assumption that so many turns of the spring cap nut represents so many pounds, they may vary as much as 200 pounds as between one and another. With such differences between atomisers the engine cannot possibly give of its best.

If the spray is still unsatisfactory, even after brushing the carbon away from around the atomiser nozzle with the fine wire brush specially designed for the purpose and illustrated in Fig. D.15, the atomiser should be placed on the atomiser holding plate already described. (See Fig. D.14).

Before attempting to dismantle the atomiser, the tension on the spring should be released by unscrewing the spring cap nut. Use ring spanner 22760 to slacken the holder cap nut and the spring cap locknut. The nozzle cap nut, 4, Fig. D.13, should be slackened with the special ring spanner 22761 . To hold the nozzle cap nut in the vice or to use ill-fitting "packed" or adjustable spanners or wrenches is to invite disaster.

Examine the pressure face of the nozzle cap nut to see it is not damaged so as to have "nipped" the atomiser nozzle in any way.

The nozzle cap nut should now be removed and the atomiser nozzle completely lifted from the atomiser body for examination. The surfaces "A" and "B" in Fig. D.17, on the top of the atomiser nozzle should be clean and bright, free from damage, likewise the under-surface "C" of the flange, the face of the atomiser body "D" and the interior retaining shoulder of the nozzle cap nut. All of these must register together absolutely cleanly and squarely to form the high pressure joint between the atomiser body and nozzle.

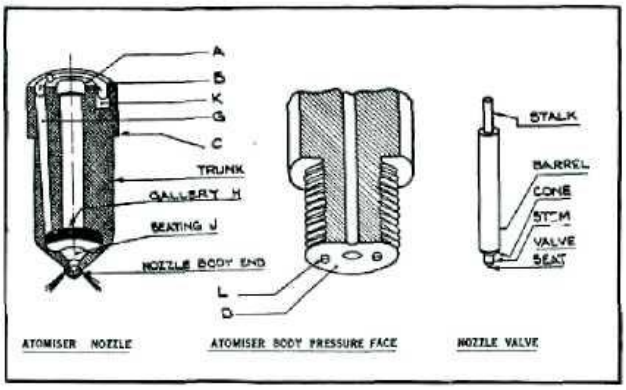



**Fig. D.17—Atomiser Nozzle Details.**

The atomiser body should now be removed from the plate, and together with the cap nut immersed in clean paraffin and left to soak in a suitable container. The nozzle valve should be grasped by the stalk between finger and thumb and withdrawn, carefully, for examination. The stem of the nozzle valve should be clean and bright, and free from high spots, bad scratches or dull patches, and the grooves free from dirt, metal particles or other foreign matter.

The stem and the valve seat of the nozzle valve should now be examined, and if dirty or "coked," cleaned until bright metal is shown.

**Cleaning:** Assuming that the nozzle valve has been soaking and the two surfaces "A" and "B" on the top of the atomiser nozzle flange already mentioned, are clean and free from damage, the inside of the atomiser nozzle should be examined. The kit of tools shown in Fig. D.15 are recommended. The three small drilled passages "G" (Fig. D.17), should be explored to see that they are clear and clean, followed by an examination of the valve stem bore in which the nozzle valve slides. This surface should be clean and bright and free from high spots or scratches or dull patches. The valve seating "J" (Fig. D.17), should now come under observation under a strong light to ascertain whether or not it is free from dirt or carbon. If this is not so, and indeed, in any case, it is advisable to use the soft brass seat scraper, No. ET.070, to remove any carbon or particles that may be imprisoned on the seat. The gallery "H" (Fig. D.17), should now be cleaned with the aid of the special soft brass scraper No. ET.071 to ensure that it is also clean and free from dirt or carbon.

The spray holes in the atomiser nozzle end should be probed with the special tool ET.120.

In cases where the holes cannot be cleaned by this process, the complete atomiser should be returned securely wrapped and packed as described above. Assuming that the spray holes have been cleaned satisfactorily, the atomiser nozzle can then be placed in the container to soak in paraffin or preferably assembled in the atomiser flushing tool No. 22762 and thoroughly flushed through to ensure that all carbon particles are removed from the inside of the atomiser nozzle.

The nozzle valve should now be polished by rubbing with an absolutely clean cloth—a piece of used boiled cotton is best—upon which there is no suggestion of fluff. Particular attention should be given to the valve seat. This and the smaller cylindrical portion above it, called the "Stem" and

"cone" in Fig. D.17, can be cleaned with the fine brass wire brush. To ensure that the stem and cone are free from any particles, the soft brass stem cleaner No. ET.072 should be applied with a rotary action, pressing the nozzle valve into the cleaning tool with the fingers.

After ensuring that the exterior of the atomiser nozzle is clean and free from carbon, the valve and atomiser nozzle may be assembled together. This should be after the two parts have been thoroughly washed in clean paraffin or fuel oil and placed together, preferably with the fingers whilst submerged in the clean oil.

The atomiser body should now receive attention: it should be washed in clean paraffin, care being taken to ensure that the highly ground face "D" (Fig. D.17) is clean and free from scratches. This face must register with the atomiser nozzle flange cleanly and squarely to form a high-pressure joint and must, therefore, be handled in such a way as to avoid damage to the surface. The exterior of the atomiser body, of course, should be cleaned thoroughly from dirt and grease in the usual manner. Periodically, it is advisable to dismantle the interior of the atomiser body to examine the springs and nozzle spindle. When dismantling, the special spanner, No. 22760, should be applied for the removal of the nozzle holder cap and the spring cap lock nut. The interior of the atomiser body and the parts removed should be washed carefully to remove any dirt or moisture. If the spring and the parts are in good condition, they should be re-assembled carefully, and preferably after having been slightly coated with lubricating oil.

The serviceable life of the atomiser valve spring can be considerably enhanced by careful treatment, and great care should be taken to avoid the damage likely to be caused by moisture, corrosion arising in storage, handling, or by reason of condensation owing to temperature changes in service. It is recommended that these valve springs should be inspected, cleaned and greased whenever the atomisers are removed for cleaning, whilst care should be taken in storing spares to preclude all possibility of the access of moisture.

**Re-Assembly of Atomisers:** The atomiser body and atomiser nozzle may now be assembled carefully, after having immersed the pressure faces of each in clean fuel oil, to ensure that they are free from dirt. The nozzle cap nut should be screwed on to the body by use of the special spanner. Excessive tightening of the nozzle cap nut may result in constriction or distortion of the atomiser nozzle and its consequent failure; care should be exercised to ensure that the leverage applied is not excessive.

After cleaning, the atomiser should be tested, always on the atomiser testing pump as previously described. If the pressure at which the spray breaks is not 120 atmospheres, it can be adjusted by the spring cap nut and lock nut, using spanner 22760.

A perfect atomiser, when tested by pumping fuel through it in the open air gives a short "pinging" sound as the fuel emerges from the holes, no matter how slowly the fuel be pumped. After the atomiser has been in service for some time, the "pinging" changes to a crackling sound. It is not until the atomiser sounds "dead" that its condition is likely to affect the running of the engine.

When replacing the atomiser in the cylinder head, follow carefully the instructions for fitting given on page D-12.

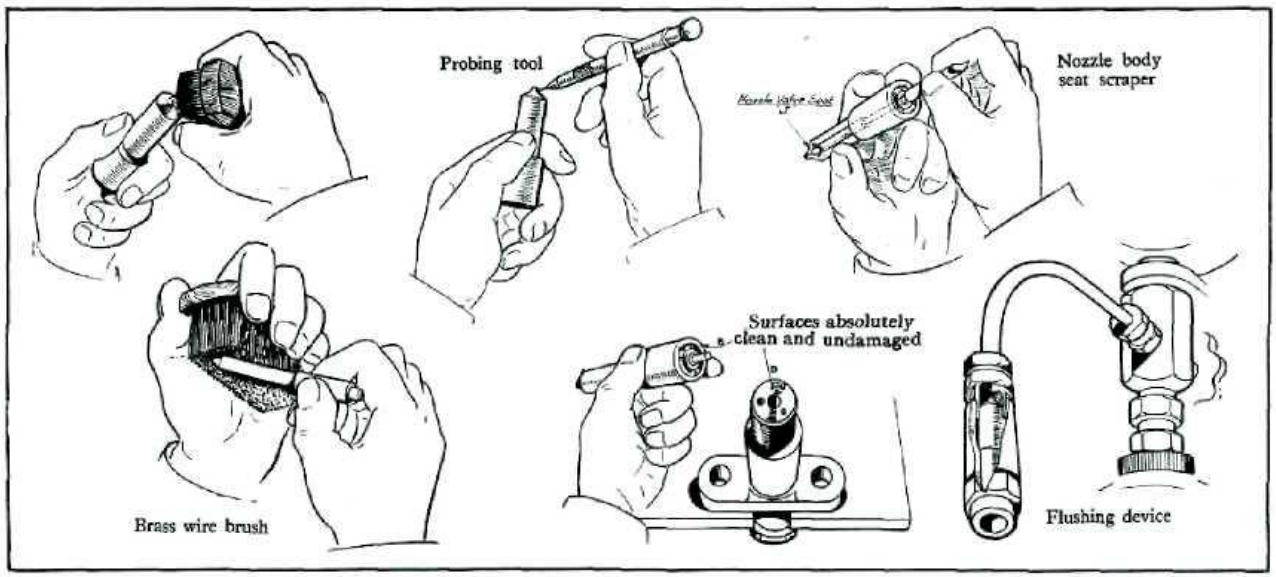



**Fig. D.18—Atomiser Cleaning Processes.**

# FUEL SYSTEM FAULT FINDING

As mentioned in the engine section, the following engine troubles may be caused by faults in the fuel system:

1. Failure to start or stopping in service.
2. Rough running or mis-firing.
3. Knocking.
4. Smoking exhaust.
5. Fall-off of engine power.
6. Over-heating.
7. Erratic governor operation.

**Failure to Start or Stopping in Service:** If the engine is turned over at a reasonable speed by the starter motor, the starting heater has been used if the engine is cold, and the engine fails to start, proceed as follows:

1. Whilst the engine is turned over listen closely to the atomisers. A distinct "squeek" or "clack" should be heard from each atomiser as it injects. If this is so, check the fuel pump timing as detailed on page D-9, if not, proceed as follows:

2. Slacken the injection pump vent tap, unscrew and operate the hand priming pump, and observe the discharge from the vent drain. A reasonable back pressure should be felt in the hand pump and a good discharge of fuel, free of air bubbles, should be pumped from the vent.

(a) No back pressure—poor vent discharge—would be caused by:
Insufficient fuel in tank — Replenish and bleed the system. (See page D-5).
Air locked system — Bleed the system, check for leaks in the suction pipes. (See page D-5).
Blocked pre-filter — Dismantle pre-filter, clean, replace and bleed the system. (See page D-5).
Fouled or damaged feed pump valves — Remove and examine the valves. Clean and replace if necessary. (See page D-5).

(b) Good back pressure with poor discharge — would be caused by:
Air locked system — Bleed the system, check for leaks in the suction system. (See page D-5).
Blocked fuel filter — Replace element and bleed the system. (See page D-3).
Blocked vent tap or drain — Remove tap and drain and try hand pumping with these removed.

(c) Good back pressure — good discharge.
Fouled or damaged feed pump spring, plunger or spindle — Retighten the hand pump and turn the engine over with the vent tap open. If the discharge is still satisfactory, the fuel supply system is not at fault. If the discharge is now unsatisfactory, remove and examine the spring, plunger and spindle. (See page D-5).

3. If the fuel supply is found to be in order, slightly slacken the atomiser pipe nuts on each of the atomisers and turn the engine over. Air locks in all four atomiser pipes is a possible but unlikely cause of engine stoppage as this portion of the system will usually clear itself of air after a few strokes. If air bubbles are discharged from the pipe nuts, retighten when the bubbles are cleared and re-attempt to start the engine. If the injection pump is not delivering fuel, examine the delivery valves. (See page D-8).

**Rough Running or Mis-firing:** This may be caused by the fuel system, but may also be caused by faulty lubrication or valve gear.

1. Check for air in the fuel system as described in 2 of the "Failure to Start" procedure.

2. Isolate a faulty atomiser or injection pump section by slackening each atomiser pipe nut on the atomisers one at a time, whilst the engine is running at idle speed. No decrease in engine speed, or increase in roughness, when one particular atomiser nut is slackened indicates that either that atomiser or fuel pump section is faulty. A list of the possible faults are as follows:

Atomiser nozzle holes blocked or dirty. (See page D-13).

Atomiser spring broken. (See page D-14).

Atomiser valve or spindle stuck. (See page D-14).

Atomiser incorrectly adjusted. (See page D-14).

Injection pump delivery valve faulty. (See page D-8).

Injection pump delivery valve fouled. (See page D-8).

Injection pump plunger faulty. (See page D-8).

Injection pump tappet faulty. (See page D-8).

**Knocking:** This may be caused by any one of several engine faults, but may be caused by fuel system faults as outlined under "Rough Running."

**Smoking Exhaust (black):** Check the atomisers as detailed on page D-13. If no fault is found with these, it is possible that one, or more, of the plunger quadrants has slipped out of adjustment.

**Fall-off of Engine Power:**

1. Check that, with the speed control lever in the 2000 R.P.M. position, the lever on the venturi butterfly is firmly against the maximum speed stop screw. Slacken the lever clamp screw and adjust, if necessary.

2. Check the fuel system as detailed under "Rough Running."

3. Check the fuel pump timing. (See page D-9).

**Overheating:** This is usually caused by cooling or lubricating system faults, but may be caused by faulty atomisers. However, if the atomisers are the source of the trouble, rough running or misfiring will also be evident. Check as described under that heading.

**Erratic Governor Operation:** Check as described on page D-11.

Sluggish governor operation may be caused through fuel oil in the right hand airtight governor compartment. It will be necessary to dismantle the governor as detailed on page D-11 and remove all trace of fuel oil. The diaphram should be thoroughly dried before re-assembly. If this condition occurs frequently, it will be necessary to have the fuel pump overhauled.

## L4 COLD STARTING EQUIPMENT

As mentioned in the Electrical System Section, engine starting in cold weather is assisted by spraying fuel oil onto a heated element plug.

The fuel is supplied from a small tank situated under the engine cowling and is forced through a vaporiser connection in the engine inlet manifold by a small hand pump on the dash.

The operation of the unit is described on page B-4.

Lack of pumping pressure when operating the hand pump indicates either an empty fuel tank, closed valve or faulty hand pump valves.

Excessive back pressure indicates a blocked vaporiser.

The pump valves may be inspected by uncoupling the fuel pipes, then removing the unions from the pump ports. Care must be exercised in this latter operation, otherwise the springs and balls may fall from the pump ports when the unions are removed.

The vaporiser connection may be inspected by removing the banjo bolt from the connection, then removing the complete vaporiser from the venturi.

Tools mentioned in this section are listed in Section P with corresponding Chamberlain part numbers.

# FOUR-270D FUEL SYSTEM

(1) The principal components comprising the Four 270D fuel system are as follows:

Filters.

Fuel Lift Pump.

D.P.A. Fuel Pump.

Atomisers.

The fuel pump delivers fuel oil to the Atomisers in regulated quantities and at a pressure of 170 atmospheres and the fuel feed pump supplies fuel oil to the fuel injection pump at a pressure of 2¾-4¼ lbs/sq. inch.

The fuel lift pump draws the fuel through a coarse strainer fitted to the fuel tank and then through the pre-filter mounted on the inlet side of the fuel filter to the injection pump.

*Two conditions are essential for efficient operation* of this fuel system.

(1) The fuel oil should be clean, free from water, suspended dirt and other foreign matter.

(2) The fuel oil must reach the fuel pump in a perfectly clean state.

Given these conditions a large percentage of potential engine troubles will be eliminated.

## FUEL FILTERS

The importance of correctly servicing filters cannot be over emphasised, as many complaints of fuel pump wear can be traced to lack of care in servicing filters. If filters are found to choke with dirt in an unreasonably short time, this may point to unsatisfactory fuel supply storage or handling conditions, and steps should be taken to investigate in order to find out how, and at what point, an undue amount of impurities can enter the system.

Protection for the Four 270D engine is provided by three filters, the first being fitted to the fuel tank.

1. Water Trap
2. Pre Filter
3. Paper Element Type.

**Water Trap:**

This is fitted in the form of a sump, on the offside bottom of the fuel tank. Every ten hours, the tap should be opened to drain off any accumulated water or sediment. The coarse gauze strainer fitted to the suction pipe in the fuel tank should not normally require service.

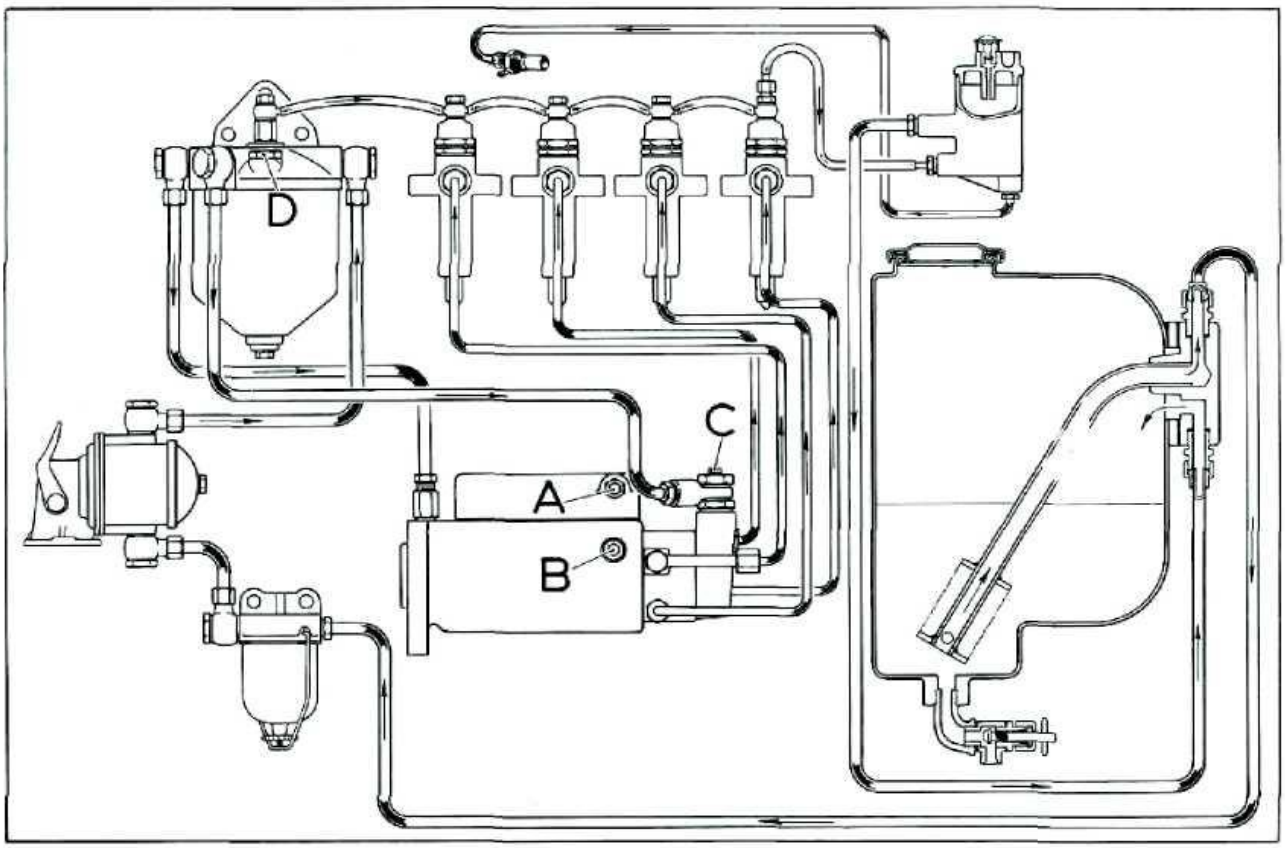



Fig. D.19 — 4-270D Fuel System.

**Pre Filter:**

This unit's main purpose is to act as a water trap prior to the entry of fuel oil to the fuel lift pump. Every 100 hours or more often if circumstances warrant, the glass bowl should be removed and thoroughly cleaned.

To remove, unscrew the knob at the bottom of the bowl, swing the stirrup clear and remove the filter bowl. Clean out and wash the filter bowl in clear kerosine or fuel oil.

When re-assembling, take care that a good joint is made between the top of the bowl and the filter body, as any leakage of air here on the suction side of the fuel pump, may cause air locks in the fuel system.

**Paper Filter Element:**

Paper elements are not intended to be cleaned and must be renewed every 500 hours.

The filter is one of the cross flow type, the inlet and outlet connections being carried on the cover, which also incorporates a bracket for support. The bowl is of pressed steel and forms an oil tight container for the paper element. An air vent plug is also carried on the cover as is a pressure relief valve.

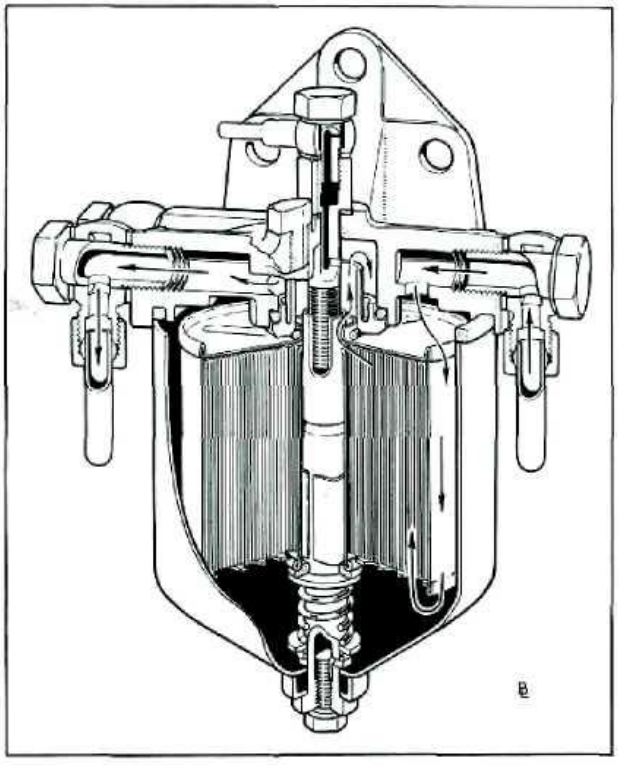


Fig. D.20 — Sectioned Filter.

A drain plug is provided at the bottom of the filter bowl. The paper element, wound round a circular case in the form of a spiral, is contained in a thin metal canister. The winding is done in such a manner as to provide a very large filter area within minimum filter bowl dimensions, and actually gives six times the filter area of the normal cloth filter within a bowl of approximately 2/3 of the size.

Every 100 hours unscrew the drain plug at the bottom of the filter bowl and allow fuel to flow through until clean fuel oil appears. Replace drain plug.

To remove the element, unscrew the centre nut on the cover and take the filter bowl away.

Remove the dirty element and throw away.

Before placing new element in position, clean the filter bowl and inspect the relief valve.

Ensure that the rubber joints are in good condition, if not, renew.

**Note:** If either, or both, of the pre-filter or the paper element filter have been disturbed either for cleaning, or for any other reason, it is necessary to bleed any air from the system.

This procedure is covered at the end of the Section.

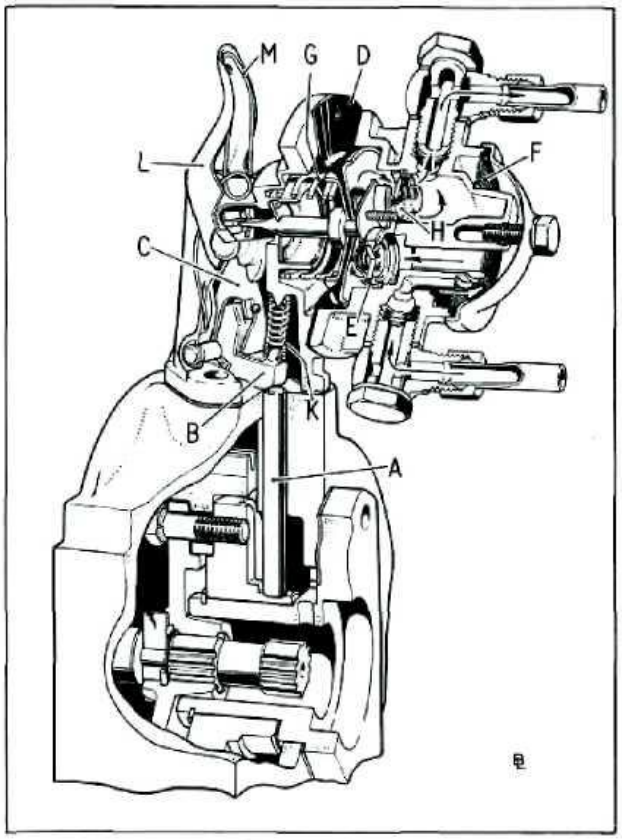



Fig. D.21 — Fuel Lift Pump.

## THE FUEL LIFT PUMP

**Description:**

The fuel lift pump is of the diaphragm type, mounted on the top of the timing case immediately above and forward of the fuel injection pump. Operation is by a small push rod riding on an eccentric on the fuel pump gear carrier hub.

A hand primer is fitted for the purpose of supplying fuel to the fuel injection system without turning the engine.

**Operation:**

As the push rod (A) moves upwards, the rocker arm (B) and lever (C) are actuated, causing the diaphragm (D) attached to the lever, to be displaced. The depression thus caused enables the inlet valve (E) to depress its spring and fuel to flow through a gauze strainer (F) into the cavity on top of the diaphragm.

Downward movement of the push rod allows a spring (G) to return the diaphragm to its former position, creating pressure in the fuel filled cavity. This fuel pressure closes the inlet valve and opens the outlet valve (H) through which the fuel flows via the micronic filter to the injection pump.

The spring controlling the return stroke of the diaphragm limits the flow of the fuel oil to maintain a pressure of 2¾-4¼ lbs./sq. in. in the fuel system.

When the diaphragm is not making its full stroke, the rocker arm is kept in close contact with the push rod by a spring (K).

The action of the hand primer lever (L) is to actuate the diaphragm operating lever independent of the rocker arm. When the push rod is controlling the diaphragm action, the hand lever is held out of engagement by an external spring (M).

**Maintenance:**

The only regular maintenance required is that the gauze strainer located in the top of the pump be removed and cleaned at 100 hourly intervals. Cleaning should only be done with a stiff brush dipped in petrol or fuel oil. If a cloth is used, minute pieces of fabric are liable to be left in the gauze.

**Service:**

Some of the troubles which may be experienced in service are listed below:

1. Air lock in the system.
Check for air leaks in the suction pipes. Bleed the system.
2. Hand primer lever engaging the diaphragm lever restricting the stroke.
Check the lever return spring.
3. Blocked gauze strainer.
Remove and clean.
4. Faulty diaphragm.
Renew.
5. Inlet and outlet valve retainer plate screws loose.
Re-tighten the screws.
6. Inlet or outlet valve spring collapsed.
Renew Valve.
7. Diaphragm return spring broken.
Renew.
8. Rocker arm spring broken.
Renew.
9. Push rod worn.
Renew.

**To Dismantle:**

With the exception of the rocker arm and lever, repairs can be effected without removing the pump from the tractors. The inlet and outlet fuel connections and the six screws holding the body to the base should be removed. Clean the gauze strainer and examine the inlet and outlet valves. The diaphragm spindle is slotted and engages with the actuating lever. It may be removed by depressing the spring and giving the diaphragm a half turn to disengage the mating slot.

If the rocker arm is to be serviced, remove the two bolts retaining the base to the timing case and lift the pump clear of the engine. Carefully remove the rocker arm spindle circlip and withdraw the spindle.

**Inspection:**

Thoroughly examine the component parts. The diaphragm must be free of holes. Check the action of the valves and if any doubt exists regarding their servicibility, renew. Wash all parts in clean petrol or fuel oil before commencing re-assembly.

**Re-assembly:**

Re-assembly is a reversal of the dismantling procedure with the following points noted:

1. Check the action of the rocker arm and lever before assembling the body to the base.
2. Check that the diaphragm return spring is painted green. Any other coloured spring indicates the wrong tension for this application.
3. Be sure that the diaphragm is correctly engaged with the actuating lever.
4. Check that the inlet and outlet valves are assembled correctly.
5. Ensure that an air tight seal is made between the body and the base. Air leaks will cause faulty operation in the fuel system.
6. Bleed the fuel system before attempting to start the engine.

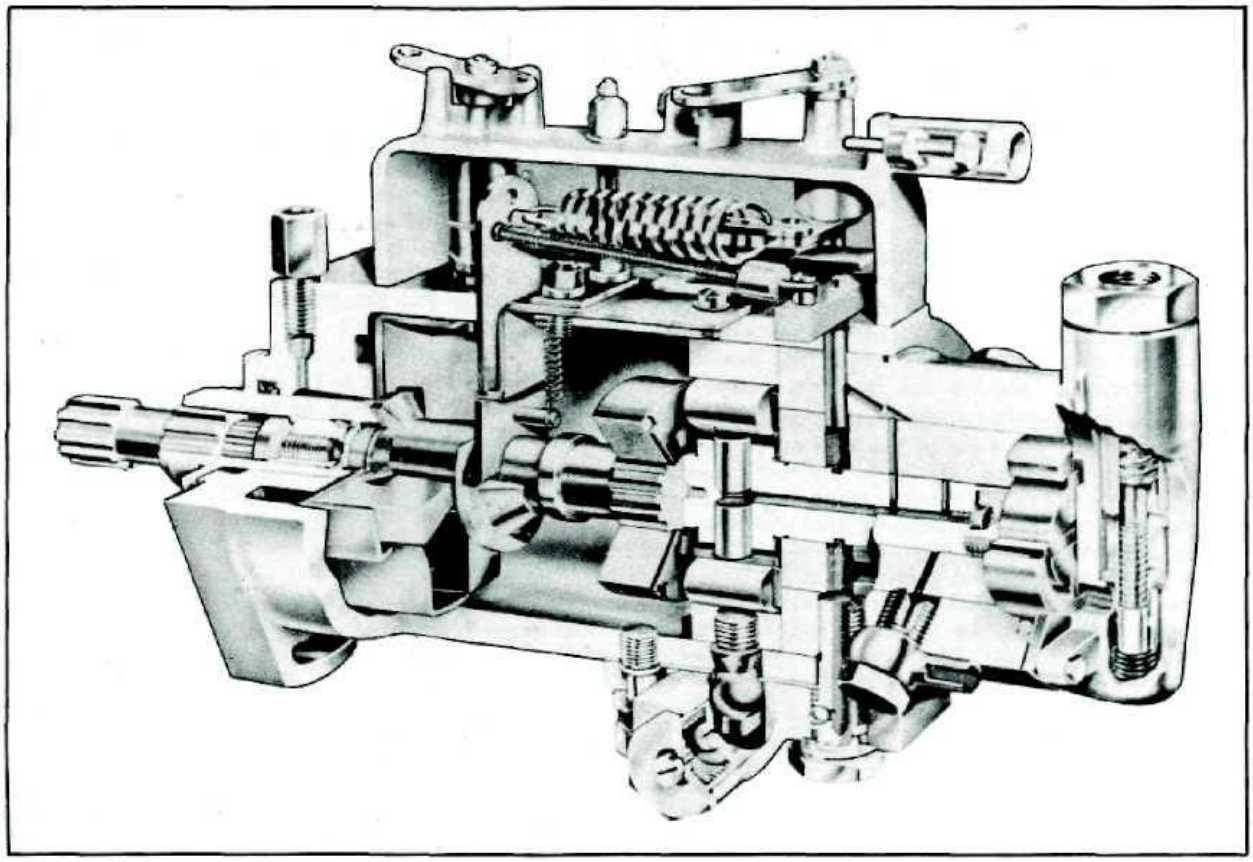


Fig. D.22 — Fuel Pump.

## THE "D.P.A." FUEL PUMP

The C.A.V. "D.P.A." type injection pump may be described as a single cylinder, opposed plunger, inlet metering, distributor type pump. It is relatively simple in design, contains no ball or roller bearings, no gears, no highly stressed springs. The pump, together with its governor, fuel transfer pump, pressure regulating piston, and automatic advance device, forms an oil tight unit in which pressure is maintained, thus preventing the ingress of dust, water or foreign matter during operations.

In this pump, the fuel is pumped by a single element and the fuel charges are distributed in the correct firing order and at the required timing to each cylinder in turn by means of a rotary distributor, integral with the pump. Equality of delivery to each injector is an inherent feature of the pump and deliveries are not subject to maladjustment. Since the timing intervals between injection strokes are determined by the accurate spacing of distributor ports and high precision operating cams and are not therefore subject to adjustment, accurate phasing is also an inherent feature.

There is a central rotating steel member known as the pumping and distributing rotor. It is driven by splines from a drive shaft carried in the base of the pump housing, and carries at its outer end a vane type fuel transfer pump. The rotor is a close fit in a stationary steel cylindrical body called the hydraulic head.

The pumping section of the rotor has a transverse bore containing two opposed pump plungers. These are operated by means of a stationary cam ring, carried in the pump housing, through rollers and shoes sliding in the rotor. The cam ring has four internal lobes. The opposed plungers have no springs, but are moved outwards by fuel pressure.

The distributing port of the rotor contains a central axial passage connecting the pumping space between the plungers with ports drilled radially in the rotor which provide for fuel inlet and delivery. A radial hole is the distributing port, and, as the rotor turns this aligns successively with the four outlet ports in the hydraulic head, from which the injectors are fed via external high pressure pipes.

Four inlet ports are spaced round the rotor at an intermediate position and align successively with a single port in the head. This is the inlet or metering port and admits fuel under the control of the governor.

## METERING OF FUEL

Fuel entering the pump through the fuel oil connection on the end plate, passes through a fine gauze filter to the inlet side of the vane type transfer pump.

The fuel pressure is then raised to an intermediate level, known as transfer pressure, which is controlled by a piston type regulating valve housed in the end plate. Transfer pressure does not remain constant but increases with the speed of rotation of the pump. Fuel at transfer pressure then passes through a passage in the hydraulic head to an annular groove in the rotor and thence to a chamber which houses the metering valve. The metering valve is operated by the engine throttle control and regulates the flow of fuel through the metering port into the pumping section of the rotor. The volume of fuel passing into the pumping element is thus controlled by the transfer pressure, the position of the metering valve, and the time during which an inlet port in the rotor is aligned with the metering port in the hydraulic head.

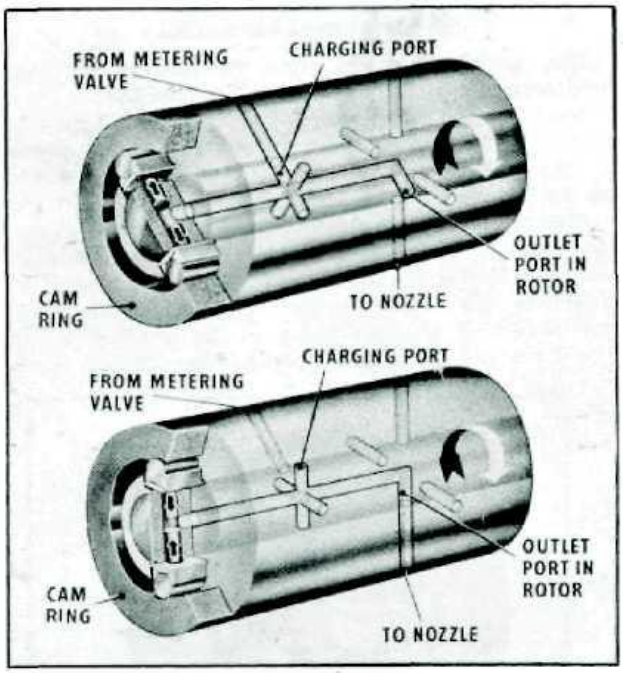



Fig. D.23 — Metering of Fuel.

## PUMPING AND DISTRIBUTION

The functions of pumping and distribution of the metered fuel are clearly illustrated in Fig. D.24. The left hand diagram shows the charging phase and the right hand diagram the actual pumping and distribution of the metered charge.

As the rotor turns, a charging port in the rotor is aligned with the inlet port in the hydraulic head and fuel at metered pressure flows into the central passage in the rotor and forces the plungers apart. The amount of plunger displacement is determined by the amount of fuel which can flow into the element while the ports are aligned. See left hand diagram.

The inlet port closes as rotation continues, and as the single distributor port in the rotor comes into alignment with one of the distributor ports in the hydraulic head, the actuating rollers contact the cam ring lobes, and the plungers are forced inwards as shown in the right hand diagram. High pressure is generated and fuel passes to the injector.

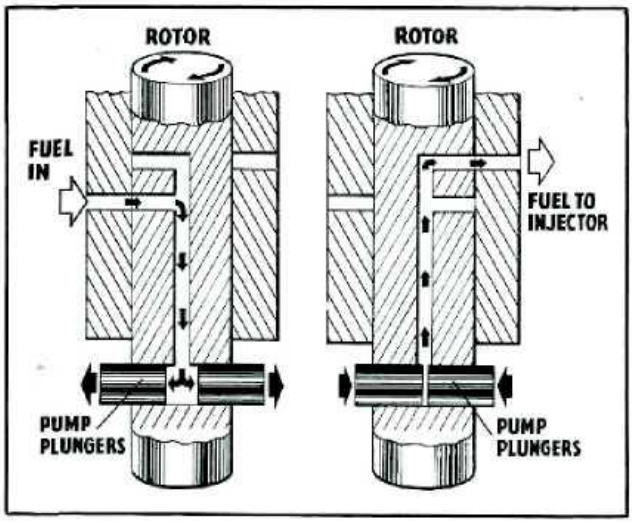



Fig. D.24 — Pumping and Distribution.

## AUTOMATIC ADVANCE

An automatic advance control mechanism is fitted to this "D.P.A." fuel pump. This operates by rotating the cam ring within the pump body. The sectional illustration Fig. D.25 shows the device. A ball ended lever projects from the cam ring and is moved by means of a small piston operated by transfer pump pressure which increases with speed, and rotates the cam ring to advance the point of injection.

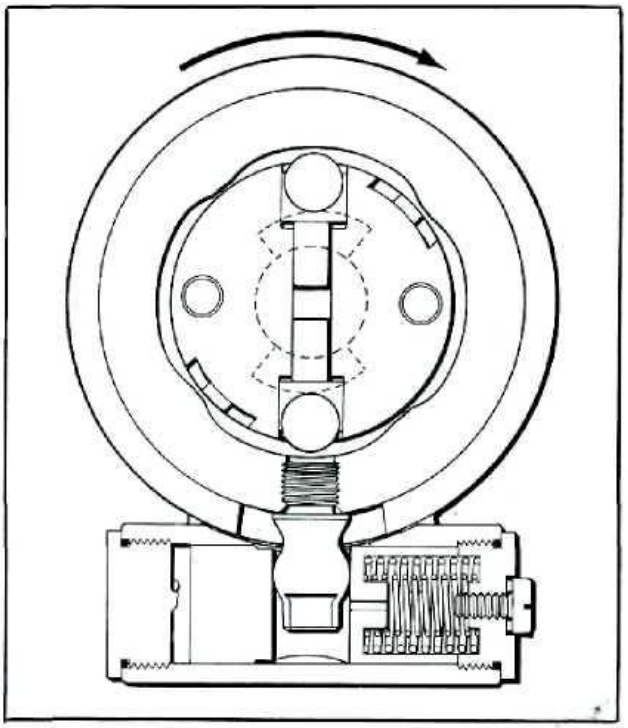


Fig. D.25 — Automatic Advance.

## PRESSURE REGULATING VALVE

The transfer pump end plate houses a pressure regulating valve which controls the transfer pump pressure and also provides a means of by-passing the transfer pump when priming. The sectional view Fig. D.26 shows the valve, which is cylindrical and contains a small free piston, the travel of which is limited by two light springs. In the position shown, the piston is resting against the priming spring; on priming, fuel enters from the central port, moving the valve to the left, uncovering the priming port seen in the valve barrel and enabling fuel to by-pass the stationary transfer pump and fill the system. When in operation, pressure of the fuel from the transfer pump forces the piston back against the regulating spring at the right until the central regulating port is uncovered.

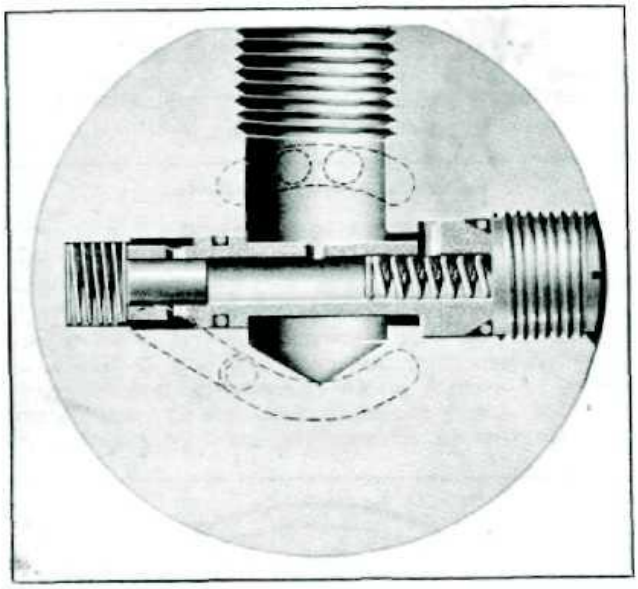


Fig. D.26 — Pressure Regulating Valve.

## MECHANICAL GOVERNOR

The "D.P.A." type distributor pump incorporates a mechanical flyweight governor. The governor unit is fitted on the fuel pump drive shaft.

The rotary metering valve has an axial bore feeding a woodruff slot in its surface, and as the valve is turned by the governor, the slot varies the metering orifice opening.

The action of the flyweights with varying speed is transmitted by a sleeve and simple linkage mechanism directly to the metering valve.

A spring link connects the governor lever with the rotary valve, thus enabling the valve to be closed by the stopping mechanism without having to overcome the governor spring.

A bowden cable, terminating at the dash panel, enables the driver to operate the stopping mechanism whilst remaining seated.

## MAXIMUM FUEL ADJUSTMENT

Since the amount of outward displacement of the plungers is governed by the amount of fuel permitted to enter the element, a maximum fuel setting can be made by limiting the maximum outward movement of the plungers.

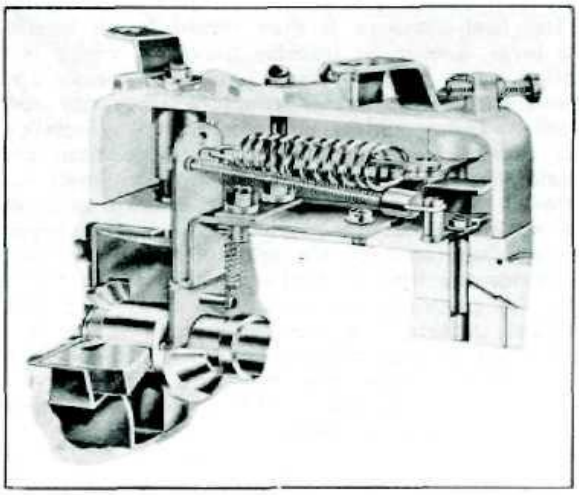


Fig. D.27 — Mechanical Governor.

This setting is made after manufacture or overhaul and cannot be altered by the operator.

The pumping rotor is shown end on, with a drawing of the parts below. The cam rollers (A) are carried in cam roller shoes (B), which gear against the ends of the pump plungers (D). The shoes slide in slots in the rotor and are provided with eccentric projecting lugs (F). These lugs engage with corresponding slots (G) in the top and bottom adjusting plates, the clearance (C) between the lugs and slots being the remaining plunger travel in the position shown. The assembly is locked when set by locking screws

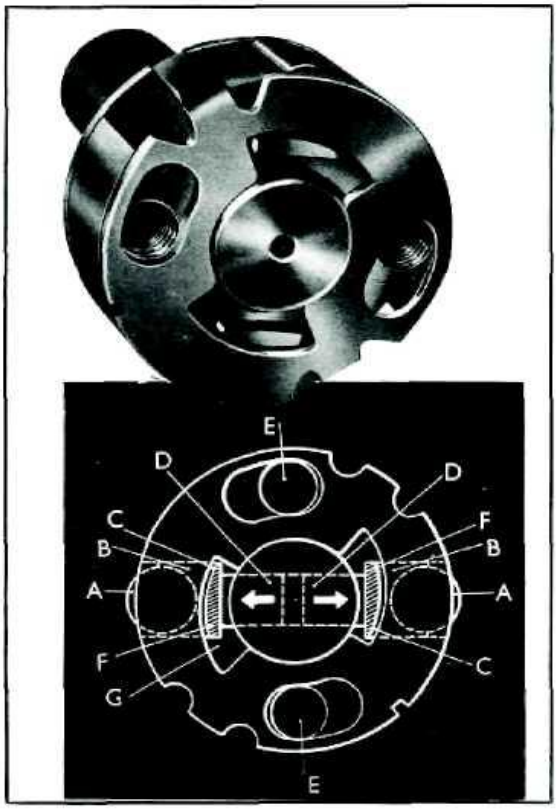



Fig. D.28 — Maximum Fuel Adjustment.

(E). Rotation of the plates controls the travel of the pump plungers and thus limits the maximum fuel injected. This is the only adjustment possible with the pump and is made only to engine makers' requirements.

### REMOVAL AND FITTING THE INJECTION PUMP TO AN ENGINE

The fuel pump is driven by a splined shaft provided with a master spline to ensure the correct relationship between pump and engine. The quill shaft which couples the pump to the engine is mated to the pump with which it was supplied.

On early Four-270D engines, a hexagon-headed screw, screwed into the inner end of the shaft, serves as a locking device and engages the socket head of the hub locking screw. The head of the locking screw is aligned with the socket head of the hub locking screw after the latter has been tightened and quill shafts are therefore not interchangeable and must be returned with the pump when returned for service or overhaul.

When fitting the quill shaft, ensure that it is right "home" as damage will result if the pump is tightened against the mounting flange while the locking screw is seated against the head of the hub securing screw.

Later engines have this locating screw deleted, making the quill shafts interchangeable.

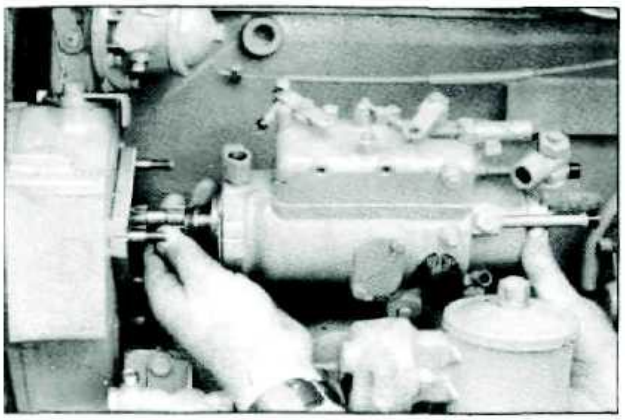


Fig. D.29 — Replacing Injection Pump.

The following procedure should be adopted for the removal and fitting of fuel pumps; —

(1) Remove injector pipes and all fuel pipes.
(2) Remove all controls.
(3) Check the position of the timing marks on the fuel pump flange and fuel pump carrier. These should align.
(4) Remove the three fuel pump securing nuts.
(5) Withdraw the pump and its quill shaft.
(6) Offer up the replacement fuel pump observing the precautions stated above.
(7) Position the fuel pump, check that the scribed lines on the fuel pump flange and the carrier flange align, then tighten the three securing nuts.
(8) Replace all fuel pipes and controls.
(9) Vent the fuel system to ensure that all air is bled from the fuel pump.

### ATOMISERS (Injectors)

**Description:**

From the fuel pump, the fuel is directed via a pressure pipe to the atomiser. The atomiser consists of two main components, the nozzle and the nozzle holder.

The nozzle is of the 'long stem' type and has an extended body (A) in the tip of which is provided the usual valve seating (B) and dome for the injection holes (C). The valve stem (D) is also elongated, but is a clearance fit in the body, the lapped portion of the barrel being confined to the section located above the fuel gallery (E).

The nozzle holder (F) is held in the engine cylinder head at an angle of 25 deg. from the perpendicular by a flange and two studs, and holds the nozzle in its correct position. A spring (G) is carried in the top of the holder against which the nozzle valve opens as a result of the fuel delivery pressure.

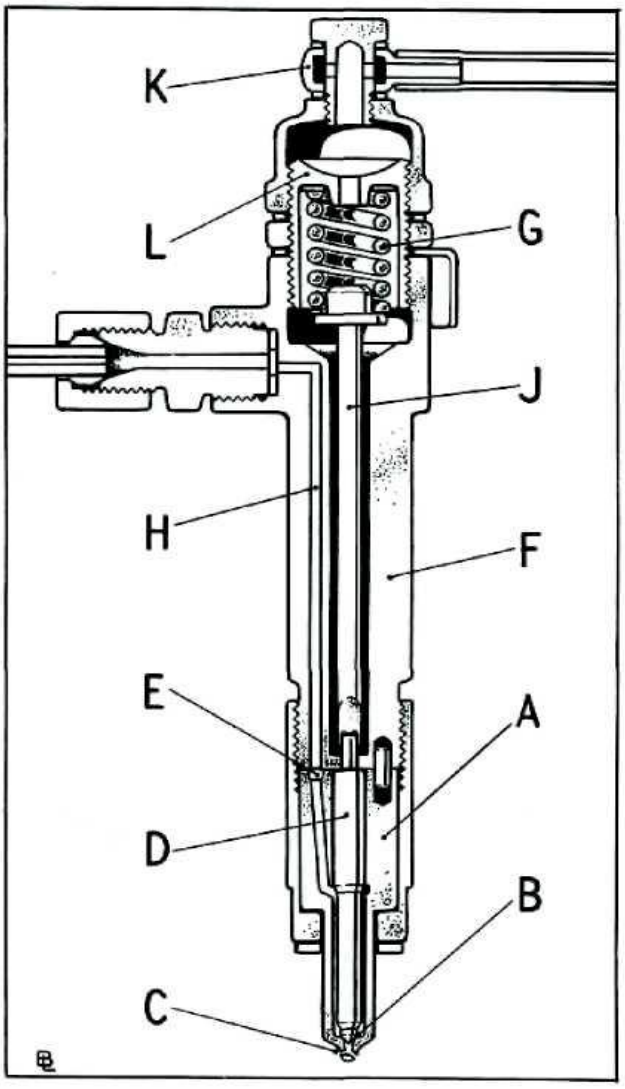



Fig. D.30 — Sectioned Injector.

## OPERATION

The fuel flows via the passage (H) to a fuel gallery at the base of the nozzle body, where pressure is built up until it is sufficient to raise the nozzle needle which is held on its seat by means of a spring bearing on the pressure spindle (J). When the valve lifts, the fuel charge is forced at high pressure through the small discharge area of the spray holes (C) and is broken up into a very fine spray in which form it enters the engine combustion chamber.

Lubrication of the nozzle is by means of excess-fuel within the nozzle holder, the surplus being led away by a pipe attached to the fuel return connection (K).

The nozzle valve operating pressure, in this engine 170 atmospheres, is controlled by the spring acting through the spindle and is adjusted by a compression screw (L).

## REPLACING AN ATOMISER

The joint between the atomiser and cylinder head is made by a copper washer between the lower face of the nozzle cap and the metal of the cylinder.

When preparing to fit the atomiser into place in the cylinder head, care should be taken that only the correct copper washer is used to make this joint. The metal of the cylinder head, the faces of the copper joint ring, and the corresponding face on the nozzle holder cap nut should be perfectly clean if a leak-proof joint is to result.

It is advisable to fit a new joint washer when the atomiser is replaced after having been removed for any reason.

*Ensure that the old washer has been removed from* atomiser or cylinder head.

This joint washer should be an easy, but not loose fit for the atomiser nozzle, and it is because this is such an important feature that the washers especially made for the purpose should be used and none other. *On no account should ordinary sparking plug* type washers be used.

The atomiser can now be fitted in place, care being taken to see that it is an easy fit in the cylinder head and on the holding-down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should then be tightened down evenly in order to prevent the atomiser nozzle being canted and so 'nipped' in the cylinder head.

When fitting the leak-off pipes make sure new washers are used, and before tightening the banjo bolt make sure the washers are a good fit and are placed centrally, and remain central when tightening the bolt.

**Service:**

Atomiser service, service troubles, testing, adjustment and re-assembly are as detailed on pages D-13 to D-16 providing the Four-270D pressure of 170 atmospheres is substituted wherever reference is made to atomiser pressure. The spray pattern of these atomisers also varies in comparison with the L4 atomiser in that they have four spray holes equally spaced around the nozzle tip.

## FUEL PIPES

Two sets of fuel pipes have been fitted to these engines, the current set being introduced at engine number 6233789. A conversion kit P/N 25908 is available for engines prior to that quoted.

No two of the pressure pipes are alike but, with the original set, No. 2 and No. 3 pipes could be positioned incorrectly. To simplify the fitting procedure, the pipes are marked as follows:

**No. 1 Cylinder:**
Nut fuel pump end stamped with letter "X".
Nut atomiser end stamped with figure 1.

**No. 2 Cylinder:**
Nut fuel pump end stamped with letter "U".
Nut atomiser end stamped with figure 2.

**No. 3 Cylinder:**
Nut fuel pump end stamped with letter "W".
Nut atomiser end stamped with figure 3.

**No. 4. Cylinder:**
Nut fuel pump end stamped with letter "V".
Nut atomiser end stamped with figure 4.

As the fuel pump outlet connections are also marked X, U, W, V, no difficulty should be experienced when replacing fuel injection pipes. Fig. D31 shows the fuel pipes correctly fitted.

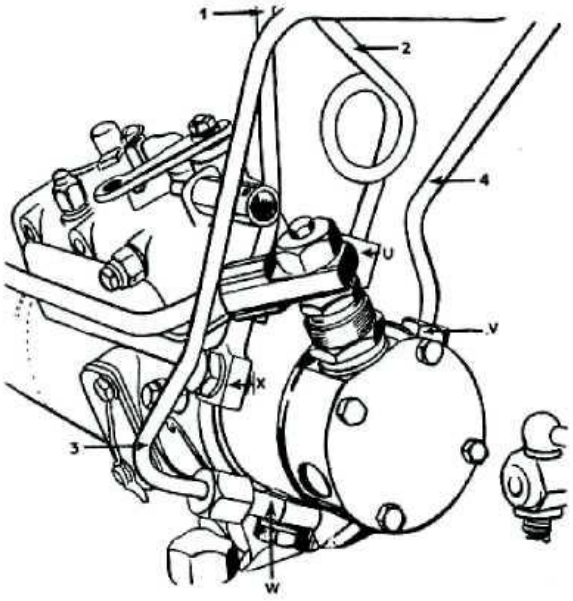



Fig. D.31 — Fuel Pipe Markings.

These markings have been deleted on current fuel pipes as they cannot be assembled incorrectly.

Examine the nipples which will be found on each end of these pipes. If the union nuts have at any time been overtightened there is a risk that the nipples will have cracked or been unduly compressed. If so, leakage will result and a new pipe should be fitted. In this connection bear in mind that the working pressure which these joints must sustain is several thousand pounds p.s.i. Only a perfect joint is satisfactory.

Offer up the pipe to the fuel pump and atomiser unions to check that the pipe fits square at both ends. Do not fit one end and then bend the pipe to square it with the other union. Tighten the unions alternately a little at a time, first one end and then the other. If the nipples are in good condition and the pipe is square to the unions at each end as described previously, no force will be needed to make a good joint.

Use only a standard open-ended 5/8" A.F. spanner.

When changing an atomiser always remove the pipe entirely. Never undo only one end, leaving the other tight.

## FOUR-270D COLD STARTING EQUIPMENT

Fuel for this unit is stored in a container on the nearside of the engine bulkhead. Air enters the container through a check valve to displace fuel gravitating to the heater. The container is inserted in the line returning fuel from the filter and atomiser leak-off connections to the tank and the check valve prevents air leaving the container and maintains the level at the height of the tank return outlet.

Early containers were equipped with a float and needle valve which were lifted up by the fuel to close an orifice in the cap, but a check valve is less prone to damage and leakage. All replacements will be of this type.

## LEAK-OFF PIPES

Plastic pipes form a connection between the Micronic filter relief valve, the four atomiser banjos and the 'Thermostart' reservoir which has a return pipe to the fuel tank.

Should the filter become blocked, the relief valve by-passes the fuel through the leak-off pipe to the 'Thermostart' reservoir. Excess fuel from the atomisers also collects in this pipe and flows to the reservoir.

Prior to serial numbers DM3276, IND1114, CR172, HC226, a copper pipe was fitted between No. 4 banjo and the reservoir. At these serial numbers, the pipe was changed to plastic and all replacements should be of the new pipe P/N30429.

## FUEL PUMP TIMING MARKS

If the fuel pump timing, as outlined on Page B.19 is correct and the engine is still running rough, tests should be conducted to ascertain the condition of the atomisers, valves and rings as possible sources of the above condition.

Should all these components be functioning efficiently, the fuel pump markings must be checked.

The scribed time on the fuel pump driving gear should coincide with a scribed time on the triangulated driving plate.

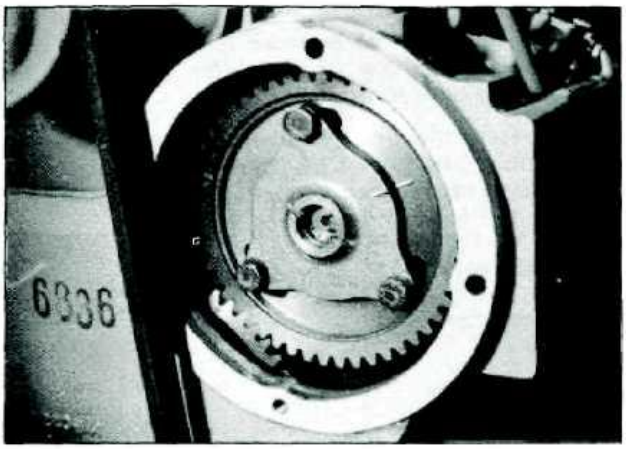



**Fig. D.32 — Driving Gear and Plate Markings.**

If any adjustment is necessary, the three securing bolts should be released and the driving plate turned until the lines match. Tighten the securing bolts.

Should the engine persist with the rough running condition after the above checks have been carried out, an experienced Serviceman can resort to inspecting the fuel pump internal timing marks. This involves removing the manufacturer's seal from the pump side cover plate, and possibly voiding the warranty.

It will be necessary to drop a valve on to No. 1 piston to enable the piston displacement from T.D.C. to be measured, with No. 1 piston on compression. Great care is necessary with this operation as the consequences of a valve dropping right down into the cylinder bore need not be described.

With the aid of a Dial Gauge Indicator on the valve now sitting on the No. 1 piston, the crankshaft should be positioned so that the piston will be .116" B.T.D.C., this being equivalent of 16 deg. B.T.D.C. (on a 15½" dia. flywheel this represents 2.162" of circumference).

At this setting, the position of the scribed line marked "E" in the fuel pump should coincide with the circlip scribed line. If this setting is found to be incorrect, the fuel pump should be removed for servicing.

**Note:** Removal of this inspection plate allows the fuel oil to run out and the fuel system should be bled before attempting to start the engine.

## PRIMING THE FUEL SYSTEM

The fuel system should be bled on any occasion that a fuel connection or fuel filter is removed. Failure to carry out the following procedure will result in erratic engine operation.

To bleed the system, using Fig. D.19:

(1) Slacken the air vent screw (A) on the side of the of the governor control cover.

(2) Slacken the bleed screw (B) on the side of the pump body.

(3) Unscrew, by two or three turns, the vent plug (D) on the top of the filter cover (not the return pipe to the tank).

(4) Operate the priming lever of the feed pump, and when fuel, free from air bubbles, issues from each venting point, tighten the screws in the following order:—

(a) Filter cover vent screw (D).

(b) Bleed Screw (B).

(C) at the pump inlet, operate the priming

(5) Slacken the bleed screw on the pipe union (c) at the pump inlet, operate the priming device and re-tighten when fuel, free from air bubbles, issues from around the threads.

(6) (a) Slacken the unions at the atomiser ends of two of the high pressure pipes, either Nos. 1 and 3 or Nos. 2 and 4.

(b) Set the throttle control at the fully open position and ensure that the "stop" control is in the "run" position.

(c) Turn the engine until fuel oil, free from air bubbles, issues from both the high pressure pipes.

(d) Tighten the unions on the high pressure pipes and the engine may be started.

# ELECTRICAL SYSTEM

The charging system common to all four tractors covered in this manual consists of a starter motor and solenoid, a shunt wound belt driven generator and a compensated voltage regulator. All these units are of Lucas Manufacture.

Two six volt batteries, connected in series, make up the 12 volt storage unit. Early Champion tractors (up to serial No. DM 1509) were fitted with 13 plate batteries, but 19 plate batteries have been fitted to all subsequent Champion models, Canelander and Crusader tractors. A kit of components to convert early Champion tractors to take 19 plate batteries has been made available (Part No. 20082).

Full lighting equipment is standard on the Champion Agricultural and is available as an optional extra for the other units.

With the introduction of the Four-270D engine, a new wiring harness was incorporated. This came in on tractors serial No. DM 1964 Champion Agricultural and serial No. IND396 Champion Industrial.

Wiring diagrams are included in this section.

Prior to serial number DM823 on Agricultural Champions and HC183 on Canelander an electric hour meter was fitted. This has since been superseded by a tractometer driven by a flexible cable from the engine fuel pump drive gear.

## WIRING HARNESSES

Early Champion Agricultural tractors were equipped with one wiring harness containing the wiring for all the electrical equipment. Since then, the harness for all four tractors mentioned in this manual, has been divided into sections to allow for:—

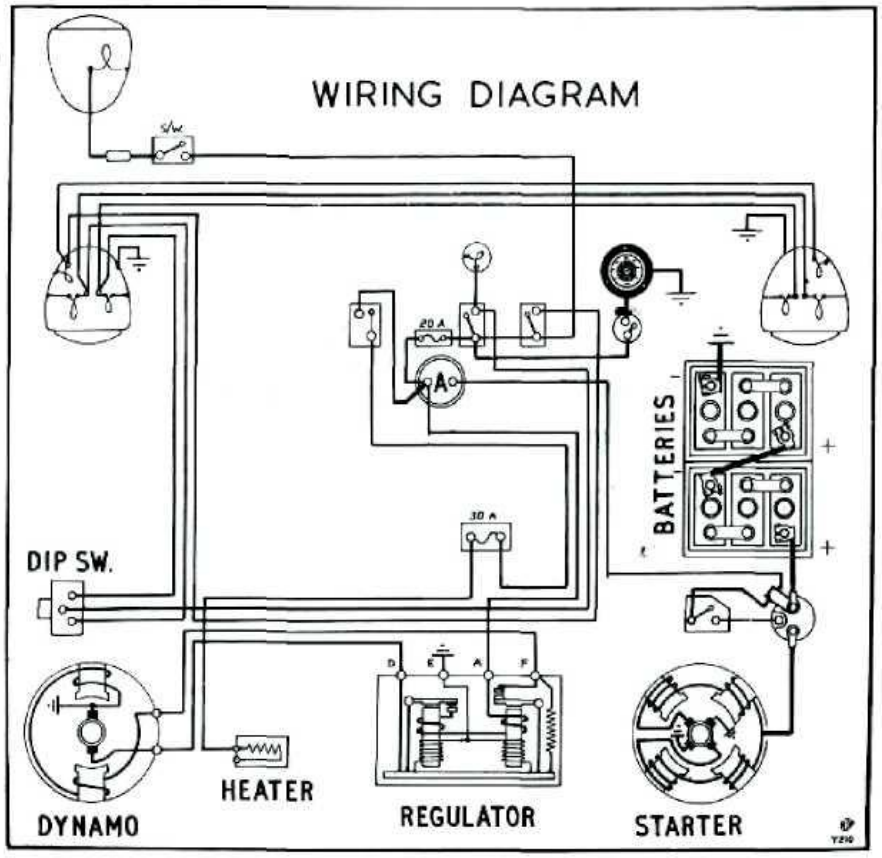
(a) Standardisation of equipment. All models now use the same basic harness.

(b) Ease of removal for tractor overhaul. Break-away coupling are provided in the headlight loom.

(c) Replacement of a section instead of a complete assembly in the event of a wire failure.

(d) To allow ease of fitting for optional equipment.

Early tractors had the battery earth connection attached to a stud welded to the battery frame but due to cases of poor connection to the starter motor earth via the bulkhead, engine mount, flywheel housing and starter motor housing, later tractors have the negative battery terminal connected directly to an earth stud attached to the starter motor end cover.




Wiring diagram for Champions prior to Serial Numbers DM1964 and IND396

## FUSES

On L4 engines prior to the tractor serial Nos. DM1964 Agricultural and IND396 Industrial, the wiring harness incorporated two fuses.

1. A capsule type 20 amp fuse fitted in a bayonet type fitting in the cable connecting the ammeter to the lighting switches. If the tractor is wired as shown in the first wiring diagram complete protection is given to the lighting system and hour meter, if fitted. Tractors should be wired so that the parking lights will still operate when the fuse is blown so that emergency lighting is available. Fuses of larger capacity than 20 amps must not be used with this electrical system.

2. A replaceable wire, 30 amp type fuse is incorporated in the starting heater system. It is fitted in a box attached to the rear of the engine bulkhead. The fuse has a spare supply of 27 S.W.G. fuse wire. Larger fuse wire must not be used, otherwise the ammeter will be damaged.

Tractors subsequent to DM1964 Agricultural and IND396 Industrial and all Canelander and Crusaders, incorporate a 35 amp fuse in the electrical system.

The fuse is fitted in a bayonet fitting in the cable between the ammeter and switch and provides protection from shorting in the electrical system and starting solenoid.

## LIGHTING

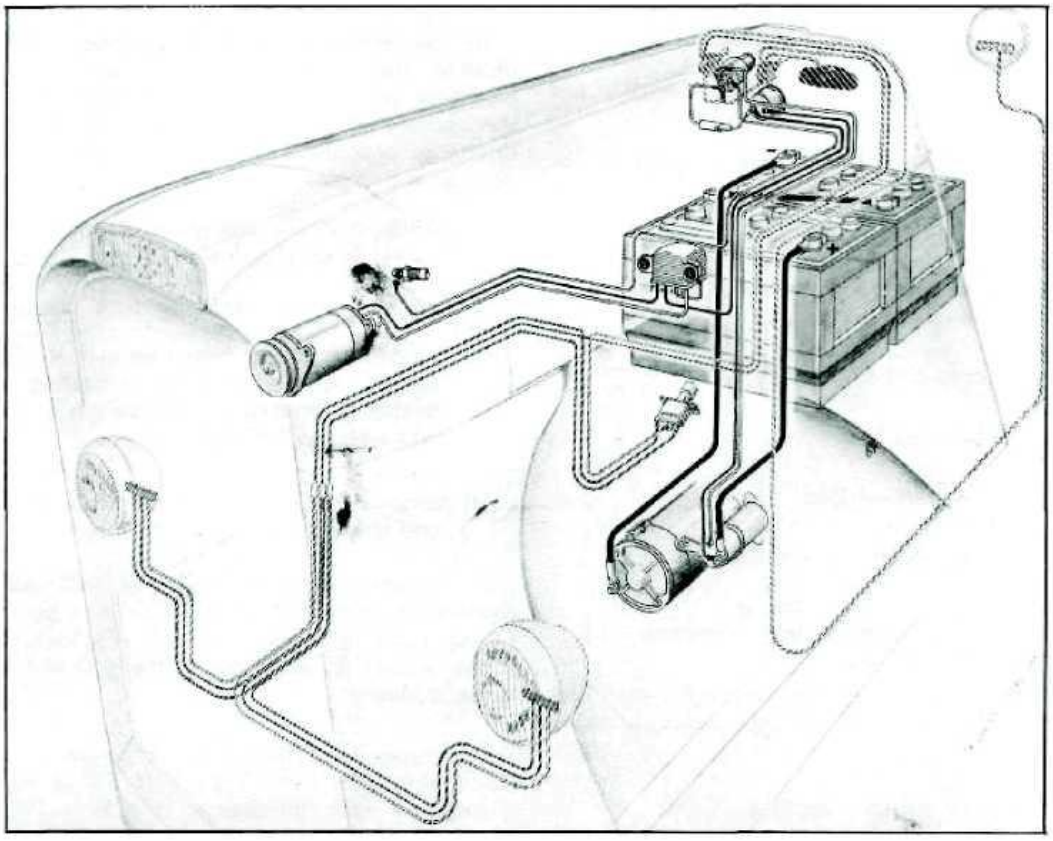
The lighting equipment, standard on Agricultural Champions and optional extras for the other three units, consists of twin headlights, a rear light and an instrument light. The headlights have high and low beams, operated by a foot controlled dipper switch, and parking lights.

Prior to Agricultural Champion Serial No. DM2744, the headlights are of Bosch Manufacture with main globes of 25/25 watt and the parking globes 2 watt. These globes are accessible by backing off the rim screw until it clears the body lug, then pressing the rim, lens and reflector unit free from the base of the lamp body. If any leads are disconnected from the lamp terminals, care must be exercised that they are re-connected correctly.

The rear light, although it is of the same type as the headlights has only one beam connected and no parking globe fitted. This light is operated by a separate switch adjacent to it.

Subsequent to the serial number quoted above and for all future lighting kits, the three Bosch lights have been replaced by three Hella lights with which mounting brackets are not required.

The two Hella headlights are similar to the Bosch units other than they are side mounted directly to holes cut in the radiator shells. The twin headlight filaments and parking light features are retained.



Wiring Diagram for Champions after S/Ns 1964, IND 396, Canelander and Crusaders.

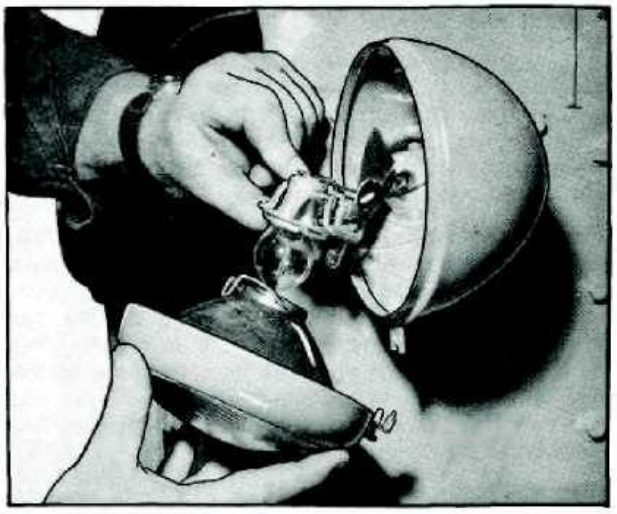


Fig. E.1 – Hella Headlight.

The Hella rear light is fitted with a 35 watt white globe and a 5 watt red globe which are controlled by an integral 3 position switch (white, off red). This light is a fully swivelling unit and is bolted directly to the flange of the offside guard.

A list of possible lighting troubles and their probable causes and corrections are as follows:—

1. Complete failure of all lights:

(a) Batteries flat—Recharge and check the charging circuit.

(b) Fuse Blown—Check wiring and components for shorting. Correct the fault and replace the fuse.

(c) Open circuit between the ammeter and batteries—If this is the case, the charging circuit will also be inoperative.

2. Failure of only one filament:

(a) Blown Globe—Replace.

(b) Faulty Connection—Adjust.

(c) Broken Cable—Repair or replace.

3. Failure of both high or low filaments:

(a) Faulty panel switch (all four headlight main filaments and the panel light will not operate) – replace.

(b) Faulty dipper switch – replace.
Tractors prior to S/Ns DM 1964 and IND 396 only.

(c) Faulty connection in offside headlight – adjust.

(d) Faulty connection between the panel switch, dipper switch and the offside headlight – locate, repair or replace.

In all cases where an open circuit is suspected in a cable or a component, a check may be made by connecting a separate lead across the suspected part. Care must be taken that the separate lead does not connect a "live" terminal to earth otherwise the fuse will be blown, a shorting component may be detected with a battery and lamp or by visual inspection. Shorting is usually accompanied by scorching of the insulation and may usually be readily detected. A good policy is to periodically check that the wiring is not chafing against sharp edges or corners and that all connections are tight.

## STARTING HEATER

Tractors with serial numbers prior to DM1964 Agricultural and IND396 Industrial have a unit consisting of a resistance wire element wound on a plug which is inserted in the intake manifold of the engine. Current is supplied through the ammeter and the previously mentioned separate 30 amp fuse when the dash heater button is pressed. Fuel supplied from a separate tank by the hand pump is sprayed onto the heated plug. The fuel is thus fired and drawn into the cylinders to assist in starting the engine.

As the heater is silent in operation, the only indication that it is functioning is the 20-25 amp discharge registered on the ammeter. Provided that the battery is in a good state of charge, if no discharge or only a small charge is registered, proceed as follows:—

(1) Check that the connections to the ammeter, heater switch and element are tight.

(2) Check the fuse and the fuse connections.

(3) Bridge the switch terminals. If a discharge is shown on the ammeter indicating that the heater is operating, the switch is faulty and will need to be replaced.

(4) Remove the heater element from the manifold and inspect the resistance wire.

An excessive current drain, as indicated by the repeated burning out of the fuse may be caused by wiring shorting to earth or a faulty heater element. If the wiring is not at fault, the element will need to be replaced.

Two types of hand pumps have been fitted with this system, the latter type P/N 23116 being interchangeable with the earlier one P/N 21000. The operation of the pump and fuel connections is covered in section D.

With the introduction of the four 270D engine at engine serial number 6200733, a new cold starting aid known as the 'Thermostart' was incorporated.

The unit is inserted in a tapped hole in the inlet manifold, orientated with the aid of an external arrow engraved on the solenoid cover, and locked in position by a single locknut. The connection of a fuel pipe, complete with shut-off tap and an electrical terminal completes the installation.

In order to provide for automatic operation of the 'Thermostart' a rotary switch which operates both the 'Thermostart' and the starter, is used.

When the switch is operated clockwise, only the starter is engaged, whilst anti-clockwise operation actuates first the 'Thermostart' solenoid and then the starter and 'Thermostart'.

Details of the fuel reservoir are covered in Section D.

At Four-270D engine serial number 6235765 a new cold starting aid was introduced. This unit P/N 25971 uses the same starting switch and fuel reservoir as the previous model, but the solenoid operating switch and the fuel shut-off tap have been deleted.

The new unit can be assembled to engines prior to the above serial number providing the air intake body P/N 25972 is also fitted.

When the element is energised by turning the starter switch to position "H", the resultant element expansion causes an attached check valve to open and fuel to flow across the heated coils. After approximately 15 seconds sufficient heating is accomplished and the switch can be turned to position "HS" engaging the starter, causing the burning fuel to be drawn into the combustion chamber through the inlet manifold.

When the engine starts, the key is released de-energising the element which closes the fuel check valve as it contracts.

## ELECTRIC HOUR METER

Tractors with Serial Numbers up to D.M.823 on both Agricultural and Industrial application, and Canelanders up to Serial Number HC.183, are fitted with Hobbs electric hour meters. The hour meter can also be fitted as optional equipment on both Crusaders and later Industrial tractors.

When fitted, the meter is situated either in the dash panel or on a bracket under the nearside of the top engine cowling. Control is by a pressure switch incorporated in the oil pressure line. The pressure switch sets the meter in operation when a pressure of 4 p.s.i. is reached in the oil pressure line.

The hour meter is sealed against the ingress of dust and moisture and also to prevent tampering. No provision is made for re-setting or zero-ing the meter.

If a replacement hour meter is to be fitted, check that it is a 12-volt unit, and connect the black lead to earth and the red lead to the pressure switch. The second pressure switch terminal is connected to the headlight switch lower terminal.

To check that the hour meter is operating correctly, time the small indicator needle (with the engine running). The needle should take one minute per revolution. The meter may continue to run for up to three minutes after the engine has been stopped.

## BATTERIES

Agricultural and Industrial tractors prior to Serial Number D.M.1510 were originally equipped with 13-plate batteries. At this Serial Number the batteries were changed to 19-plate.

An interim conversion consisted of an outside battery box, fitted to the chassis below the nearside bottom cowl, holding one battery while the other battery was fitted in the original holder.

The final conversion, now current on all Champion, Crusader and Canelander tractors, has the 19-plate batteries fitted to an expanded carrier in the original battery position.

It is important that the units be kept clean, the terminals kept tight and the electrolyte level maintained at the correct level. A sodium bi-carbonate (or ammonia) solution is an effective battery cleaning agent. If the terminals show a tendency to corrode, clean them and apply a coating of petroleum jelly. Keep the filler plug vents clear and maintain the fluid level above the surface of the plates. Use only distilled water for battery topping up.

A check on the battery condition may be made with a hydrometer. A reading of 1.280 indicates a fully charged battery. 1.200 indicates a half charged battery. 1.100 indicates a discharged battery. The battery should usually be at least half charged.

To check that the battery will maintain a high discharge rate, as required by the starter motor, use a heavy discharge tester with a load resistance which will pass about 300 amperes. Apply the tester for about 10 seconds and, with a fully charged battery the voltage for each cell should not drop below 1.5 volts. A rapid fall-off of voltage below this figure would indicate a faulty cell and the battery will need to be reconditioned or renewed.

# GENERATOR

## 1. GENERAL

The generator is a shunt-wound two-pole two-brush machine, arranged to work in conjunction with a regulator and cut-out unit. The output of the generator is controlled by the regulator and is dependent on the state of charge of the battery and the loading of the electrical equipment in use.

When fitting a new control box, it is important to use only an authorised replacement. An incorrect replacement can result in damage to the generator.

## 2. ROUTINE MAINTENANCE

### (a) Lubrication:

Every 100 hours, inject a few drops of engine oil into the hole marked "OIL" at the end of the bearing housing.

On earlier models, unscrew the cap of the lubricator and oil.

### (b) Inspection of Brushgear and Commutator:

Every 1,000 hours, remove the metal band cover to inspect the brushgear and commutator. Check that the brushes move freely in their holders by holding back the brush springs and pulling gently on the flexible connectors. If a brush is inclined to stick, remove it from its holder and clean its sides with a petrol-moistened cloth. Be careful to refit brushes in their original positions in order to retain the bedding. Brushes which are badly worn must be replaced. (See also para. 4 (a) (vii) ).

The commutator should be clean, free from oil or dirt and should have a polished appearance. If it is dirty, clean it by pressing a clean dry fluffless cloth against it while the generator is slowly turned. If the commutator is very dirty, moisten the cloth with petrol.

### (c) Belt Adjustment:

Occasionally inspect the generator driving belt and adjust, if necessary, to take up any undue slackness by turning the generator on its mounting. Care should be taken to avoid overtightening the belt, the tension needed being just enough to drive without slipping. See that the machine is properly aligned, otherwise undue strain will be thrown on the generator bearings.

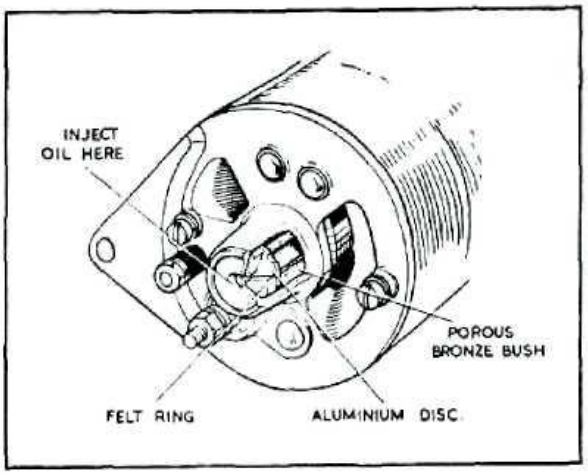



**Fig. E.2 — C.E. Bushing Lubrication.**

| Model | C45P-4 | C45P-5 |
|---|---|---|
| Nominal Voltage | 12 | 12 |
| Cutting-in Speed (r.p.m.) | 900 – 1050 | 1100 – 1250 |
| At Generator Volts | 13.0 | 13.0 |
| Max. Output (Amp.) | 13 | 13 |
| At r.p.m. | 1200 – 1350 | 1450 – 1650 |
| At Generator Volts | 13.5 | 13.5 |
| On Resistance Load (ohms) * | 1.04 | 1.04 |
| Field Resistance (ohms) | 6.0 | 6.0 |

* The load resistors must be capable of carrying the maximum output current without overheating.

## 4. SERVICING

### (a) Testing in Position to Locate Fault in Charging Circuit:

In the event of a fault in the charging circuit, adopt the following procedure to locate the cause of trouble:

(i) Inspect the driving belt and adjust if necessary (see para. 2c.).

(ii) Check that the generator and control box are connected correctly. The larger generator terminal must be connected to control box terminal "D" and the smaller generator terminal to control box terminal "F". Check the earth connection to control box terminal "E".

(iii) Switch off all lights, disconnect the cables from the terminals of the generator and connect the two terminals with a short length of wire.

(iv) Start the engine and set to run at normal idling speed.

(v) Clip the positive lead of a moving coil type voltmeter, calibrated 0—20 volts, to one generator terminal and the other lead to a good earthing point on the yoke.

(vi) Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the voltmeter reading to reach 20 volts, and do not race the engine in an attempt to increase the voltage. It is sufficient to run the generator up to a speed of 1000 r.p.m.

If there is no reading, check the brushgear as described in (vii) below. If there is a low reading of approximately ½—1 volt, the field winding may be at fault (see para. 4e). If there is a reading of approximately half the nominal voltage, the armature winding may be at fault (see para. 4d).

**Note:** Excessive sparking at the commutator in the above test indicates a defective armature which should be replaced.

(vii) Remove the cover band and examine the brushes and commutator. Hold back each of the brush springs and move the brush by pulling gently on its flexible connector. If the movement is sluggish, remove the brush from its holder and ease the sides by lightly polishing on a smooth file. Always refit brushes in their original positions. If the brushes are badly worn, new brushes must be fitted and bedded to the commutator. The minimum permissible length of brush is 7/16". Test the brush spring tension with a spring scale. The tension of the springs when new is 36—44 oz. In service, it is permissible for these values to fall to 30 oz. before performance may be affected. Fit new springs if the tension is low.

If the commutator is blackened or dirty, clean it by holding a petrol-moistened cloth against it while the generator is turned slowly. Refit the cover band and re-test the generator as in para. 4 (a) (vi).

If there is still no reading on the voltmeter, there is an internal fault and the complete unit, if a spare is available, should be replaced. Otherwise the unit must be dismantled (see para. 4b) for internal examination.

(viii) Slacken the driving belt and check the generator bearings for free-running by spinning the pulley by hand. If the armature fails to spin freely, with the brushes raised from the commutator, the generator should be dismantled and the bearings examined.

(ix) If the generator is in good order, remove the link from between the terminals and restore the original connections, taking care to connect the larger generator terminal to control box terminal "D" and the smaller generator terminal to control box terminal "F". Proceed to test the regulator unit as described in that section.

### (b) To Dismantle the Generator:

(i) Take off the driving pulley.

(ii) Remove the cover band, hold back the brush springs and remove the brushes from their holders.

(iii) Unscrew and withdraw the two through bolts. With earlier types it will be necessary first to remove

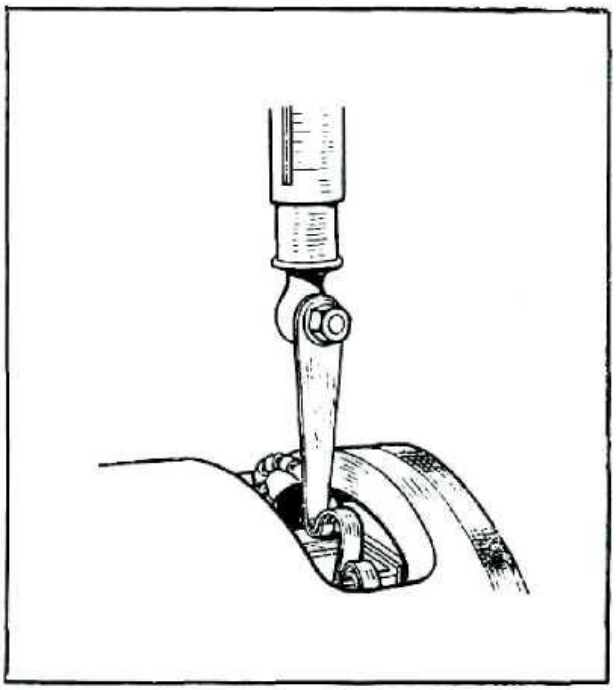


**Fig. E.3 — Checking Brush Spring Tension.**

**To Dismantle—Continued**

the nut, spring washer and flat washer from the smaller terminal (i.e., the Field terminal) on the commutator end bracket.

(iv) The commutator end bracket can now be withdrawn from the generator yoke.

(v) The driving end bracket together with the armature can now be lifted out of the yoke. Take care not to lose the fibre thrust washer or collar.

(vi) The driving end bracket, which on removal from the yoke has withdrawn with it the armature and armature shaft ball-bearing, need not be separated from the shaft unless the bearing is suspected and requires examination, or the armature is to be replaced; in this event, the armature should be removed from the end bracket by means of a hand press.

**(c) Commutator Service:**

A commutator in good condition will be smooth and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. If this is ineffective, carefully polish with a strip of fine glass paper while rotating the armature. To remedy a badly worn commutator, mount the armature, with or without the drive end bracket, in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove more metal than is necessary. Polish the commutator with very fine glass paper. Emery cloth must not be used on the commutator. Undercut the insulators between the segments to a depth of 1/32" with a hack saw blade ground to the thickness of the insulator. (See Fig. E.6).

**(d) Armature Service:**

Indication of an open-circuited armature winding will be given by burnt commutator segments. If armature testing facilities are not available, an armature can be checked by substitution.

To remove the armature shaft from the drive end bracket and bearing, support the bearing retaining plate firmly and press the shaft out of the drive end bracket. When fitting the new armature, support the inner journal of the ball bearing, using a mild steel tube of suitable diameter, whilst pressing the armature shaft firmly home (see also para. 4g).

No attempt should be made to machine the armature core or to true a distorted armature shaft.

**(e) Field Coils Service:**

Measure the resistance of the field coils, without removing them from the generator yoke, by means of an ohm meter connected between the field terminal and the yoke.

Field resistance values are tabulated in para. 3.

If an ohm meter is not available, connect a 12-volt d.c. supply between the field terminal and generator yoke with an ammeter in series. The ammeter reading should be approximately 2 amperes. Zero reading on the ammeter or an "Infinity" ohm meter reading indicates an open circuit in the field winding.

If the current reading is much more than 2 amperes, or the ohm meter reading much below 6 ohms, it is an indication that the insulation of one of the field coils has broken down.

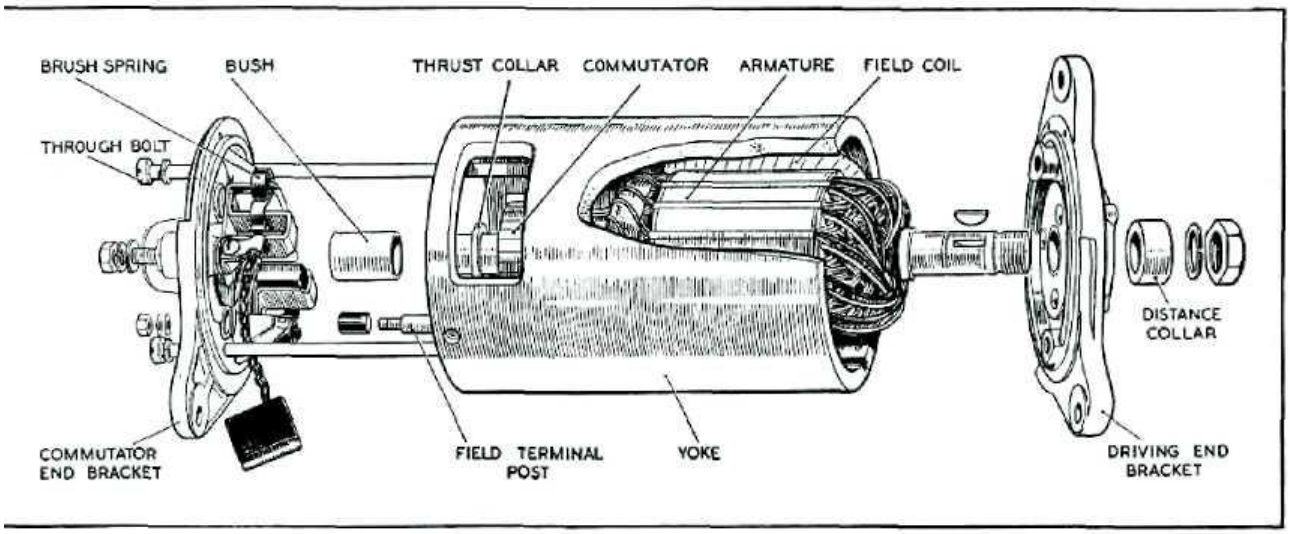



Fig. E.4 — Dismantled view of Generator with Yoke cut away.

In either event, unless a substitute generator is available, the field coils must be replaced. To do this, carry out the procedure outlined below:

(i) Drill out the rivet securing the field coil terminal assembly to the yoke, and unsolder the field coil connections.

(ii) Remove the insulation piece which is provided to prevent the junction of the field from contacting with the yoke.

(iii) Mark the yoke and pole shoes so that the latter can be refitted in their original positions.

(iv) Unscrew the two pole shoe retaining screws by means of a wheel-operated screwdriver.

(v) Draw the pole shoes and coils out of the yoke and lift off the coils.

(vi) Fit the new field coils over the pole shoes and place them in position inside the yoke. Take care to ensure that the taping of the field coils is not trapped between the pole shoes and the yoke.

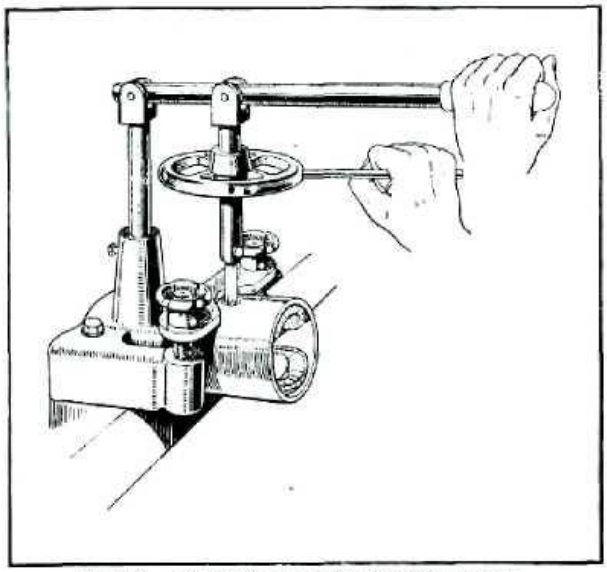


Fig. E.5 — Tightening Pole Shoe Retaining Screws.

(vii) Locate the poll shoes and field coils by lightly tightening the fixing screws.

(viii) Fully tighten the screws by means of the wheel operated screwdriver and lock them by caulking.

(ix) Replace the insulation piece between the field coil connections and the yoke.

(x) Re-solder the field coil connections to the field coil terminal tags and re-rivet the terminal assembly to the yoke.

**(f) Bearings Service:**

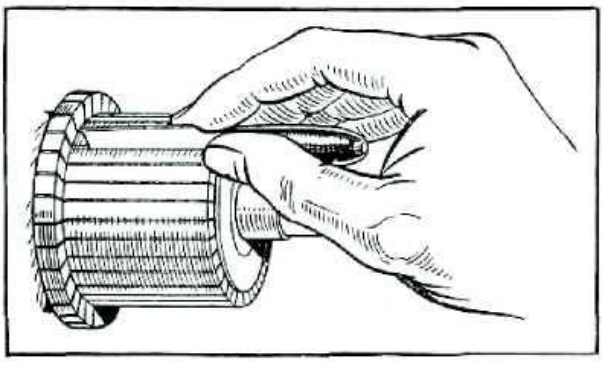
Bearings which are worn to such an extent that they will allow side movement of the armature shaft must be replaced.

To replace the bearing bush in a commutator end bracket, proceed as follows:

(i) Remove the old bearing bush from the end bracket. The bearing can be withdrawn with a suitable extractor or by screwing a tap into the bush for a few turns and pulling out the bush with the tap. Use an 11/16 inch tap. Screw the tap squarely into the bush to avoid damage to the bracket.

With earlier generators, the bush can be pressed out of the bracket using a suitable mandrel.

(ii) Insert the felt ring and aluminium disc in the bearing housing, then press the new bearing bush into the end bracket, using a shouldered, highly polished mandrel of the same diameter as the shaft which is to fit in the bearing, until the visible end of the bearing is flush with the inner face of the bracket. (A few generators were made in which the lubricator incorporated a single porous bronze disc. When replacing a commutator end bearing lubricated by this system, it is important to press the new bush fully



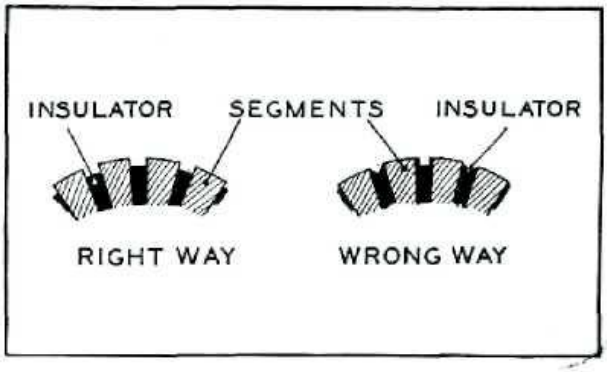



Fig. E.6 — Method of undercutting Commutator Insulation.

**Bearing Service—Continued**

home against the porous bronze disc). Earlier models, fitted with screw-cap type lubricators, do not have a felt ring or aluminium disc in the bearing housing.

Porous bronze bushes must not be opened out after fitting, or the porosity of the bush may be impaired.

**NOTE:** Before fitting the new bearing bush, it should be allowed to stand for 24 hours completely immersed in a good grade thin engine oil; this will allow the pores of the bush to be filled with lubricant.

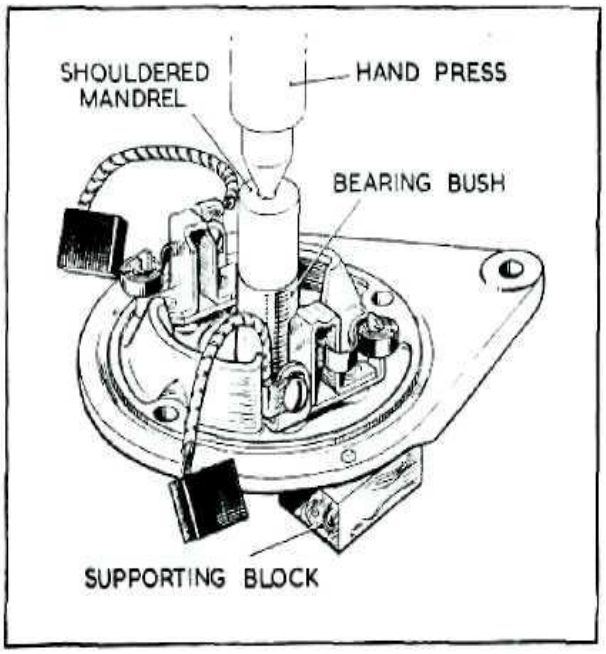



**Fig. E.7 — Fitting Bushing.**

The ball bearing at the driving end on all models is replaced as follows:

(i) Drill out the rivets which secure the bearing retainer plate to the end bracket and remove the plate.

(ii) Press the bearing out of the end bracket and remove the corrugated washer, felt washer and oil retaining washer.

(iii) Before fitting the replacement bearing see that it is clean and pack it with high melting point grease.

(iv) Place the oil retaining washer, felt washer and corrugated washer in the bearing housing in the end bracket.

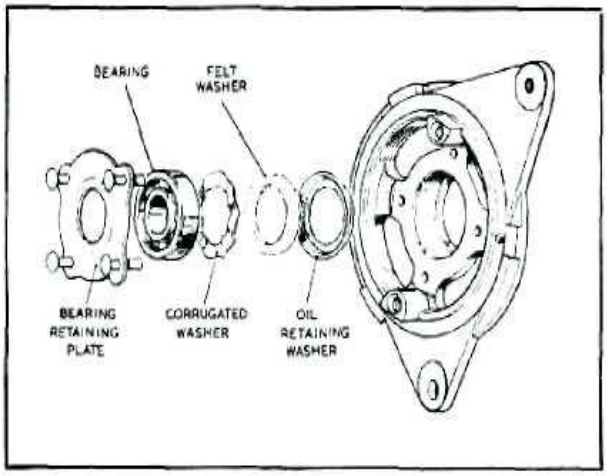



**Fig. E.8 — Exploded view of D.E. Bearing.**

(v) Locate the bearing in the housing and press it home. On earlier models the outer journal should be pressed home by means of a hand press.

(vi) Fit the bearing retaining plate. Insert the new rivets, or original screws, from the inside of the end bracket and open the rivets by means of a punch to secure the plate rigidly in position.

**(g) Reassembly of the Generator:**

In the main the reassembly of the generator is a reversal of the dismantling operations.

The dimensions of the drive end bearing housing have been modified to give a light push fit for the bearing outer journal instead of a tight press fit.

When fitting any drive end bracket to an armature shaft, the inner journal of the bearing **must** be supported by a suitable tube. Mild steel tubes approximately 4 in. long and 1/8 in. thick can be used, the internal diameters being 11/16 inch.

**Do not use the drive end bracket as a support for the bearing whilst fitting an armature.**

# CONTROL BOX

**MODEL RB.107 - RB.108**

## 1. GENERAL

The two control boxes are identical in their operation, completely interchangeable, and have similar methods of adjustment. The difference is apparent in the method of mounting the unit.

Early tractors used the RB.107 box which has the mounting flanges attached to the unit base, and has a removable cover for checking mechanical adjustments. The cover is removed by slackening the clamp screws situated at either end of the unit base.

The RB.108 box has the mounting flanges on the sides of the cover, and the cover is riveted to the base. Electrical faults originating from the control box are few, so the rivets were used to eliminate unwarranted interference with the unit. When an experienced serviceman has completed the electrical tests contained elsewhere in this Section, and traced a fault to the control box, the rivets can be removed and the mechanical settings of the unit checked.

In both these control boxes, the regulator and cut-out contacts are positioned above their respective armatures. It will be noticed that some of the internal electrical joints are resistance brazed.

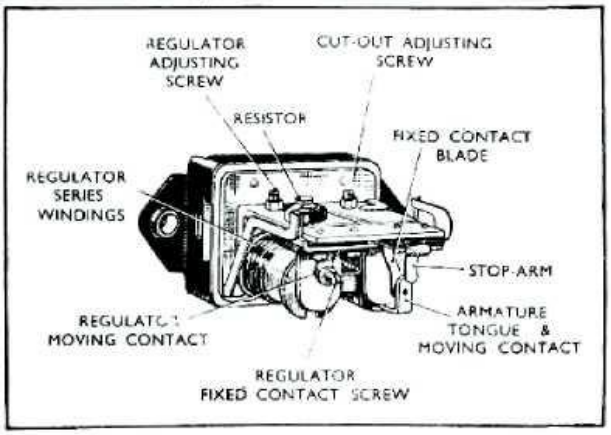



**Fig. E.9 — Control box with cover removed.**

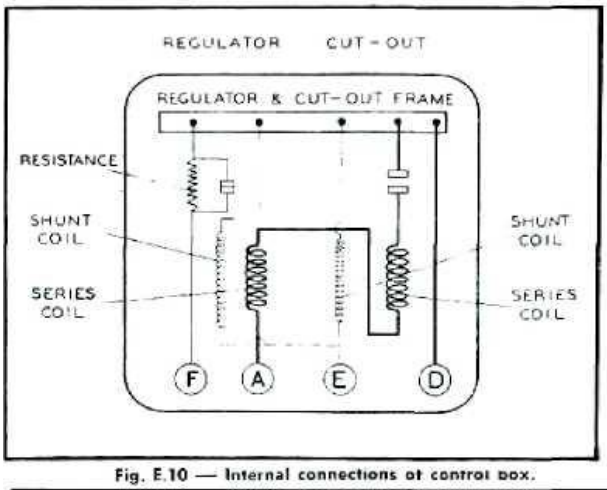



**Fig. E.10 — Internal connections of control box.**

## 2. SETTING DATA

**(a) Cut-Out:**

| | |
|---|---|
| Cut-in voltage . . . . . | 12.7 - 13.3 volts |
| Drop-off voltage . . . . . | 8.5 - 11.0 volts |

**(b) Regulator:**

Setting an open circuit relative to ambient temperature:

| | |
|---|---|
| 10°C. (50°F.) . . . . . | 15.9 - 16.5 volts |
| 20°C. (68°F.) . . . . . | 15.6 - 16.2 volts |
| 30°C. (86°F.) . . . . . | 15.3 - 15.9 volts |
| 40°C. (104°F.) . . . . . | 15.0 - 15.6 volts |

## 3. SERVICING

Before making any adjustment to the regulator, ensure that the dynamo, dynamo drive and battery are in order. When a sound battery does not keep in a charged condition, or if the dynamo output does not fall when the battery is fully charged, the following procedure should be adopted:

**(a) Checking the Wiring Between Battery and Control Box:**

Remove the control box from its mountings and withdraw the cable from terminal 'A' and connect it to the positive terminal of a voltmeter.

Connect the negative terminal of the voltmeter to an earthing point on the machine. If a voltmeter reading is given, the circuit from the battery to terminal 'A' is in order.

If there is no voltmeter reading, examine the wiring between the battery and the control box for defective cables or loose connections. Re-connect the cable to terminal 'A'.

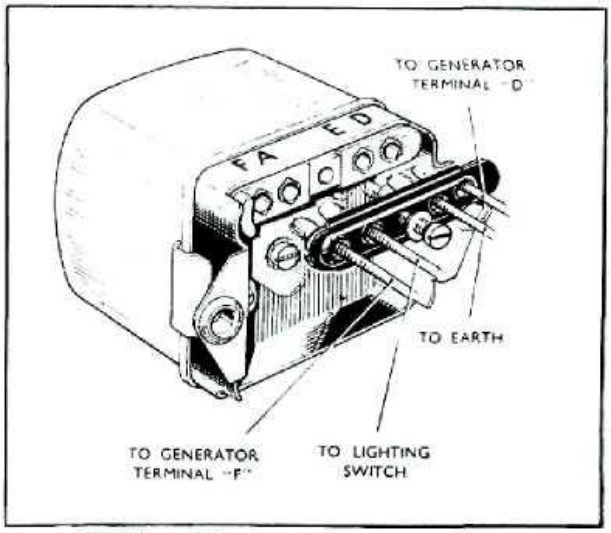



**Fig. E.11 — External connections to control box.**

Check that the dynamo terminal 'D' is connected to control box terminal 'D' and that the cable is in good condition. Similarly, check the cable between terminals 'F' and the dynamo and control box.

**(b) Regulator Adjustment:**

(i) Checking the electrical setting.

The regulator is carefully set during manufacture and, in general, it should not be necessary to make further adjustment. If, however, the charging system is suspected it is important that only a good quality MOVING COIL VOLTMETER (0—20 volts) is used to check the system. The electrical setting of the regulator can be checked without removing the cover from the control box.

Withdraw the plug-in connectors a small distance so that a voltmeter connection can be made to terminals 'D' and 'E'.

Connect the positive lead of the voltmeter to control box terminal 'D' and the negative lead to terminal 'E'.

Remove the earth lead from the battery and check that all the lights are switched off. Never switch on the lights when the engine is running and the batteries are removed or disconnected.

Start the engine. Slowly increase the speed until the voltmeter needle "flicks" and then steadies. Note the reading and stop the engine. If the voltage lies outside the limits given in para. 2 (b), the regulator setting must be adjusted.

If the voltage is within the limits, examine the cut-out as described in para. 3 (c).

(ii) Adjusting the electrical setting.

Adjustment of the regulator requires removal of the control box cover. This is facilitated by removing the control box from the machine and providing temporary connections. Loosen the control box cover securing clips by slackening the securing screws or removing rivets set in the base of the control box and lift off the cover.

It is important that regulator adjustments are carried out with the control box supported in a similar position to that on the machine.

Restart the engine.

Slacken the locknut of the regulator adjusting screw (see Fig E.9) and turn the screw in a clockwise direction to raise the setting or an anti-clockwise direction to lower the setting. Turn the screw only a fraction of a turn at a time and then tighten the locknut. Repeat as above until the correct setting is obtained.

Adjustment of regulator open-circuit voltage should be completed within 30 seconds, otherwise heating of the shunt winding will cause false settings to be made.

Stop the engine.

Remake the original connections and replace the cover. Ensure that the cover seats correctly on the sealing washer.

**Note:** A dynamo run at high speed on open circuit will build up a high voltage. Therefore, when adjusting the regulator, do not run the engine up to more than half throttle or a false setting will be made.

(iii) Adjusting the mechanical setting.

The mechanical or air-gap settings of the regulator, shown in Fig E.12, are accurately adjusted before leaving the works and, provided that the armature carrying the moving contact is not removed, these settings should not be tampered with. If, however, the armature has been removed, the regulator will have to be reset. To do this proceed as follows:

Slacken the fixed contact locking nut and unscrew the contact screw until it is well clear of the armature moving contact.

Slacken the locking nut on the voltage adjusting screw and unscrew the adjuster until it is well clear of the armature tension spring.

Slacken the two armature assembly securing screws.

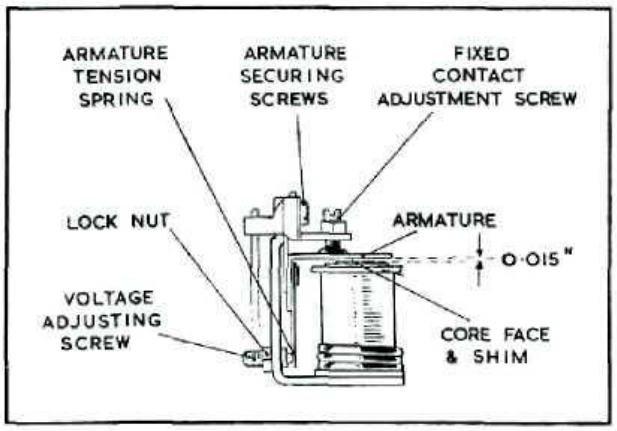



**Fig. E.12 — Mechanical settings of regulator.**

Using a 0.015" thick feeler gauge, wide enough to cover completely the core face, insert the gauge between the armature and core shim, taking care not to turn up or damage the edge of the shim.

Press the armature **squarely** down against the gauge and re-tighten the two armature assembly securing screws.

With the gauge still in position, screw the adjustable contact down until it just touches the armature contact. Re-tighten the locking nut.

Re-set the voltage adjusting screw as described under para. 3 (b) (ii).

**(iv) Cleaning contacts.**

After long periods of service it may be found necessary to clean the regulator contacts. Clean the contacts using fine carborundum stone or fine emery cloth.

Carefully wipe away all traces of dust or other foreign matter with methylated spirits (de-natured alcohol).

**(c) Cut-Out Adjustment:**

**(i) Checking the electrical setting.**

If the regulator is correctly set but the battery is still not being charged, the cut-out may be out of adjustment.

Replace the control box in the testing position, remake the temporary connections and remove the control box cover. Connect a voltmeter between terminals 'D' and 'E'.

Start the engine and slowly increase the speed until the cut-out contacts close. Note the voltage at which this occurs and stop the engine.

This should be 12.7—13.3 volts. If operation of the cut-out takes place outside these limits, it will be necessary to adjust.

**(ii) Adjusting the electrical setting.**

Restart the engine.

Slacken the locknut securing the cut-out adjusting screw and turn the adjusting screw in a clockwise direction to raise the voltage setting or in an anti-clockwise direction to reduce the setting.

Turn the screw only a fraction of a turn at a time and then tighten the locknut. Test after each adjustment by increasing the engine speed and noting the voltmeter reading at the instant of contact closure.

Stop the engine.

Electrical setting of the cut-out, like the regulator, must be made as quickly as possible because of temperature-rise effects.

**Note:** If the cut-out does not operate, there may be an open circuit in the wiring of the cut-out and regulator unit, in which case the unit should be removed for examination or replacement.

**(iii) Adjusting the mechanical setting.**

If for any reason the cut-out armature has to be removed from the frame, care must be taken to obtain the correct air-gap settings on re-assembly. These can be obtained as follows:

Slacken the adjusting screw locking nut and unscrew the cut-out adjusting screw until it is well clear of the tension spring.

Slacken the two armature securing screws.

Press the armature **squarely** down against the copper-sprayed core face and re-tighten the armature securing screws.

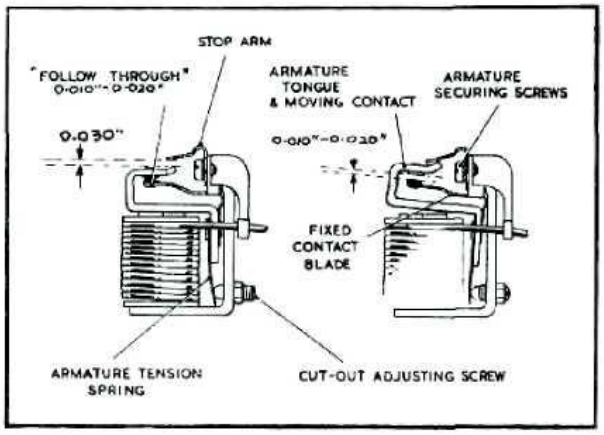



**Fig. E.13 — Mechanical settings of cut-out.**

Using a pair of suitable pliers, adjust the gap between the armature stop arm and the armature tongue by bending the stop arm. The gap must be .030" when the armature is pressed squarely down against the core face. Similarly, the fixed contact blade must be bent so that when the armature is pressed squarely down against the core face there is a "follow through" or blade deflection of .010" to .020".

The contact gap, when the armature is in the free position must be .010" to .020".

Re-set the cut-out adjusting screw as described under para. 3 (c) (ii).

**(iv) Cleaning contacts.**

If the cut-out contacts appear rough or burnt, place a strip of fine glass paper between the contacts—then, with the contacts closed by hand, draw the paper through. This should be done two or three times with the rough side towards each contact. Wipe away all dust or other foreign matter, using a clean fluffless cloth moistened with methylated spirits (de-natured alcohol).

Do not use emery cloth or a carborundum stone for cleaning cut-out contacts.

# PRE-ENGAGED STARTING MOTOR

## WITH PLATE CLUTCH DRIVE

### MODEL M45G 12-VOLT

**1. GENERAL**

The pre-engaged starting motor provides the positive pinion engagement needed when cranking a diesel engine. The characteristic behaviour of the diesel engine when warming up is such that an inertia type drive can be thrown out of mesh with the flywheel. With the pre-engaged type drive, a positive engagement is effected between pinion and flywheel before torque is developed by the motor armature. This engagement can be maintained, despite isolated firing strokes, until the engine runs freely under its own power.

The starting motor is a four-brush four-pole series-wound machine with a yoke diameter of 4½ inches. A lever-operated pre-engaged drive assembly is carried on the armature shaft extension. In the event of tooth-to-tooth engagement, this pre-engagement feature is overruled by the action of a compression spring which, as for a normal engagement, allows the operating lever to close the pilot switch contacts. This energises a solenoid starter switch and causes the armature to rotate and the specially sectioned pinion teeth to slide immediately into mesh with the flywheel.

Also incorporated is a dual-purpose clutch. This protects the motor from overload in the event of backfire and also prevents the motor from being driven by the diesel engine flywheel. The clutch is shim-set during manufacture to slip against two to three times normal full load starting torque. The clutch also allows torque to be transmitted from the starting motor to the engine but not in the reverse direction. In the event of the drive remaining in mesh with the flywheel after the engine has run up to speed, no damage will occur to the starting motor since the clutch is free-running in this direction. Details of drive and clutch assembly are given in Para. 5.

**Operation:**

When starting the engine, a spring-loaded forked lever slides the clutch and driving pinion assembly outwards along the armature shaft extension. The shaft is straight-splined for part of its length so that torque is transmitted, via the clutch, to the pinion. As the latter meshes with the engine flywheel, the final movement of the forked lever operates a pilot switch connected in the solenoid circuit of the main starter switch. Closure of the starter switch contacts

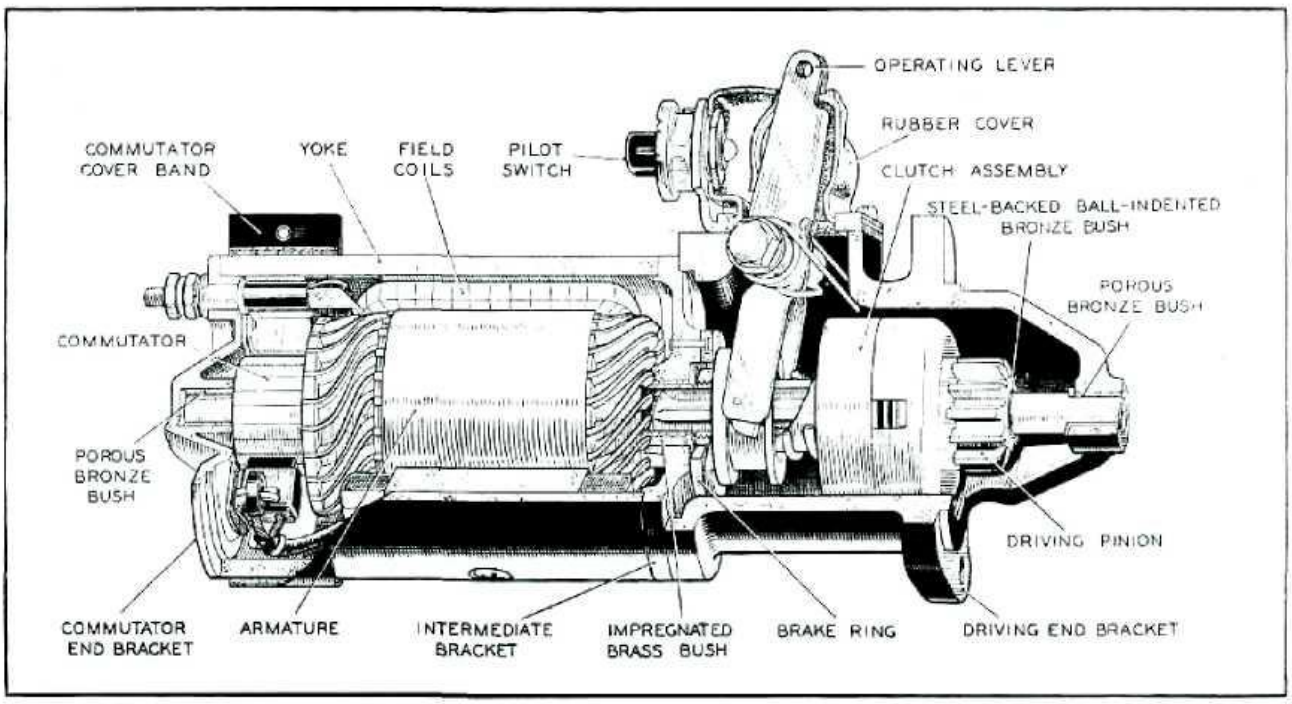



Fig. E.14 — Sectioned view of Starting Motor.

connects the motor to the battery, the armature rotates and cranking commences.

When the engine fires and the forked lever is released, the switch contacts open and the drive assembly is returned to its out of mesh position where it is held under spring pressure against a braking ring mounted on the intermediate bracket. In this way, the starting motor armature is brought rapidly to rest.

## 2. PERFORMANCE DATA

| Lock Torque (lb. - ft.) | Current (amp.) | Starter Terminal Voltage | Torque at 1,000 r.p.m. (lb. - ft.) | Current (amp.) | Starter Terminal Voltage |
|---|---|---|---|---|---|
| 29 | 930 | 5.2 | 13.5 | 510 | 8.0 |

Light Running Current: 70 amp.

Light Running Speed: 8,000 r.p.m. (approx.).

## 3. ROUTINE MAINTENANCE

The only normal maintenance required by the starter motor is to occasionally check the condition of the brushes, brush springs and the commutator. These are accessible by removing the metal band cover from the starter.

Clean the outside of the starter before removing the metal band cover. Check that the brushes move freely in their holders by holding back the brush springs and pulling gently on the flexible connectors. If a brush is inclined to stick, remove it from its holder and clean its sides with a petrol-moistened cloth. Be careful to replace brushes in their original positions in order to retain the 'bedding'. Brushes which are badly worn must be renewed. (See also para. 4(c) (iii).

The commutator should be clean, free from oil or dirt and should have a polished appearance. If it is dirty, clean it by pressing a fine dry cloth against it while the starter is turned by hand from the pinion end.

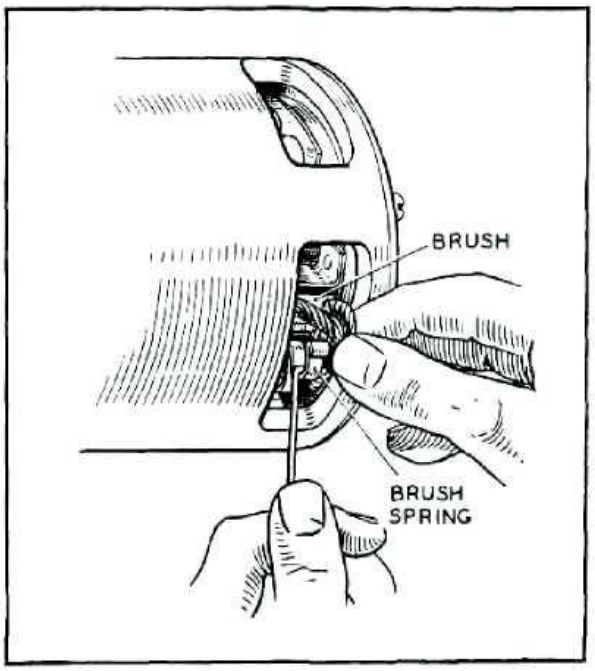



Fig. E.15 — Checking Brush Gear.

If the commutator is very dirty, moisten the cloth with petrol.

## 4. SERVICING

**(a) Testing in Position:**

(i) If the motor is heard to operate but does not crank the engine, this indicates damage to the drive. Remove the starting motor for examination.

(ii) Connect a 0—20 voltmeter across the battery terminals and operate the starter control. If the voltmeter reading drops to about 6 volts, but the starting motor is not heard to operate, this indicates that current is flowing through the starting motor windings but that the armature is not rotating. Remove the starting motor from the engine for examination.

(iii) If the voltmeter reading remains steady at about 12 volts when the starting mechanism is operated, check the circuit for continuity from battery to starting motor via the starter switch. Examine the connections at these units.

(iv) Sluggish or slow action of the starting motor can usually be traced to a loose terminal connection in the wiring circuit.

**(b) To Test the Starter Switch Circuit:**

(i) Connect the voltmeter between the supply terminal of the pilot switch (mounted on the drive-end casting of the starting motor) and earth. No reading indicates a completely discharged battery, faulty cable or loose connection.

(ii) Connect the voltmeter between the second terminal on the pilot switch and earth. Operate the

starter. No reading indicates a faulty pilot switch. To remove the switch, disconnect the pilot cables, pull back the rubber cover from the recess in the pilot switch lock nut, undo the lock nut and remove the switch. The switch adjustment must be checked before the motor is used again. (See para. 4 (k) (ii).

(iii) Connect the voltmeter to the small terminal on the main starter switch and to earth. Operate the starter and observe reading on voltmeter. No reading indicates faulty cable or loose connection.

(iv) Connect the voltmeter between the large supply terminal on the main starter switch and earth. No reading indicates faulty cable or loose connection.

(v) Connect the voltmeter between the second large terminal on the main starter switch and earth, and operate starter. No reading indicates a faulty switch, which must be replaced.

(vi) If the wiring and the pilot and main switches are in order, the starter must be removed from the engine for examination.

**(c) Bench Testing and Examination of Brushgear and Commutator:**

(i) If it is necessary to remove the starting motor from the engine, proceed as follows:

Disconnect the cable from the positive battery terminal to prevent possible short circuits.

Disconnect the heavy cable from the starting motor terminal, and the light cables from the pilot switch.

Remove the pin which couples the starting motor operating lever to the operating linkage. Undo the three fixing bolts and withdraw the starting motor.

(ii) Hold the starting motor yoke in a vice and test by connecting it with heavy gauge cables to a 12-volt battery. One cable must be connected to the starter terminal and the other held against the body or end bracket. Pull back the operating lever slightly, to disengage the drive from the brake ring. Under these light load conditions the motor should run freely at about 8,000 r.p.m.

(iii) If the operation of the starting motor is unsatisfactory, remove the cover band and examine the brushes and commutator. Hold back each of the brush springs and move the brush by pulling gently on its flexible connector. If the movement is sluggish, remove the brush from its holder and ease the sides by lightly polishing on a smooth file. Always refit brushes in their original positions. Renew the brushes when they have worn to 5/16 in. in length. Failure to do this will result in exposure of the running face of the brush flexibles, with consequent damage to the commutator. Check the tension of the brush springs with a spring scale. The correct tension is 30-40 ounces. New springs should be fitted if the tension is low.

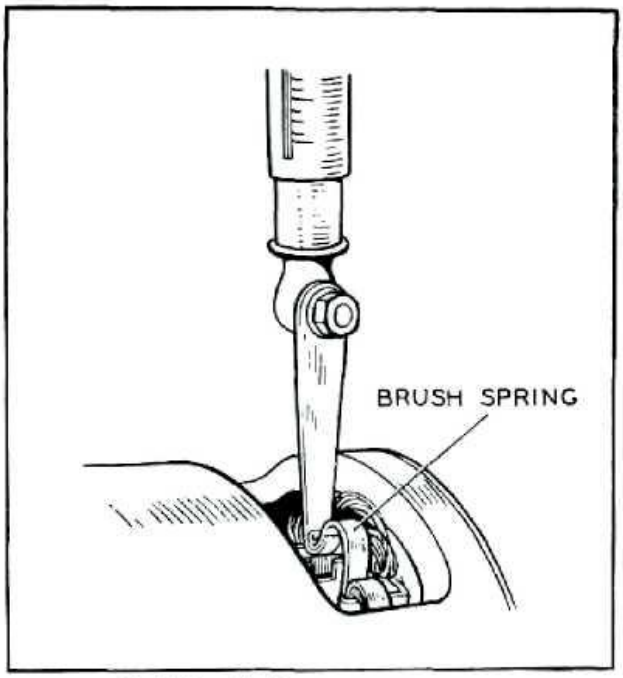



**Fig. E.16 — Checking Brush Spring Tension.**

If the commutator is blackened or dirty, clean it by holding a petrol-moistened cloth against it while the armature is rotated.

(iv) Re-test the starter as described under (ii). If the operation is still unsatisfactory, the unit must be dismantled for detailed inspection and testing.

**(d) To Dismantle:**

(i) Remove the cover band, hold back the brush springs and lift the brushes from their holders.

(ii) Remove the four screws which hold the pilot switch bracket and rubber cover. Lift off the complete pilot switch assembly.

(iii) To release the pinion return spring, use a notched screwdriver or similar tool and press the spring legs inwards and upwards.

(iv) Undo the hexagon nut securing the operating lever pivot bolt. Knock out the bolt using a 2½-in. x 3/8-in. stem. The assembly of lever, distance collars and return spring may then be lifted out and will form a complete unit ready for reassembly.

(v) Unscrew the nut on the starting motor terminal and remove the spring washer, plain washer, and insulating washer from the terminal stem.

(vi) Unscrew and withdraw the two through bolts from the commutator end bracket, and remove bracket from the starter motor yoke.

(vii) Remove the driving end bracket; the drive and clutch assembly can then be slid off the armature shaft extension. Remove the intermediate bracket from the yoke.

(viii) Draw out the armature, carefully.

**(e) Replacement of Brushes:**

The flexible connectors are soldered to terminal tags; two are connected to brush boxes, and two are connected to the free ends of the field coils. These flexible connectors must be removed by unsoldering, and the flexible connectors of the new brushes secured in their places by soldering.

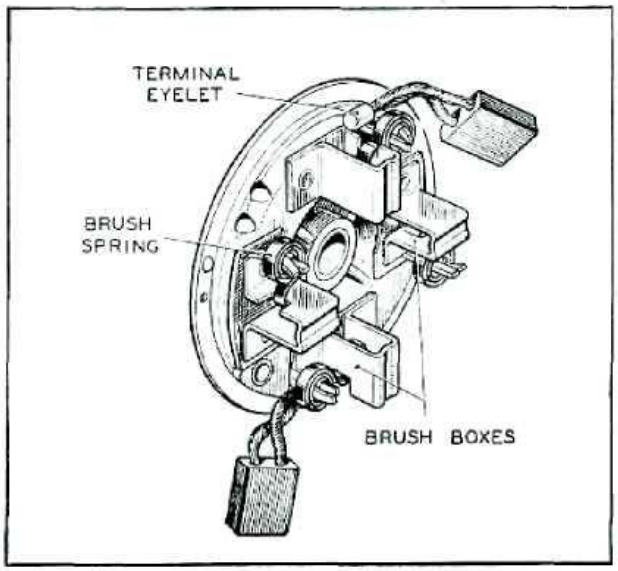



**Fig. E.17 — Brush Connections to C.E. Bracket.**

The brushes are pre-formed so that 'bedding' to the commutator is unnecessary.

**(f) Commutator:**

A commutator in good condition will be burnished and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. Should this be ineffective, spin the armature and polish the commutator with fine glass paper; remove all abrasive dust with a dry air blast. If the commutator is badly worn, mount the armature between centres in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove more metal than is necessary. Finally polish with very fine glass paper. The **insulators** between the commutator segments **must not be undercut.**

**(g) Armature:**

*Examination of the armature may reveal the cause* of failure.

(i) Conductors lifted from the end or ends of the armature core; this would indicate overspeeding or overheating. In either case the clutch would be suspect.

*(ii) Fouling of armature core against the pole faces.* This indicates worn bearings or a distorted shaft. A damaged armature must in all cases be replaced and no attempt should be made to machine the armature core or to true a distorted armature shaft.

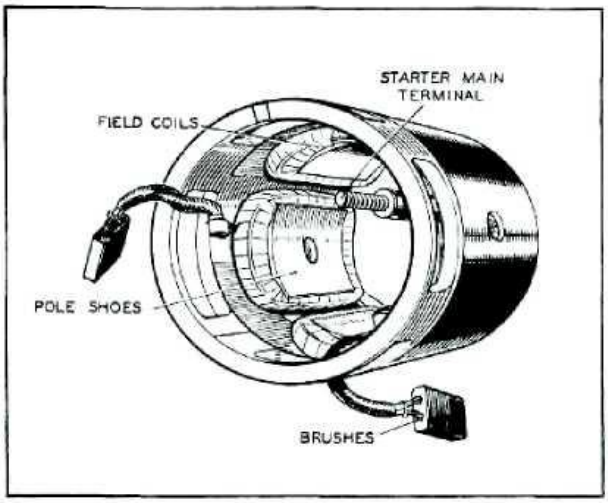



**Fig. E.18 — Brush Connections to Field Coils.**

**(h) Field Coils:**

(i) Test the field coils for continuity using a 12-volt test lamp and battery between the starter terminal and each brush in turn (with the armature removed from machine). Make sure that both brushes are clear of the yoke.

(ii) Using a mains test lamp check between the field terminal and the yoke. (When using the mains for testing, the voltage should be not more than 110 volts supplied through a suitable transformer). Should the lamp light, faulty insulation is indicated of one or more coils. Defective coils must be replaced.

(iii) When carrying out (ii) also test between the insulated pair of brush boxes on the commutator end bracket. Clean off all traces of carbon deposit before testing. If the 110-volt lamp lights, this indicates faulty insulation and the end bracket must be replaced.

**(j) Bearing and Bearing Replacement:**

The armature shaft is supported by three bearings. The commutator and driving end brackets each carry porous bronze bushes, while the intermediate bracket carries a graphite-impregnated brass bush.

Bearings which are worn to such an extent that they

will allow excessive side play of the armature shaft must be replaced as follows:

(i) In the case of the commutator end bracket bearing, a thin-toed extractor will be required to remove the old bush. Alternatively, an 11/16-in. tap can be screwed in and withdrawn complete with bush.

The driving end bush and the intermediate bracket bush can be pressed out.

(ii) New bushes can be fitted using a shouldered, highly polished mandril of the same diameter as the shaft which is to fit in the bearing. Porous bronze bushes **must not be reamered after fitting** as the porosity of the bush will be impaired.

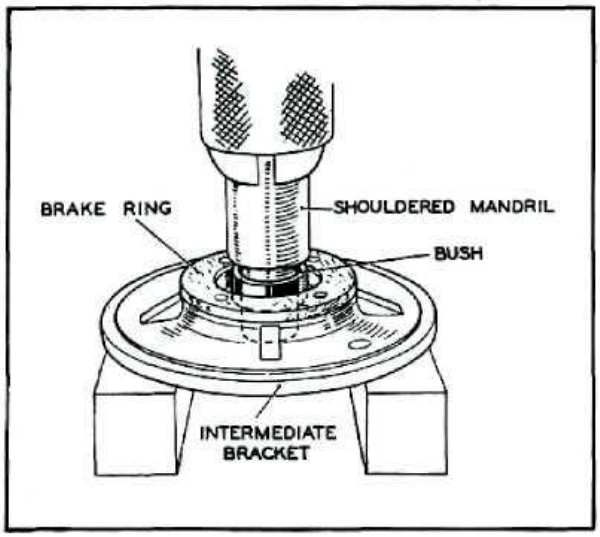



**Fig. E.19 — Fitting Bearing Bush to Intermediate Bracket.**

**Note:** Before fitting a new porous bronze bearing bush it should be completely immersed for 24 hours in clean engine oil SAE.30-40.

**(k) Re-Assembly and Installation of Starting Motor:**

The re-assembly of the starting motor is a reversal of the dismantling procedure, but the following special points must be noted:

(i) When refitting a driving fork assembly of earlier design see that the flat surfaces of the pivoted operating shoes face towards the driving pinion. The shoes must be free to pivot without undue slackness.

(ii) An important adjustment to be made before re-fitting the starting motor to the engine, is to position the pilot switch bracket with respect to pinion travel. A test lamp and battery should be wired in series with the pilot switch terminals in order to determine the instant of contact closure. This must occur when the forked operating lever has moved the pinion 5/8-in. outwards along the armature shaft extension. To adjust, slacken the four pilot switch bracket securing screws, actuate the operating lever by hand, and position the bracket (which has four elongated holes) so that the above conditions are obtained. Tighten the four screws and re-test.

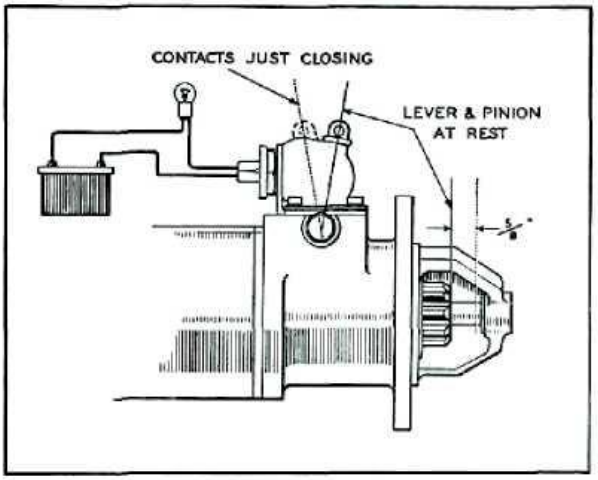



**Fig. E.20 — Method of checking instant of closure of Pilot Switch Contacts with respect to Pinion travel.**

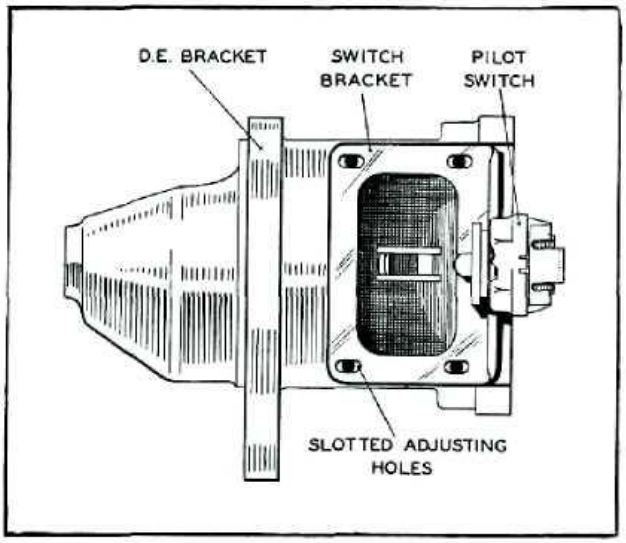



**Fig. E.21 — Pilot Switch Bracket with rubber cover removed to show slotted adjusting holes.**

(iii) In the event of a replacement motor or drive end bracket being fitted, a check must be made, after assembling the starting motor to the engine, of the out-of-mesh clearance. This should be 1/8-in. between the leading edge of the pinion and the engine flywheel.

## 5. PLATE CLUTCH DRIVE

**(a) General Operation:**

The drive assembly is mounted on the armature shaft extension with the Central Core (A) splined to the shaft. When the forked operating lever is moved, the Operating Bush (B) moves the whole of the drive assembly along the motor shaft to engage the pinion with the engine flywheel gear ring. When the teeth are correctly engaged, the pilot switch, actuated by the forked operating lever, energises a solenoid starter switch and the engine is cranked.

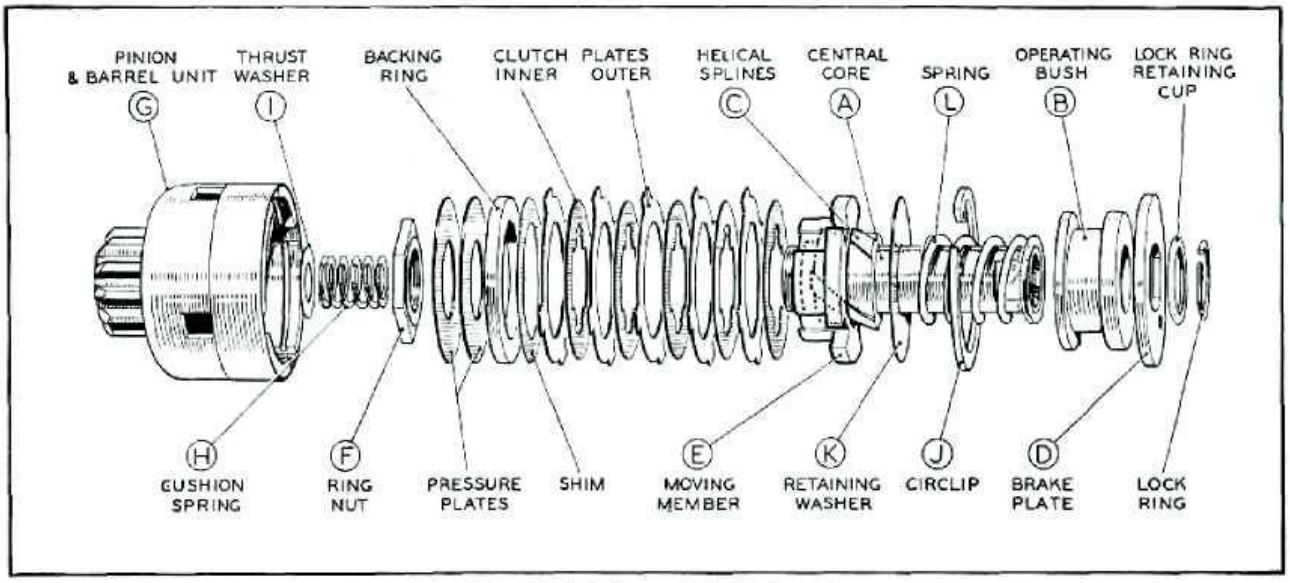



**Fig. E.22 — Exploded view of Clutch Plate Drive.**

If the pinion teeth butt directly on to the flywheel teeth, compression Spring (L) is compressed and causes a build up of pressure behind the pinion until the pilot switch contacts close. The armature then rotates and the pinion slides into mesh.

The drive torque is transmitted through a multi-plate clutch; this is engaged by pressure from the Moving Member (E) which rides up the Helical Splines (C) on the Central Core when the motor is switched on. The Cushion Spring (H) absorbs the initial shock when the drive clutch engages whilst the end thrust from the clutch assembly is taken on the Thrust Washer (I). If the drive remains in engagement after the engine has fired, the clutch automatically disengages and releases the armature shaft—only the Pinion and Barrel (G) are then driven by the engine. The clutch also serves as an overload protection—it is set by means of shims so that it slips at a torque two or three times greater than the maximum developed by the motor. This will protect the whole starter from damage in the event of an engine backfire occurring.

**(b) Dismantling:**

(i) Remove the drive assembly from the armature shaft.

(ii) Take the Lock Ring off the Central Core. To do this, either, place the drive upright with the pinion resting on a soft metal block and compress Spring (L) by using a hand press and distance pieces to push down the Brake Plate (D); or, place the drive in a vice with soft metal jaws and two small metal blocks (1-in. x ½-in. x ½-in.) on either side of the centre core, so that they press on the Brake Plate, then tighten the vice until spring pressure is removed from the Lock Ring.

In either case it will be necessary to prise up the edge of the Lock Ring Retaining Cup so that this can be pushed down the Central Core to release the Lock Ring.

(iii) After the Lock Ring has been removed, gradually release the pressure on the Brake Plate, then remove the Brake Plate, Operating Bush and Spring (L) from the Central Core.

(iv) Next remove the large Circlip (J) and withdraw the Central Core and Clutch Unit from the Pinion and Barrel.

(v) The drive can now be completely dismantled by removing all the parts from the Central Core—with the exception of the two Pressure Plates which are held in position by the Ring Nut (F). If these have to be removed, hold the Centre Core by means of

a spanner placed across the flats on the rear end (by the Lock Ring Groove) and use a large plate spanner to turn the Ring Nut (or a 'C' spanner on later models). This Ring Nut is held in position by peening the core and should be removed only if it is absolutely necessary. If it is taken off, then the core must be peened over again when the drive is re-assembled.

**(c) Re-Assembly:**

The drive is built up in the reverse order, i.e.:

(i) Refit Ring Nut (F) and Pressure Plates, if these have been stripped down.

(ii) Place the Backing Ring, Clutch Plates, Moving Member (E) and Retaining Washer (K) on the core **in the correct order.** Place the Thrust Washer (I) and the Cushion Spring (H) inside the Pinion and Barrel so that they are correctly positioned over the bearing bush.

(iii) Insert the Clutch Unit and refit the Circlip (J).

(iv) Check the slipping torque of the clutch as follows:

Place the unit, pinion down, in a vice with soft metal jaws and tighten until the pinion is firmly gripped.

Apply an anticlockwise torque to the centre sleeve with a suitable 'torque wrench' fastened on to the flats on the central core (near the lock ring groove).

The clutch should not slip until the load applied exceeds 800 to 950 lb.-in.

If the clutch slips at too low a torque figure, dismantle again and **add** shims one at a time until the correct figure is obtained.

If the clutch **does not slip** between the torque limits given, again remove the circlip—dismantle and **remove** shims one at a time until the torque test gives correct figures.

(v) Place the compression spring and brake plate on the core and again compress the spring as for dismantling.

(vi) Place a new lock ring retaining clip in position on the shaft and replace the lock ring.

(vii) Release the pressure on the brake plate so that the retaining cup is pushed over the lock ring.

(viii) Press the edge of the lock retaining ring cup inwards so that it holds firmly **over** the lock ring.

Refit the drive assembly to the motor. The assembled clutch unit and lever mechanism must be capable of being pushed to the full extent of the set travel and of returning under the action of the lever return spring. The drive assembly must move along the armature shaft extension smoothly and freely, but without slackness.

**Adjusting Shims:**

| Part No. | Thickness |
|---|---|
| 22440 .. .. .. .. .. | 0.006" |
| 22441 .. .. .. .. .. | 0.005" |
| 22442 .. .. .. .. .. | 0.004" |

**Starter Motor Modification:**

If starting difficulties are encountered in Champion Agricultural and Industrial tractors fitted with L4 engines, due to low starter motor cranking speed, the complete electrical system should be checked.

Where 13 plate batteries are fitted, it is advisable to replace them with 19 plate batteries, and at this time, or where the conversion has already been done and the electrical check fails to reveal a fault other than the low starter motor cranking speed, it is recommended that the following modification be carried out to the starter motor:—

1. Remove the end plate P/N 21433.

2. Drill out one of the rivets securing an Earth brush holder to the end plate with a 5/16" diameter drill.

3. Fit a 5/16" x 1½" Brass setscrew and locknut in place of the rivet and solder the head of the setscrew to the brush holder.

A longer battery to earth cable will be required and should be connected to the new setscrew.

# PRE-ENGAGED STARTING MOTOR

## WITH SELF-INDEXING DRIVE

### MODEL M45G 12-VOLT

### 1. GENERAL

This starting motor is a four-pole four-brush earth-return machine with series-parallel connected field coils.

A solenoid-operated pre-engaged drive assembly is carried on an extension of the armature shaft. The main features of this type of drive are as follows:

(a) Positive pinion engagement, preventing the pinion being thrown out of mesh whilst starting.

(b) Dual-purpose plate-clutch incorporated in the drive assembly giving over-speed and over-load protection.

(c) Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starting motor begins to rotate.

(d) Armature braking system to ensure rapid return to rest when the starter button is released.

**Operation:**

On depressing the starter button, a solenoid unit mounted on the starting motor yoke is energised and actuates a forked lever to engage the drive pinion with the engine flywheel.

On occasions of tooth-to-tooth abutment, axial movement of the pinion is arrested whilst a helically splined sleeve on which the pinion is carried, continues to move forward. This causes the pinion to rotate relative to the flywheel. When the teeth become aligned, spring pressure slides the pinion into mesh with the flywheel.

When the pinion is properly engaged with the flywheel teeth, a pair of contacts are closed in the rear of the unit. Closure of the contacts connects the motor to the battery, the armature rotates and the starter pinion commences to crank the engine.

When the engine fires and the starter push is released, the solenoid unit is de-energised and the spring-loaded plunger withdraws the starter pinion to its out-of-mesh position. The armature is brought rapidly to rest by the centrifugal action of a pair of spring-loaded brake shoes bearing against a brake drum inside the intermediate bracket.

Provision is made to ensure that in the case of the pinion jamming in mesh (this may occur with an engine which fails to start), there is sufficient slack in the engagement lever-to-solenoid plunger linkage to permit the solenoid switch contacts to open.

In the event of the drive remaining in mesh with the flywheel after the engine has run up to speed, the starting motor armature is protected from over-speeding by the plate clutch assembly. This clutch allows torque to be transmitted from the starting motor to the engine but not in the reverse direction which is free-running.

The clutch is set to slip at between two and three times normal starting torque, thus providing over-load protection for the starting motor. Back firing is a typical example of overloading.

### 2. ROUTINE MAINTENANCE

The only normal maintenance required by the starter motor is to occasionally check the condition of the brushes, brush springs and the commutator. These are accessible by removing the metal band cover from the starter.

Clean the outside of the starter before removing the metal band cover. Check that the brushes move freely in their holders by holding back the brush springs and pulling gently on the flexible connectors. If a brush is inclined to stick, remove it from its holder and clean its sides with a petrol-moistened cloth. Be careful to replace brushes in their original positions in order to retain the 'bedding'. Brushes which are badly worn must be renewed.

The commutator should be clean, free from oil or dirt and should have a polished appearance. If it is dirty, clean it by pressing a fine dry cloth against it while the starter is turned by hand from the pinion end.

If the commutator is very dirty, moisten the cloth with petrol.

Check all connections periodically for looseness, corrosion or dirt.

Sluggish or slow action of the starting motor can usually be traced to a loose terminal connection in the wiring circuit.

### 3. PERFORMANCE DATA

**(a) Starting Motor:**

(i) Light running current: 90 amp. at 8,000—9,000 r.p.m.

(ii) Lock torque: 32.5 lb.-ft. with 900 amp. at 6.4 terminal volts.

(iii) Torque at 1,000 r.p.m.: 15.5 lb.-ft. with 570 amp. at 8.8 terminal volts.

These figures are based on the use of a fully charged 12-volt battery having a capacity of 12.8 amp.-hr. at the 10-hour rate.

**(b) Solenoid Model 7S:**

(i) Operating coil resistance: 0.144-0.166 ohm.

(ii) Holding coil resistance: 0.688-0.792 ohm.

(iii) Spring pressure to close contacts: 3-5 lb. with plunger return spring removed.

(iv) Spring pressure to push plunger home: 9½-14½ lb. with plunger return spring removed.

(v) Plunger movement to close contacts: 0.116-0.189 in.

(vi) Total plunger movement: 0.263-0.273 in.

## 4. SERVICING

**(a) Testing in Position:**

Switch on the headlamps, operate the starter knob or push and watch for the following symptoms:

(i) The lamps dim and the motor does not crank the engine.

Check by hand-cranking that the engine is not abnormally stiff.

Check the battery by substitution.

(ii) The lamps do not dim and the motor does not crank the engine.

Check the starter circuit for continuity.

Check the solenoid unit, see Para. 4 (d) (i).

If the armature rotates, check for a defective drive mechanism.

**(b) Bench Testing:**

(i) Removing the starting motor from the engine. Disconnect the battery. Disconnect and remove the starting motor from the engine.

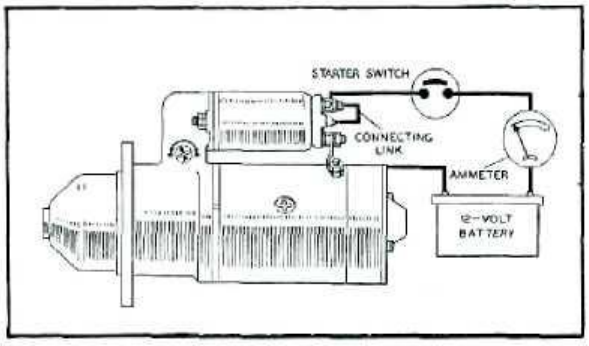



**Fig. E.23 – Measuring light running current.**

(ii) Measuring the light running current.

With the starting motor securely clamped in a vice and using a 12-volt battery, check the light running current and compare with the values given in Para. 3. If there appears to be excessive sparking at the commutator, check that the brushes are clean and free to move in their boxes, and that the spring pressure is correct. See symptoms 7 and 8 in Para. 4. (b) (iv).

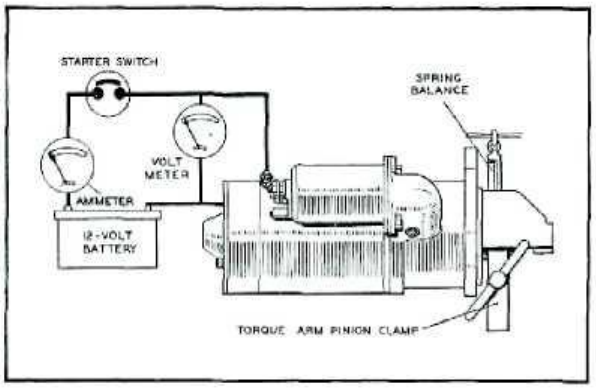



**Fig. E.24 – Measuring lock torque and lock current.**

(iii) Measuring lock torque and lock current.

Carry out a torque test and compare with the values given in Para. 3. If a constant voltage supply is used, it is important to adjust this to be 6.4 volts at the starter terminal when testing.

(iv) Fault diagnosis.

An indication of the nature of the fault, or faults, may be deduced from the results of the no-load and lock torque tests.

| | Symptom | Probable Fault |
|---|---|---|
| 1. | Speed, torque and current consumption correct. | Assume motor to be in normal operating condition. |
| 2. | Speed, torque and current consumption low. | High resistance in brush gear, e.g. faulty connections, dirty or burned commutator causing poor brush contact. |
| 3. | Speed and torque low, current consumption high. | Tight or worn bearings, bent shaft, insufficient end play, armature fouling a pole shoe, or cracked spigot on drive end bracket. Short-circuited armature, earthed armature or field coils. |

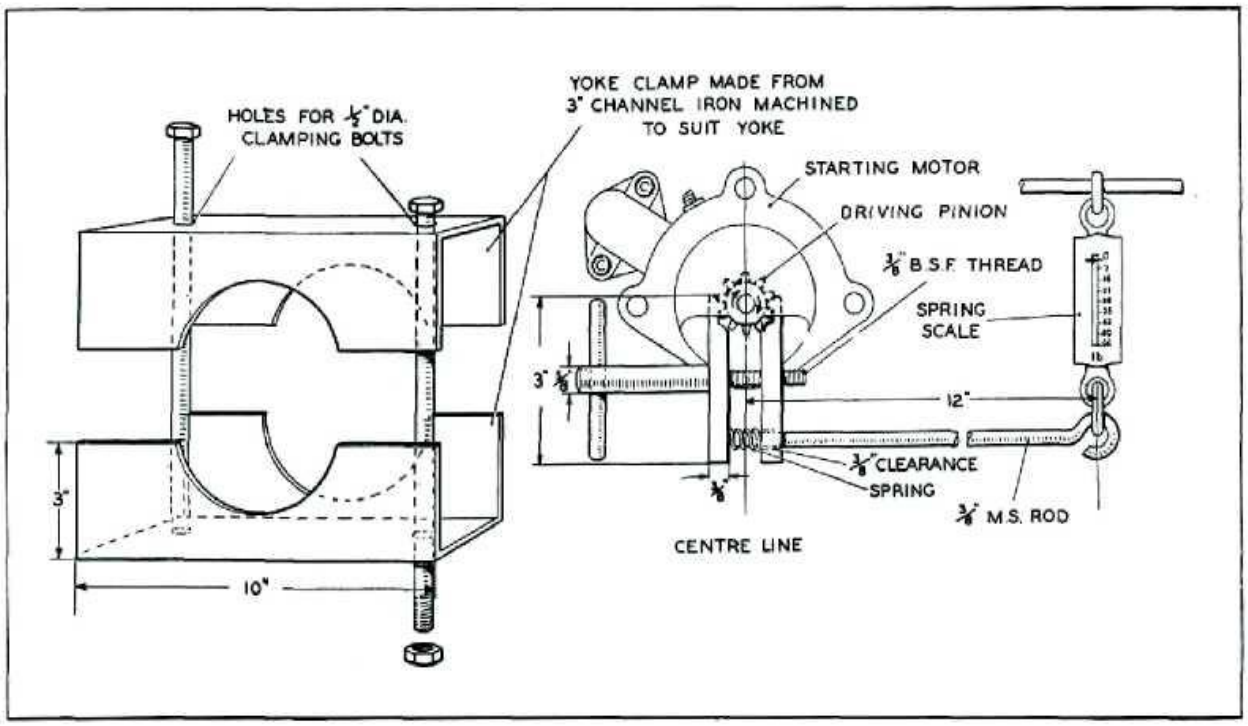



**Fig. E.25 – Apparatus for measuring lock torque.**

| | | |
|---|---|---|
| 4. | Speed and current consumption high, torque low. | Short-circuited windings in field coils. |
| 5. | Armature does not rotate, no current consumption. | Open-circuited armature, field coils, or solenoid unit. If the commutator is badly burned there may be poor contact between brushes and commutator. |
| 6. | Armature does not rotate, high current consumption. | Earthed field winding or short-circuited solenoid unit. Armature physically prevented from rotating. |
| 7. | Excessive brush movement causing arcing at commutator. | Low brush spring tension, worn or out-of-round commutator. 'Thrown' or high segment on commutator. |
| 8. | Excessive arcing at the commutator. | Defective armature windings, sticking brushes or dirty commutator. |

**(c) Dismantling:**

(i) Disconnect the copper link between the lower solenoid terminal and the starting motor yoke.

(ii) Remove the solenoid unit securing nuts. Withdraw the solenoid from the drive end bracket casting, carefully disengaging the solenoid plunger from the starter drive engagement lever.

(iii) Remove the cover band and lift the brushes from their holders.

(iv) Unscrew and withdraw the two through bolts from the commutator end bracket. The commutator end bracket and yoke can now be removed from the intermediate and drive end brackets.

(v) Extract the rubber seal from the drive end bracket.

(vi) Remove the nut securing the eccentric pin (see Fig. E.26) on which the starter drive engagement lever pivots, and withdraw the pin.

(vii) Separate the drive end bracket from the armature and intermediate bracket assembly.

(viii) Remove the washer from the end of the armature shaft extension and slide the drive assembly and engagement lever off the shaft.

(ix) If it is necessary to dismantle the drive assembly proceed as described in Para. 5 (b).

(x) Remove the intermediate bracket retaining ring from the armature shaft extension and slide the bracket and brake assembly off the shaft.

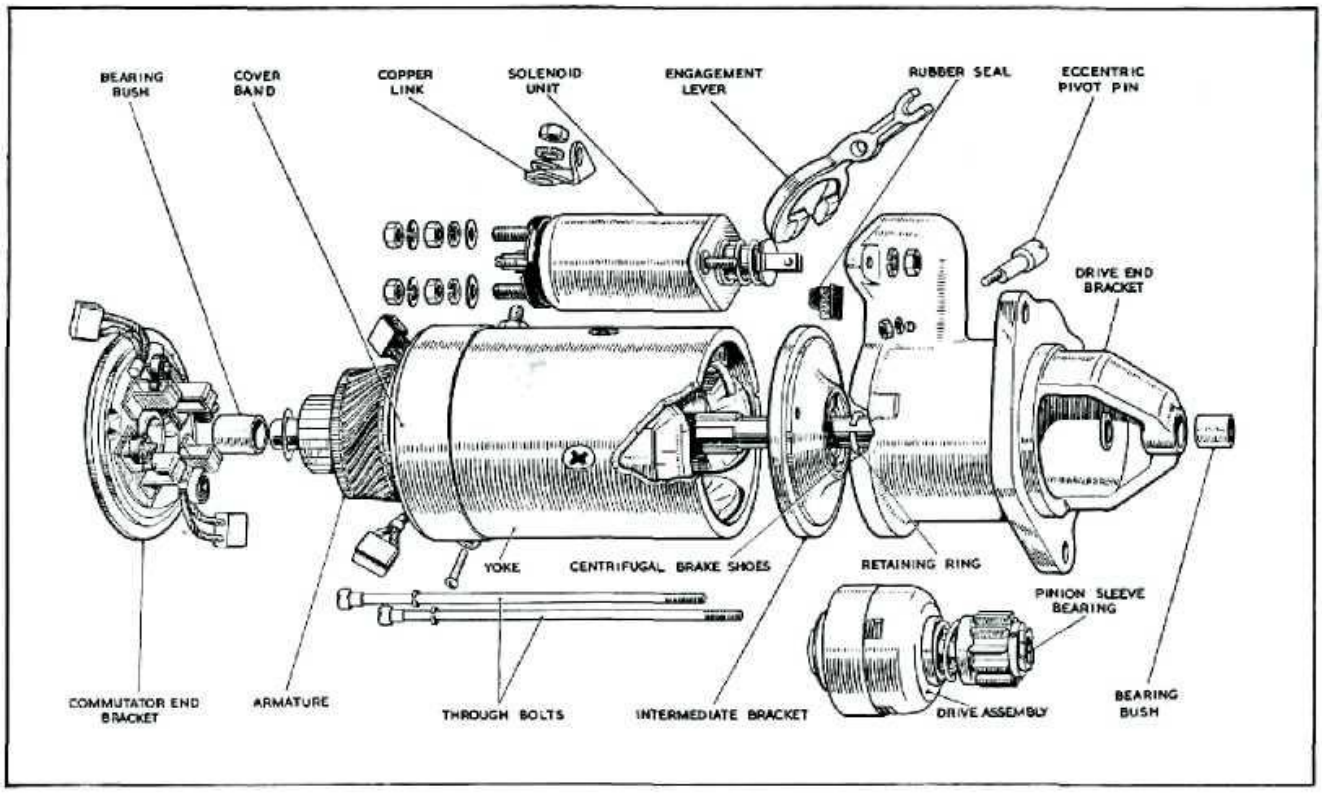



**Fig. E.26 – Starting motor dismantled.**

**(d) Bench Inspection:**

After dismantling the motor, examine individual items.

(i) Solenoid.

The solenoid unit contains two coils; a closing coil which is by-passed when the plunger is drawn fully home, and a hold-on coil to retain the plunger in the fully home position. To check the individual coils, remove the existing connections and using a constant voltage 4-volt d.c. supply with cables of adequate size, proceed as follows:

**Closing coil:**

Connect the supply between the solenoid terminal marked 'STA' and the small terminal on the moulded cover. This should cause a current of 24-28 amperes to pass.

**Hold-on Coil:**

Connect the supply between the solenoid body and the small terminal on the moulded cover. This should cause a current of 5.1-5.8 amperes to pass.

**N.B.** Do not carry out these tests while the solenoid unit is hot.

If a constant voltage supply is not available check the coil resistances, using an accurate method of measuring low resistance values, such as the Wheatstone Bridge. Connect the measuring instrument as for measuring the current and compare the resistances with those given in Para. 3. Also check the spring pressure and plunger travel with the figures given in Para. 3.

If, after testing, the solenoid is found to be faulty it should be replaced by a serviceable unit. Do not attempt to repair a faulty solenoid.

**(ii) Replacement of Brushes.**

The flexible connectors are soldered to terminal tags; two are connected to brush boxes, and two are connected to free ends of the field coils. Unsolder these flexible connectors and solder the connectors of the new brush set in their place.

The brushes are pre-formed so that 'bedding' to the commutator is unnecessary.

Check that the new brushes can move freely in their boxes.

**(iii) Commutator.**

A commutator in good condition will be burnished and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. Should this be ineffective spin the armature and polish the com-

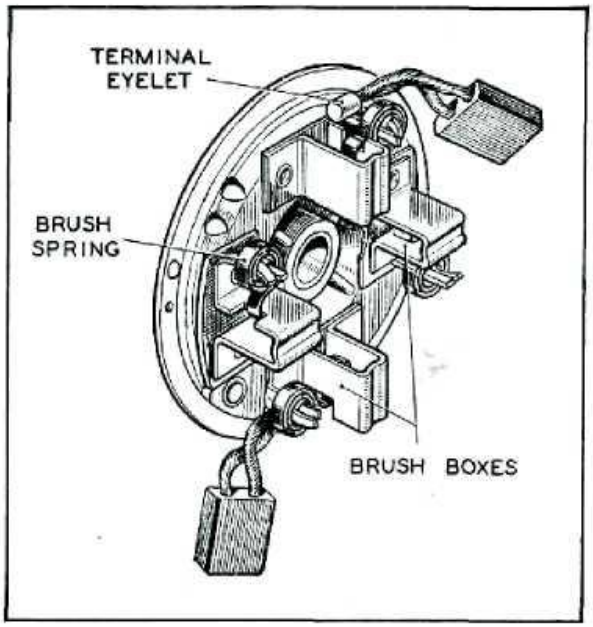



Fig. E.27 – Commutator end bracket.

mutator with fine glass paper; remove all abrasive dust with a dry air blast. If the commutator is badly worn, mount the armature between centres in a lathe, rotate at high speed and make a light cut with a very sharp tool. Do not remove more metal than is necessary. Finally polish with very fine glass paper. The INSULATORS between the commutator segments MUST NOT BE UNDERCUT.

**(iv) Armature—Lifted conductors:**

If the armature conductors are found to be lifted from the commutator risers, overspeeding is indicated. In this event, check that the clutch assembly is disengaging correctly when the engine fires. See para. 5 for details.

**Fouling of armature core against the pole faces:**

This indicates worn bearings or a distorted shaft.

A damaged armature must in all cases be replaced and no attempt should be made to machine the armature core or to true a distorted armature shaft.

**Insulation test:**

To check armature insulation, use a 110-volt a.c. test lamp. The test lamp must not light when connected between any one commutator segment and the armature shaft.

If a short circuit is suspected check the armature on a 'growler'. Overheating can cause blobs of solder to short circuit the commutator segments.

If the cause of an armature fault cannot be located or remedied, fit a replacement armature.

**(v) Field Coils—Continuity test:**

Connect a 12-volt test lamp and battery between the insulated terminal on the yoke and each individual brush (with the armature removed from the yoke). Ensure that both brushes and their flexible connectors are clear of the yoke. If the lamp does not light, an open circuit in the field coils is indicated. Replace the defective coils.

**Insulation test:**

Connect a 110-volt a.c. test lamp between the terminal post and a clean part of the yoke. The test lamp lighting, indicates that the field coils are earthed to the yoke and must be replaced.

When carrying out this test, check also the insulated pair of brush boxes on the commutator end bracket. Clean off all traces of brush deposit before testing. Connect the 110-volt test lamp between each insulated brush box and the bracket. If the lamp lights this indicates faulty insulation and the end bracket must be replaced.

**Replacing the field coils:**

Unscrew the four pole-shoe retaining screws using a wheel-operated screwdriver.

Remove the insulation piece which is fitted to prevent the inter-coil connectors from contacting with the yoke.

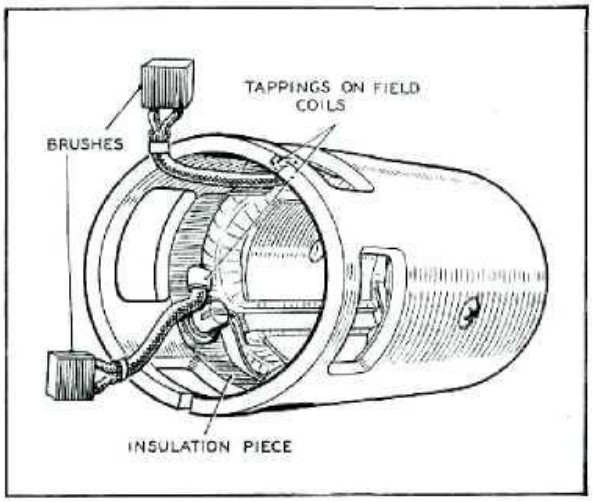



Fig. E.28 – Brush connections to field coils.

Draw the pole shoes and coils out of the yoke and lift off the coils.

Fit the new field coils over the pole shoes and place them in position inside the yoke. Ensure that the taping of the field coils is not trapped between the pole shoes and the yoke.

Locate the pole shoes and field coils by lightly tightening the retaining screws.

Replace the insulation piece between the field coil connections and the yoke.

Finally, tighten the screws by means of the wheel-operated screwdriver while the pole pieces are held in position by a pole shoe expander (see Fig. E.29) or a mandrel of suitable size.

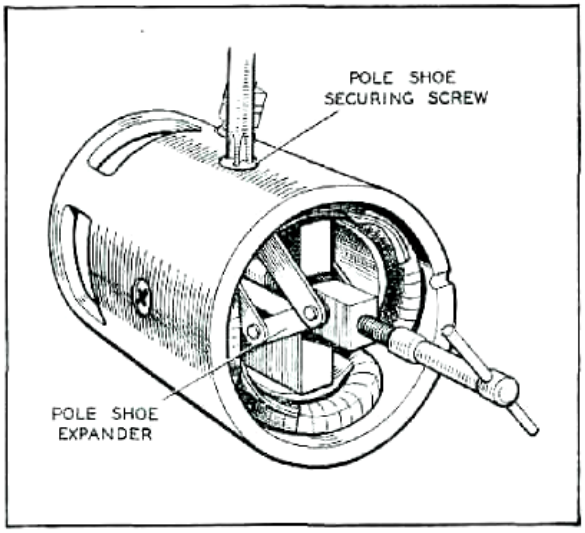



**Fig. E.29 – Tightening pole shoe retaining screws, using pole shoe expander.**

**(vi) Bearings and Bearing Replacement.**

The commutator and drive end brackets are each fitted with a porous bronze bush and the intermediate bracket is fitted with an indented bronze bearing.

Replace bearings which are worn to such an extent that they will allow excessive side play of the armature shaft.

The bushes in the intermediate and drive end brackets can be pressed out, whilst that in the commutator end bracket is best removed by inserting a 11/16" tap squarely into the bearing and withdrawing the bush with the tap.

Before fitting a new porous bronze bearing bush, immerse it for 24 hours in clean engine oil (SAE30-40). *In cases of extreme urgency, this period may* be shortened by heating the oil to 100° C. for 2 hours and then allowing the oil to cool before removing the bush.

Fit new bushes by using a shouldered, highly polished mandrel approximately 0.0005" greater in diameter than the shaft which is to fit in the bearing. ***Porous bronze bushes must not be reamered out after fitting,*** as the porosity of the bush will be impaired.

After fitting a new intermediate bearing bush, lubricate the bearing surface with high quality Lithium or Molybdenium base multi-purpose grease.

**() Reassembly:**

After cleaning all parts, re-assembly of the starting motor is a reversal of the dismantling procedure given in Para. 4 (c), but the following special points should be noted:

(i) To facilitate fitting the solenoid unit to the drive end bracket, ease the drive assembly forward along the armature shaft.

(ii) Set the pinion movement before tightening the eccentric pivot pin securing nut. Para. 4 (f).

**(f) Setting Pinion Movement:**

After complete assembly of the starting motor connect the small centre terminal on the solenoid unit by way of a switch to a 6-volt supply. Connect the other side of the battery to one of the solenoid fixing studs.

Close the switch (this throws the drive assembly forward into the engaged position) and measure the distance between the pinion and the washer on the armature shaft extension. Make this measurement with the **pinion pressed lightly towards the armature** to take up any slack in the engagement linkage. For correct setting this distance should be .020" - .030".

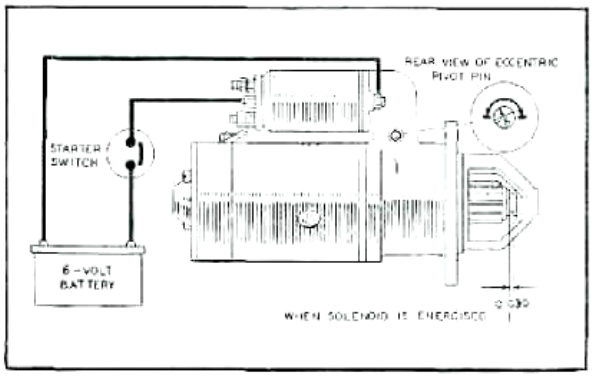



**Fig. E.30 – Setting pinion movement.**

To adjust the setting, slacken the eccentric pivot pin securing nut and turn the pin until the correct setting is obtained. Note that the arc of the adjustment is 180° and the head of the arrow marked on

the pivot pin should be set only between the arrows on the arc described on the drive end bracket casting.

After setting, tighten the securing nut to retain the pin in position.

**Note:** In the event of a replacement motor or drive end bracket being fitted, check the out-of-mesh clearance when assembling the starting motor to the engine. This should be 1/8" ± 1/32" between the leading edge of the pinion and the engine flywheel.

## SELF-INDEXING PLATE CLUTCH DRIVE

### (a) General Operation:

The drive assembly is mounted on the armature shaft extension with the clutch driving sleeve splined to the shaft. When the starter switch is operated the engagement lever pushes the drive assembly along the shaft to engage the pinion with the flywheel.

This movement clamps the clutch plates together and torque is transmitted to the barrel unit.

If, after the engine fires, the torque reverses direction, the moving member releases its pressure on the clutch plates and the clutch automatically disengages and releases the armature shaft—only the pinion and barrel unit are driven by the engine.

If the clutch is overloaded it slips at a torque two or three times greater than the maximum developed by the motor. This overload protection feature is effected by shim-setting the engagement pressure on the clutch plates. When the moving member exerts pressure on the clutch plates, pressure plates are compressed by the backing ring. This compression determines the amount of torque which can be transmitted by the clutch plates, and is pre-set by shims inserted between the backing ring and the clutch plates.

### (b) Dismantling:

(i) Remove the drive assembly from the armature shaft.

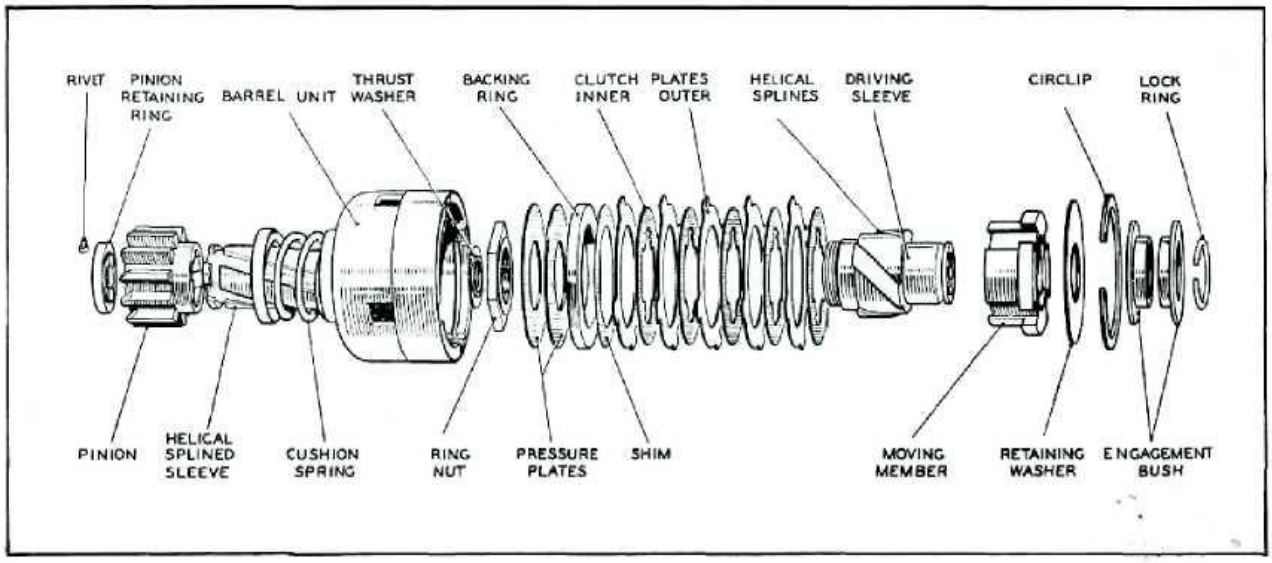



Fig. E.31 – Starter drive dismantled.

The pinion is carried on a helically splined sleeve which is cleated to the barrel unit containing the plate clutch assembly. In the event of tooth-to-tooth engagement the forward movement of the pinion ceases while the helical splined sleeve continues to be pushed forward. This rotates the pinion relative to the flywheel gear ring. When the teeth become aligned for meshing the compressed cushion spring slides the pinion into mesh with the flywheel.

When the armature shaft rotates the drive, torque is transmitted from the shaft through the clutch driving sleeve, plate clutch assembly and barrel unit, to the driving pinion. The clutch is engaged by pressure from the moving member which rides up the helical splines on the driving sleeve when the armature shaft rotates.

(ii) Remove the lock ring from the driving sleeve.

(iii) Lift two halves of the engagement bush off the driving sleeve.

(iv) Using a suitable circlip extracting tool, extract the clutch retaining circlip from the barrel unit and withdraw the driving sleeve and clutch unit.

(v) The clutch assembly can now be dismantled by removing all the parts from the driving sleeve—with the exception of the two pressure plates which are held in position by the ring nut. To remove the ring nut, slide the driving sleeve on to the splined armature shaft and, using soft metal jaw plates, clamp

the armature in a vice. File away the peened rim and use a spanner measuring 1-5/16" across the flats to remove the ring nut.

When re-assembling, fit a new ring nut and peen the rim over the notch in the driving sleeve to lock the nut in position.

(vi) To remove the pinion from the helically splined sleeve, knock out the rivet which secures the pinion retaining ring. The retaining ring, pinion, cushion spring with cup washers and the sleeves can now be separated.

**(c) Re-Assembly:**

Reverse the dismantling procedure described in Para. 5 (b) noting the following important points:

(i) The correct cushion spring tension is 11 lb. measured with the spring compressed to 7/8" in length and 16 lb. with the spring compressed to ½" in length.

(ii) Check the slipping torque of the clutch as follows:

Fit the drive assembly on the splined armature shaft and clamp the armature between soft metal jaw plates in a vice.

Apply an anticlockwise torque to the pinion with a suitable 'torque wrench' fastened to the pinion teeth. The clutch should slip between 800-950 lb. in.

If the clutch slips at too low a torque figure, dismantle again and add shims one at a time until the correct figure is obtained.

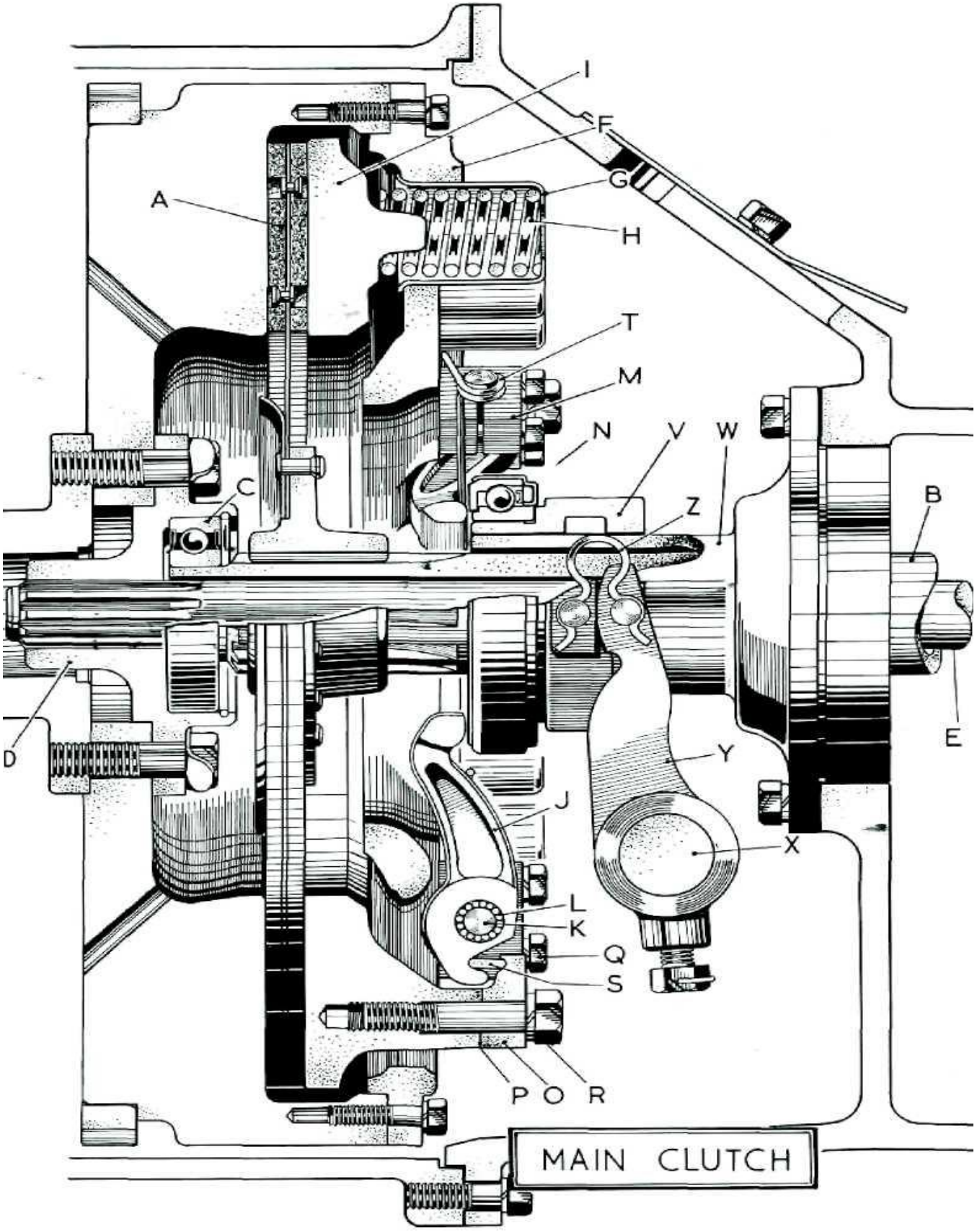
If the clutch does not slip between the torque limits given, again remove the circlip—dismantle and remove shims one at a time until the torque test gives correct figures.

The correct adjusting shims are:

| Part No. | Thickness |
|---|---|
| 22440 .. .. .. .. .. | 0.006" |
| 22441 .. .. .. .. .. | 0.005" |
| 22442 .. .. .. .. .. | 0.004" |

(iii) The assembled clutch unit and lever mechanism must be capable of being pushed to the full extent of the set travel. The assembly must move along the armature shaft extension smoothly and freely, but without slackness.

(iv) Before fitting the drive assembly to the armature shaft lightly smear the shaft and pack the space between the indented bearings inside the pinion sleeve.



## DESCRIPTION

The clutch is a 14" single dry plate type and consists of a driven plate assembly (A), a cover assembly and a ball release bearing assembly.

The cover assembly consists of a cast iron cover (F), bored to receive spring cups (G) which retain thrust springs (H) to transmit load to a cast iron pressure plate (I). Mounted on the cover are three release levers (J) each carried on a release lever pin (K) surrounded by needle bearings (L).

The pin is carried in two release lever lugs (M) (one of each pair being split to form a clamp for the release lever pin), secured to the cover by set-screws (Q). Grease is retained on the needle bearings by distance washers surrounded by sealing washers.

Pressure pads (O) behind which are shims (P), are mounted on projections on the pressure plate and secured by setscrews (R). Between the inner end of each pressure pad and the outer end of the release levers is a strut (S). Anti-rattle springs (T), mounted on the release lever pins, bear on the release levers and the cover.

The release mechanism consists of a sealed ball thrust bearing (N), pressed onto a bearing carrier (V) which is mounted on an extension of the gear box mainshaft bearings retainer (W). A new superior type, pre-packed bearing has been introduced and is interchangeable with bearing P/N 20205 providing the bearing carrier P/N 20156 is re-worked at the inner shoulder to allow for the bearing radius.

The clutch is actuated by foot pressure transmitted through a cross shaft (X) and clutch fork (Y), the thrust bearing carrier is retained against the clutch fork by spring clips (Z).

Two shafts carry the drive from this unit into the gearbox, the P.T.O. driving shaft (E) passing through the hollow main drive shaft (B). The main drive shaft, onto which is splined the clutch driven plate, is supported at its forward end by the pre-lubricated and sealed pilot bearing (C). This shaft carries the drive, when the clutch is engaged, from the clutch driven plate (A) into the front gearbox, from where it is transmitted via the main coupling shaft, rear gearbox, differential and final drives, to the rear wheels. The P.T.O. drive shaft is splined into the pilot bearing retainer (D) and into the first of a train of helical gears at the rear of the gearbox. As the pilot bearing carrier is bolted directly to the fly wheel, the P.T.O. drive shaft will rotate at the same speed as the engine irrespective of whether the main clutch is engaged or dis-engaged. This drive is then carried via the train of helical gears, the P.T.O. coupling shaft and a splined shaft through the differential housing to the P.T.O. clutch at the rear of the tractor.

## CLUTCH BRAKE

Crusader and early model Champions are not fitted with a clutch brake which is standard equipment for later Champions, both Industrial and Agricultural, and Canelander tractors, to facilitate the selection of gear ratios in the tractor front gearbox. The screw operated brake is connected by a linkage to the clutch cross shaft and disengaging of the clutch operates the screw which causes a lined brake shoe to engage with the boss of the reverse idler gear.

## SPECIFICATION

| | |
|---|---|
| Make | — Borg & Beck |
| Type | — Single dry plate |
| | — Foot Control |
| Lining — Material | — Asbestos composition |
| " — Outside Diameter | — 14" |
| " — Inside " | — 8½" |
| " — Thickness | — 3/16" |
| Release mechanism | — Three levers on needle bearings. Ball thrust bearing. |
| Adjustment | — Adjustable link under foot plates. |
| Lubrication | — Pre-packed pilot bearing. Grease nipples in cross-shaft, release bearing and clutch pedal. |

## MAINTENANCE

Service the grease nipple on the clutch pedal and the two nipples on the clutch cross-shaft with chassis grease every 50 operating hours.

Unless the pre-packed throw out bearing is fitted, it is necessary to lubricate the bearing every 500 hours. This can be accomplished by removing the clutch inspection plate on early tractors, or applying grease to the exposed grease nipple on the inspection plate on later production tractors.

**Adjustment:** Periodically check the pedal adjustment. Press the pedal downward by hand until the resistance to movement sharply increases, indicating that the throw-out bearing has made contact with the clutch release levers. The distance the pedal moves before contact is made should be 1" to 2" and should not be allowed to reduce to less than 1". Should the measurement reduce to zero severe wear and clutch slippage will result.

To adjust the pedal, slacken the two locknuts on either side of the block on the clutch link (on the inside of the chassis, under the footplate), adjust them to suit, then re-tighten.

**Clutch Brake Adjustment.** As the lining wears, or if the main clutch is adjusted, it will become necessary to adjust the clutch brake. After adjusting the main clutch, check the clutch brake linkage. With the clutch engaged (pedal released), the small lever on the clutch brake screw (protruding from the side of the gearbox) should be at an angle of approximately 90° to the spring loaded link. If necessary slacken the bolt in the cross-shaft lever slot and adjust to suit. Retighten the bolt and fully depress the clutch pedal. In this position the cross-shaft lever should compress the springs on the link by moving $\frac{1}{4}$" to $\frac{3}{8}$" away from the lower stop nut. If necessary slacken the locknut on the brake adjusting screw and adjust the slotted screw to suit. Re-tighten the locknut and re-check the linkage movement.

## SERVICE

The following is a guide to faults, causes and corrections:

**Slipping:**

(a) Incorrect pedal adjustment—Adjust.
(b) Binding throw-out mechanism—Lubricate.
(c) Worn or oil soaked linings—Replace.

**Dragging:**

(a) Incorrect pedal adjustment—Adjust.
(b) Badly worn linkage—Replace.
(c) Distorted or oil soaked linings—Replace.
(d) Driven plate splines sticking—Clean and inspect.
(e) Mal-adjustment of pressure plate—Adjust.
(f) Pilot bearing failure—Replace.

**Fierceness or Grab:**

(a) Binding throw-out mechanism—Lubricate.
(b) Worn or oil soaked linings—Replace.
(c) Mal-adjustment of pressure plate—Adjust.
(d) Worn or scarred flywheel and/or pressure plate—Replace.

**Judder or Chatter:**

(a) Loose engine mountings—Tighten.
(b) Worn or oil soaked linings—Replace.
(c) Mal-adjustment of pressure plate—Adjust.
(d) Flywheel mis-aligned—See Engine section.
(e) Distorted driven plate—Replace.
(f) Bent clutch shaft—Replace.

**Rattling or Squeaking:**

(a) Throw-out mechanism dry—Lubricate.

(b) Throw-out mechanism worn—Replace.

(c) Broken pressure springs—Replace.

(d) Pilot bearing failure—Replace.

(e) Worn driven plate (splines)—Replace.

Apart from the external linkage and to some extent, the throw-out mechanism, it will be necessary to separate the gearbox from the engine to service the clutch unit. The removal of the gearbox is fully covered in the front gearbox section. As mentioned under Service in this section, the clutch components may be serviced by sliding the gearbox back along the chassis and not removing it entirely from the tractor.

## TO DISMANTLE THE CLUTCH

1. Remove the front gearbox. (See Section G).

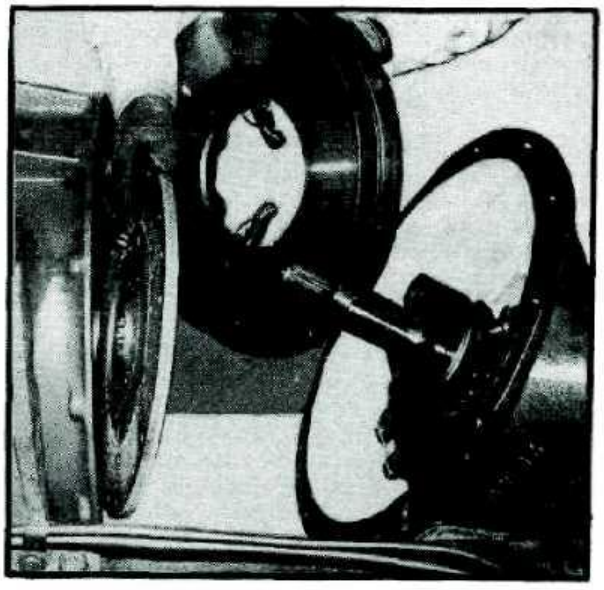


Fig. F.2 — Removing the Clutch Assembly

2. Mark all the major clutch components as they must be returned in their original positions if the balance of the unit is to be preserved.

3. Remove the clutch cover assembly by unscrewing the sixteen cover bolts each a turn at a time, working by diagonal selection, until the cover is free. Do not remove the bolts individually as damage may be caused by the spring pressure forcing the clutch assembly out unevenly.

4. Remove the driven plate.

The release lever mechanisms may be removed individually, but if the assembly is to be completely dismantled, proceed as follows:

5. Support the pressure plate on blocks and arrange three suitable blocks with either a hydraulic press or a jack placed under the tractor chassis to bear down evenly on the cover assembly. When the spring pressure is relieved, remove the previously marked pressure pads from the pressure plate. Note any shims under the pressure pads. Slowly release the jack pressure. (See Fig. F.3).

6. The cover may now be lifted clear of the pressure plate and the springs and spring cups removed.

7. The release levers may be removed by unscrewing the two bolts from each lug and removing the assemblies. Hold the units down by hand against the anti-rattle spring tension whilst removing the bolts. Note spacers and seals.

Fig. F.3 — Relieving Clutch Spring Pressure

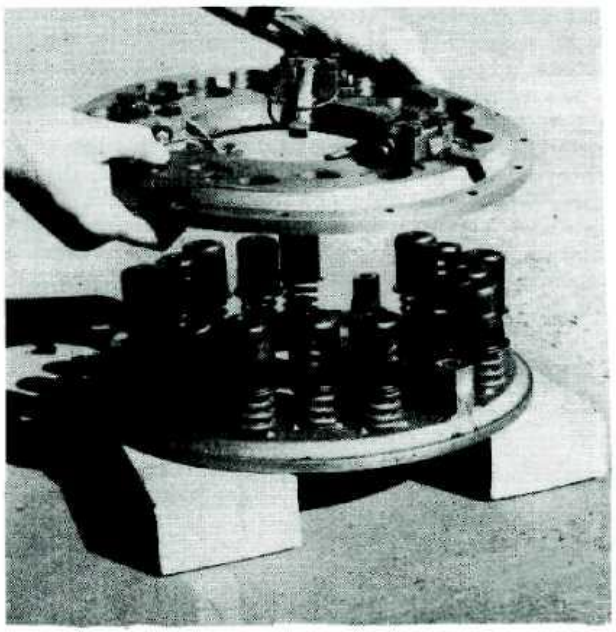


Fig. F.4 — Removing the Clutch Cover

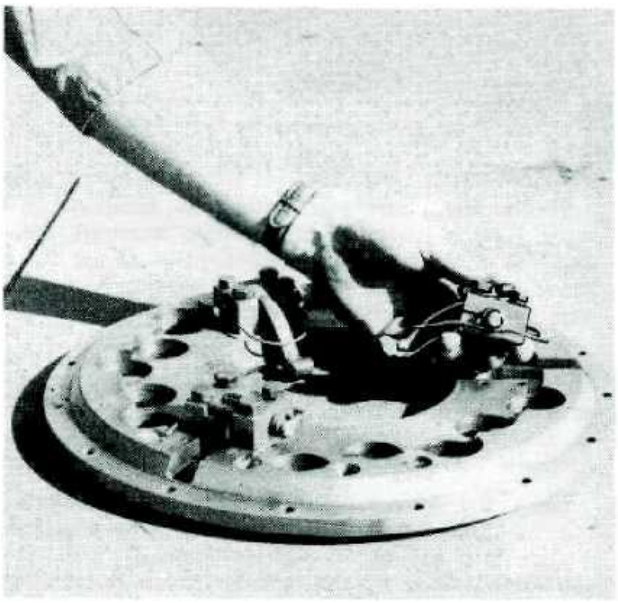


Fig. F.5 — Removing a Clutch Release Lever

8. The throw-out bearing and carrier may be removed by releasing the spring clips and sliding the carrier free.

9. The clutch pilot bearing may be removed from its retainer after removing the circlip. The fit of this bearing is such that it should be possible to prise it free. Should it be necessary to remove the retainer to drive the bearing free it will be necessary to un-

lock and remove flywheel bolts (7 on early tractors—later reduced to 6). When this is done the flywheel is only supported on the crank shaft by a small spigot. For this reason it is advisable to remove an upper bolt first and replace it with a stud having a ½" U.N.F. thread. This will support the flywheel whilst the retainer is removed and, if necessary, whilst the flywheel itself is removed. If the flywheel is removed, care must be exercised (on six bolt models) to ensure its correct location on re-assembly. When refitting, tighten the bolts to 90 lbs./feet.

The procedure for re-assembling the flywheel is covered in detail in Section B.

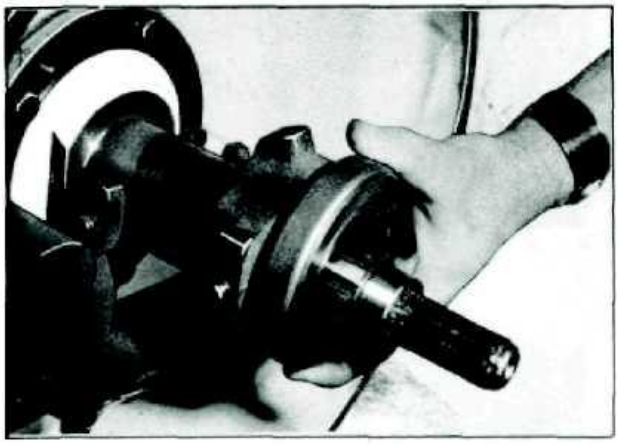


Fig. F.6 — Removing the Thrust Bearing

## INSPECTION

Thoroughly clean and inspect all components for wear, paying particular attention to bearings, splines and the flywheel and pressure plate faces. Do not allow petrol or kerosine to contact the friction facings (linings), or the clutch pilot bearing.

The possibility of further use of the friction facings is sometimes raised, because they have a polished appearance after considerable service. It is natural to assume that a rough surface will give a higher frictional value against slipping, but this is not correct.

Since the introduction of non-metallic facings of the moulded asbestos type, in service, a polished surface is a common experience, but it must not be confused with a glazed surface which is sometimes encountered due to conditions discussed below.

The ideal smooth or polished condition will provide a normal contact, but a glazed surface may be due to a film or a condition introduced, which entirely alters the frictional value of the facings. These two conditions might be simply illustrated by the comparison between a polished wood, and a varnished surface. In the former the contact is still made by the original material, whereas in the latter instance, a film of dried varnish is interposed between the contact surfaces.

The following notes are issued with a view to giving useful information on this subject: —

(a) After the Clutch has been in use for some little time, under perfect conditions (i.e., with the clutch facings working on true and polished or ground surfaces of correct material, without the presence of oil, and with only that amount of slip which the clutch provides for under normal conditions) then the surface of the facings assumes a high polish, through which the grain of the material can be clearly seen. This polished facing is of a mid-brown colour and is then in a perfect condition, the co-efficient of friction and the capacity for transmitting power being up to standard.

(b) Should oil in small quantities gain access to the clutch in such a manner as to come in contact with the facings it will burn off, due to the heat generated by slip which occurs under normal starting conditions. The burning off of this small amount of lubricant, has the effect of gradually darkening the facings, but, provided the polish on the facings remains such that the grain of the material can be clearly distinguished, it has very little effect on clutch performance.

(c) Should increased quantities of oil or grease obtain access to the facings, one or two conditions, or a combination of the two, may arise, depending upon the nature of oil, etc.

1. The oil may burn off and leave on the surface facings a carbon deposit which assumes a high glaze and causes slip. This is a very definite, though very thin deposit, and in general it hides the grain of the material.
2. The oil may partially burn and leave a resinous deposit on the facings, which frequently produces a fierce clutch, and may also cause a "spinning" clutch due to a tendency of the facings to adhere to the flywheel or pressure plate face.
3. There may be a combination of (1) and (2) conditions, which is likely to produce a judder during clutch engagement.

(d) Still greater quantities of oil produce a black soaked appearance of the facings, and the effect may be slip, fierceness, or judder in engagement, etc., according to the conditions. If the conditions under (c) or (d) are experienced, the clutch driven plate should be fitted with new facings, the cause of the presence of the oil removed and the clutch and flywheel face thoroughly cleaned.

Correction of oil leaks from either the engine or the front gearbox is covered in the engine and front gearbox sections.

It is advisable, if the clutch operation has been faulty, or if the flywheel has been removed, to check the flywheel alignment as described in the engine section.

To check the alignment of the three release levers, a gauge plate may be used to give accurate results. A reasonably accurate method of checking this alignment is to assemble the clutch unit to the engine, mount a scriber block on the chassis in line with the

face of one of the levers, then rotate the engine to obtain a comparative reading on the other two

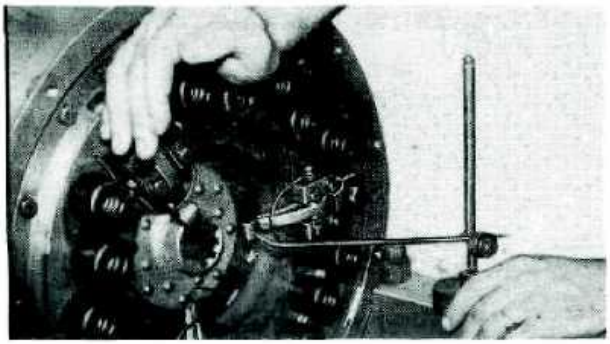


Fig. F.7 — Checking Lever Alignment

levers. Mark the lever which lies furthest to the rear, slacken the clutch unit, rotate the driven plate through approximately 90°, re-tighten and re-check. This latter procedure is to eliminate the possibility of incorrect readings due to inaccuracies in the driven plate. The alignment may be corrected by adding or removing shims from below the thrust pads.

### TO RE-ASSEMBLE

Re-assembly is a reversal of the dismantling procedure. Note the following points:

1. Return components in their previously marked positions.

2. Lubricate the release lever needle bearings with wheel bearing grease. Replacement of the seals is recommended.

3. Check that the driven plate moves freely on the clutch shaft splines without undue clearance.

4. Do not attempt to lift the clutch assembly by the release levers otherwise the struts may become displaced.

5. Fit the driven plate with the longer side of splined boss towards the rear of the tractor.

6. When fitting the cover assembly, tighten the bolts evenly to just nip the driven plate, centralise the driven plate with a dummy pilot shaft or a front gearbox clutch shaft passed through the driven plate and into the pilot bearing. With the driven plate centralised in this manner, tighten the flange bolts evenly with diagonal selection until snug. Finally tighten with a torque wrench to 25 lbs./feet.

The driven plate may be centralised by sighting or by using a suitably stepped straight edge but the dummy shaft or clutch shaft is recommended as,

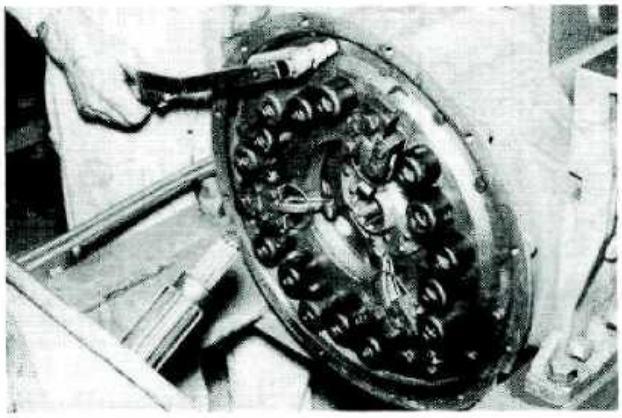


Fig. F.8 — Re-fitting the Clutch Assembly

if the plate is not accurately centralised, difficulty will be experienced when re-assembling the gearbox.

7. When replacing the gearbox, lightly smear the splines with graphite grease and exercise care not to distort the driven plate by allowing the gearbox to move out of line after the clutch shaft spline has entered the plate.

8. Re-adjust the throw-out linkage as previously described on page F.4.

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### CLUTCH BRAKE KIT

Crusader and early model Champions do not have a clutch brake fitted. A kit P/N20009 is available to convert these tractors.

A check should be made before endeavouring to assemble the kit to early model Champions that:

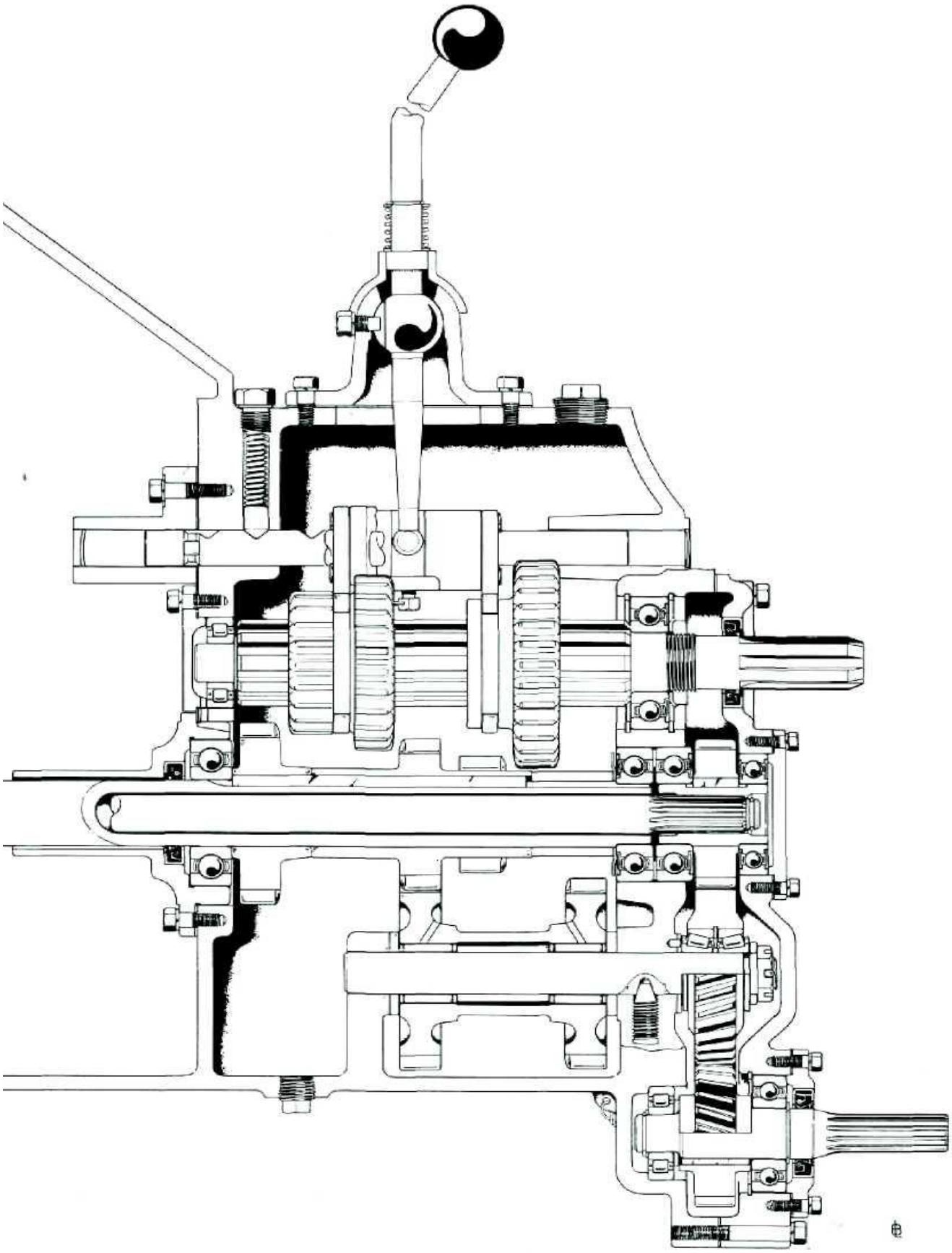
(a) The clutch cross-shaft protrudes from the nearside of the gearbox housing to enable the brake lever to be fitted.

(b) The reverse idler gear machined surface is wide enough to accommodate the brake shoe and the surface is smooth ground.

The unit cannot be assembled to the tractor if either or both of the above components are not as stipulated.

The idler gear can be inspected by removing the inspection cover situated on the nearside of the gearbox.

Current model clutch brakes have a longer setscrew P/N31181 and a locknut P/N4323 fitted to the brake lever.



## DESCRIPTION

The housing of the front gearbox bolts directly to the engine flywheel housing and also serves to enclose the clutch unit. The mechanism is a normal three speed and reverse, sliding spur gear assembly except for the provision of the "live" P.T.O. To provide this, the primary shaft (B) is hollow and a shaft (E) passes through its centre to couple the engine flywheel directly to a train of three helical gears (9, 10 and 11) inside the rear cover. The third gear of the train (11) is keyed to a splined shaft (F) onto which is fitted a universal coupling shaft which transmits the drive to the rear P.T.O. assembly.

Power transmitted to the driven clutch plate by the main clutch is transmitted per medium of a shaft (B) to a cluster of gears (1, 2 and 3) keyed and shrunk to the shaft.

To engage first gear, slide gear 6 into mesh with gear 3.

To engage second gear, slide gear 5 into mesh with gear 2.

To engage third gear, slide gear 4 into mesh with gear 1.

To engage reverse gear, slide gear 6 into mesh with gear 8.

Gear 8 is integral with gear 7 which is in constant mesh with gear 2.

All the shafts are arranged in a flat plane for clarity in the main diagram, but in practice, the splined shaft (C) lies behind the upper shaft (B) and the reverse idler shaft (D) so that the gear 6 may mesh with the gear 8.

Gear selection is obtained by means of a gear lever (A) and selector forks (G and H). The selector forks are retained in their selected positions by means of two spring loaded plungers (K) which engage in grooves in the selector rails. As a preventive measure against both shifter forks being moved at once from the neutral position, thus engaging two gears at the same time, a shifter rail interlock (J) is fitted between the two rails.

Motion applied through any one of the selected gear ratios is transmitted by the splined shaft (C), via a universal coupling shaft to the rear assembly.

Lubrication is by oil bath and splash, an oil ramp being provided to prevent the lower P.T.O. gear from being over-lubricated. Filler, level and drain plugs are provided.

## SPECIFICATION

| | | | |
|---|---|---|---|
| Make | — | Own | |
| Type | — | Sliding spur | — totally enclosed |
| Ratios | — | First Gear | — 2 : 1 |
| | | Second Gear | — 1.182 : 1 |
| | | Third Gear | — 0.777 : 1 |
| | | Reverse Gear | — 1.507 : 1 |
| | | P.T.O. | — 1 : 1 |
| Gears | — | Main drive | — straight spur |
| | | P.T.O. | — helical |
| Gear lever positions | — | left-forward | — Reverse |
| | | left-rear | — First |
| | | right-forward | — Second |
| | | right-rear | — Third |

## MAINTENANCE

The oil level should be checked every 100 operating hours and the oil should be drained and replaced with S.A.E. 90 gear oil every 1,000 operating hours.

No other maintenance is necessary.

## SERVICE

**Oil Leakage:** The two output shaft oil seals may be serviced by removing the universal coupling shafts and the rear cover. Leakage into the clutch compartment may be from either the engine or the front gearbox. Engine seal leakage is covered in the engine section. Gearbox leakage could be caused by failure of the upper mainshaft oil seal, faulty gasket, faulty shifter rail welsh plug, or possibly failure of the pilot bearing sealing. To examine these components, the gearbox may be moved back along the chassis and left supported at the front by the flange and by blocks or a jack at the rear.

## TO REMOVE THE GEARBOX FROM THE TRACTOR

**Note:** Refer to item 7 of the procedure before commencing dismantling.

1. Drain the oil from the gearbox. A small quantity of oil will be trapped in the P.T.O. compartment, and this should be borne in mind when removing the rear cover.

2. Remove the top and both side cowls.

3. Disconnect and remove the batteries.

**Gearbox Removal—Continued**

4. Remove the coupling shaft cover on Agricultural and Industrial Champions.

Crusader and Canelander Tractors have the cover welded to the nearside footplate. Remove the three bolts connecting the cover to the offside footplate.

5. Remove the nearside footplate.

Crusader and Canelander tractors have the hydraulic hose passing through the footplate.

Remove the hose prior to dismanting the footplate.

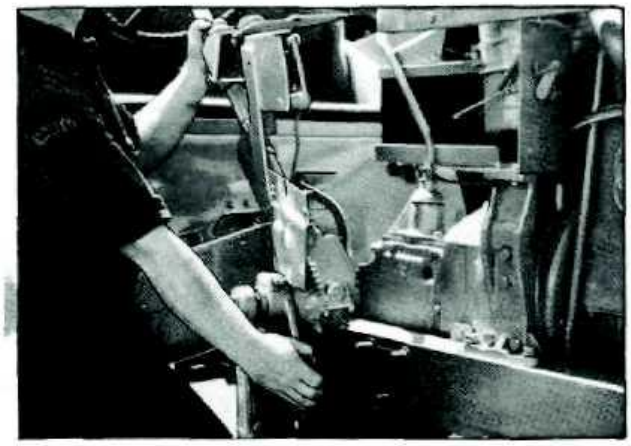


Fig. G.2 — Removing Champion O.S. Footplate, etc.

6. Remove the offside footplate, steering box and rear cowl support. On Agricultural and Industrial Champions, disconnect the hand brake, the hand lever to bellcrank rod, and the return spring and control rod from the bellcrank, to remove the assembly. Crusader and Canelander Tractors do not have the rear cowl support connected to the footplate, so this will be removed as a separate unit. Disconnect the handbrake, the footpedal to bell crank rod, and, on tractors prior to S/N CR222 and HC233 respectively the rear gear box shift lever will also require removal. Remove the steering column and rear cowl support unit.

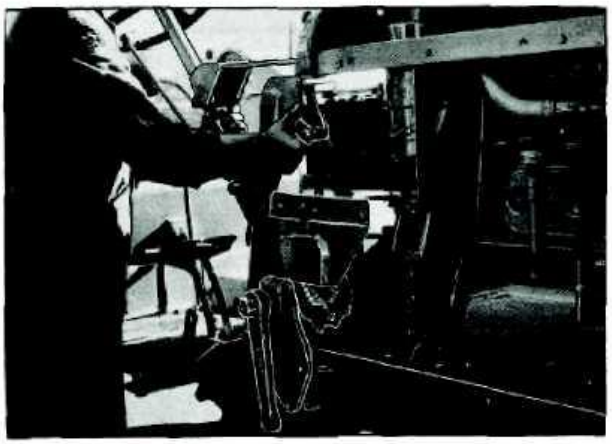


Fig. G.3 — Removing Crusader and Canelander Rear Support and Steering Column.

7. Remove the coupling shafts.

Canelander Tractors are not fitted with a P.T.O. coupling shaft as standard equipment.

P T.O. coupling shafts should be dismantled at the bolted yoke. It will be necessary to crank the engine for ease of bolt accessibility and yoke separation on all types of P.T.O. coupling shafts used. This operation can be carried out before the batteries are removed, or with the aid of a crankhandle. Early Champions may have the clutch pedal fitted on the near side of the rear gearbox and the pedal will require removal before the P.T.O. coupling shaft and the front gearbox are removed.

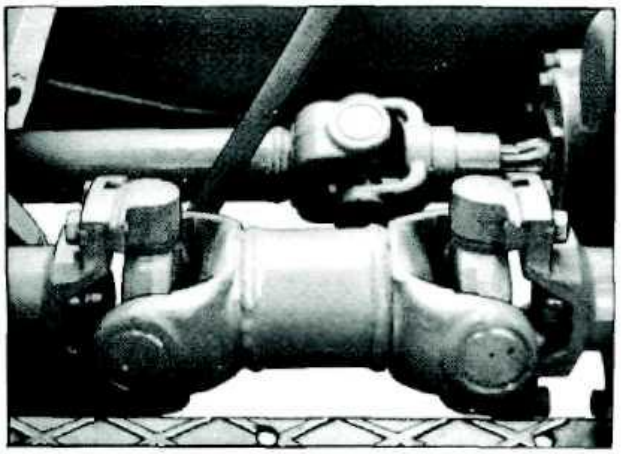


Fig. G.4 — Exposed Coupling Shafts.

8. Remove the clutch pedal.

On early tractors, this is accomplished by slackening the adjusting nuts, removing the spring and split-pin retaining the operating lever to the cross-shaft and the three bolts holding the pedal spindle to the rear gearbox.

Later type clutch pedals are fitted inside the offside chassis member and can be removed by disconnecting the operating link and return spring and removing the pedal retaining circlip and grease nipple.

9. Release the brake pedals.

Where the nearside brake pedal is situated inside the offside chassis member, it is necessary to remove the pedal in order to clear the gearbox. This can be done by disconnecting the brake linkage, removing the cross-shaft retaining circlip and the pedal lockscrew. Move the cross-shaft towards the nearside of the tractor until the pedal can be removed.

Later type Champions, all Crusaders and Canelanders have the pedals outside the offside chassis member and these should be disconnected to minimise working obstructions.

10. Where lighting equipment is fitted, the dipper switch wiring should be disconnected and the switch removed.

11. Remove the battery carrier support bracket and the gear lever housing assembly.

12. Tractors with serial numbers after those listed will require the rear gearbox change lever to be disconnected and held against the fuel tank, in order that the gearbox can be removed.

| | | |
|---|---|---|
| Champion Agricultural | — | DM3592 |
| Champion Industrial | — | IND1201 |
| Canelander | — | HC233 |
| Crusader | — | CR222 |

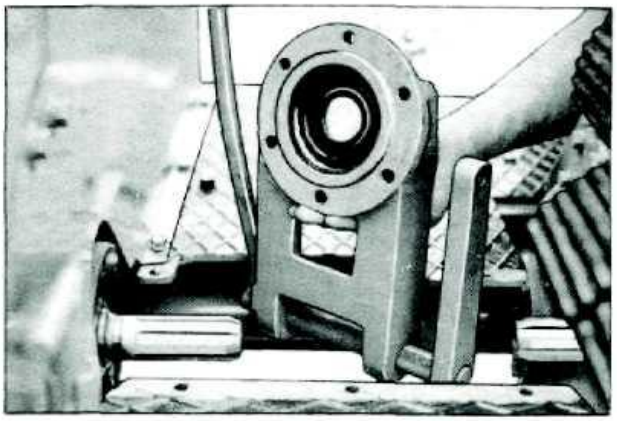


Fig. G.5 — Rear Gearbox Lever Removal.

13. Support the rear of the gearbox and remove two cross-shaft grease nipples and all the gearbox to flywheel housing retaining bolts.

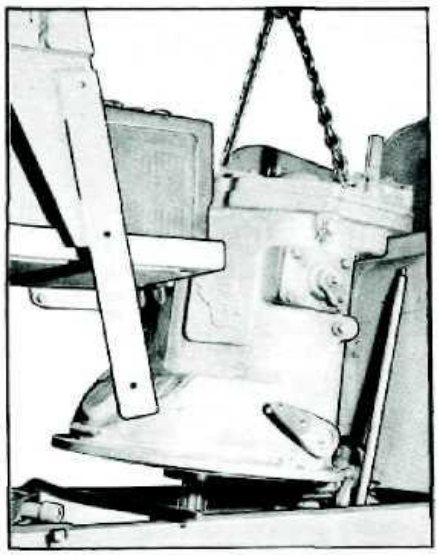


Fig. G.6 — Gearbox Removal.

14. Remove the gearbox.

This can be accomplished in a number of ways dependent upon the method of support used in Para. 13.

If a trolley jack or side mounted support brackets are used, the box can be man-handled upwards and away from the nearside of the tractor.

A preferable method incorporates the use of a tackle lifting chain, bolted either side of the rear cover plate. The gearbox is then removed as in the former method.

## DISMANTLING

**To Remove the P.T.O. Gears:** These may be removed without removing the gearbox from the tractor, but it will be necessary to remove the coupling shafts, as described in the preceding instructions, and the foot plates.

1. Drain the oil from the gearbox.
2. Remove the upper retaining plate from the rear cover (6 bolts), being careful not to damage the shims.
3. Remove the rear cover (14 bolts of three different lengths). Exercise care to avoid damaging the seal on the main drive shaft. The P.T.O. driven (lower) shaft will come away with the cover, but light tapping against the outer race of the driving gear bearing (exposed by removing the retainer plate) may be necessary to free this bearing from the cover. A retaining collar on the main drive shaft on late model tractors will also have to be removed.

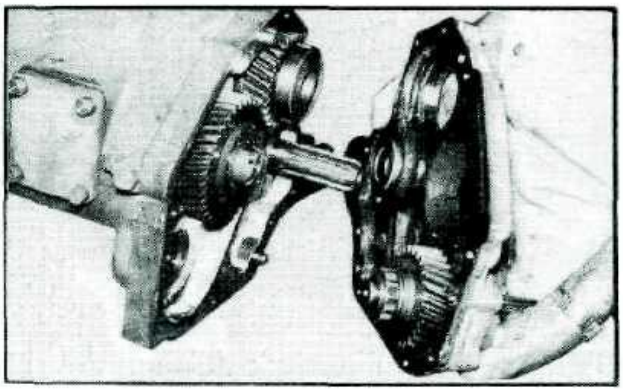


Fig. G.7 — Removing the Rear Cover.

4. The P.T.O intermediate gear may now be removed by unpinning and removing the slotted nut from the shaft and sliding the gear, bearings and washers from the shaft. If the main mechanism is to be dismantled, the gear with bearings and shaft may be removed as described in item 2 of "To remove the upper mainshaft".
5. The driving gear with the P.T.O. primary shaft and bearings may now be removed. Remove the shim from in front of the forward bearings.
6. The driven gear may be removed from the rear cover by removing the retainer plate and seal (6 bolts —note the location of the clutch spring lug on early tractors) removing the circlip thus exposed and pressing the shaft and gear through towards the inside of the cover. (See Fig G.8).

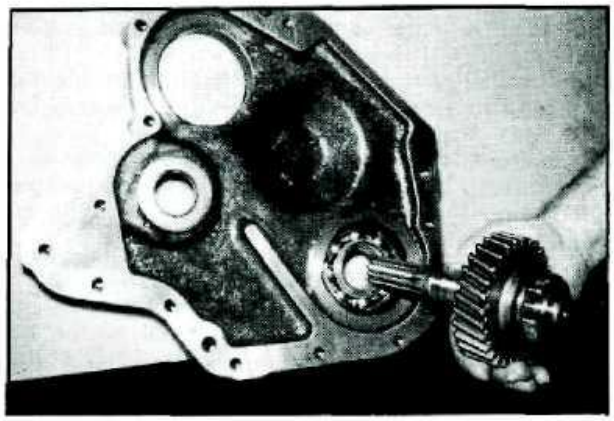


Fig. G.8 — Removing P.T.O. Driven Shaft.

**To Remove the Selector Mechanism:**

Service to the shifter rails or forks may be accomplished on the tractor, in the following manner:

(1) Remove the steering column (Page A-4) for ease of working.

(2) Remove the gearbox offside inspection cover.

(3) Remove the shifter rail welsh plugs at the rear of the gearbox.

(4) Remove the selector plunger plugs.

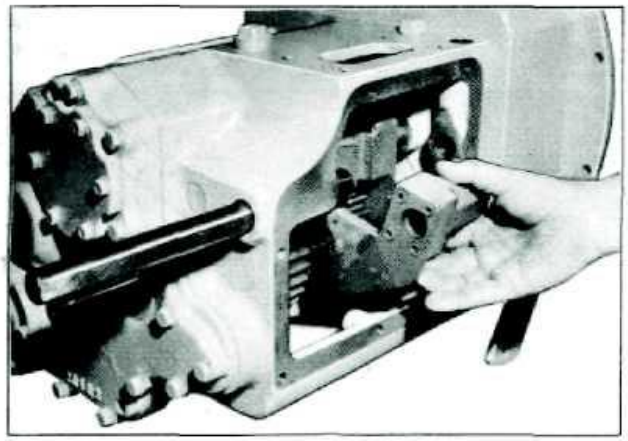


Fig. G.9 — Removing Selector Fork.

(5) With the selector setscrew removed, the rail can be pushed out through the rear of the gearbox and the selector fork removed. (See Fig. G.9.)

Should the gearbox have already been removed from the tractor, proceed as follows:

(1) Remove the gear box side cover.

(2) Unlock and slacken the setscrews in each selector fork.

(3) Remove the two selector plunger plugs and springs from the top of the housing.

(4) Remove the interlock housing from the clutch compartment (2 bolts). Collect the interlock bar.

(5) The shifter rails may now be drawn through into the clutch compartment and the selector forks and plungers withdrawn through the side opening. (See Fig. G-10).

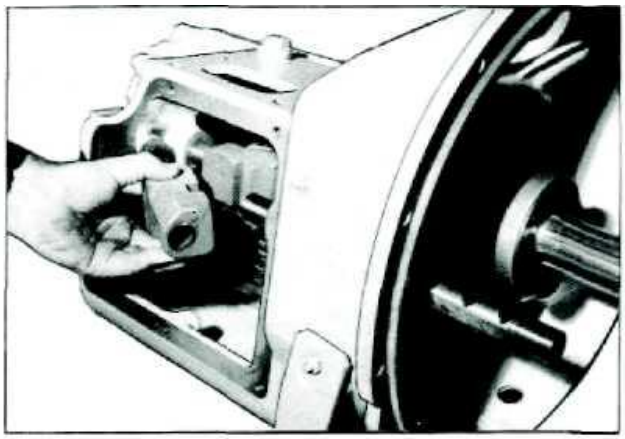


Fig. G.10 — Removing Selector Fork.

**To Remove the Lower Main (Splined) Shaft:**

It will be necessary to remove the gearbox from the tractor, and to remove the rear cover. If the sliding gears are to be removed, it will also be necessary to remove the selector mechanism.

Remove the bolts retaining the front cover for the lower mainshaft, and remove the cover. Examine the bearing. If the bearing has a lipped inner race it will be necessary to withdraw the shaft through the front of the housing. If it has a plain inner race with the lips on the outer race, it may be withdrawn through the rear of the housing. The two sequences are as follows:

**Lipped inner race:**

1. Remove the two spring clips and unlock and slacken the two setscrews in the clutch throw-out fork. Disconnect the clutch brake if fitted. Slide the cross-shaft from the housing and collect the throw-out fork and throw-out bearing.

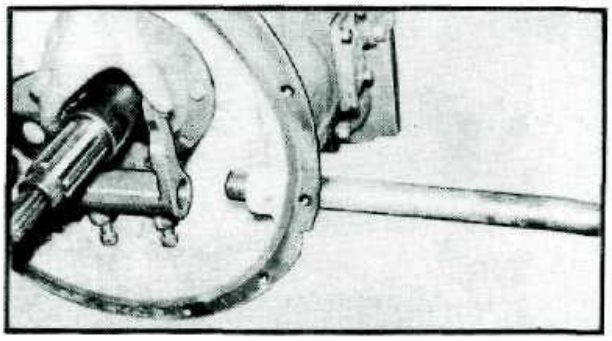


Fig. G.11 — Removing Throw-out Fork.

2. Slide two gears into mesh and unlock and remove the circular nut at the rear of the shaft using tool No. 22751, or some suitable spanner.

3. The shaft may be pressed or drifted forward through the ball bearing, carrying with it the outer

race of the front roller bearings. The two sliding gears may be removed though the side opening.

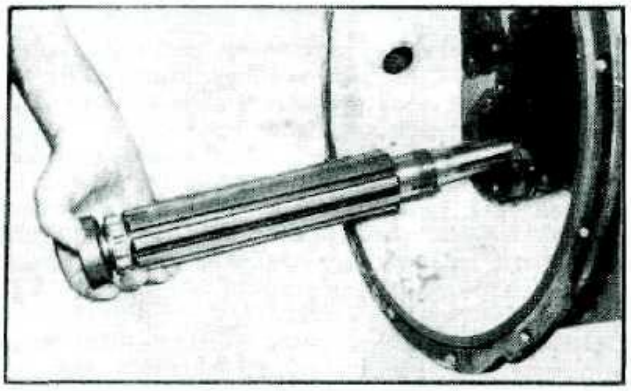


Fig. G.12 — Removing Lower Mainshaft. (Lipped front bearing inner race).

**Plain inner race:**

1. Remove the circlip from behind the rear ball bearing.

2. The shaft may be pressed or drifted to the rear taking with it the ball bearing and leaving the rollers and outer race in place in the housing.

3. If the inner race is plain on both sides (there is no lip between the rollers and the shoulder of the shaft) the housing will be peened on the inner face to prevent the rollers and outer race from wandering into the gearbox and making contact with the ends of the splines on the shaft. For this reason the outer race, if being removed, must be drifted forward into the clutch compartment.

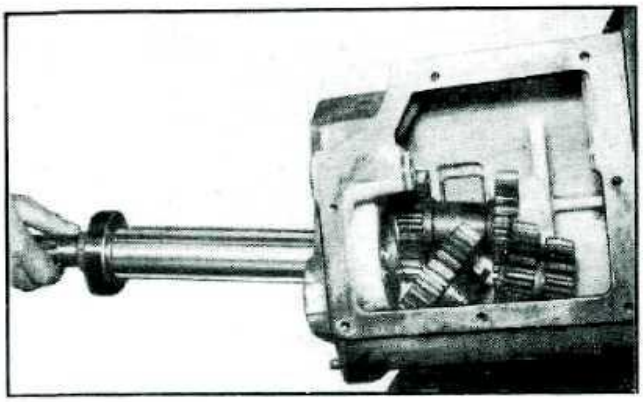


Fig. G.13 — Removing Lower Mainshaft. (Plain front bearing inner race).

**To Remove the Upper Mainshaft:**

It will be necessary to remove the gearbox from the tractor, and to remove the rear cover, selector mechanism (or at least the second and third gear shifter fork) and the clutch cross shaft and fork as already described

1. Remove the clutch thrust bearing and carrier from the front bearing housing and remove the housing retaining bolts.

2. Slacken or remove the reverse idler shaft setscrew which protrudes from the nearside of the housing, and withdraw the shaft through the rear of the housing, complete with the P.T.O. intermediate gear and bearings. (See Fig. G.17).

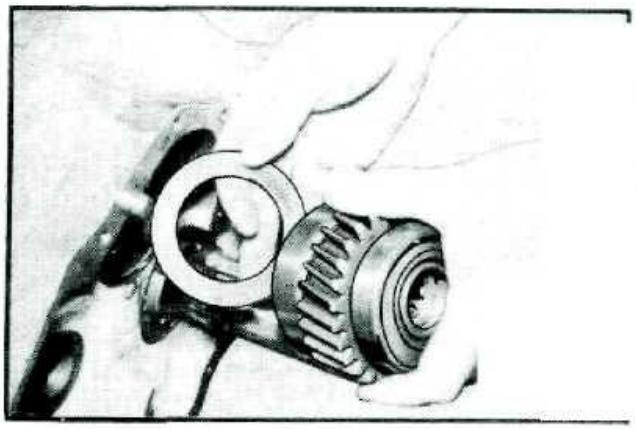


Fig. G.14 — Removing P.T.O. Driving Gear.

3. Remove the P.T.O. driving gear and shaft, together with bearings and shim, through the rear of the housing.

4. The shaft, complete with bearings and the front bearing housing, may now be drawn from the housing with the aid of jacking screws operating in the two tapped holes in the flange of the front housing.

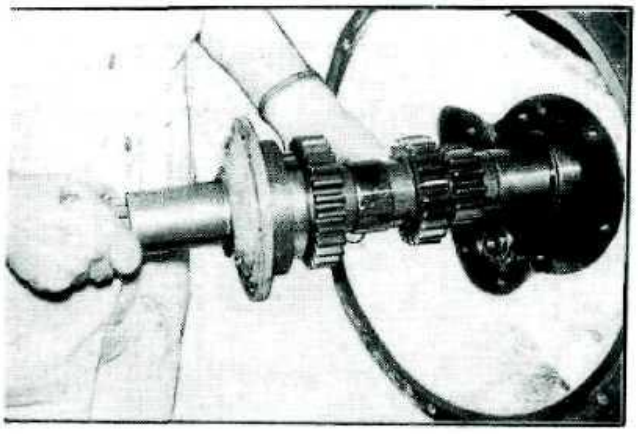


Fig. G.15 — Removing Upper Mainshaft.

**Upper Mainshaft Dismantling—Continued**

**Note:** In the event of the upper mainshaft oil seal failing, it will be desirable to remove this housing whilst leaving the shaft in place. In this case, if the flange bolts are removed and jacking screws are employed (without the gearbox internal components being disturbed), the shaft will be prevented from moving more than about 3/16" by the rear bearing fouling against the reverse idler gear, thus allowing the housing to be withdrawn separately, and the seal serviced. (See Fig. G.15).

5. If the shaft and housing have been removed as a unit, the housing may be supported and the shaft pressed or drifted through to the rear.

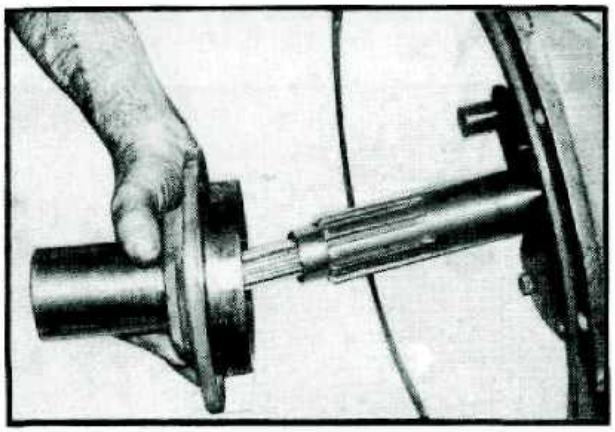


Fig. G.16 — Removing Upper Mainshaft Front Housing to service Oil Seal.

**To Remove the Reverse Idler Gear:**

Remove the gearbox from the tractor, the rear cover, the selector mechanism and the lower mainshaft from the gearbox. When fitted, the clutch brake assembly should be removed and then the idler shaft setscrew which protrudes through the nearside of the housing. The shaft, together with the intermediate P.T.O. gear, may be withdrawn through the rear of the housing. The reverse idler gear with two side spacers, two bearings and bearing spacer may now be withdrawn through the side opening.

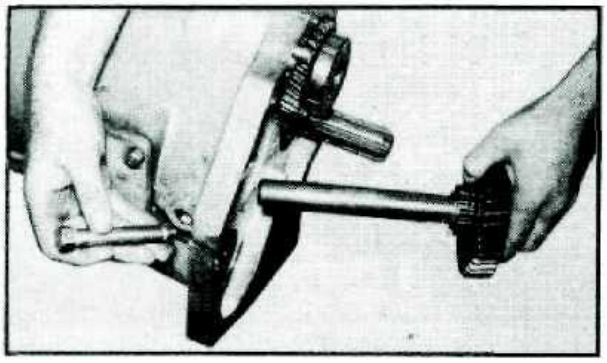


Fig. G.17 — Removing Reverse Idler Shaft.

Whilst the gearbox is removed, it is a good idea to check the condition of the main clutch. The inspection of this unit is covered in that section.

**INSPECTION**

Thoroughly clean all components and examine for wear to shafts, gears and bearings. Examine the oil seals and, if any doubt exists as to their serviceability, they should be replaced. Note any wear on the reverse idler spacer washers. Excess end float on this gear would result in noisy operation as it is in constant mesh with the upper mainshaft. Correct end float for this gear is .010" to .030" and end float in excess of this figure may be reduced by replacing either or both thrust washers P/N 20143 with .020" oversize thrust washers P/N23294.

Check for selector fork wear. Wear on these items will cause incorrect meshing of the gears with resultant gear jump out. Replacement fork part numbers are 23344 for 2nd and 3rd gears, and 23347 for 1st and Reverse gears.

If during inspection it is found that overheating has occurred in the vicinity of the front bearing on the lower mainshaft, the following modification can be carried out to assist the bearing lubrication at this point:

1. Fit retainers 20141 and 20142, modified as shown in Fig. G.18, mark the oilways and drill a 3/16" diameter hole through the housing to connect these ways, being careful not to run-off and cause damage to the retainer sealing face.
2. Reduce the spigot height of the 20142 retainer to .160"/.155".
3. Check that the oilways are aligned and clear when re-assembling.
4. Use S.A.E. 90 gear oil in the front gearbox.

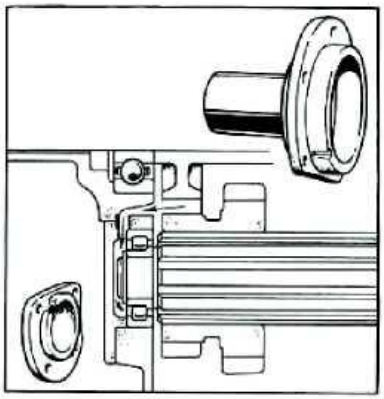


Fig. G.18 — Gearbox Modification.

**RE-ASSEMBLY**

This is a reversal of the dismantling procedure with the following points noted:—

1. The use of new gaskets throughout is recommended.
2. After the main drive and selector mechanism has been re-assembled, check the gear selection, paying attention to both engaged and disengaged gear clearances. This is particularly important if any of the selector mechanism parts have been replaced. The engaged gears should "run through" between 1/16" and 3/32".

3. When re-assembling the three components containing oil seals, the seals must be protected from damage by splines by either using a suitable seal guide or by wrapping shim stock around the splines. In some cases a sharp ridge will be found on the upper mainshaft just forward of the seal location. Protection of the seal to pass this ridge may also be made with shim stock, but blending of the ridge is recommended provided care is taken not to damage the seal contact surface.

4. Check the adjustment of the P.T.O. intermediate gear taper roller bearings. Spacers of various thicknesses are available to ensure correct adjustment of these bearings which should have neither end float nor pre-load.

5. Check that the shields on the ball bearings at the rear of the two mainshafts and on the P.T.O. driving gear are assembled as shown in the section diagram. Do not neglect to fit the shim spacer between the upper mainshaft rear bearing, and the P.T.O. driving gear front bearing. This shim thickness is now .048" and the one shim P/N 30558, replaces the two or three spacers previously fitted.

6. The upper mainshaft and P.T.O. driving gear must be fitted before the reverse idler can be assembled.

7. When assembling the reverse idler, ensure that the smaller (or 28 tooth) gear is at the rear of the gear box.

8. Before assembling the upper mainshaft, check that the front bearing is fully home in its housing. After all the components are assembled and the front bearing housing and rear cover bolted in place, tap the rear of the rear P.T.O. driving gear bearing forward to remove any clearances and offer up the rear bearing retainer without any shims. Measure the clearance between the rear cover and the flange of the retainer, remove the retainer and refit with shims to the value of between .005" to .010" greater than the measured clearance. This clearance must be rechecked whenever a new component is fitted to the upper mainshaft assembly. The depth of the spigot of the rear cover P/N 20150 is reduced from .185"-.180" to .130"-.120" to reduce the quantity of adjusting shims required.

9. Whenever a new lower mainshaft P/N 30539 is issued to replace P/N20135, new gears must also be fitted due to the bottom spline location method of production. New gears will fit the earlier type main shaft.

10. Before re-assembling the gearbox rear cover plate, check the forward bearing on the P.T.O. driven gear shaft. If the bearing has a lipped outer race (either single or double lipped), the spacer P/N 20188, .083"-.087" thick should be behind the bearing while a spacer P/N 23302, .040" thick should be inserted between the bearing and the circlip on the forward end of the shaft. If the assembly is not as described, make the necessary adjustment as failure to do so could result in over-heating and rapid deterioration of the bearing.

11. Before assembling the gear box to the tractor, check the operation of the box including the selection of gears.

12. After refitting the gearbox, refill to the bottom of the level plug with S.A.E. 90 gear oil.

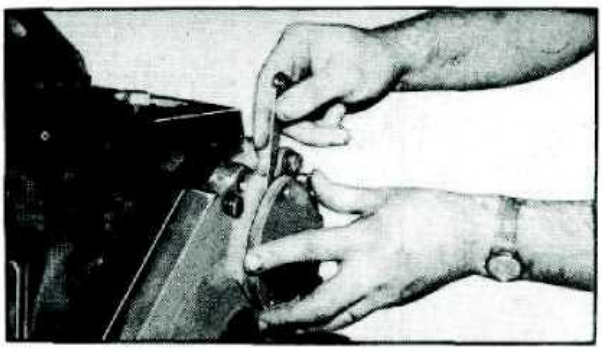
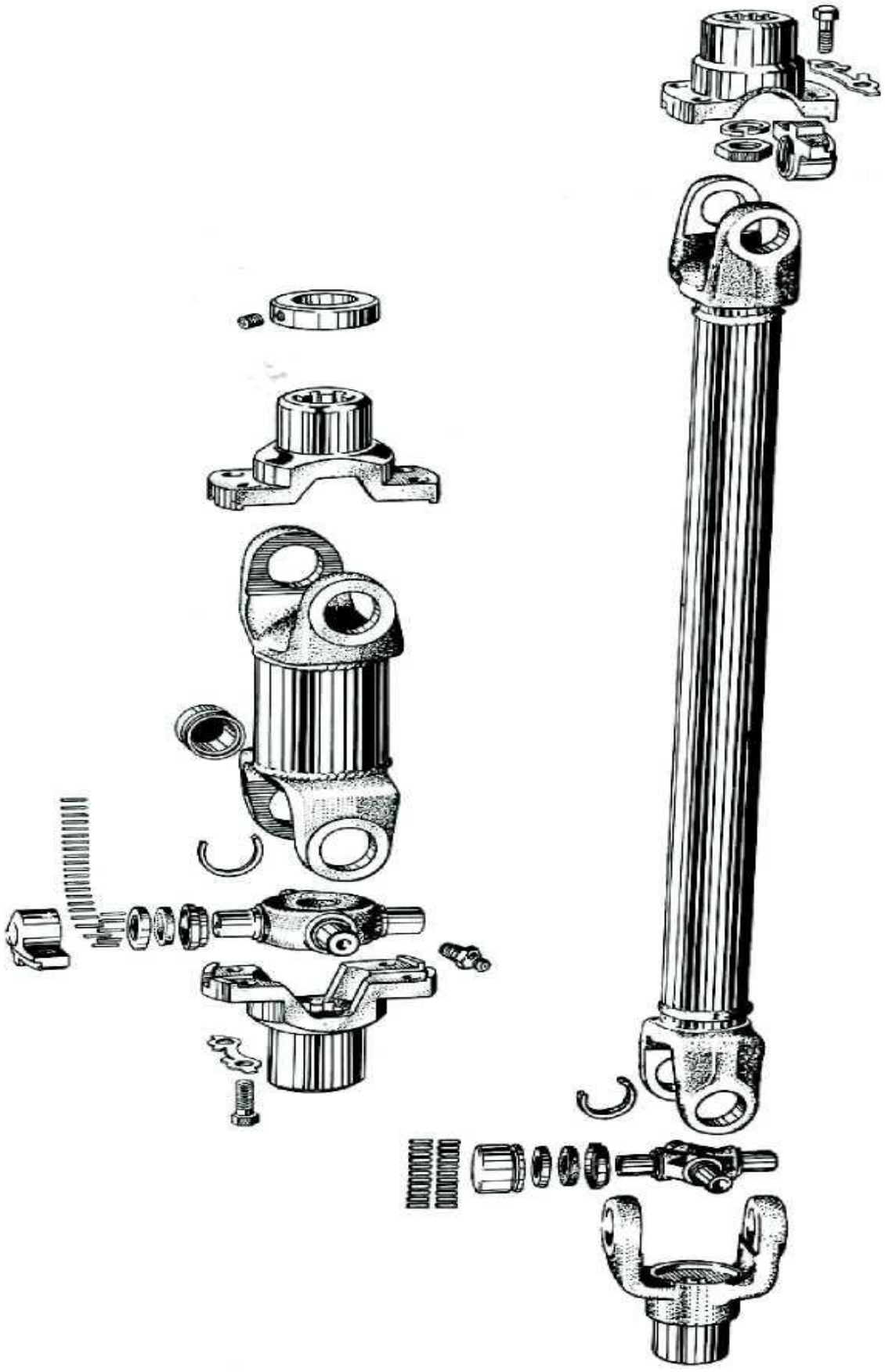


*Fig. G.19 — Measuring for Upper Mainshaft Shims.*



## DESCRIPTION

Agricultural Champion and Crusader tractors are equipped with two universal coupling shafts whilst Industrial Champion and Canelander tractors have only the main coupling shaft unless a P.T.O. unit is fitted. The shafts are of the open propellor shaft type and the shafts and universals are balanced as an assembly to prevent vibration. The universal joints are fitted with needle bearings, protected by cork seals.

The main coupling shaft is splined to the output shaft of the front gearbox and the input shaft of the rear gearbox, carrying the clutch controlled drive to the rear wheels. At or before serial Numbers DM1864 and IND371, a heavy duty main coupling shaft, incorporating a split yoke at each end, was introduced. Lock rings, to prevent coupling shaft end float, were fitted concurrently with the new shaft and are positively locked by fitting two grub screws one above the other, in each screw hole.

The later shaft is interchangeable with the former assembly provided the cover P/N20750 is suitably modified or replaced.

Two sizes of P.T.O. coupling shafts have been used on Agricultural Champions, No. 2, which is the current model for all tractors, being introduced at Champion serial number DM1804.

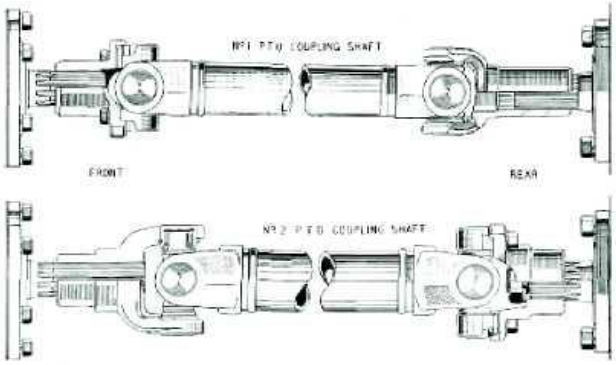



Fig. H.2 — P.T.O. Coupling Shafts

The two shafts are shown in Fig. H.2. It will be noted that modified splined shafts are used in conjunction with the No. 2 type unit. The front gearbox P.T.O. driven shaft splines have been increased in length to support the heavier universal joints and a thread has been provided on the P.T.O. clutch shaft in order that the rear yoke may be located against a shoulder by a lock nut.

As the spline size has not been increased, it is possible to fit the No. 2 Coupling to the original shafts. This is **not** recommended as rapid wear of the splines will result.

## SPECIFICATIONS

| | | |
|---|---|---|
| Type | — | Open Propeller shaft. |
| Bearings | — | Needle roller. |
| Lubrication | — | Main shaft — E.P. 140 oil. |
| | | P.T.O. shaft — W.B. Grease |
| Splines | — | Main shaft — 1⅜" 6.B. |
| | | P.T.O. shaft — 11 Splines |
| | | Involute — 12/24 D.P. |
| *Flange bolt torque* | — | Main — 16-20 lbs./feet. |
| | | P.T.O.— 12-15 lbs./feet orig. |
| | | — 16-20 lbs./feet current. |

## MAINTENANCE

The main coupling shaft universal joints are fitted with grease nipples and should be serviced with extreme pressure S.A.E. 140 oil every 100 operating hours. The P.T.O. coupling shaft is pre-packed with wheel bearing grease and should not require further service for at least 1500 operating hours.

## SERVICE

**Excessive Vibration:** This can be caused by worn universal joints, a bent shaft or worn shaft or yoke splines. To service either the joints or splines, it is necessary to remove the shaft.

## TO REMOVE THE SHAFTS

1. Stop the engine in a position to allow the yoke flange bolts to be accessible. It may be necessary to remove the bolts from one trunnion and to turn the engine to complete the dismantling.

2. Bend back the washer tabs on the flange bolts on the split yoke universal joint. On early tractors, this will be the front joint on each coupling shaft, while later shafts are parted at the rear. Remove the bolts and tap the trunnions lightly with a soft hammer to separate the driving lugs, or prise apart with a screwdriver or similar tool. The two loose trunnions on P.T.O. shafts are wire tied to the spider assembly to prevent them from falling off when dismantling.

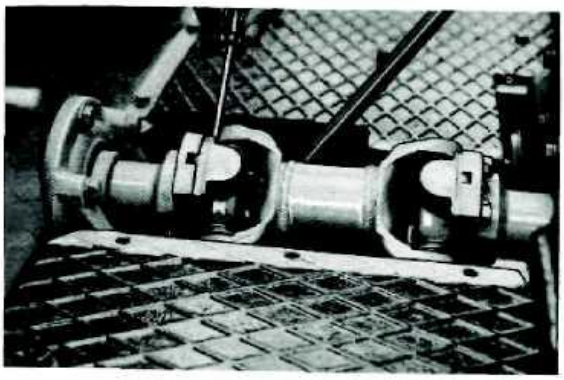


Fig. H.3 — Prising Flanges Apart

Fig. H.4 — Removing Main Coupling Shaft

3. The main coupling shaft may now be moved up to clear the rear yoke and backward from the front gearbox spline.

The removal of the clutch pedal pivot retaining bolts on early Champions having the clutch pedal fitted to the nearside of the rear gearbox, is necessary in order to remove the P.T.O. coupling shaft.

**Note:** When handling early type main coupling shafts exercise care to prevent bending or breaking the rear joint grease nipple extension.

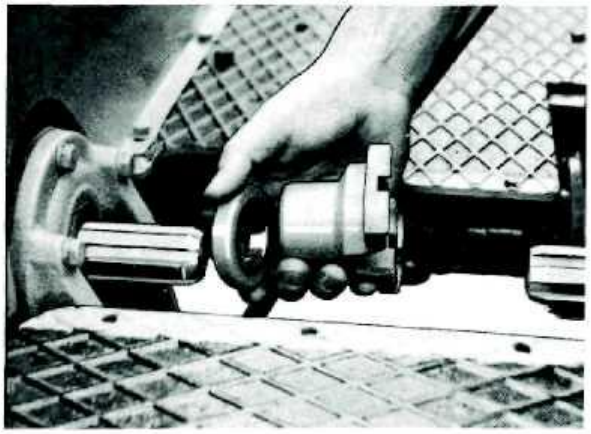


**Fig. H.5 — Removing Main Coupling shaft yoke.**

The removal of the cover from the footplates to gain access to the main coupling shaft is recommended.

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The four bolts on the No. 1 P.T.O. coupling shaft split universal joint are accessible without removing the nearside footplate.

If the shafts are being removed in order to move the front gearbox for clutch service on early Champions it is not necessary to remove the clutch pivot bracket from the rear gearbox. The P.T.O. shaft may be uncoupled, moved forward and left suspended between the clutch pedal boss and the brake cross-shaft. It may be necessary in this case to remove the inboard grease nipple from the clutch pedal to move the shaft sufficiently to clear the front yoke.

## TO DISMANTLE THE UNIVERSALS

**For each shaft:**

1. Remove the wire holding the two trunnions and remove the trunnions. (See Fig. H.6).
2. To remove the other bearing assemblies:

(a) Remove the retainer lock rings from the machined grooves at the inner end of each bearing. (See Fig. H.7).

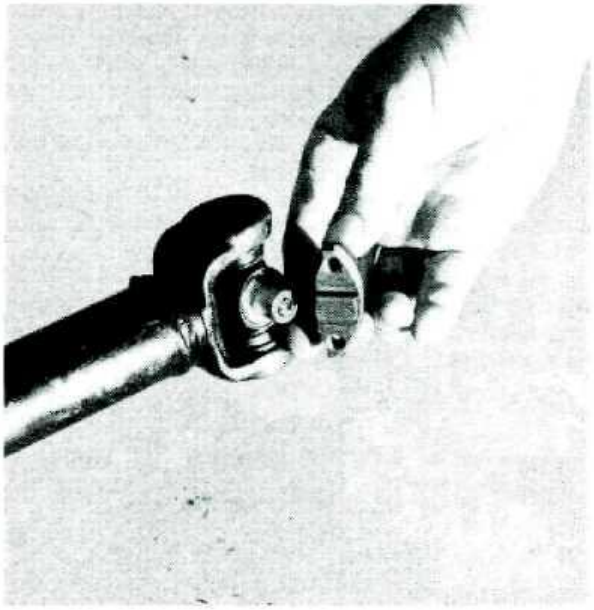


**Fig. H.6 — Removing Trunnion**

**Fig. H.7 — Removing Lock Ring**

## INSPECTION

1. Thoroughly clean all the component parts in petrol or solvent and probe the holes in the ends of the spider to remove hardened lubricant.

2. Examine the bearing surfaces on the spider and inside the outer races for signs of wear. Also inspect the needles. The outer races should be a neat fit in the yoke ends. If this is not the case, their slackness will have been noticed when dismantling. Replace worn or damaged parts.

3. Check the fit of the yokes onto the splined shafts. Excessive backlash will result in noisy operation and undue wear on the universal joint aesemblies.

4. Examine the cork seals and retainers for wear or damage. The seals should be smooth and flexible. If brittle or charred, replace with new seals.

## RE-ASSEMBLY

1. Repack the bearings of the P.T.O. coupling shaft with good quality wheel bearing grease and lubricate the main coupling shafts with extreme pressure S.A.E. 140 oil.

2. Check that the spider pilot diameters are clean and free from nicks and re-assemble the universal joint assemblies.

3. Rewire the separate front trunnions.

4. Re-fit the shafts to the tractor with the separate yokes on the appropriate shafts. Tighten the bolts to a tension of 16-20 lbs./feet for the main coupling shaft bolts and 12-15 lbs./feet for No. 1 P.T.O. coupling shaft or 16-20 lbs./feet for No. 2 P.T.O. coupling shaft.

Use new lockwashers. Bend to lock the bolts after tensioning.

## P.T.O. COUPLING SHAFT CONVERSION

A Conversion Kit (P/No. 20085) is available for converting the P.T.O. Coupling Shaft from the No. 1 type to the No. 2 type.

**Conversion Procedure:**

1. Drain the oil from the front and rear gearboxes.

2. Remove both coupling shafts and front yokes (See page H-3).

3. Remove the clutch shaft bearing retainer and seal from the front of the differential housing. Avoid damaging the seal on the shaft splines.

4. Check that the P.T.O. clutch is engaged, remove the clutch bearing shaft from the rear of the P.T.O. housing, then drift the clutch shaft forward through the differential housing. Remove the ball bearing.

5. Remove the rear cover from the front gearbox and remove the P.T.O. driven gear and shaft from the cover (See page G-5).

6. Remove the roller bearing from the P.T.O. Driven Gear Shaft.

7. Fit the roller bearing and circlip to the long splined P.T.O. driven gear and shaft observing the precaution stated in para. 10, page G - 9.

8. Fit the new shaft to the rear cover.

9. Fit circlip, retainer and seal. Avoid damage to the seal.

10. Re-fit the front gearbox rear cover.

11. Check upper mainshaft end float (see page G-9) and fit retainer.

12. Fit main coupling shaft.

13. Fit the ball bearing to the threaded end of the new clutch shaft.

14. Re-assemble the clutch shaft through the differential housing. Refit the clutch bearing shaft and check clutch adjustment.

15. Fit clutch shaft bearing retainer and seal. Avoid damage to seal.

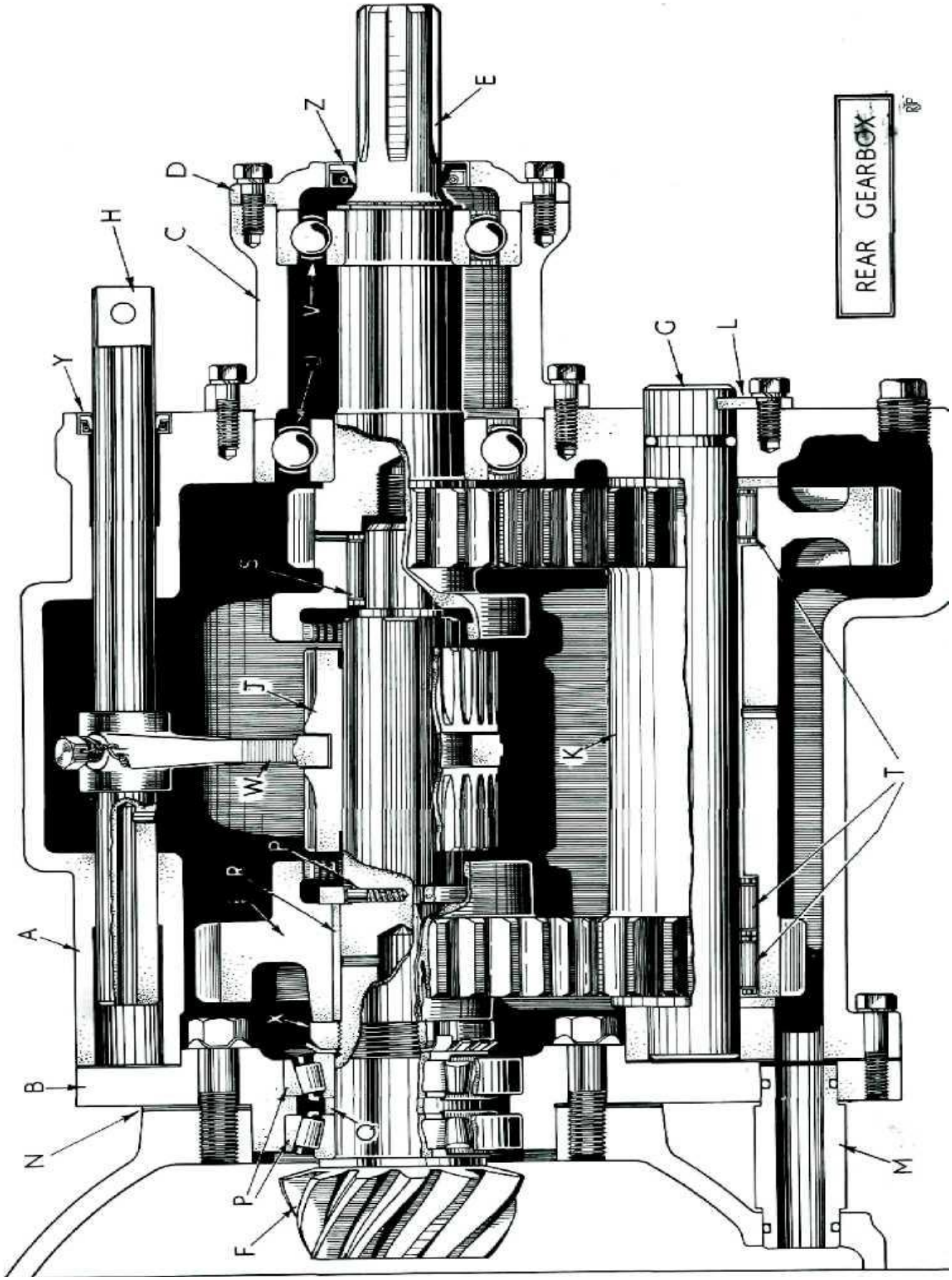
16. Fit the split yoke of the No. 2 coupling to the clutch shaft. Lock in place with spring washer and lock nut.

17. Install the coupling shaft and fit, tighten and lock the four yoke bolts.

18. Refill the front gearbox and differential to the current oil levels.

The Conversion Kit (P/No. 20085) consists of the following parts:

| Part No. | Part Name | Qty. |
|---|---|---|
| 21941 | P.T.O. DRIVE COUPLING, No. 2 Complete | 1 |
| 22929 | P.T.O. DRIVEN GEAR AND SHAFT | 1 |
| 22927 | SHAFT, P.T.O. Clutch | 1 |
| 22931 | NUT, Lock, Coupling Shaft | 1 |
| 4332 | WASHER, Spring, Coupling Shaft | 1 |
| 20181 | GASKET, Rear Cover, Front Gearbox | 1 |
| 20194 | GASKET, Rear Cover, P.T.O. Driven Gear | 1 |
| 21389 | GASKET, Retainer, Clutch Shaft | 1 |
| 20918 | WASHER, Tab, Main Coupling Shaft | 2 |


REAR GEARBOX
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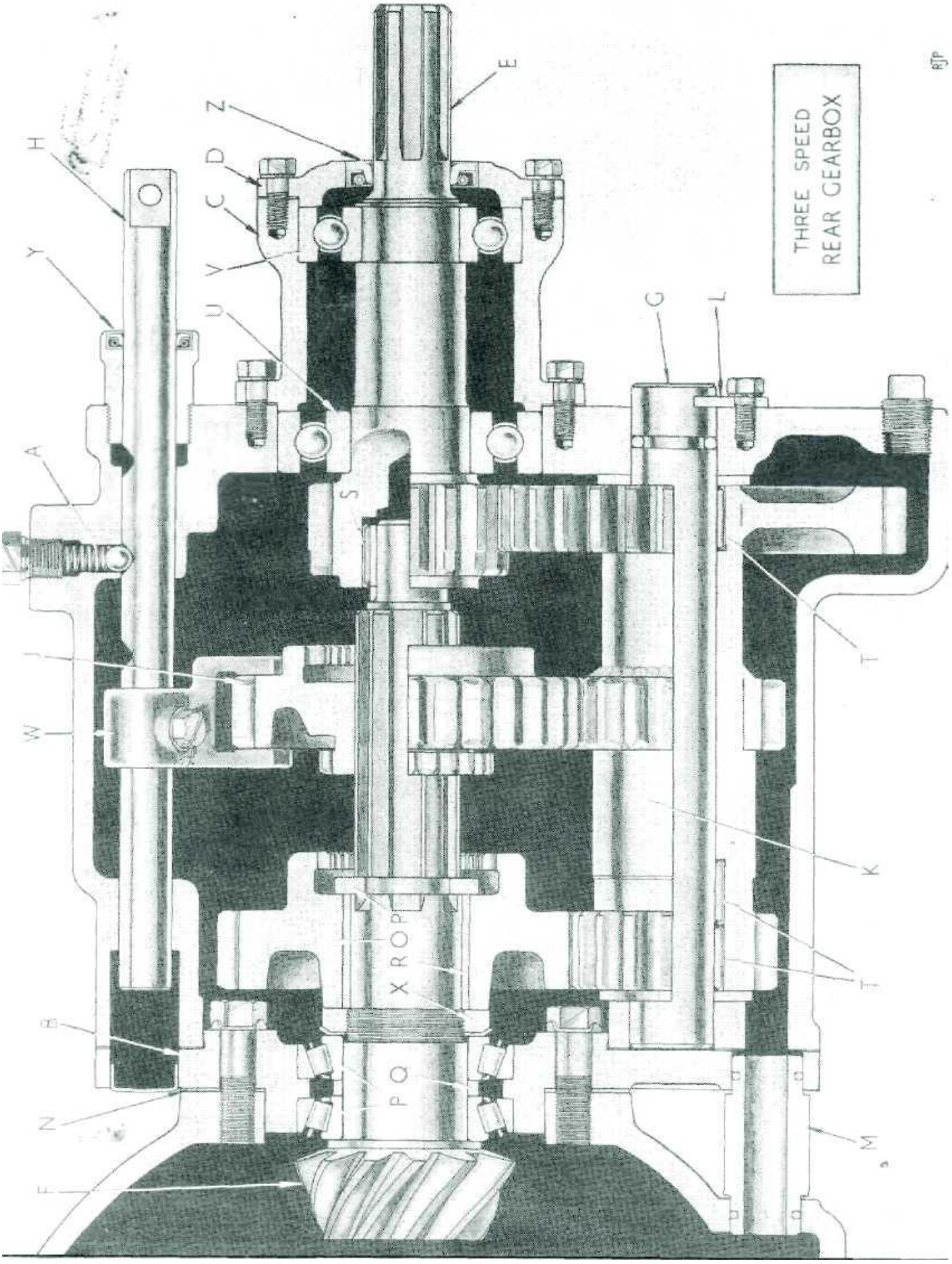
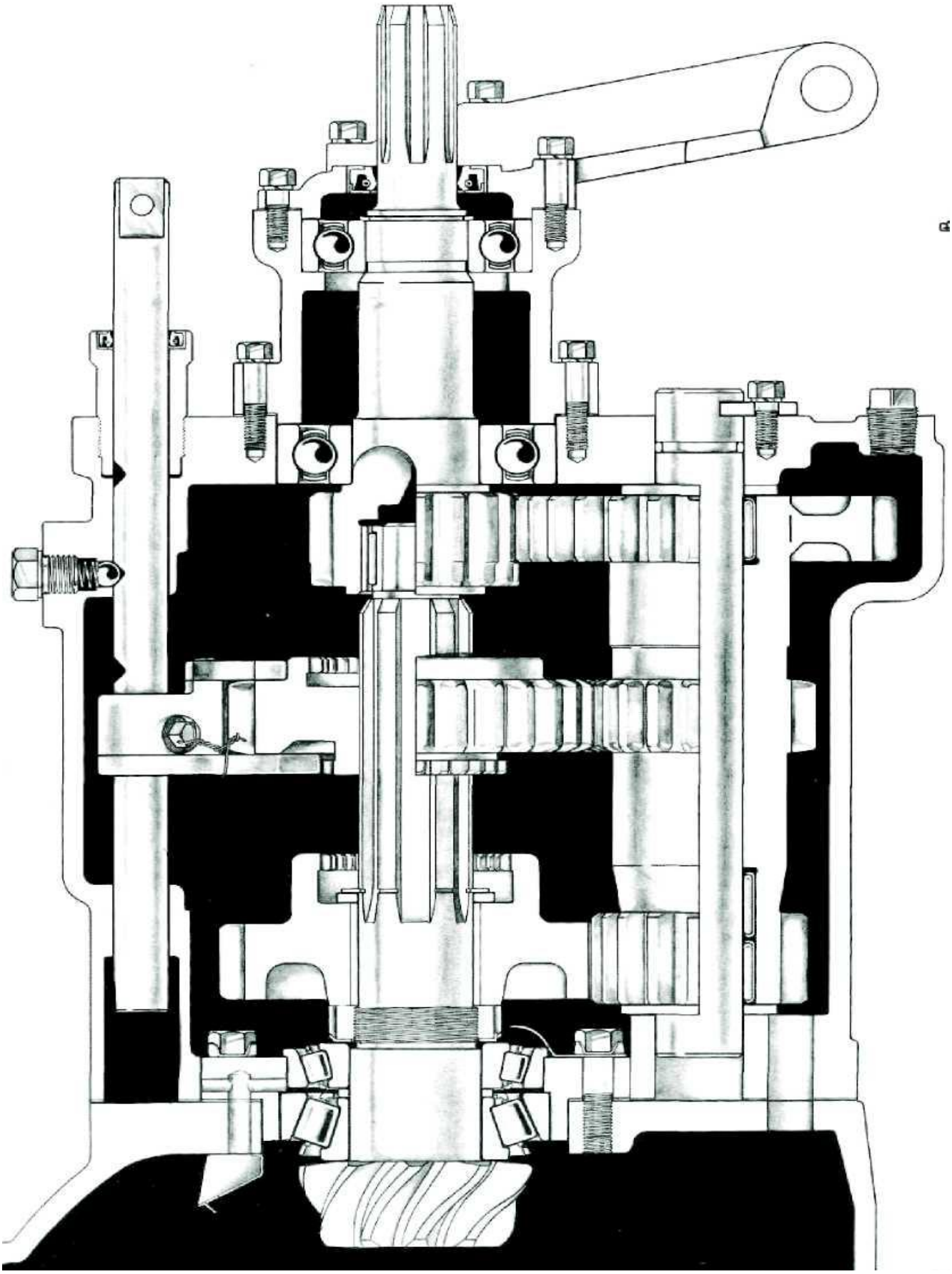




# REAR GEARBOX

## DESCRIPTION

The rear gearbox, mounted on the forward end of the differential housing, enables the drive to be transmitted to the differential unit. Agricultural tractors prior to Serial Number DM.1679 and all Industrial Champions have a 'two-speed' gearbox giving a direct drive, or alternatively, a four-to-one reduction through a train of gears. Crusader, Canelander and Agricultural Champions subsequent to DM.1679 have a 'three-speed' gearbox with an intermediate gear of 3.33 reduction interposed between high and low ratio.

The method of control for the gearbox has been changed at Serial Numbers HC.233, CR.222, DM.3592 and IND.1211, from a raise and lower lever mounted on a fuel tank pad in front of the seat, to a backward and forward type lever operating alongside the nearside of the main coupling shaft.

Of the three gearbox diagrams included in this Section, the first illustrates the original 'two-speed' unit, the second is of the first 'three-speed' unit, while the third is the current production 'three-speed' unit incorporating all the latest modifications.

At Tractor Serial Numbers DM.2074 and IND.396, the pinion end plate was modified to take steep angle bearings as illustrated in Diagram (2). A re-designed pinion bearing housing, introduced at serial numbers DM3277, IND. 1117, HC233 and RC172 has eliminated the pinion bearing end plate, the rear gearbox being extended to cover the area previously occupied by the end plate. At the same serial numbers, the gear form was modified and bottom spline location introduced.

The unit includes four shafts: the driving shaft (E), the counter shaft (G), the pinion shaft (F) and the selector shaft (H). The driving shaft is supported by two ball bearings (U and V), the bearing "U" being mounted in the main gearbox housing whilst the bearing "V" is mounted in the bearing housing (C) and located by a bearing retainer (D). The driving shaft is prevented from moving to the rear by a circlip in front of bearing "V". The bearing retainer is fitted with a spring loaded oil seal (Z).

The counter shaft (G) is located by a lock plate (L) and is fitted with an "O" ring type seal at its forward end to prevent oil leakage. A cluster gear (K) revolves on three needle bearings (T) on the counter shaft.

The pinion shaft is supported by two pre-loaded taper roller bearings (P) at the rear end and by a needle roller bearing (S), inside the driving shaft, at its forward end. The taper roller bearings are retained by a locked circular nut (X). The driven gear (O) is fitted with a bush (R) and retained on the pinion shaft by a ring (P) which is locked, on tractors prior to serial numbers DM3277, IND.1117, HC233 and CR172 by a plunger and spring and subsequently with a circlip.

The selector shaft is fitted with a fork (W) which, on the 'two-speed' gearbox, operates in the groove in the sliding dog (J), and, on the 'three-speed', gearbox, straddles the sliding gear (J). Tractors prior to DM.1679 and IND.421 had the selector retained in position by a spring leaf locating in slots in the raise and lower lever, while tractors after these Serial Numbers use a spring loaded ball (A) locating in notches in the selector shaft. An oil seal (Y) prevents oil leakage at the forward end of the selector shaft.

Lubrication is by oil bath common to the differential housing, the level being equalised by the transfer hole (M).

Adjustment of the pinion in relation to the differential crown wheel is made by shims (N) placed between the end plate and the differential housing.

The unit is ventilated by the differential vent and the drain plug at the front of the housing serves both the gearbox and the differential unit.

## OPERATION

### Two-Speed

With the selector in the "high ratio" position, the clutch, which is splined to the pinion shaft, engages in the internal teeth of the driving shaft. The driving and pinion shafts are thus locked together and a direct drive is obtained. With the selector in the "low ratio" position, the clutch engages in the internal teeth in the driven gear (1) and the drive is carried from the driving shaft gear to the cluster gear, then to the driven gear which is now locked to the pinion shaft. The gear ratios give a four to one reduction. As these gears are in constant mesh, the driven gear will revolve four times as fast the pinion shaft when the unit is operating in low ratio.

### Three-Speed:

High Range: The selector rail is moved forward so that the internal splines in the sliding gear (J) mesh with the extended teeth on the driving gear. The driving gear (E), sliding gear (J) and the pinion (F) are thus locked together to give a direct drive.

Intermediate Range: With the selector and sliding gear in the position shown the drive is carried from the driving gear to the cluster gear, then returned to the sliding gear, which drives the pinion shaft.

Low Range: The selector is moved to the rear to engage the external splines on the sliding gear with the internal spline in the driven gear. This locks the driven gear to the pinion shaft and allows the drive to be transmitted by the cluster gear.

## SPECIFICATIONS

**Ratios** — High: 1 : 1.
— Intermediate: 3.33 : 1. Three-speed gearbox only.
— Low: 4 : 1.

**Change** — Two-speed – Sliding Clutch.
— Three-speed – Sliding gear and dogs.

**Lubrication** — Oil bath and splash – S.A.E. 140 E.P.

**Bolt Tension:** Pinion bearing housing or end plate bolts, 70 lbs./feet.

**Pinion Bearing Pre-Load:** 20-26 lb./inches.

## MAINTENANCE

(As for Differential Unit).

## SERVICING

**Two-Speed Control Adjustment:**

Raise the control to the high ratio position, then note the distance past the leaf spring that the slot in the lever may be moved. Repeat this procedure for the low ratio position again noting the over-run. A small discrepancy may be corrected by slackening the two bolts in the leaf spring bracket and sliding the bracket up or down to suit. If this is insufficient adjustment, the bracket may be disconnected and the control lever turned in its lower thread until a satisfactory result is obtained.

**Oil Leakage:**

Driving shaft seal: Remove the coupling shaft cover, the main coupling shaft and the front bearing retainer.

**Shifter Rail Seal:**

Two-speed: Uncouple the selector link, remove the side cover and the selector setscrew and slide the rail through the front of the housing.

Three-speed: Disconnect the linkage and remove the extension plug. Care must be exercised when re-assembling.

Counter shaft: The shaft may be prised forward sufficiently to replace the "O" ring.

Transfer tube: Remove the rear gearbox from the tractor. The end plate may then be removed and the transfer tube removed to replace the two "O" rings.

## TO REMOVE THE REAR GEARBOX

It is possible to remove the rear gearbox whilst leaving the transmission assembly attached to the chassis. If any major overhaul work is contemplated, and provided suitable hoisting equipment is available, it is generally preferable to separate the transmission unit from the chassis.

If the former method is used, it will be necessary to remove the brake cross-shaft, fuel tank shield, coupling shaft cover (on Crusader and Canelander tractors, these last two operations necessitate the removal of the footplates), main coupling shaft and on tractors having the clutch pedal on the nearside, the clutch pedal pivot bracket. Jack up the front of the seat and the fuel tank and for ease of working, remove the P.T.O. coupling shaft, if fitted.

A curved flat ring spanner, such as the Dufor 304, will be necessary to remove one of the flange bolts.

Before the gearbox can be removed by this method, it will be necessary to remove the inspection cover, remove the selector fork setscrew, draw the selector rail through the front of the housing and remove the fork through the side opening.

The latter procedure is as follows:

## TO REMOVE THE TRANSMISSION ASSEMBLY FROM THE TRACTOR

**Agricultural and Industrial Champions:**

1. Remove the bolts coupling the mudguard brackets to the final drives, mudguards to footplates, rear gearbox shifter bracket to fuel tank (early tractors), fuel tank shield to footplates, disconnect the rear light wire (Agricultural tractors), and the guards, seat frame and fuel tank shield may be lifted clear of the tractor as a unit.

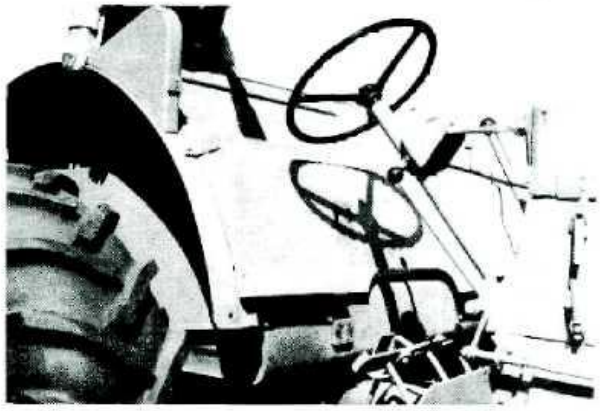


Fig. J.4 — Removing Seat and Guards (Champion).

2. Uncouple the fuel lines from the fuel tank, remove the two rear bolts and one front bolt from the fuel tank lugs, and the fuel tank may be removed. Logically, the more fuel in the tank, the greater the weight and likelihood of spillage when moving the tank.

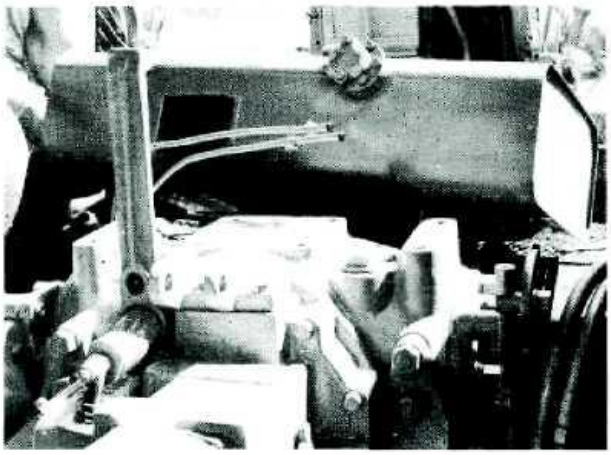


Fig. J.5 — Removing Fuel Tank (Early Champion).

3. Uncouple the brake rods from the brake levers at the rear of the final drives.

4. Remove the coupling shaft cover (6 bolts).

5. Remove the four flange bolts from the coupling shaft split yokes, separate the flanges and remove the main coupling shaft. The No. 1 P.T.O. coupling shaft will slide forward from the rear spline. If any difficulty is experienced with the P.T.O. shaft, refer to Section H.

6. On tractors prior to DM.3592 and IND.1211, uncouple the selector mechanism by removing the shouldered pin from the shifter rail and link. Tractors after these serial numbers need only have the operating lever removed.

7. Remove the two bolts from the drawbar pivot bracket and remove the bracket and drawbar.

8. Removal of the clutch pedal pivot bracket will be necessary on tractors having this unit fitted to the nearside of the rear gearbox.

9. Using tool No. 22753 or some suitable lifting bracket which will attach to the tapped holes in the top of the differential housing, take some of the weight of the rear assembly on a chain hoist. Place suitable supports under the rear of the chassis on both sides and remove the six chassis to differential housing nuts. Move the rear assembly backwards until the rear gearbox housing fouls the chassis cross-member, then raise the forward end of the rear assembly sufficiently to clear this obstruction and move the unit free. Take care not to damage the two lower studs, and the shifter bracket on later tractors, during this latter operation.

**Canelander and Crusader Tractors:**

1. Remove the mudguards.

2. Uncouple the fuel lines from the fuel tank, remove the rear gearbox shifter bracket to fuel tank bolts (early tractors) and the two rear and one front bolts from the fuel tank lugs. The fuel tank can now be removed.

3. Uncouple the brake rods from the brake levers at the rear of the final drives.

4. Remove the four flange bolts from the main coupling shaft split yoke and remove the shaft. Crusaders will also require the P.T.O. coupling shaft to be removed.

5. On tractors prior to HC.233 and CR.222, uncouple the selector mechanism by removing the shouldered pin from the shifter rail and link. Tractors after these serial numbers need only have the operating lever removed.

6. On Canelanders, it is necessary to remove the two bolts from the drawbar pivot bracket and remove the bracket and drawbar.

7. The pivot pin connecting the hydraulic cylinder to the T.P.L. bellcrank must be removed and the cylinder supported.

8. Remove the assembly as in Para. 9 of the preceding instruction.

## TO DISMANTLE THE GEARBOX

1. Drain the oil from the plug at the front of the rear gearbox. If the unit is suspended on a hoist, the forward end may be lowered to aid the draining.

2. Remove the front bearing retainer and oil seal (six bolts).

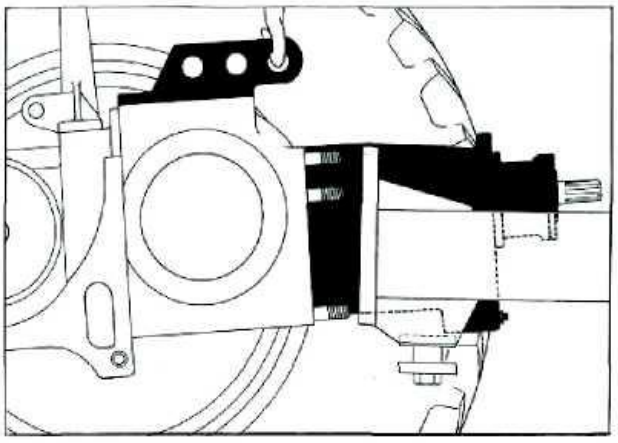


Fig. J.6 — Removing the Transmission Assembly

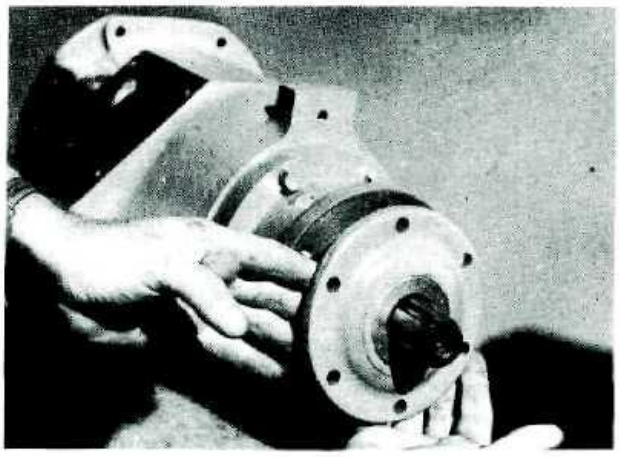


Fig. J.7 — Removing Front Bearing Retainer (Prior to lever modification)

3. Remove the 12 bolts retaining the gearbox housing to the pinion end plate (note that one bolt is fitted with a copper washer) and the rear gearbox may be moved forward as a unit to clear the pinion shaft.

4. On three-speed gearboxes, remove the selector shaft plug, spring and ball, and remove the extension plug.

On either gearbox remove the side cover plate. Unlock and slacken the selector fork setscrew. Slide the selector shaft out through the front of the housing and collect the selector fork and sliding gear. Care must be taken not to damage the shifter rail oil seal during dismantling.

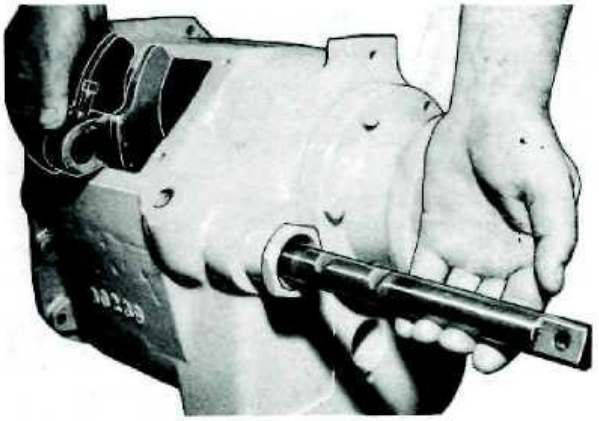


Fig. J.8 — Removing Fork and Shaft.

5. On two-speed gearboxes, the driving shaft cannot be removed through the front of the housing due to the cluster gear diameter and, although the three-speed driving gear is smaller, it is easier to remove in the manner set out in the next paragraph if complete dismantling of the driving gear is intended.

Remove the circlip from in front of the driving shaft's foward bearing and, using a press or drift, force the shaft through the bearings towards the rear of the housing. Take care not to damage the shaft splines.

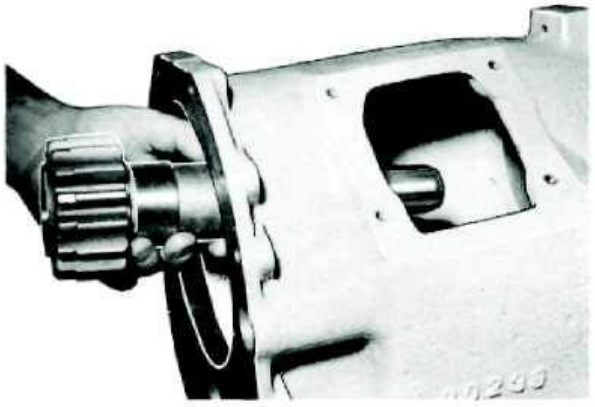


Fig. J.9 — Removing Drive Gear.

6. The driving gear bearing housing may now be removed and, if necessary, the two ball bearings may be removed from their respective housings.

7. Remove the setscrew and lock plate from the forward end of the countershaft and push the shaft out through the front of the housing. The cluster gear and its three bearings may now be removed through the rear of the main housing.

**Caution:** If the three bearings are to be removed, take care not to score the gear bore as this will make replacement of the gear necessary.

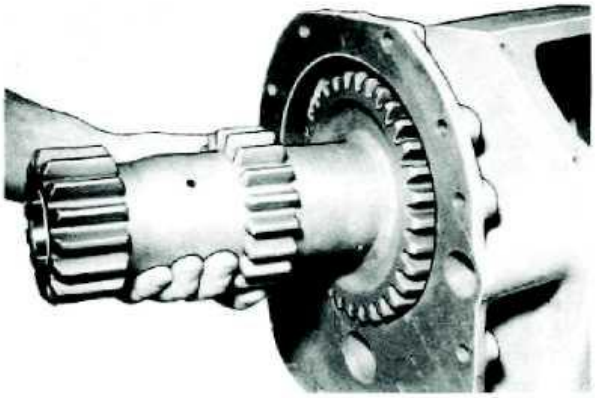


Fig. J.10 — Removing Cluster Gear.

8. Using a narrow knife blade, or some similar tool, depress the plunger locating the driven gear retaining washer. Turn the washer until its splines coincide with those of the pinion shaft and slide it from the shaft. Collect the plunger and spring and remove the gear from the shaft. Later gearboxes have a circlip retaining the washer and this can be removed with circlip pliers.

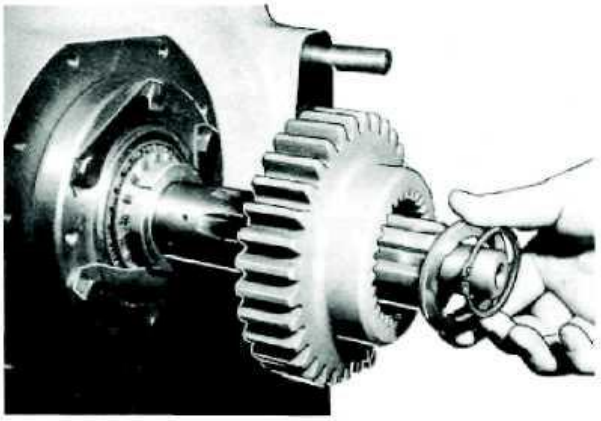


Fig. J.11 — Removing Driven Gear Retainers.

9. Unlock and remove the six bolts retaining the end plate (or pinion bearing housing) and prise the plate free of the differential unit. Take care not to damage, and note the number of, the pinion shims and avoid damage to the oil transfer tube and its "O" rings, when fitted.

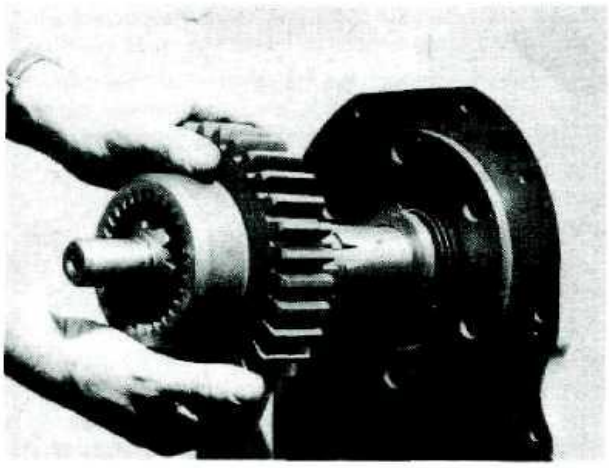


Fig. J.12 — Removing Driven Gear (2 speed)

10. The pinion shaft may be dismantled from the end plate by unlocking and removing the circular nut. Hold the shaft firmly in a soft-jawed vice and using tool No. 22752, remove the nut. The shaft may then be pressed or drifted from the plate and the bearings removed with a bearing puller. This circular nut and others used on the tractor can be removed with a drift which has its face cut at an angle, but it is difficult to avoid damage to the nut.

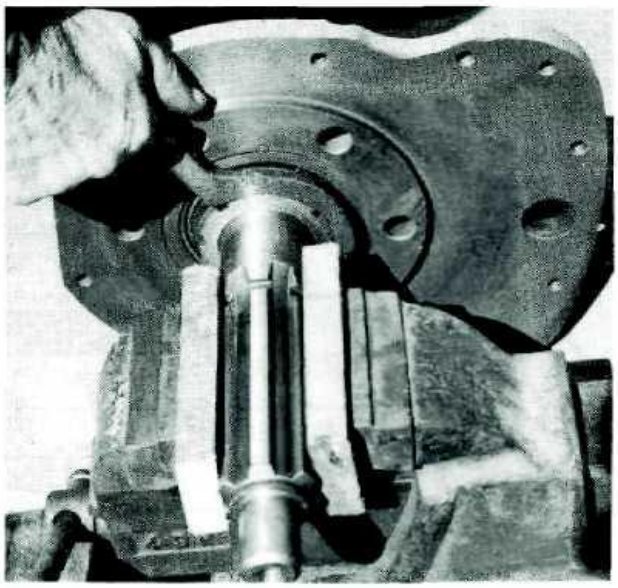


Fig. J.13 — Removing Pinion Bearing Nut.

## INSPECTION

Thoroughly clean all parts and inspect all shafts, bearings and gears for signs of excessive wear. Replace if necessary. Check the condition of the two oil seals and the three "O" rings.

Check the pinion bearings. If any doubt exists regarding their serviceability, replace them. Where the bearings are new and first assembled, the pre-load should be 20-26 lbs./inches. Initial settling in of the bearings cause a rapid drop to approximately one half of this pre-load with bearing wear controlling any further decrease. Serviceable bearings should be set to this reduced pre-load of 10-13 lbs./inches on re-assembly.

The method illustrated is to attach the spring balance to a lever arm measuring 6" from the centre of the shaft to the attachment point and slowly increase the pull until the shaft commences to turn. After the shaft inertia has been overcome, a reading on the scale of approximately four pounds (new bearings) should be recorded. The bearings must be clean and lightly oiled to give accurate results. Shims must be removed, or added, between new bearings to obtain the correct reading. (As a guide .001" shim variation changes bearing pre-load approximately 4 lbs./inches.)

**Note:** Ensure that the locknut holds the bearing against the spacing shims and not against the bearing cup. Securely tighten the nut before checking pre-load.

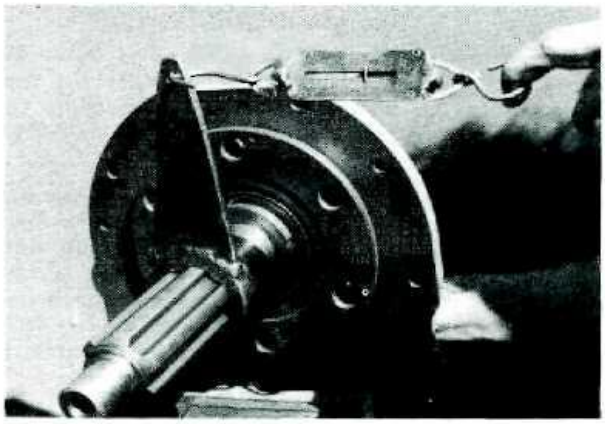


Fig. J.14 — Checking Pinion Bearing Pre-load.

## RE-ASSEMBLY

Re-assembly is a reversal of the dismantling procedure but the following points should be noted:

(a) If the pinion bearings have been replaced, it will be necessary to check the mating of the pinion with the crownwheel as described in the differential section.

(b) The six bolts retaining the end plate (or bearing housing) should be tightened with a tension wrench to give a reading of 70 lbs./feet. When not previously fitted, it is recommended that Oil Trap P/N.30611 be added to the assembly to ensure adequate lubrication of the pinion bearings.

(c) When replacing the driven gear retaining washer, place the blank spline in the washer in line with the plunger, depress the plunger and turn the washer until the blank spline is opposite its starting position.

(d) Check carefully (on early gearboxes) that each of the four needle bearings are correctly situated in their respective positions when assembling as these may fall from place when manipulating the components.

(e) It is safe practice to replace all gaskets on re-assembly.

## CONVERSION FROM 2-SPEED TO 3-SPEED REAR GEARBOX

The conversion involves the following modifications:

1. The replacement of the Cluster Gear (20218) with a three Speed Cluster (30235).

2. The replacement of the Sliding Clutch (20554) with a Sliding Gear (30238).

3. The introduction of a new main Driving Gear (30240) in place of 20372.

4. The replacement of the Cluster Gear Bearings (20513) with Needle Roller Bearings (32514).

5. The replacement of the Pinion Forward Bearing (20187) with a Needle Roller Bearing with inner race (32553) and collar (30245).

6. The introduction of a new shifter mechanism involving a new housing (30239) and the drilling of the chassis and the Gearbox End Plate.

## DISMANTLING

If care is exercised there is no need to upset the pinion to crownwheel setting, consequently the rear gearbox may be removed without separating the transmission from the chassis. This procedure is dealt with on page J - 6.

Having removed the Gearbox Housing (note that one of the flange bolts is fitted with a copper washer) dismantle the gearbox and pinion from the end-plate. Exercise extreme care not to damage or misplace the end plate to gearbox shims. The conversion does not necessitate the removal of the pinion from the end plate, but this procedure is advisable in order that the pinion bearings may be closely inspected.

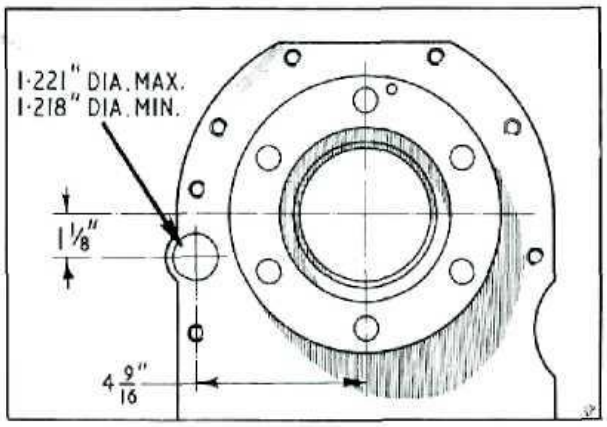



Fig. J.15 — End Plate Modification.

## CONVERSION

1. Drill a hole through the End Plate in the position shown in Fig. J.15. The hole size as shown is that which is used in the factory to ensure a tight fit on the cup plug (32588).

With field drilling it may be difficult to maintain the .003" tolerance given, and although the plug allows considerable latitude, it is important that it is a tight fit, otherwise oil leakage will result.

2. Drill a 41/64" dia. hole through the inner and outer webs of the offside chassis member as shown in Fig. J.16 and remove the existing pivot pin.

3. Drive in the plug from the front of the end plate with the flange facing forward, until about 1/16" proud of the rear of the plate.

4. Fit the collar to the forward end of the pinion and carefully press on the bearing race.

5. Re-assemble the pinion to the end plate and check the pinion bearing pre-load 20-26 lbs./inches) (See Fig. J.14).

6. Re-assemble the pinion and end plate to the differential with the original shims. Make sure shims and faces are clean and that the transfer tube "O" Rings are in good condition. Tighten the end plate bolts to 70 lbs./feet and lock.

7. Fit the front bearing retainer and seal. Use a piece of shim stock to prevent damaging the seal on the shaft splines.

8. Install the original driven gear. When replacing the gear retaining washer, place the blank spline in the washer in line with the plunger, depress the plunger and turn the washer until the blank spline is opposite its starting position.

9. Fit the three needle bearing to the cluster gear with the letters and numbers on the bearing facing outwards.

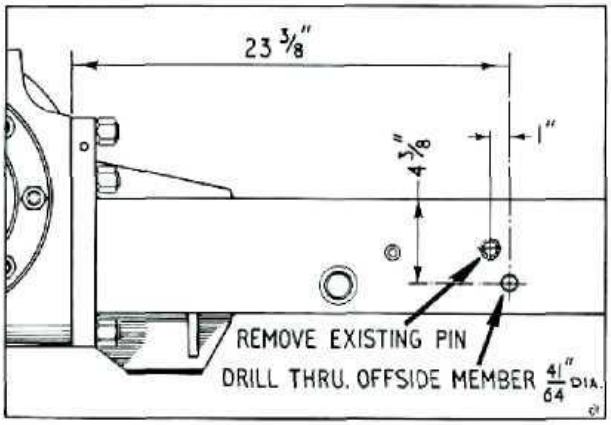



Fig. J.16 — Chassis Modification.

10. Assemble the cluster gear and shaft with thrust washers into the gearbox housing. Smear the forward end of the shaft and the "O" Ring groove with grease to avoid damaging the "O" Ring. Secure with lockplate.

11. Fit the needle bearing into the rear of the new main driving gear with the letters and numbers to the rear.

12. Fit the rear ball bearing to the main driving gear.

13. Fit the main driving gear bearing housing to the bearing and install onto the gearbox housing.

14. Install the front ball bearing to the main driving gear and fit the circlip.

15. Slide the sliding gear onto the pinion.

16. Assemble the rear gearbox to the end plate using a new gasket. Refit the copper washer under the offside bolt. Tighten the flange bolts evenly.

17. Screw the shifter rail front extension plug into the gearbox housing.

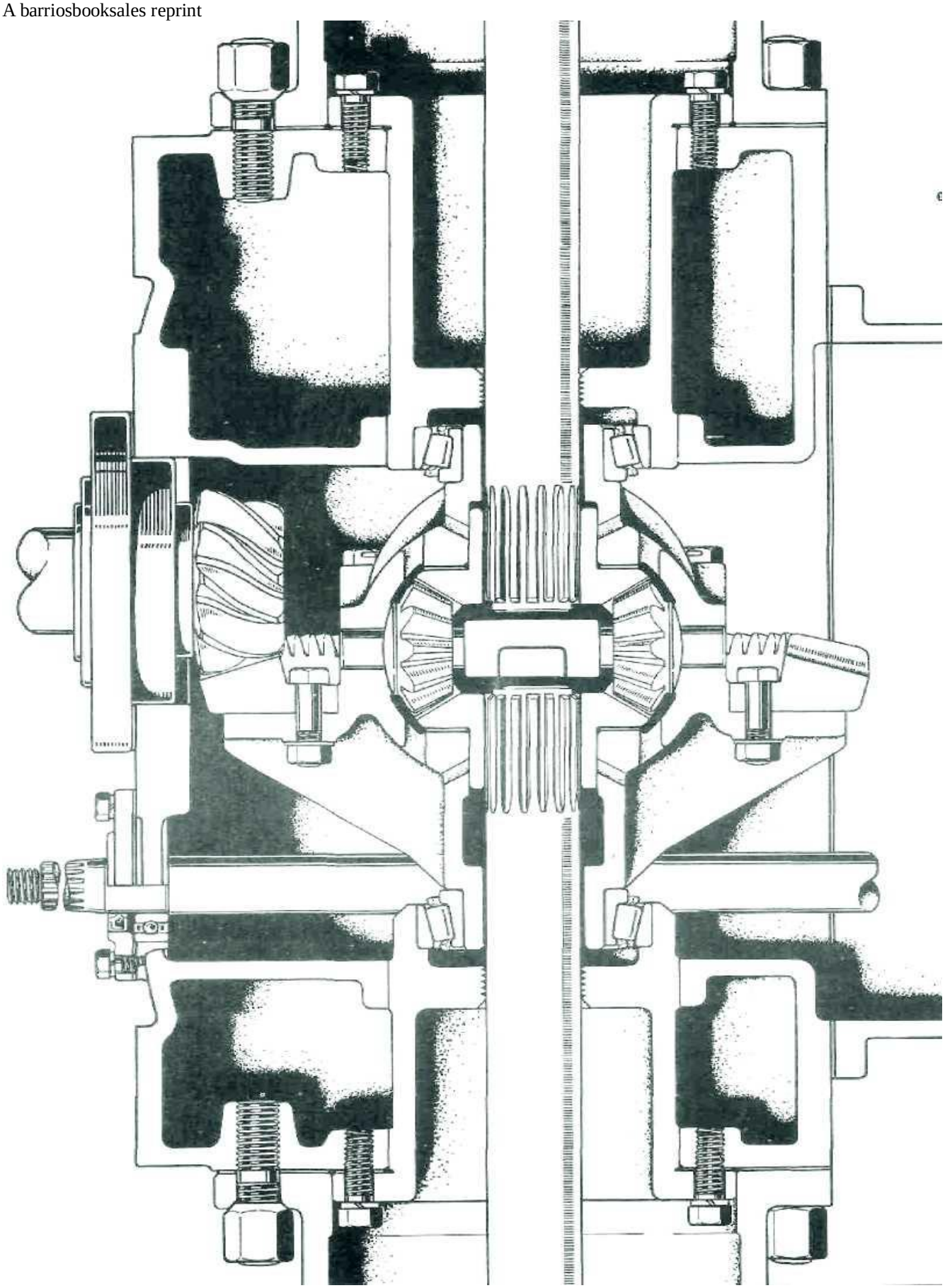
18. Through the inspection hole, hold the selector fork in position straddling the sliding gear and slide the shifter rail into position through the front of the housing. Locate the fork on the rail with its setscrews. Check that the selector mechanism operates through its full travel without fouling.

19. Lock the fork setscrew, refit the inspection cover and install the plunger ball, spring and plug.

20. Install the new pivot pin through the hole drilled through the chassis.

21. Replace the main coupling shaft and assemble the shifter linkage.

22. Replace all previously removed components, refill the transmission with oil. Test the operation and check for oil leaks.



# DIFFERENTIAL

## DESCRIPTION

The differential assembly is enclosed in a housing which is attached directly, by six studs and chamfered nuts, to the tractor chassis or underframe. Tractors prior to serial numbers DM3277, IND1117, HC233 and CR172 have, bolted to the front of the housing, a rear gear box end plate which contains the pinion bearings and onto which is in turn bolted the rear gear box assembly. Subsequent to these serial numbers, excluding reverse differential tractors, a pinion bearing housing has been fitted to a modified differential housing with the rear gear box extended to bolt directly onto the differential housing. Either a cover plate or a Live P.T.O. unit is fitted to the rear of the housing, the drive to the P.T.O. unit being carried through the differential housing by a splined shaft. Onto each side of the housing are mounted extension housings which couple the unit to the final drive units in each wheel.

The differential unit is mounted on taper roller bearings supported in two removable insert housings (8). Lateral position and bearing adjustment are achieved by shimming behind the flanges of these two housings. The pinion position, relative to the crown wheel is adjusted by shimming between the rear gear box end plate, or pinion bearing housing, and the differential housing.

A four-star bevel gear assembly provides the compensating action of the differential, and the crown wheel (2) and pinion (1), are of the mated spiral bevel type. The drive is carried from the crown wheel by the differential casing (3) to the differential pinions (5), these pinions being mounted on two half-lapping cross shafts (4). The four pinions mesh with two gears (6) supported in the differential case and into which are splined two half shafts (7) which carry the drive through the insert housings to the final drive units. Prior to the serial numbers quoted above, the crown wheel thrust is taken by an adjustable bronze block, the location of which is controlled by a screw which protrudes through the flange of the nearside extension and is locked by a locknut. Tractors produced after these serial numbers do not have the block fitted and it may also be deleted at overhaul of the earlier units.

Lubrication to the unit is by oil bath and splash. The oil bath is inter-connected with that in the rear gear box on early tractors by an "O" ring sealed oil transfer tube, and currently through a matching hole in both housing and gear box. At serial numbers DM2986, IND981, CR172 and HC183, an oil trap (9) P/N30611 was introduced to ensure adequate lubrication of the pinion bearings. Subsequently, for forward differentials only, an oil scraper and trough (10) P/N30654 has been included to assist this lubrication. It is recommended that oil trap P/N30611 be fitted during overhaul of the differential unit on tractors prior to the serial numbers quoted. The differential vent also serves the rear gear box and P.T.O. unit, if fitted. Extreme pressure S.A.E. 140 oil is the recommended lubricant.

## MAINTENANCE

Check the oil level every 100 hours and drain and replace every 1,000 operating hours. Two methods of obtaining the oil level have been used, one using a dipstick and the other an oil level plug. When a dipstick is fitted, either to the filler plug or to the tapped hole in the mounting pad, the reading is taken with the plug resting on the face of the housing. If an oil level plug is fitted to the left hand side of the P.T.O. unit, oil should be present when the plug is removed, but in the case of an elbow and plug being fitted to the rear cover of the differential housing, the oil level is correct when oil reaches the bottom thread in the elbow. Current model tractors have two drain plugs, one located beneath the differential housing and the other at the front of the rear gear box, whilst earlier tractors have only the latter. Most effectual scavenging will be achieved when draining if the operation is carried out with the tractor heated from working.

With the introduction of the modified differential housing, the quantity of oil has been reduced to approx.mately three-four gallons.

## SPECIFICATIONS

| | |
|---|---|
| Make | — Own. |
| Type | — Spiral Bevel 4-star Bevel. |
| Ratio | — 11 : 40. |
| | — 9 : 40 (Canelander prior to Serial Number HC233). |
| Backlash | — As indicated on the crown wheel periphery. |
| | — .008" - .013" – sidegear and pinion. |
| Bearing preload | — Pinion bearings – 20 - 26 lbs. inches. |
| | — Differential bearings 15 lbs. inches. |
| Adjustment | — Shims – Pinion and Differential. |
| Thrust block (when fitted) | — .004" - .006" clearance. |
| Bolt torque | — Rear gearbox end plate 120 lbs. ft. (prior to modified housing). |
| | — Pinion bearing housing 70 lbs. ft. |
| | — Differential case 70 lbs. ft. |
| | — Inserts, carrier bearings 70 lbs. ft. |
| | — Crown wheel to carrier 50 lbs. ft. |
| Lubricant | — Extreme pressure S.A.E. 140 oil. |
| Oil change | — 1000 operating hours. |

## SERVICING

**Oil leakage:** As the rear gearbox and P.T.O. units are inter-connected with the differential unit, any leakage from these units will adversely affect the differential oil level. Correction of leakage in these units is covered in their respective sections.

On the modified differential housing bearing inserts, labyrinth grooves are introduced to prevent carryover of the lubricating oil into the outer compartments and final drive extensions.

**Inspection:** Should an inspection of the differential unit be considered advisable, it is necessary to remove the P.T.O. unit, if fitted, as described in section M.

**TO REMOVE THE DIFFERENTIAL ASSEMBLY:**

1. Drain the oil from the assembly.

2. If three point linkage is fitted, disconnect the ram at the bellcrank end and remove both lower links and swaychains.

3. Remove the P.T.O. unit, if fitted. This operation is fully covered in the P.T.O. section.

4. Remove any wheel weights fitted to the rear wheels. With segment type weights, the upper weight should be removed first so that these may be rested on the lower weights until lifted clear.

5. With the tractor weight still being carried by the rear wheels, slightly loosen the wheel nuts on each wheel. It should be noted at this stage that if a complete overhaul involving final drive dismantling is to be carried out, it is advisable to slacken the large hexagon nuts on each rear axle whilst the wheels are on the ground. Support the tractor by jacking under the rear of each chassis member so that the wheels are just resting on the ground, remove the wheel nuts and the wheels.

6. Agricultural and Industrial Champions. Where the rear gear box change lever is attached to a fuel tank mounting pad, remove the bolts. Slacken the two bolts coupling the mudguards to the foot plates and the four bolts coupling the fuel tank shield to the foot plates. Block between the fuel tank and the base of the seat and remove the three bolts coupling each mudguard bracket to the final drive units. Raise the rear of the mudguard sufficiently to clear the brake mechanism when the final drives and extensions are being removed. Hold in this position by blocking between the seat and fuel tank.

Canelander and Crusader. Remove the mudguards.

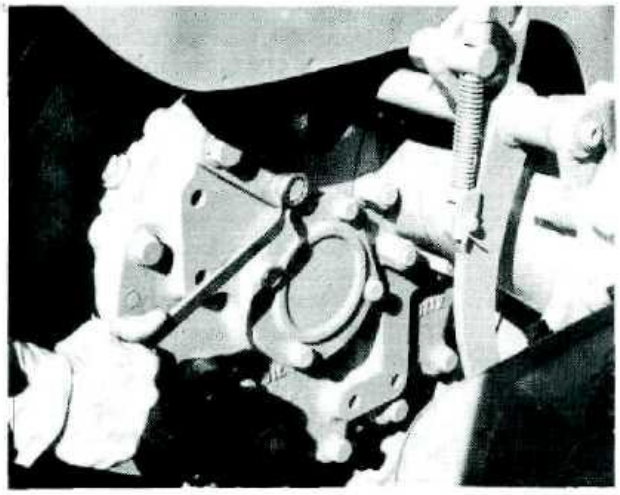


Fig. K.2 — Removing Mudguard Bracket Bolts.

7. Uncouple the brake rods from the brake lever arms.

8. Place a jack under the offside final drive to take the weight when the nearside unit is removed. Support the nearside unit with a suitable chain hoist. On tractors using separate brake drums, the use of a chain sling, as illustrated in Fig. K3, with the lifting point in line with the brake shaft has been found a suitable method of supporting this unit. Where cast centres are fitted, it is necessary to use a bracket and chain attached to the rim clamp stud together with a chain sling fitted around the final drive extension, to adequately support and balance the additional weight.

Remove the flange nuts and the thrust block screw, if fitted, and remove the final drive unit and extension. Check that the half shaft is being withdrawn with the unit as some difficulty may be experienced in guiding the shaft through the oil seal on reassembly if the shaft becomes separated from the final drive unit.

Repeat for the offside unit.

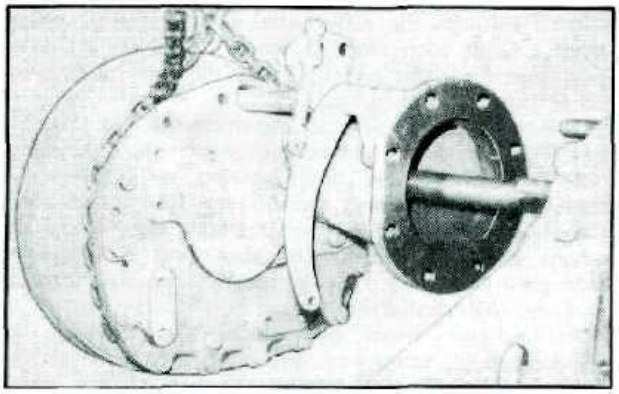


Fig. K.3 — Removing Final Drive Assembly.

9. If fitted, unscrew the thrust block screw until the thrust block may be removed. On some tractors a small steel disc is fitted between the end of the screw and the thrust block. If the block is reassembled, this must be refitted otherwise the thread may not protrude sufficiently through the extension flange to accommodate the locknut.

9. Remove the six bolts from the flange of the nearside insert housing and whilst supporting the differential assembly (wood blocks are suitable), withdraw the insert housing until it is well clear of

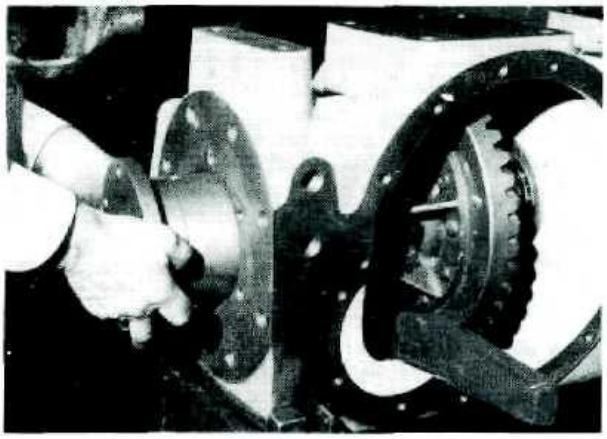


Fig. K.4 — Withdrawing Insert Housing.

their bearing. Take care not to damage the shims behind the flange.



10. The differential unit may now be manipulated from the housing.

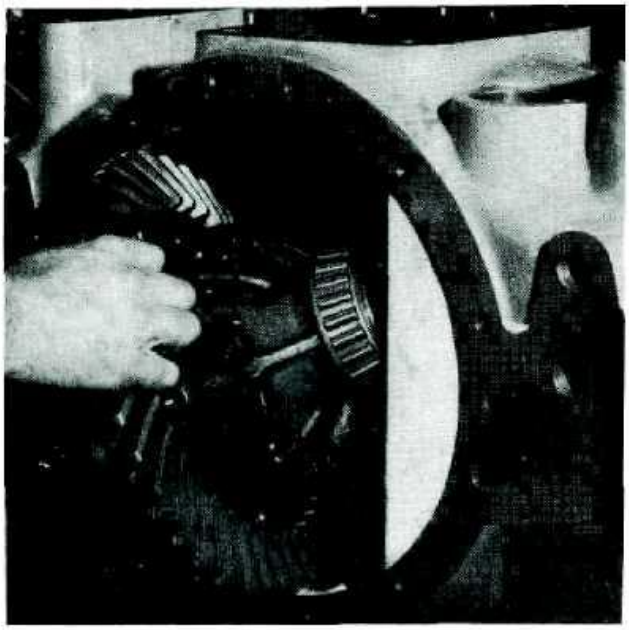


Fig. K.5 — Removing Differential Unit.

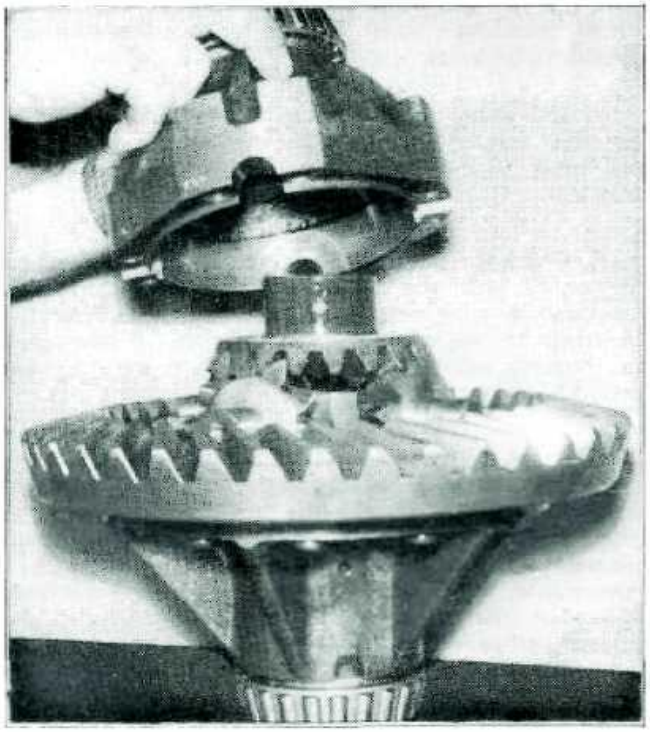


Fig. K.6 — Dismantling the Differential Unit.

## TO DISMANTLE THE DIFFERENTIAL

1. Mark the differential casing to ensure that it is re-assembled in the same position. A centre punch may be used to mark adjacent points on each half of the casing.

2. Unlock and remove the eight bolts coupling the two halves of the casing.

3. The casing may now be parted and the components removed. Care must be taken to ensure that the parts are replaced in the same positions.

4. If required, the bearings may be removed from the housing and differential casing with the aid of suitable bearing pullers.

When re-assembling, tension the casing bolts to 70 lbs./ft. and wire lock.

## INSPECTION

Thoroughly clean and inspect all parts of the differential, crown wheel and pinion gear. If one of the differential gears or pinions is found to be faulty, carefully examine the remainder as these may have been affected. Should the gear or pinion thrust washers show appreciable wear, replace the set (4 pinion or 2 gear washers) to ensure an even distribution of loads when the unit is re-assembled.

To maintain the backlash of .008" to .013" between the gears in this unit, the thrust washers P/N20903 (.048") have sometimes been supplemented with a .010" shim. A new thrust washer P/N31386 (.058") has been introduced making the .010" shim unnecessary. It is recommended that where a differential has previously had both the .048" thrust washer and .010" shim fitted, that these two items be replaced with the .058" thrust washer.

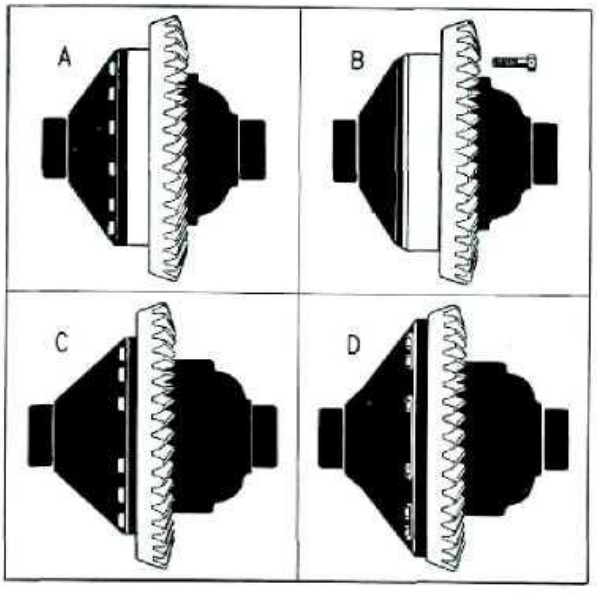



Fig. K.7 — Differential Models.

In the event of differential parts being required, refer to the above illustration to determine the model of the differential. Model "A" may be identified by the presence of a spacer rivetted between the crown wheel and the casing. Model "B" has a spacer rivetted to the casing, with the crown wheel bolted to the spacer. Model "C" has no spacer and the crown wheel is rivetted directly to the casing. Model "D" has an increased diameter supporting flange and the crown wheel is bolted to the carrier.

Internal parts are available for Models "A", "B" and "C", but should a complete replacement be necessary, it is advisable to replace the assembly with Model "D" unit. The assemblies are interchangeable other than the necessity of replacing the offside insert housing (P/N20145) with P/N20909 when fitting a Model "D" unit in place of Models "A" or "B". This replacement unit includes the crown wheel so that if the unit is fitted it will be necessary to also fit a mated pinion shaft. Should the existing crown wheel be still serviceable, the casing, internal parts and the offside insert housing may be obtained separately and the crown wheel transferred to the replacement casing.

## TO REPLACE THE CROWNWHEEL

As previously mentioned, the crownwheel and pinion shafts are available only as mated pairs, so that, in the event of failure of either of these components, both must be replaced. To remove the pinion shaft, it is necessary to remove the rear gearbox housing from the differential housing. A detailed account of the recommended procedure is given under the heading of "To Dismantle the Rear Gearbox", in Section J.

Model "A" and "C" differentials have the crownwheel rivetted to the casing. It is recommended that the Model "C" rivets be replaced with bolts, nuts and locktabs P/Ns 31145, 4302 and 32682.

The procedure to be adopted for replacing the Model "A" rivets should be:—

(a) Drill the heads from one end of all the rivets and drift them out.

(b) Ensure that the faces of the crownwheel and casing are perfectly clean and that the crownwheel is tight against the face.

(c) Place the crownwheel in position and align two or more rivets through the holes.

(d) Heat the rivet to a temperature of 950°C-1050°C (yellow), place in position and commence riveting. The rivet should be expanded into the hole before forming of the head is completed.

Due to the tolerance allowance of .002", a crownwheel on the low limit may be matched with a casing on the high limit and be an interference fit. In this case, it will be necessary to heat the crownwheel in an oven or an oil bath to a temperature of 100°C-120°C (212°F to 248°F) before assembling.

Whenever a new crownwheel is fitted to a carrier, the assembly should be checked for crownwheel run-out. This must not exceed .003". In the event of run-out exceeding that specified, the crownwheel must be removed and the carrier flange inspected and if necessary trued up.

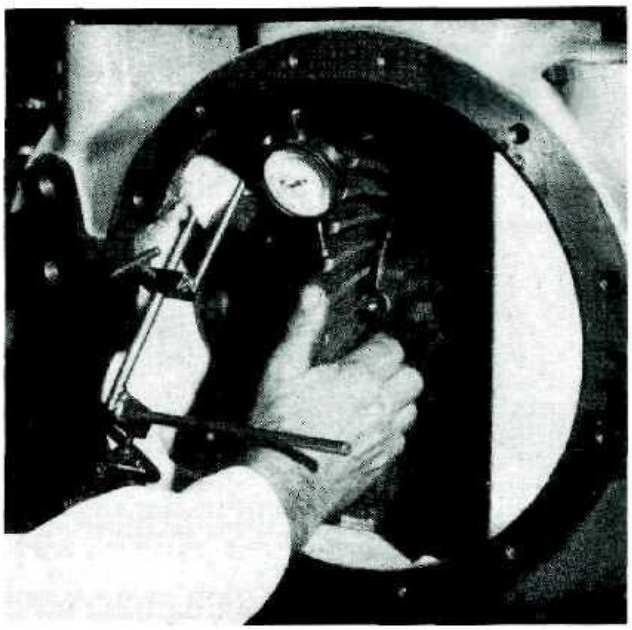


Fig. K.8 — Checking Backlash.

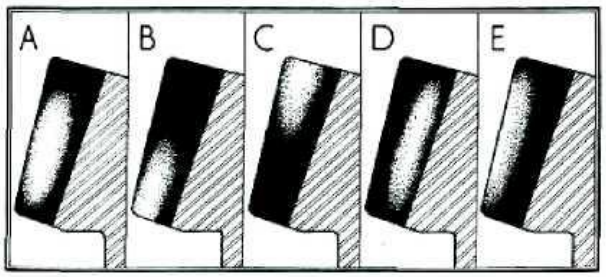
## ADJUSTMENT OF DIFFERENTIAL BEARINGS

If the P.T.O. has been removed for inspection of the differential unit, use two suitable levers to force the assembly from side to side. If it appears that some end float may exist, mount a dial test indicator against the plane face of the crownwheel and measure the total movement. Remove an equal number of shims from each insert housing to give the required preload of 15 lbs. inches.

*If any appreciable adjustment* to either the differential assembly or the pinion shaft is made, check the mesh of the crownwheel and pinion as detailed below.

1. Check the backlash, indicated on the crownwheel periphery, with the aid of a dial test indicator. The backlash may be increased by moving shims from the nearside to the offside insert housing, or decreased by moving shims from the offside to the nearside insert housing.

2. Paint at least a dozen of the crownwheel teeth with Prussian blue or red lead. Turn the assembly by hand several revolutions in both directions to secure impressions of tooth contact. The points of contact will be indicated by the coating having been worn away at these points. Concentrate on the driving sides of the teeth as, if these are correct, the coasting or reverse sides of the teeth will usually be satisfactory. The driving sides of the crownwheel teeth at the rear are the upper sides. Compare the markings with those in the diagram below:




Crownwheel Marking.

A — Correct.

B — Insufficient backlash—Move differential towards nearside (L.H.).

C — Excessive backlash—Move differential towards offside (R.H.).

D — Pinion too close—Add shims behind end plate.

E — Pinion out too far—Remove shims from behind end plate.

After making all adjustments, recheck the differential bearings for end float.

Whilst removing insert housings to make adjustments, care must be taken to avoid damaging the bearings. In the event of a major operation, such as the renewal of bearings or crownwheel and pinion, it will be found simpler to assemble the insert housings without shims and with two bolts each side. The bolts may then be tightened or slackened to adjust the mesh, the gaps measured and appropriate shims fitted. Care must be taken not to over-tighten the bolts, thus over-loading the bearings and giving an incorrect reading of shim requirements.

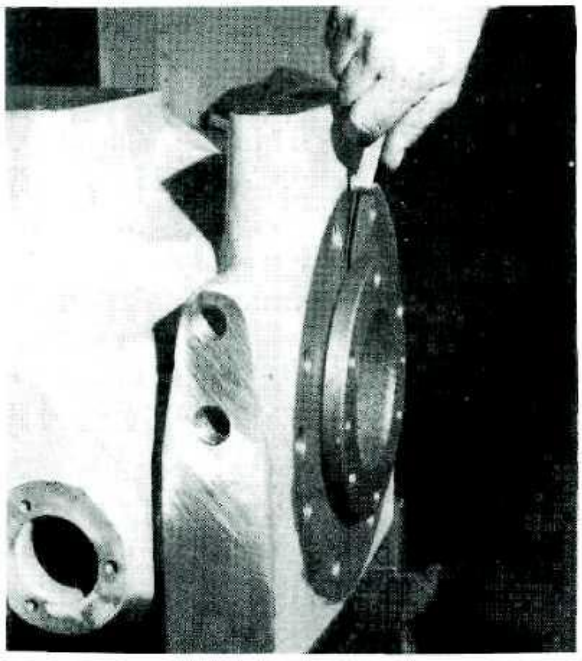


Fig. K.9 — Measuring for Insert Shims.

## RE-ASSEMBLY OF THE DIFFERENTIAL

Re-assembly is a reversal of the dismantling procedure.

The use of new gaskets throughout is recommended.

Check and if necessary adjust the crownwheel to pinion mesh as previously described.

Re-assemble the nearside (L.H.) final drive unit and extension and, if the crownwheel thrust block is to be refitted, assemble and adjust the screw until the block just binds against the crownwheel face. Rotate the crownwheel to find the tightest point and use this point to set the block adjustment. Once the screw has been adjusted to give no free movement at this point, back it off approximately one eighth of a turn and lock with the locknut. This movement will give the required clearance of .004" to .006".

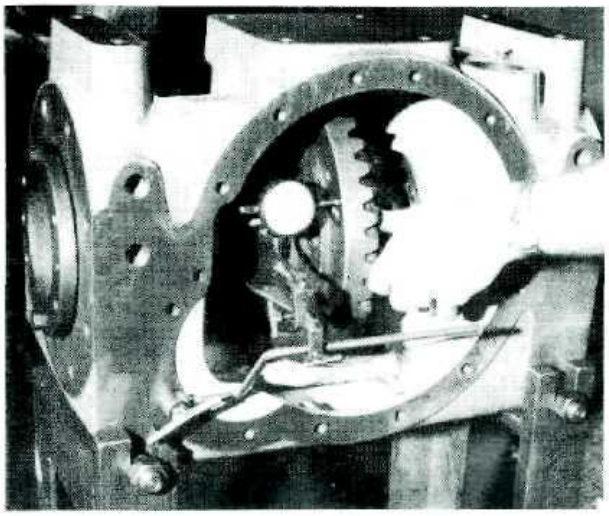


Fig. K.10 — Checking Crownwheel Run-out.

## SETTING BY GAUGE

A gauge as shown in Fig. K11 may be used to adjust pinions at their correct cone centre distance from the crownwheel centre line.

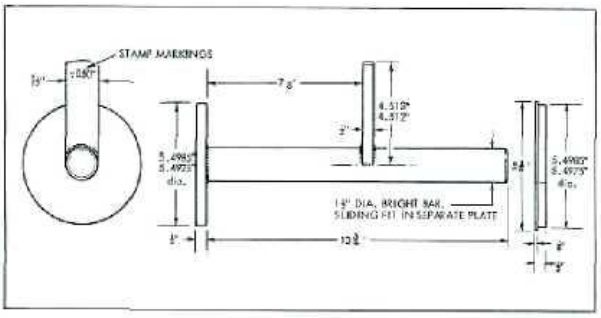



Fig. K.11 — Differential Setting Gauge.

To use the gauge, the differential and crownwheel assembly must be removed and the insert housings withdrawn. The pinion must be assembled onto the differential housing with correctly adjusted bearings and with the pinion bearing housing (or end plate) bolts tightened. Fit the original shims between the bearing housing and the differential housing.

1. Manipulate the gauge into position with the circular plates located in the bores of the differential housing (see Fig. K12).

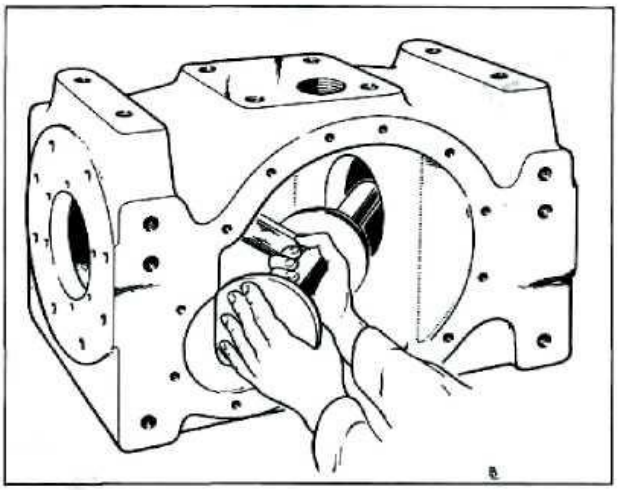


Fig. K.12 — Positioning the Gauge.

2. Swing the bar into line with the pinion head and measure the gap between the bar and the pinion head machined face with feeler gauges. (See Fig. K13).

3. Calculate the alteration necessary in the pinion head housing shim thickness. (See Fig. K14). Shims available will allow adjustment to within .002" of the ideal setting.

4. Remove the pinion and the bearing housing assembly and remove or add shims as necessary.

5. Re-assemble and re-check the gap between the gauge bar and the pinion head.

6. Assemble the differential and insert housings and adjust the backlash in accordance with the figure etched on the outside diameter of the crownwheel.

7. Check the markings on the crownwheel and pinion in both forward and reverse direction as detailed on Page K.6. Due to tolerances allowed in the machining of the differential housing, it may be found necessary to deviate slightly from the correct cone centre distance in order to obtain the best possible marking.

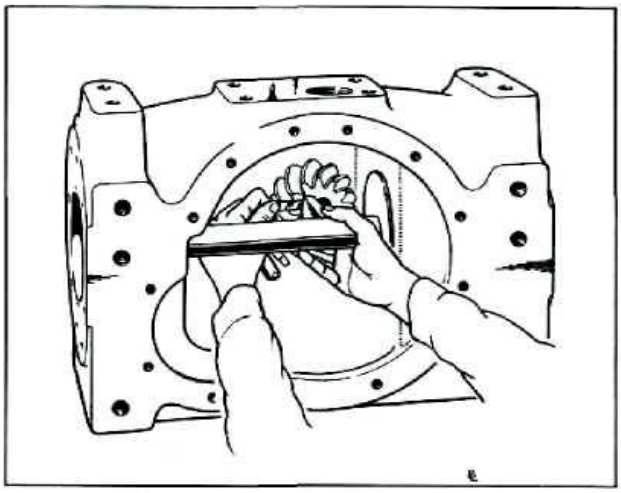


Fig. K.13 — Measuring Pinion Head to Bar Gap.

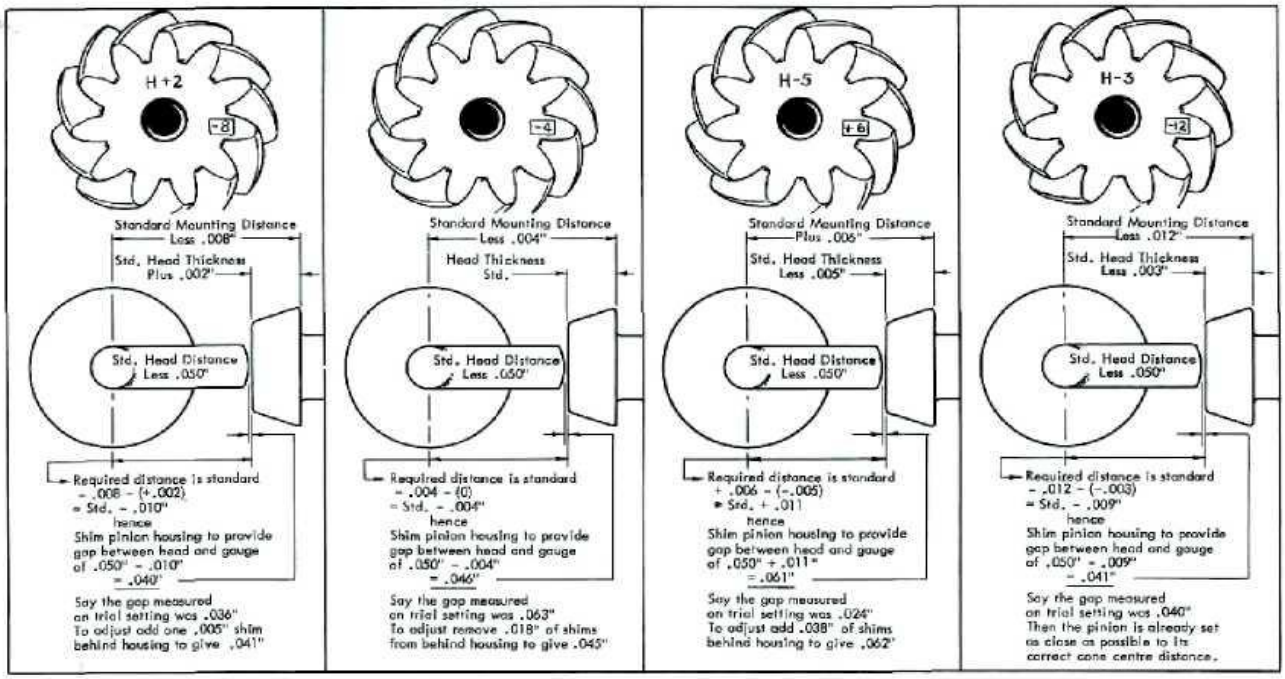
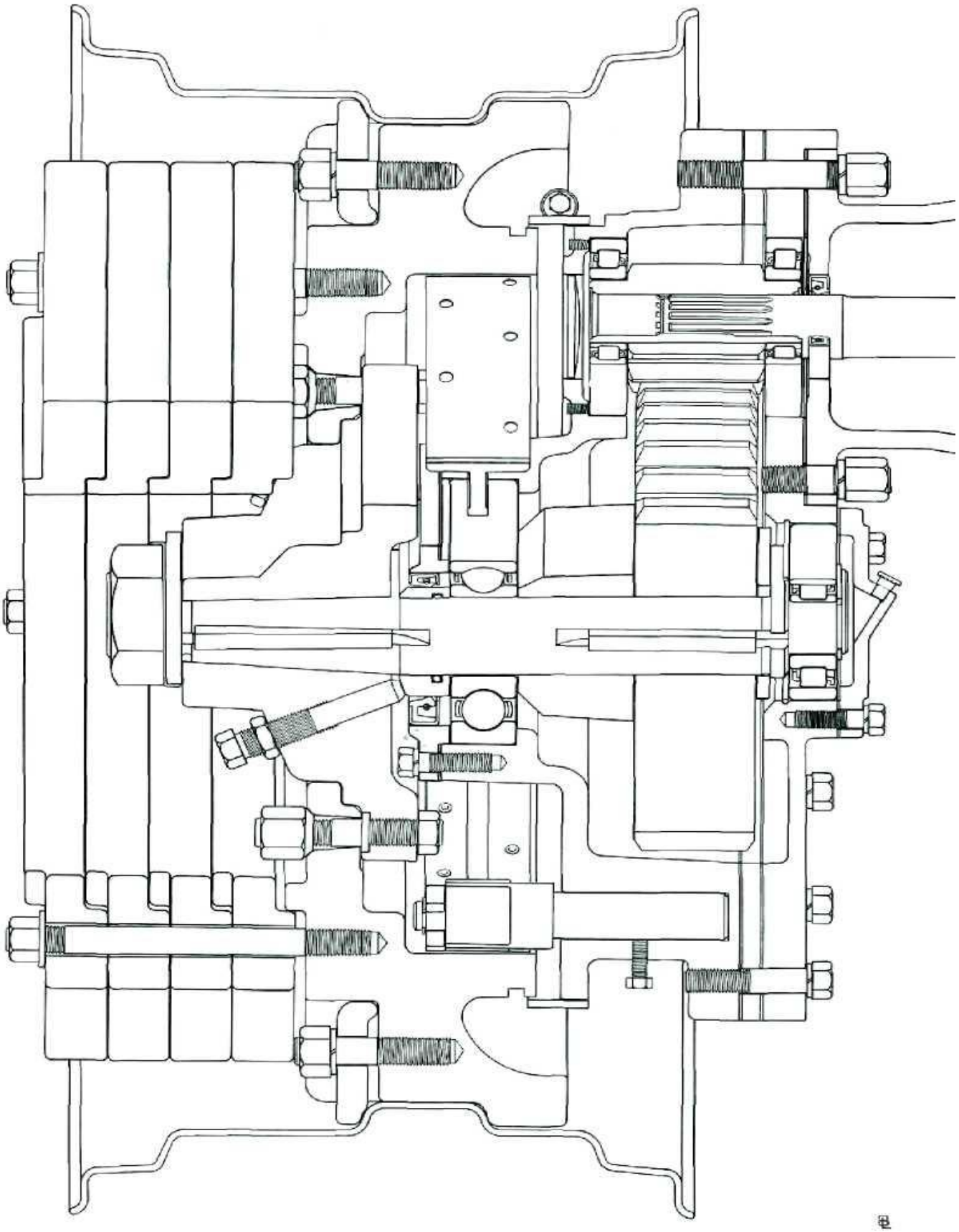



Fig. K.14 — Calculation of Pinion Head Housing Thickness.



# FINAL DRIVES

## DESCRIPTION

The final drive units are self-contained assemblies attached to the differential unit by two extensions through which pass the two half shafts. The half shafts are splined into the differential and also the final drive pinions. The pinions engage the bull gears which are shrunk and keyed onto the rear axles. The rear wheel hubs are retained on a taper and key on the rear axle and to the hubs are attached the brake drums or cast centres. The brake shoes are anchored to, and operated through, the final drive housings.

The rear axles and bullgears are mounted on heavy duty ball bearings on their outer ends and roller bearings on the inner ends. The side thrusts are taken by the ball bearings. Ball bearings carried the pinions on earlier tractors, but these have been superseded by roller bearings. Bullgears with cast centres and butt welded steel rims having 49 teeth 2½" wide, are fitted to tractors from serial numbers DM3419, CR172 and HC233 onwards, whilst an all steel bullgear having 49 teeth 3" wide is fitted to Industrial Champions from serial number IND498. Bullgear replacements should be of the type indicated above.

Large hexagon nuts retain the hubs on the rear axle tapers and keys, and four setscrews serve the dual purpose of retaining the rear axle bearing in position and may also be used to jack the hub from the rear axle of each unit. At serial number IND962 heavy duty hubs P/N30597 were introduced for Industrial Champions. If, for any reason, a rear hub is removed, care must be taken to ensure that these screws are backed off until the hub is firmly installed on the axle taper by the large hexagon nut. The screws may then be re-tightened, backed off 1/8 turn and locked. Failure to observe this precaution could result in the wheel and hub working loose on the axle.

Lubrication of the units is by oil bath and splash, each unit being fitted with a filler, level and drain plug. The lubricant specified is extreme pressure S.A.E.140. A seal is fitted in the outer end of each extension. Some tractors were provided with breather holes between the final drives and differential extensions to prevent a pressure build-up in the final drives. Due to the possibility of oil transferring from the final drives through these holes, they have been deleted in later production and breathers are now fitted in the centre of the bearing cap (P/N 20114).

## SPECIFICATIONS

| | |
|---|---|
| Make | — Own |
| Type | — Straight spur gear |
| Bull Gear | — Orig. 48 teeth, current 49 teeth (S/N DM104 - DM1561) |
| Bull Pinion | — Orig. 13 teeth, current 12 teeth (S/N DM104 - DM1561) |
| Rear Axle | — High tensile steel 3.35" diameter |
| Lubrication | — Extreme pressure S.A.E. 140 oil |

## MAINTENANCE

Check the oil level every 100 operating hours and drain and replace every 1,000 operating hours. With the tractor standing on level ground, the oil should be level with the bottom of the level plug hole. No other routine maintenance is required.

## SERVICING

**Oil Leakage:** To renew the extension oil seal, it will be necessary to remove the wheel and to separate the final drive from the extension. Should the final drive be removed to trace excessive oil transfer and it is found that vent holes have been provided, it is recommended that these holes be suitably blocked and the breather fitted to the axle bearing cap.

To replace the rear axle oil seal or final drive housing plug (20722), it will be necessary to remove the wheel, hub and brake drum or cast centre.

## TO DISMANTLE A FINAL DRIVE UNIT

1. If fitted, remove the wheel weights. With segment type weights, the upper weight should be removed first so that these may be rested on the lower weights until lifted clear.

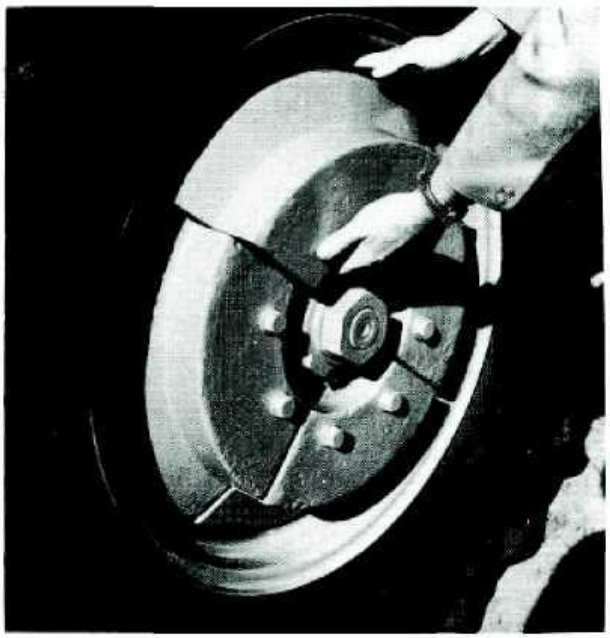


Fig. L.2 — Removing Wheel Weights. *(Crusader and early Champions)*

**Dismantling—Continued**

2. Unlock and slacken the large hexagon nut on the rear axle using tool No. 21039.

3. Slightly loosen the wheel nuts, jack under the chassis until the wheel is just resting on the ground, then remove the nuts and the wheel.

4. Remove the large hexagon nut, lock washer and pegged washer from the rear axle. Fig. L.3 shows the axle nut being removed with the axle nut spanner (P/N.21039)

5. Release the brakes, back off the locknuts and jack the wheel hub and brake drum from the axle with the four setscrews which protrude through the hub. Where cast centres are fitted, it is advisable to remove the centre separated from the hub as the hub may not be properly located on re-assembly, due to the weight, if the two items are left bolted together.

6. Drain the oil from the unit.

7. The bearing retainer and oil seal may now be removed (6 bolts) and the collar and "O" ring may be removed.

8. To remove the brake camshaft, remove the circlip from the inboard end and slacken the quadrant setscrew. Drift the shaft towards the final drive until the key is exposed. Remove the key being careful not to damage the key or shaft, and the shaft may be removed through the final drive housing. It is also necessary to remove the three point linkage sway chain on Canelander and Crusader tractors.

9. Support the final drive unit with a hoist anchored to a pin passed through the brake camshaft apertures. Support the mudguards and remove the bolts coupling the mudguard bracket to the final drive. Remove the eight nuts from the final drive to extension studs, and the final drive housing may be separated from the extension.

Owing to the extension flange being recessed into the final drive, it is impracticable, in the event of tight dowels, to prise the units apart, so that if difficulty is experienced, it will be necessary to arrange suitable leverage between the final drive housing and the differential housing.

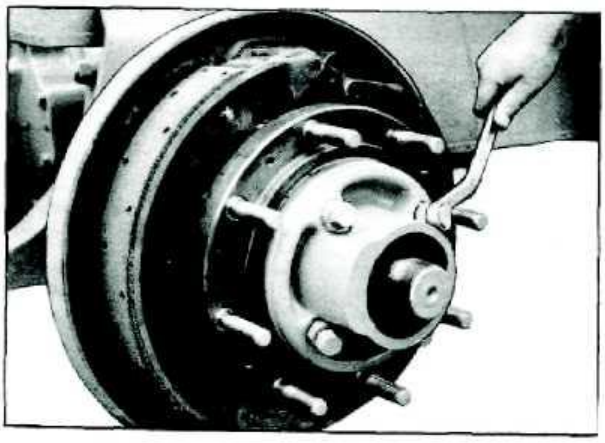


Fig. L.4 — Jacking Hub from Axle.

Fig. L.3 — Removing Axle Nut. (Crusader and early Champions)

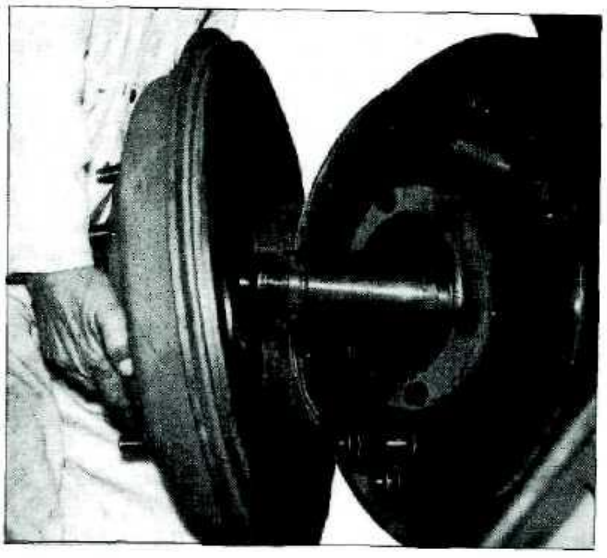


Fig. L.5 — Removing Hub and Drum. (Early Champions)

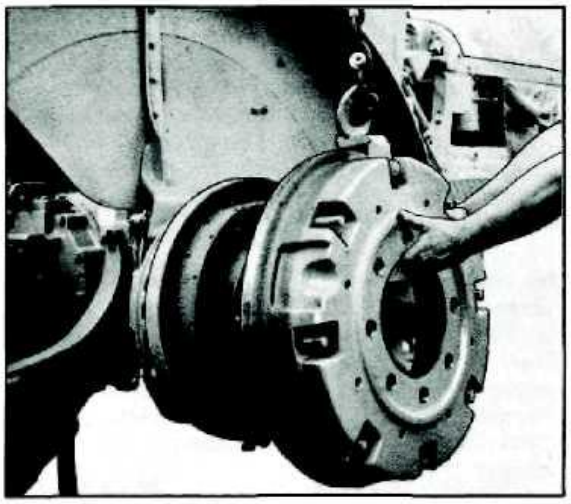


FIG. L.6—Removing Cast Centre (Champion)

10. Remove the remaining flange bolts and the cover may be separated from the housing to expose the bull gear and pinion.

At this stage all parts other than the outer pinion bearing may now be visually inspected. This bearing necessitates the removal of the bullgear and pinion before a thorough inspection can be made. An indication of the bearings condition can be obtained by manipulating the pinion and noting any roughness or excess free movement.

11. The rear axle roller race may be removed with the aid of a bearing puller after the circlip is removed. The outer race may be removed after the bearing cap is removed (6 bolts). The inner pinion bearing may be removed with a bearing puller, but with the early ball bearings it is advisable to leave this bearing in place if the outer bearing is to be removed.

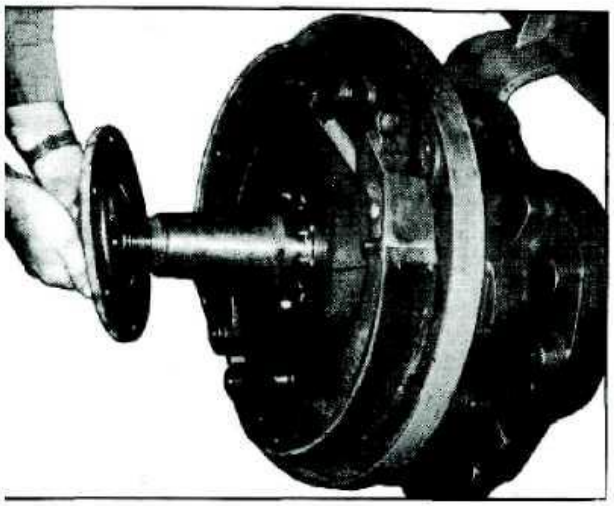


Fig. L.7 — Removing Retainer and Seal.

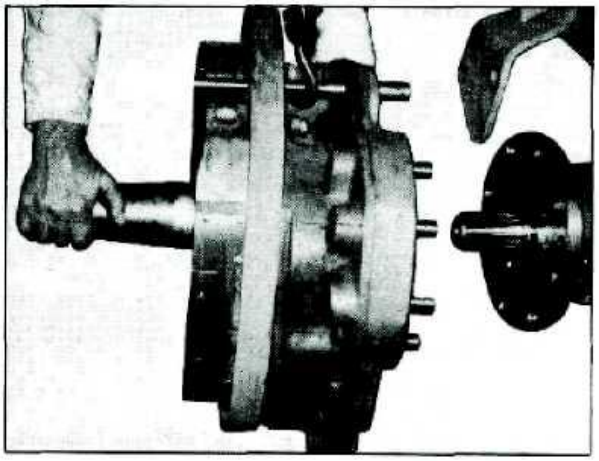


Fig. L.9 — Removing Assembly.

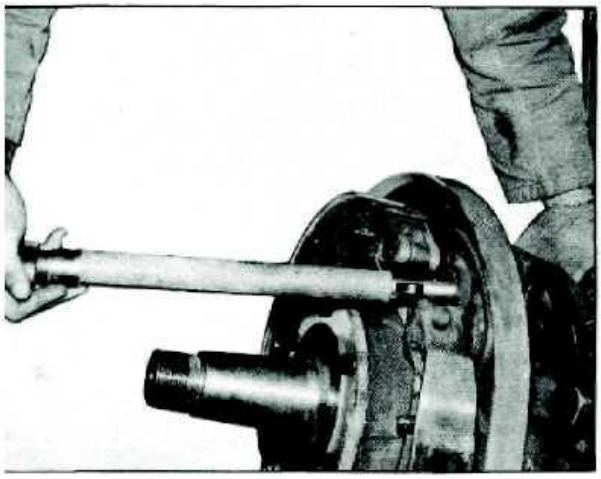


Fig. L.8 — Removing Brake Camshaft.

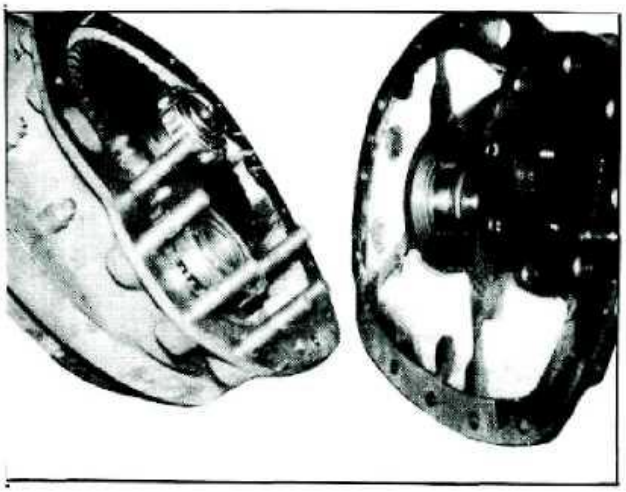


Fig. L.10 — Cover removed to expose Bull Gears.

12. Mount the unit in a press with the housing supported on wooden blocks and press the rear axle and bull gear from the housing. The bull gear teeth will engage the pinion inner bearing so that, if the pinion is tapped in towards the bull gear to prevent jamming, the pinion, complete with its bearings, will be removed with the bull gear and axle. The axle ball bearing may now be pressed or drifted from the housing and the two pinion bearings may be removed with a puller. The outer race of the current roller pinion bearing can be removed by using jacking screws in the holes provided.

13. The half shaft may be withdrawn from the differential extension and the seal examined.

## INSPECTION

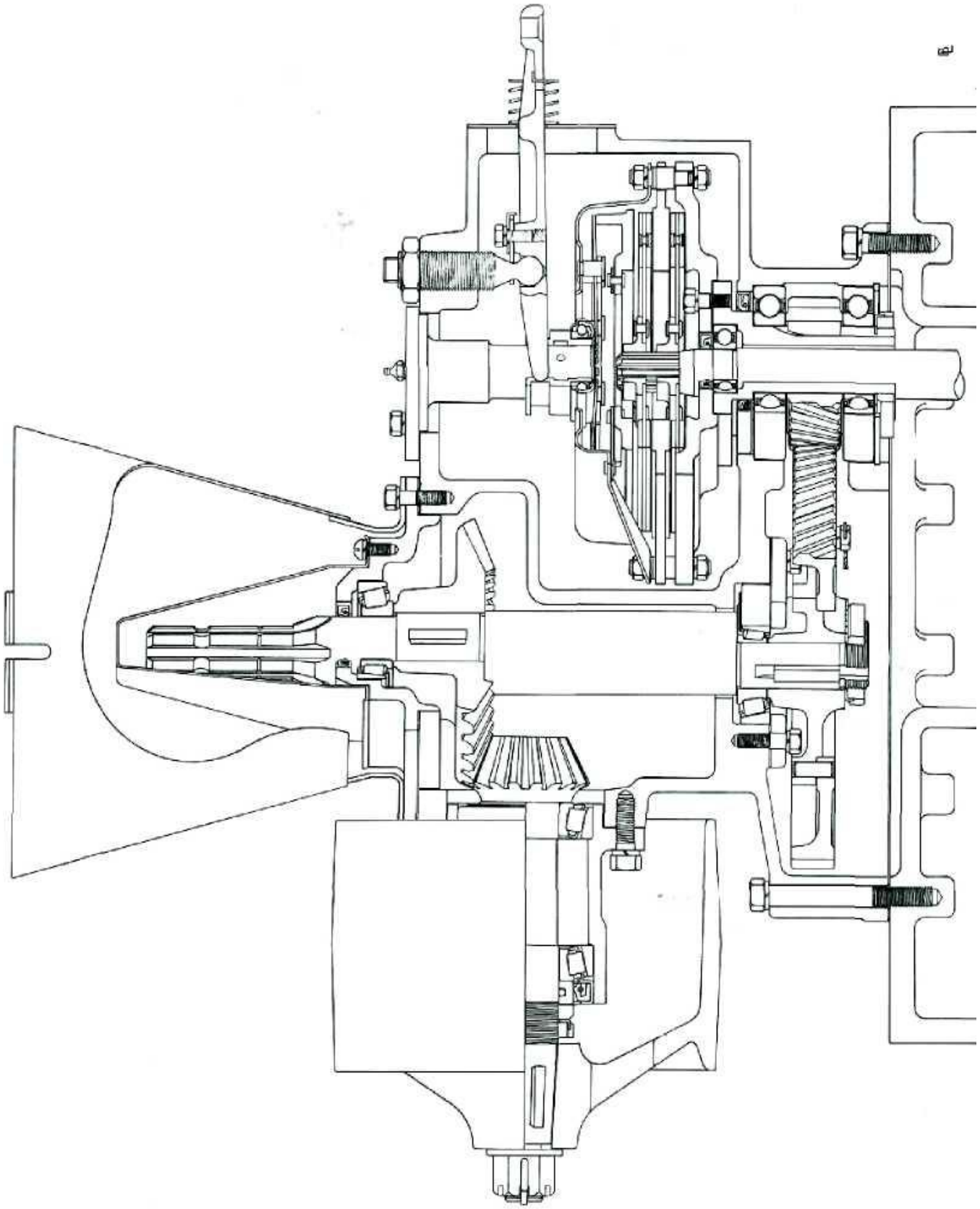
Thoroughly clean and examine the bearings, shafts, gears and the seals. If any doubt exists as to the serviceability of any part, replace it. If the differential extension oil seal is to be replaced, re-assemble it with the lip facing the final drive.

## RE-ASSEMBLY

Re-assembly is a reversal of the dismantling procedure. It is advisable to renew all gaskets Be sure to install the pinion outer bearing in the housing before the bull gear and axle are re-assembled. The inner bearing must be fitted after the bull gear and axle are assembled.

As mentioned in the unit description, care must be exercised when fitting the rear wheel hub to the axle. Back off the four setscrews in the hub, firmly tighten the hub onto the axle taper with the large hexagon nut, then re-tighten and lock the setscrews. It is recommended that hubs be bedded in, on Industrial Champions, to ensure correct seating on the axle taper.

Refill the unit to the bottom of the level plug hole with extreme pressure S.A.E. 140 oil.



# POWER TAKE-OFF AND BELT PULLEY

## DESCRIPTION

The power take-off unit and belt pulley are incorporated in a unit mounted on the rear of the differential housing. The unit is coupled to the engine by a splined shaft fitted into the engine flywheel and passing through the main clutch and front gearbox upper mainshaft to drive a train of three helical gears at the rear of the front gearbox.

Onto the shaft of the lowest gear is coupled a universally jointed tailshaft which carries the drive to the front of the differential housing. A further splined shaft passes through the differential housing into the twin driving plates of the P.T.O. clutch mounted in the nearside of the unit. The clutch is operated by an over-centering lever behind the driver's seat which is so sprung that a slight movement from the fully engaged (forward) position causes the lever to swing to the fully dis-engaged position.

When the clutch is engaged it drives a pair of helical gears at the forward end of the unit. The latter of these gears is attached to the P.T.O. shaft which passes through the housing and protrudes at the rear. The belt pulley is in turn driven by bevel gears from the P.T.O. shaft. Both the P.T.O. and belt pulley shafts are mounted on taper roller bearings.

*The unit is splash lubricated from the differential unit.*

From the foregoing description it will be seen that the unit is "live". In other words it is not affected by the main drive clutch.

## SPECIFICATIONS

| | | | |
|---|---|---|---|
| Input Shaft Speed | — Engine R.P.M. | | |
| P.T.O. SHAFT | — Speed – 540 R.P.M. at 1600 engine R.P.M. | | |
| | Spline – Standard S.A.E. 1⅜" 6B. | | |
| | DM | HC | CR |
| Height above ground | — 28¼" | 31¾" | 27⅝" |
| End of Shaft ahead of drawbar pin | — 14" | 9" | 8½" |
| Right of centre viewed from rear | — 1⅜" | 1⅜" | 1⅜" |
| B.P. Shaft Speed | — 1188 R.P.M. at 1600 Engine R.P.M. | | |
| Belt Speed | — 3100 ft./min. at 1600 Engine R.P.M. (actual). | | |
| Clutch Type | — Twin dry plate 8" dia. | | |
| Clutch Control | — Over-centering hand lever. | | |
| Clutch Lining | — Wire woven asbestos composition. | | |
| Clutch Adjustment | — Lever pivot screw. | | |
| Pulley Size | — 10¼" dia. x 6¼" wide. | | |

## MAINTENANCE

The two grease nipples on the operating lever should be serviced every 50 hours with chassis grease. Sparing lubrication of the grease nipple for the clutch throwout bearing every 500 hours should be sufficient.

## CLUTCH ADJUSTMENT

Adjustment is provided by means of altering the position of the internal lever fulcrum. To the nearside of the P.T.O. shaft the fulcrum screw protrudes through the rear of the housing and is fitted with a locknut. If the locknut is loosened the screw may be screwed in to increase the dis-engagement should the clutch tend to drag (P.T.O. and belt pulley con-

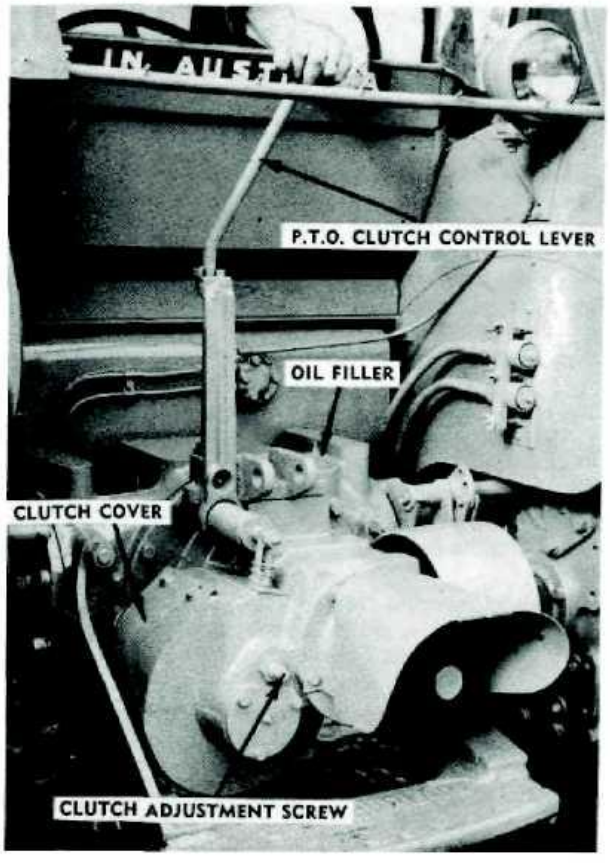



Fig. M.2 – P.T.O. and Belt Pulley Unit.

**Clutch Adjustment—Continued**

tinue to turn with the lever in the disengaged position), or screwed out should the clutch tend to slip under load. Tighten the locknut after adjustment. It is advisable to open the sheet metal clutch cover to check that the thrust bearing is free of the clutch when the clutch is engaged.

A modified clutch plate stud P/N 23365 and packing washers P/N 23364 have been introduced to obtain the maximum useful service from the clutch plates. Should the clutch still slip under load when it has been correctly adjusted, remove a washer from each stud.

**Caution:** If packing washers are removed prematurely the clutch cannot be fully disengaged.

The large coil spring around the connecting link on top of the unit controls the over-centering action and counters the clutch's internal spring when the lever is moved to disengage. This spring should be tensioned so that the lever returns firmly to its stop in the disengaged position. Excessive tightening will only increase the pull necessary to move the hand lever.

## SERVICING

**Clutch Faults:** The subject of lining wear and failure have been discussed thoroughly in the main clutch section. In this unit the plates may be visually inspected by removing the side cover. In the same way the operation of the throwout bearing, etc., may also be inspected.

**Oil Leakage:** Two seals prevent lubricating oil entering the clutch compartments so that oil in this section may have gained access through leakage past either of these seals. Should the outer seal be at fault there is much less likelihood of oil being on the plates than if the inner seal is leaking, as oil seeping from this seal must pass the plates before reaching the housing.

To increase the clearance between the seal lip and the edge of the clutch sleeve shoulder, the width of the inner seal has been reduced from 7/16" to 3/8".

The inner seal may be removed by following the sequence under the heading "Clutch: to Dismantle", and the outer seal by following the sequence "Clutch Shaft: To Dismantle".

Both the P.T.O. shaft and the belt pulley shaft are fitted with oil seals. The P.T.O. seal may be removed by removing the rear bearing housing, and the belt pulley seal by following the sequence "Belt Pulley: To Dismantle". The condition of the bevel gears may be inspected by removing the plug below the belt pulley unit.

## DISMANTLING

**CLUTCH: To Dismantle:**

1. Remove the three nuts and three special capscrews which couple the nearside drawbar bracket to the differential housing and the drawbar track and remove the bracket.

**Note:** On later tractors the drawbar track and the two brackets are a welded unit. On these tractors it will be necessary to remove the drawbar (remove the two bolts from under the chassis), then remove the track and brackets as a unit if the clutch plates are to be removed. With this, and the original arrangement, it is not necessary to remove the brackets and track if the unit is to be removed from the tractor, as the clutch parts may be readily dismantled when the unit has been removed.

2. Remove the two bolts from the clutch cover, and the cover may be slid down and around to clear the two lower locating pins. Remove the cover. **Note:** The cover may, for inspection purposes, be removed without disturbing the drawbar bracket.

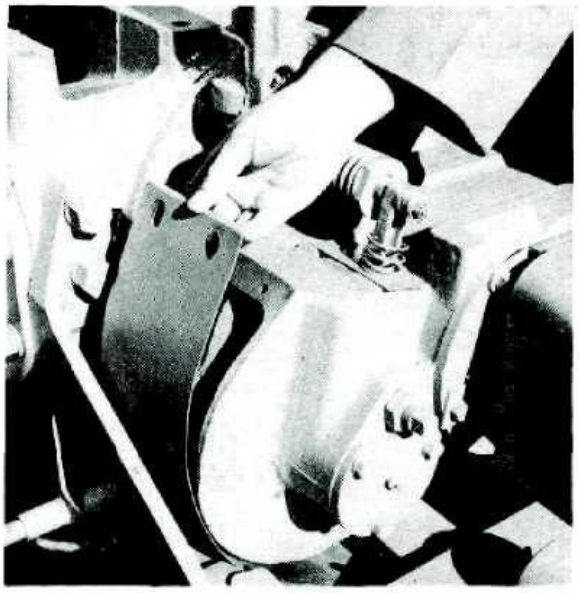


*Fig. M.3 — Removing Clutch Cover.*

3. Remove the three bolts retaining the flange of the clutch throw-out shaft and slide the shaft from the rear of the housing. By manipulating the control lever the throwout bearing may be freed from the fork and removed through the rear of the housing.

4. Remove the four rear nuts on the clutch flange and the clutch body, rear driving plate, centre plate and front driving plate may be removed in that order.

5. Should it be necessary to remove the clutch driven plate to service the seal, remove the four flange studs and the six locating bolts and the plate may be removed. If further dismantling is contemplated, leave the plate in position until the clutch shaft is removed so that it is not necessary to remove the flange studs.

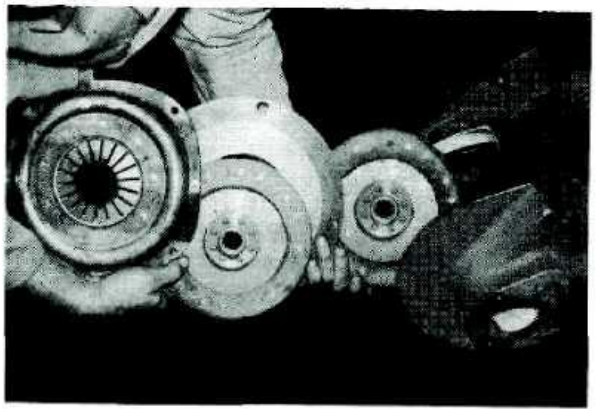


Fig. M.4 — Removing Clutch Body and Plates.

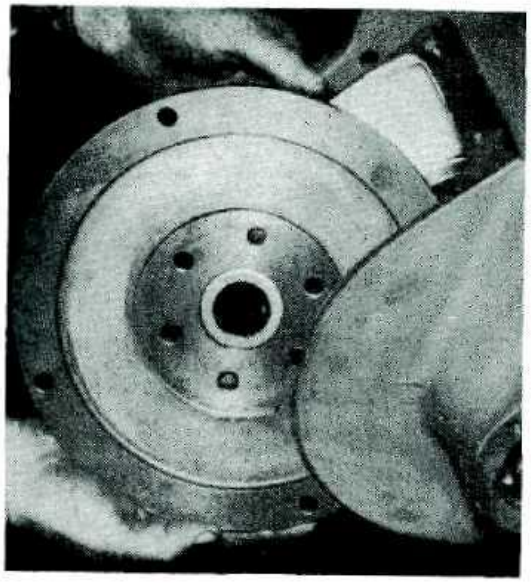


Fig. M.5 — Removing Driven Plate.

**BELT PULLEY: To Dismantle:**

1. Remove the split pin, slotted nut and washer from the belt pulley shaft.

2. Using tool No. 22756, or some suitable puller, remove the pulley. A sharp tap with a hammer against the centre screw of the puller may be necessary to free the pulley from the taper on the shaft. Remove the key.

If the bearings and seals are not to be dismantled, disregard Item 3 and proceed with Item 4.

3. Unlock and remove the two circular nuts on the shaft using tool No. 22751, or some suitable 'C' spanner.

4. Remove the five flange bolts and remove the belt pulley housing complete with shaft, bearings and seal. Some prising may be necessary but care must be taken to avoid damage to the flange shims. Note the number of these and all other shims on dismantling.

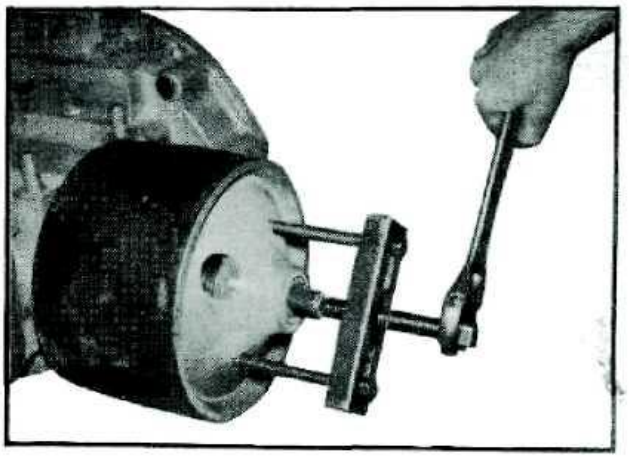


Fig. M.6 — Removing Belt Pulley.

Fig. M.7 — Removing Bearing Nuts.

**Belt Pulley Dismantling—Continued**

5. The housing may now be supported and the shaft drifted or pressed from the bearings. If using a drift, care must be exercised to avoid damaging the threaded end of the shaft.

6. The bearings, seal and seal retainer may now be drifted from the housing and the bearing removed from the shaft with a bearing puller.

Apart from removing the P.T.O. shaft rear bearing housing to service the oil seal, or removal of the control mechanism, no further dismantling can be carried out without first removing the unit from the tractor.

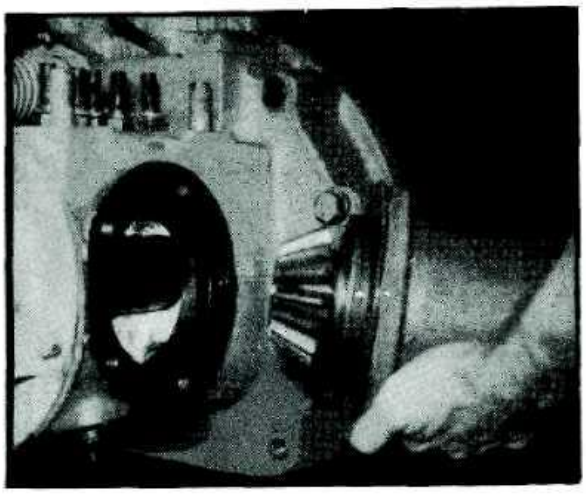


Fig. M.8 — Removing Belt Pulley Housing.

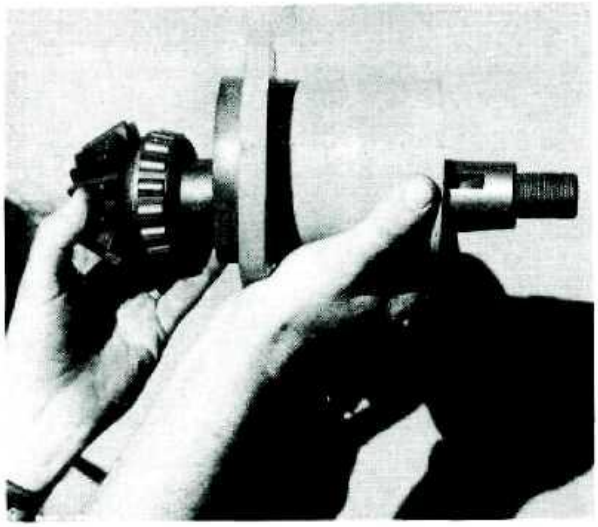


Fig. M.9 — Removing Belt Pulley Shaft.

**TO REMOVE THE P.T.O. UNIT FROM THE TRACTOR**

1. Drain the transmission oil from the plug at the front of the rear gearbox or beneath the differential housing on later tractors.

2. Remove the P.T.O. coupling shaft. If any difficulty is experienced with this operation, refer to Section H.

3. Using a socket and extension, or a tube spanner, remove the three capscrews on the retaining plate on the front of the differential housing and remove the plate. Take care to avoid damaging the seal. In some cases it may not be possible to move the plate past the side of the rear gearbox. If this is the case, replace the plate and remove when the shaft is withdrawn.

4. Remove the four special bolts retaining the P.T.O. control bracket to the housing, remove the three flange bolts from behind the bracket, then replace the bracket.

5. Support the P.T.O. unit from a pin placed through the lugs on the control bracket (the use of a chain block is recommended) and remove the remaining flange bolts. If the belt pulley has not been previously removed, it will be noted that two of the bolts are trapped behind this unit and this must be remembered if the belt pulley is subsequently removed and replaced. The unit may now be moved back from the differential housing. Some prising may be necessary to clear the two locating dowels and the unit must be manipulated to allow the clutch housing to clear the nearside drawbar bracket.

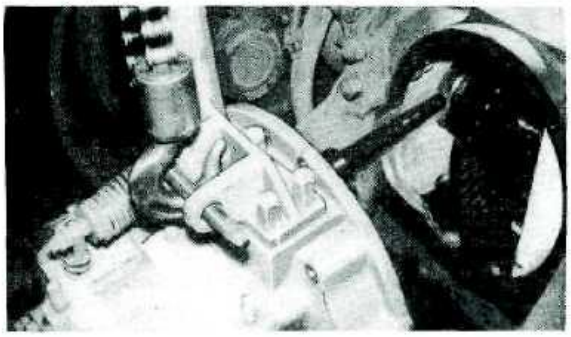


Fig. M.10 — Removing P.T.O. Assembly.

**P.T.O. SHAFT: To Dismantle:**

The P.T.O. unit must be removed from the tractor and the belt pulley unit removed.

1. Unlock and remove the circular nut on the forward end of the P.T.O. shaft using tool No. 22751 or some suitable 'C' spanner. It should be noted that if the clutch shaft is to be dismantled before the P.T.O. shaft is re-assembled, proceed at this stage with Items 1, 2 and 3 of the sequence under the heading of "Clutch Shaft: To Dismantle".

2. Remove the six bolts retaining the large gear to its centre and remove the gear.

3. Using a suitable puller, remove the gear centre from the P.T.O. shaft. Remove the key.

4. Remove the front bearing retainer (four bolts) taking care not to damage the flange shims. Note the number of shims.

5. Remove the five bolts retaining the rear bearing housing and master shield and remove the shield and retainer. Careful drifting against the forward end of the shaft will move the retainer about 1/16" from the flange. Note the shims and avoid damaging same.

6. Drift or press the shaft forward through the housing until the front bearing cup is freed. Remove the cup.

7. Carefully drift or press the shaft towards the rear of the housing until the front bearing cone is freed from the shaft. Do not damage the shaft threads. Remove the bearing cone and withdraw the shaft with the bevel gear out through the rear of the housing.

8. If required, the gear and bearings may be removed with the aid of a press or bearing puller.

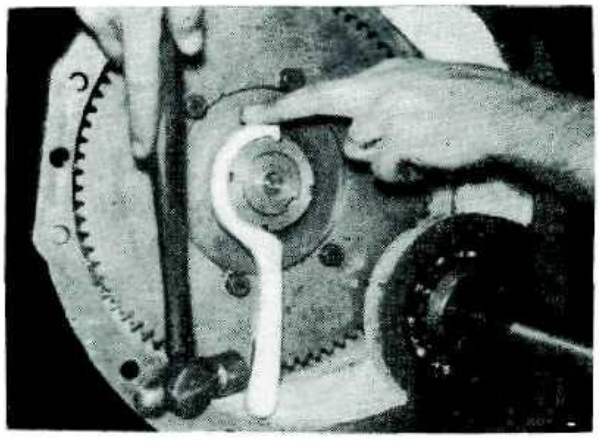


Fig. M.11 — Removing P.T.O. Shaft Nut.

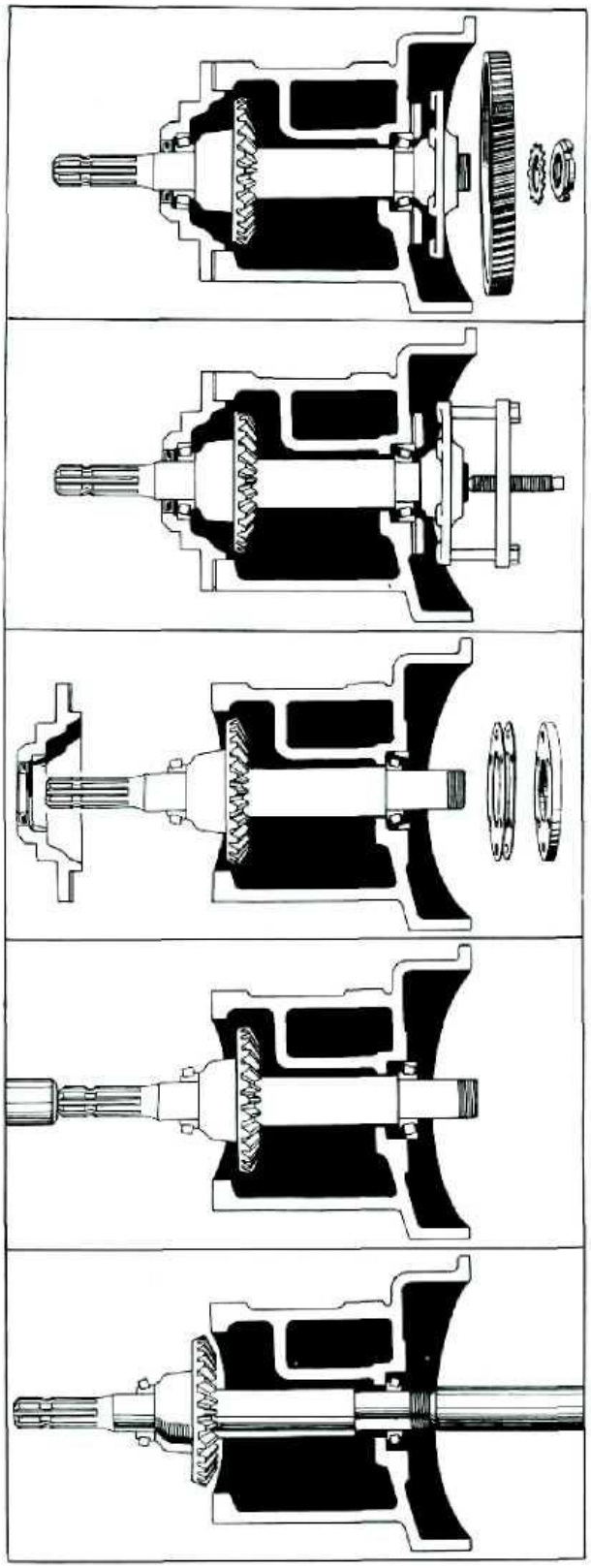


Fig. M.12 — P.T.O. Shaft removal sequence.

**CLUTCH SHAFT: To Dismantle:**

The clutch must be dismantled and the P.T.O. unit removed from the tractor.

1. With a long drift through the rear of the housing, drive the clutch (splined) shaft out through the front of the housing.

2. If not already removed as under "Clutch: To Dismantle", remove the driven plate (six bolts) complete with flange studs and seal. Lock the helical gears in the front of the unit with a suitable soft drift whilst slackening the bolts.

3. Unlock and remove the circular nut from the front of the clutch driven shaft using tool No. 22752 or some suitable 'C' spanner.

4. Remove the six bolts retaining the large gear on its centre and remove the gear.

5. With a drift or press force the clutch driven shaft through the bearings and into the clutch compartment. Do not damage the shaft threads.

6. Remove the large bearing circlip from the housing and drift the front bearing, gear and the rear bearing forward from the housing. It will be necessary to drive the rear bearing through both bearing bores and care must be exercised when starting the bearing through the front bore to prevent jamming.

7. The oil seals may now be removed if required.

**INSPECTION**

**Clutch: Inspection:** Inspect the linings for wear and deterioration as described in Section F for the main clutch. Should replacement be considered necessary, fit two new clutch plate assemblies, P/N. 20853.

Replacement linings and rivets are available as a kit P/N 30860.

Check the fit of the replacement plates on the shaft splines before assembling the unit. The cover assembly is only serviceable as a unit.

**Driven Mechanism: Inspection:** Thoroughly clean all parts. Carefully examine shafts, bearings and gears for signs of wear and replace if necessary. Check the condition of all five oil seals and the belt pulley shaft "O" ring. If they are at all worn, replace as the cost of subsequent dismantling to correct leakage would be much higher than the cost of the seals.

At serial number DM1474 two dowels were added to the driven gear and centre to locate the rim more accurately. At the same time, bolts with drilled heads were fitted and wired together ensuring more positive locking. Subsequently, at S/N DM1774, the separate parts of driven gear and centre were replaced by assembly P/N 23103 consisting of matched driven gear and centre. Whenever this assembly is fitted to tractors prior to S/N DM1474 it will be necessary to also fit the two dowels P/N 2398 and six bolts P/N 4288.

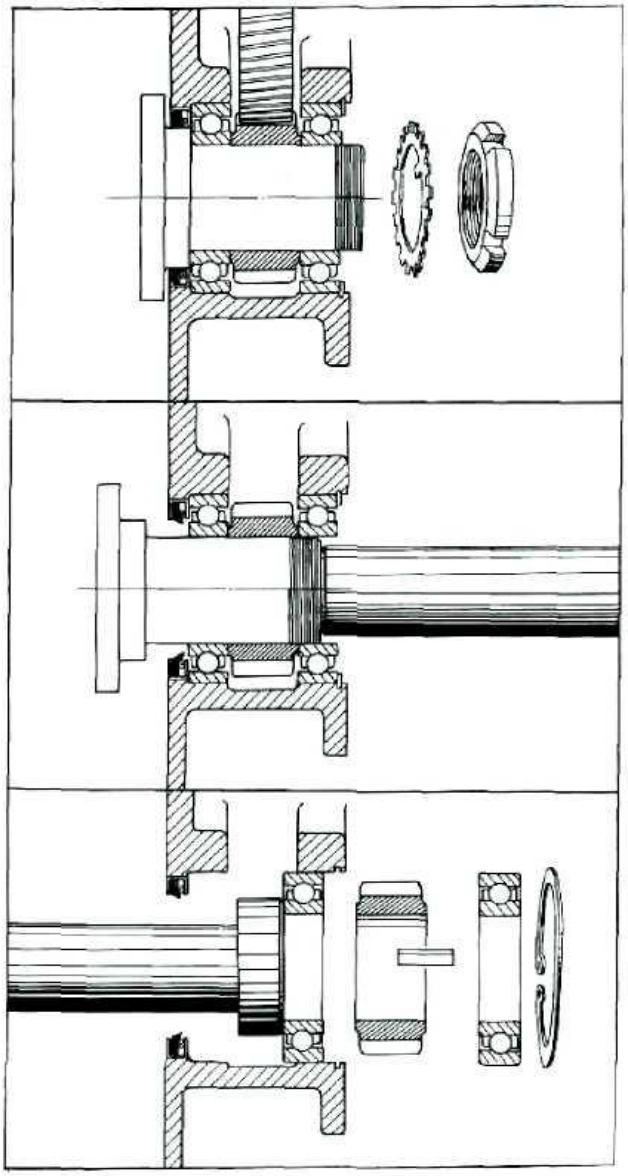


Fig. M.13 — Clutch Shaft removal sequence.

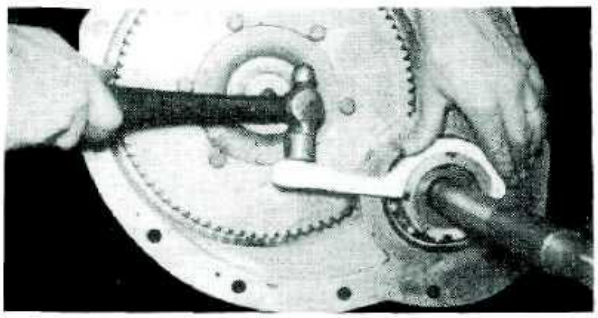


Fig. M.14 — Removing Clutch Shaft Nut.

## RE-ASSEMBLY

The procedure for re-assembly is virtually a reversal of the dismantling sequence given, but the following points should be noted.

(a) Use new gaskets throughout on thoroughly cleaned faces.

(b) Exercise care with all oil seals when assembling the respective shafts. If moving a seal over a tight spline or sharp shoulder, always protect the seal lips with either a suitable seal guide or by wrapping shim brass around the shaft.

(c) Clutch shaft re-assembly: It will be necessary to fit the outer seal, pass the driven shaft through the seal, block the shaft to prevent it moving towards the rear, then drive the two bearings, gear and key onto the shaft from the front.

**Bevel Gear Adjustment:**

1. Assemble the P.T.O. shaft rear bearing housing with its original shims, together with the shaft, bearing and seal.

2. Assemble the forward bearing and retainer plate without shims. Tap the plate in squarely until the shaft has just zero end float and no preload. Measure the clearance between the plate and the housing with feeler gauges.

3. Remove the plate and re-assemble with shims of the same width as the measured clearance.

4. Assemble the belt pulley housing complete with shaft and bearings, but without shims, onto the P.T.O. housing. Use three of the flange bolts to pull the housing in squarely whilst slowly turning the drive until the tightest point has just zero backlash. Measure the clearance between the faces and add .040". This total figure represents the thickness of shims needed on the belt pulley housing flange to give an approximate backlash of .015" between the bevel gears.

5. After assembling, check the rotation for freedom of movement. Adjust the belt pulley shaft locknuts to give zero end float to the bearings.

## COUPLING OF P.T.O. DRIVEN IMPLEMENTS

Although some early implements were fitted with constant velocity joints, most modern implements use the simple Hookes type joint with provision for adjustment to provide a final output to the implement mechanism at a constant velocity even though the intermediate shaft, or shafts, may have a considerable speed fluctuation.

The Chamberlain live P.T.O. drive will transmit more than 100 H.P., but it can be damaged when driving an implement using less than 30 H.P., if that implement incorporates a heavy revolving component having appreciable flywheel inertia and the joints are badly maladjusted.

Basically, the output shaft from a Hookes joint bent at an angle doesn't turn at a steady speed but flicks twice in every revolution as the forks pass over dead centre. This flick or jerk is mild if the joint is bent at only 5° or even 10°, but becomes violent at 20° or 30°.

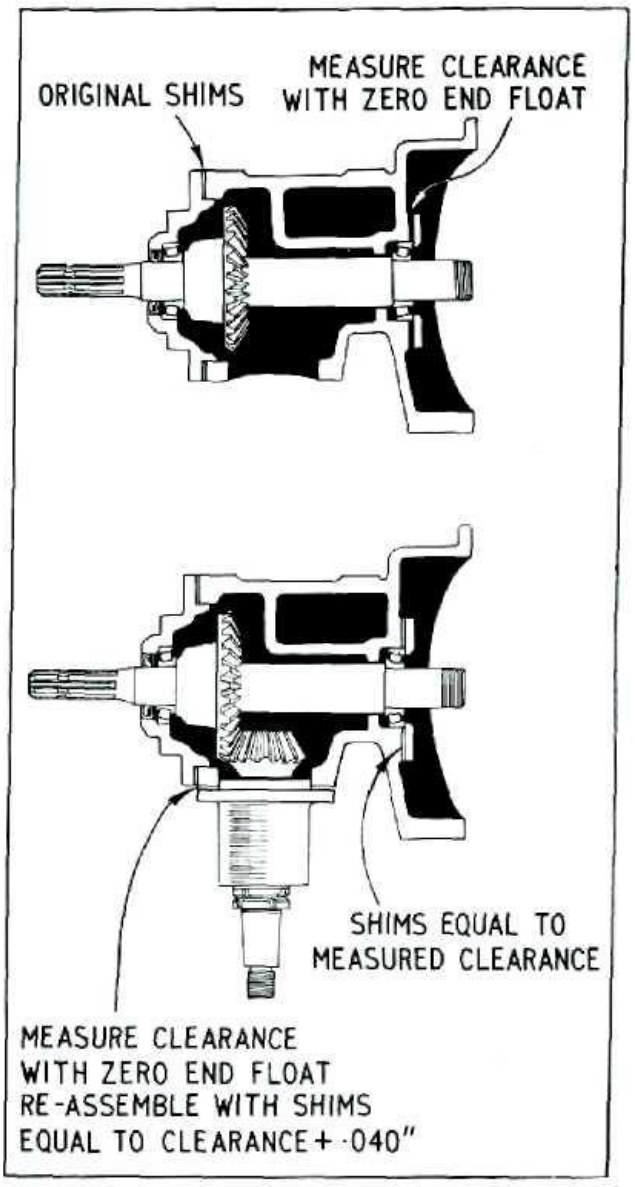



Fig. M.15 — Bevel Gear Adjustment.

As an illustration of this, if a tractor P.T.O. shaft turning at 540 R.P.M. is coupled to a universal joint bent at 30°, the speed of the output shaft from the joint will fluctuate between 629 and 467 R.P.M. every 180°. See Figure M.16.

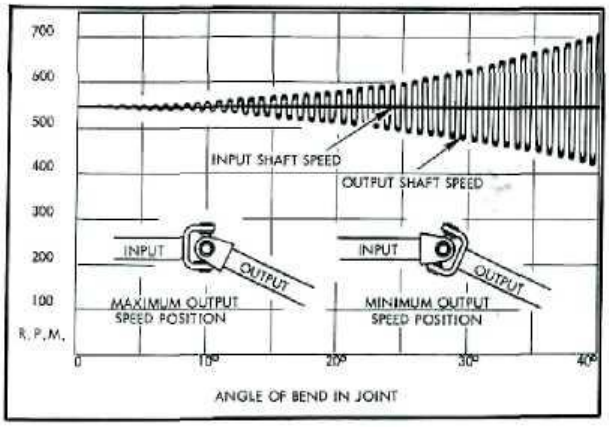



**Fig. M.16 — Shaft Fluctuation Graph.**

This jerking motion can be corrected if the drive is taken through a second joint provided:

(a) Both joints are bent at the same angle and

(b) The yokes on the intermediate shaft connecting the two joints are in the same plane and not turned at 90° to each other.

If adjusted in this manner the shaft ends can safely be connected to heavy revolving parts without damage. See Fig. M.17.

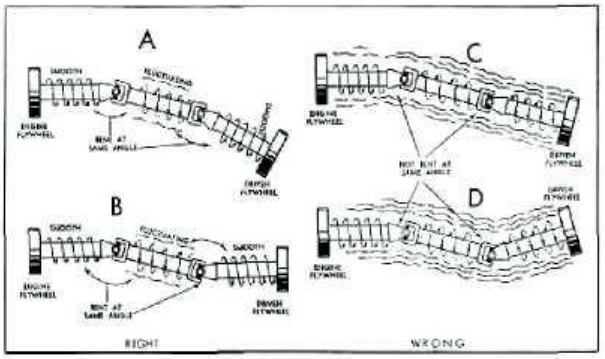



**Fig. M.17 — Coupling Shaft Action.**

Most implement manufacturers provide precise instructions to ensure that the tractor and implement are not damaged and provide adequate means of adjustment to ensure correct alignment, but the following is a general instruction:

With the tractor and implement in line, the joints directly in front and behind the hitch point must be—

(a) Straight or bent as (A) in Fig. M.17, viewed from above and from the side.

(b) Equi-Distant from the hitch point. In other words the hitch point must be half way between the two joints.

If connected in this manner the two joints will be bent at the same angle when the tractor and implement are turning a corner, or crossing a rise or gully, and the implement mechanism will be driven at a constant speed. See Fig. M.18.

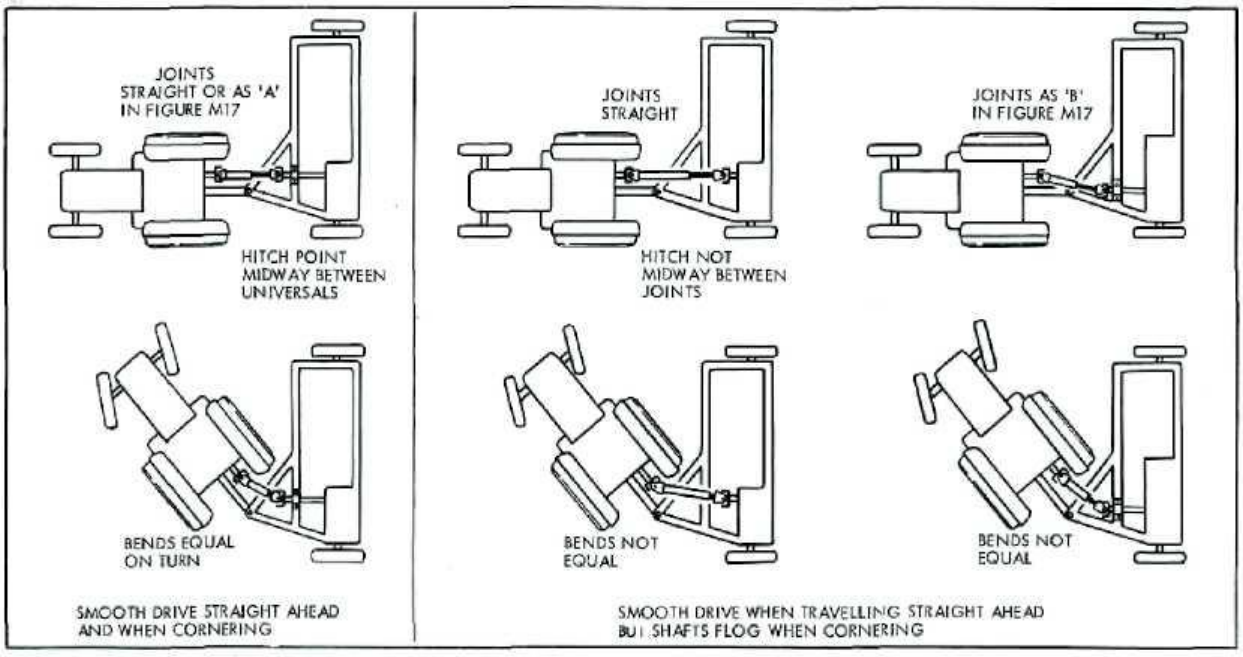



**Fig. M.18 — Correct and Incorrect Hitching.**

Some implements are fitted with either one or two additional joints to line up the implement drive.

If two additional joints are provided (making a total of four joints) they must be adjusted as A or B in Figure M.17. See Figure M.19.

If only one additional joint is fitted however, its purpose is to provide only slight adjustment and must be kept as straight as possible as any appreciable bend in this joint cannot be counteracted.

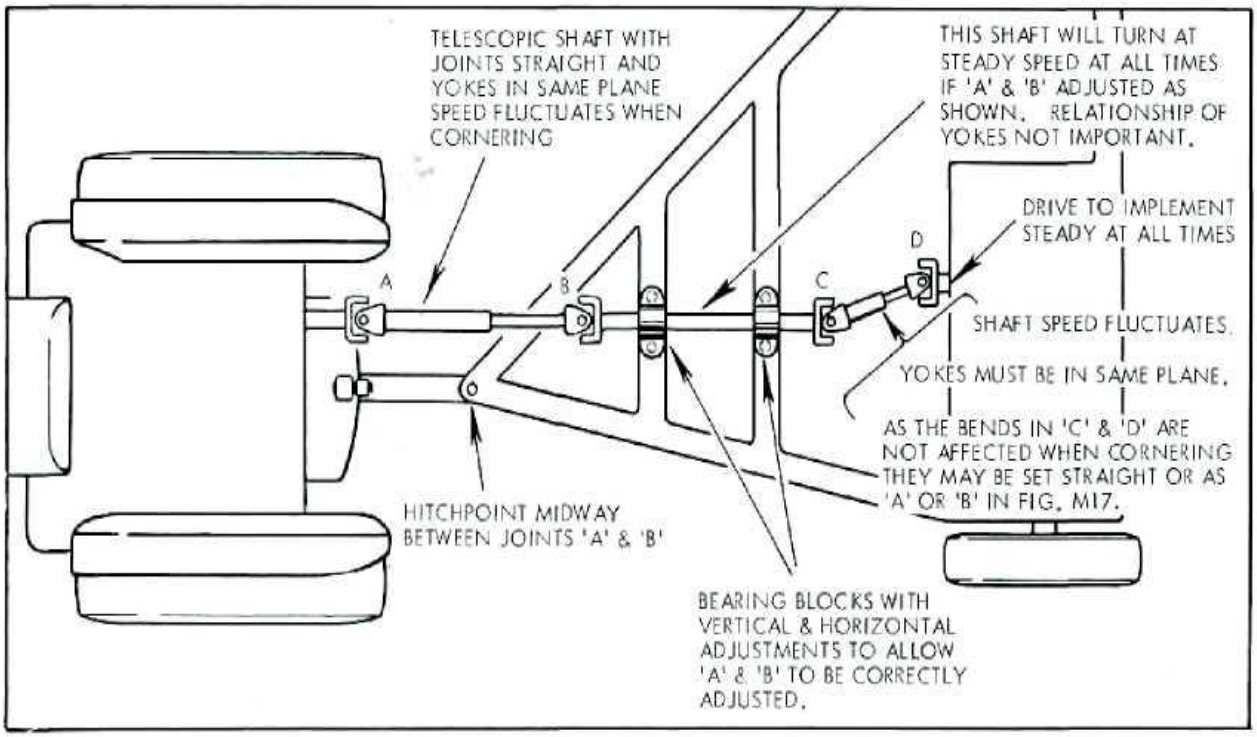
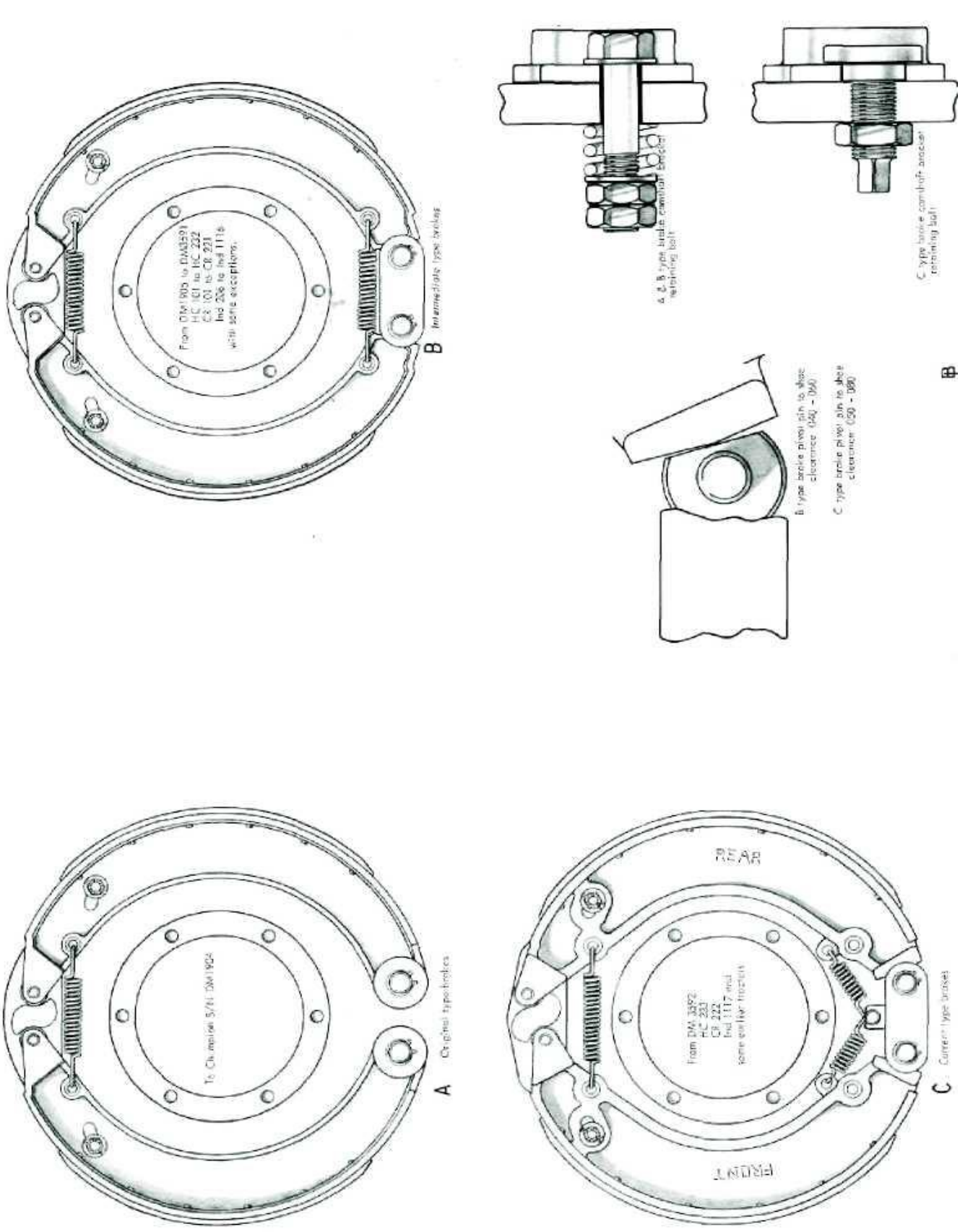



**Fig. M.19 — Correct Hitching and Two Additional Joints.**


From DM1805 to DM3591
HC 101 to HC 222
CB 101 to CB 221
Ind 206 to Ind 1116
with some exceptions.
B Intermediate type brakes
A, B type brake camshaft bracket retaining bolt
C type brake camshaft anchor retaining bolt
B type brake pivot pin to shoe clearance (040 - 060)
C type brake pivot pin to shoe clearance (050 - 080)
To Chassis S/N DM1904
A Original type brakes
From DM 3592
HC 223
CB 222
Ind 1117 and some earlier models
REAR
FRONT
C Current type brakes

# BRAKES

## DESCRIPTION

Heavy duty brakes are provided in each rear wheel. Brake drums or cast centres may be fitted and they are mounted directly on to the rear wheel hubs. The cast centres are retained by nuts and studs to the hubs whilst the brake drums are clamped between the wheel and the hub on the wheel nut studs and also retained on the hub with counter sunk screws.

Each wheel has two brake shoes pivoted at their lower ends on pins, protruding from, and locked into, the final drive housing. Early type brake shoes (A) were fitted onto the pivot pins through a hole at the lower end of the shoe and were retained by a circlip, whilst intermediate and current production shoes (B and C) operate on flats on both the shoe and pivot pin with a pivot pin link arresting side ways movement.

Actuation is provided by a camshaft which passes through the final drive housing to operate on rollers in the upper ends of both shoes. The camshaft is mounted on two bronze bushes, the inner of which is contained in a bracket attached to the differential extension whilst the outer is contained in a bracket adjacent to the cam and brake shoes. On early tractors this latter bracket was attached by spring loaded bolts to the final drive housing so that it could move fore and aft to allow even pressure on both shoes but prevented it from moving in a veriical direction. Current production tractors have this bracket attached by special, adjustable screws, screwed into the final drive housing, the bracket being slotted and moving fore and aft on ferrules attached to the screws. The upper ends are supplied with anti-chatter, spring loaded studs attached to the final drive housing and a tension spring links the shoes to prevent the shoes rubbing against the drum when the brakes are disengaged.

Keyed to the camshaft is a quadrant to which is coupled an adjustable lever. Adjustment of this lever rotates the camshaft to decrease, or increase, the shoe clearance on the drum, the cam faces having ample movement to cover the life of the brake linings.

The adjustable levers are coupled by tie rods to a cross shaft on the tractor chassis just forward of the driver's seat in such a manner that each brake may be operated independently by its respective foot pedal.

The two foot pedals may be latched (recommended for any high speed operation) by a small plate bolted to the offside pedal, but no equalising of the brakes is provided when operating in this manner. It will be necessary for the operator to adjust each brake as described later.

A hand brake, with a parking lock, is provided on early tractors which operates via a further tie rod to a lever on the brake cross shaft. A bar pivoted on this lever bears, when the hand brake is engaged, against the rear of vertical extensions of the two brake pedals, thus giving an equal pressure to each brake assembly. The hand brake was deleted from later tractors, the parking lock only being retained.

Early tie rods are adjustable but should not require further attention after the tractor has been initially assembled. Return springs are provided on each brake pedal.

To obtain more efficient braking, the brakes have been re-designed incorporating the following modifications:—

(1) The heel angle (brake shoes and pivot pins) has been altered to increase the servo action.

(2) The brake shoes have been designed to reduce flexing.

(3) The brake linings are bonded and rivetted to the shoes.

(4) The brake drums have a very fine finish to improve efficiency and reduce noise.

(5) The cam rate has been increased to reduce pedal springiness.

(6) The cam rollers have been re-positioned to give increased pressure and more even lining wear.

(7) The camshaft bearing block has been re-designed to prevent vertical movement of the camshaft.

(8) The final drive housing has been amended to suit the new bearing block.

Instructions relating to field conversions are included at the end of the section.

**Caution:** Partial modification of the existing brakes should not be attempted as the new arrangement is designed to operate in its entirety and consequential damage will result unless all the component parts are fitted.

## SPECIFICATIONS

| | |
|---|---|
| Make | — Own |
| Type | — Enclosed internal expanding |
| Adjustment | — External operating lever |
| Operation | — Mechanical – cam |
| Control | — Singly or coupled by foot pedal or through equaliser by handbrake on early tractors. |
| Diameter of Drum | — 18" |
| Length of Lining | — 15" orig., 15⅝" current. |
| Width of Lining | — 2½" |
| Area of Lining | — 75 original, 79 current, square inches per wheel. |

## MAINTENANCE

Grease nipples are provided in the handbrake spindle and in either end of the brake pedal cross shaft. The servicing of these three points with chassis grease every 50 operating hours is recommended.

## BRAKE ADJUSTMENT

Adjust to provide 1" to 2½" of free pedal movement.

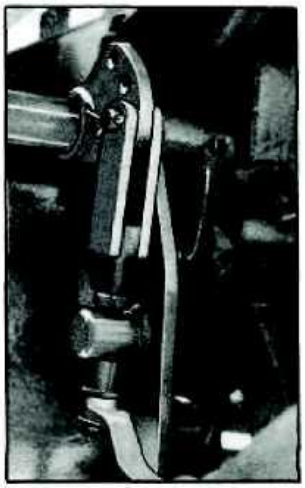


Fig. N.2 — Adjusting Brakes.

The operating levers, at the rear of the driver's seat, are coupled by adjustment screws to the quadrants keyed to the camshafts. Adjustment is by tightening, or loosening, the notched nuts above or below the fulcrum pins on each screw.

Two additional holes are provided in each quadrant, into which the fulcrum pins (or later type clevis pins) may be moved to provide adjustment throughout the life of the linings.

Pedal adjustments can be made in the following manner: —

(a) Unlatch the pedals.

(b) Depress each pedal and, should the free movement not be as stipulated, or the free movement vary between the two pedals, adjust the notched nuts on the adjusting screws.

**Caution:** When adjusting early type brakes, take care to avoid binding of the adjustment screws in the fulcrum pins. If necessary, slacken the nuts on the fulcrum pins re-align with the screw. These nuts must be firmly tightened after adjustment.

The locknut fitted to the adjusting screw on later type brakes must be backed off before adjusting the notched nut and then re-tightened before re-checking the pedal free movement.

(c) Re-latch the pedals, road test and correct any noticeable swing to right or left by tightening the opposite brake.

Over tightening of the brakes must be avoided, as this will cause the brakes to bind, resulting in overheating and excessive wear to the brakes and also loss of tractor power. A check that the brakes do not bind may be made in the normal automotive manner of jacking the tractor and turning the rear wheel, but careful adjustment to give even braking as previously described should prove satisfactory.

**Brake Cross Shaft:** The offside pedal may be removed for re-bushing by removing the offside footplate, the connecting link and the shaft circlip.

Ream the bushes to size after installing in the lever. The brake cross shaft is carried in bushes in the chassis. Owing to the wide spacing of these bushes considerable wear may be tolerated. Should replacement be considered necessary, remove the nearside rear wheel, and the circlip from the offside end of the shaft. On early tractors slacken the two clamp screws in the boss of the nearside pedal and drift the shaft towards the nearside until the key is exposed. Remove the key and withdraw the shaft. Current tractors necessitate the circlip, pedals and key being removed from the offside end of the shaft and the shaft removed from the nearside.

If necessary adjust the links coupling the pedals to the rear lever on early tractors until adequate clearance is obtained between the levers and the differential extension housing when the pedals are depressed to the floor and the handbrake is fully back.

**Brake Mechanism:** Should it be necessary to remove the brake mechanism on either side, proceed as follows:

1. Remove the wheel weights. With segment type weights it will be necessary to remove the upper weight first to allow it to be rested on the others before being lifted clear.

2. Slightly slacken the wheel nuts, jack the tractor until the wheel is just touching the ground. Remove the nuts and the wheel.

3. On early tractors remove the four countersunk screws attaching the drum to the wheel hub and remove the drum. The cast centre on current tractors necessitates the removal of the centre to hub retaining nuts. It will be necessary to disengage the brakes before the drum or centre can be removed.

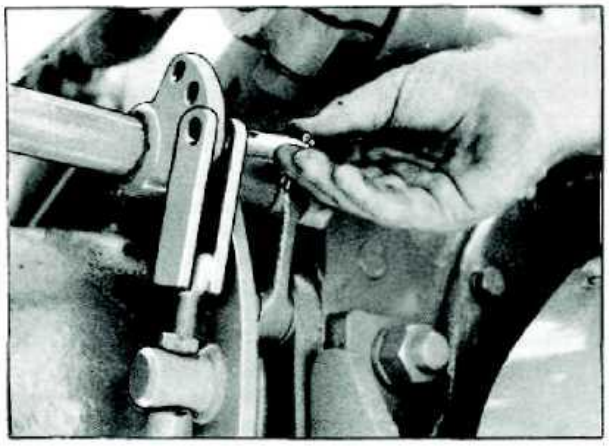


Fig. N.3 — Changing Quadrant Position.

4. To remove the brake shoes, remove the spring coupling the upper portions of the shoes. Unpin and remove the slotted nut, spring and washer from the retaining stud protruding through each shoe, remove the circlips from the pivot pins on early tractors, and the shoes may be removed. Note the washers on the retaining studs.

5. The pivot pins may be removed by first slackening the two setscrews protruding from below the housing and then pressing the pins free.

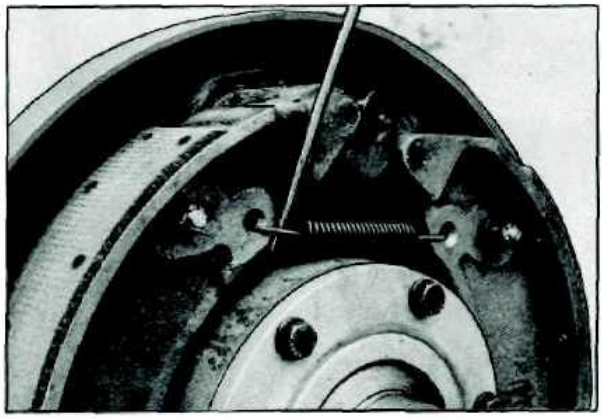


**Fig. N.4 — Removing Brake Shoe Spring.**

6. To remove the camshaft, remove the circlip from its inboard end and slacken the quadrant setscrew, drift the shaft towards the final drive until the key is exposed, remove the key and slide the shaft free. The two bushes may now be serviced if required.

Thoroughly examine the linings for wear. Examine the pivot pins, camshaft, bushes and cam rollers for signs of excessive wear. Examine the drums for scoring if the linings have been allowed to become excessively worn.

Lightly oil or grease the camshaft bushes, rollers and pivot pins when re-assembling and after reassembly, adjust as previously described.

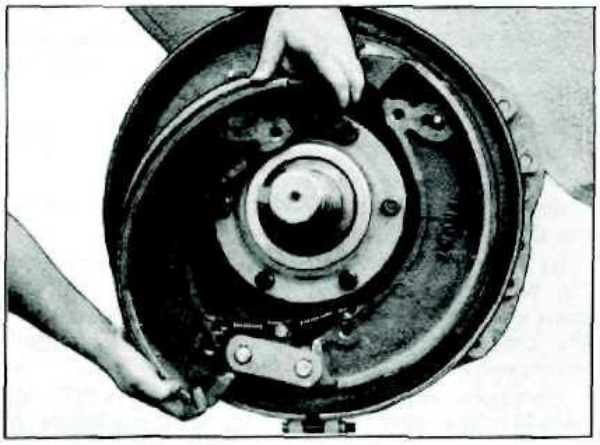


**Fig. N.5 — Removing Brake Shoe**

To increase the efficiency of the original type floating brake shoes, the following points should be observed:—

(a) **Replacement Linings.** These should be rivetted from the centre of the lining, working towards each end, and must fit snugly on the shoe between the rivets. Check the fit of the lined shoe in the drum. Using two levers, hold the centre and one end of the lining against the drum. The clearance at the other end of the lining must be .005" to .010". Hand if necessary.

(b) **Pivot Pins.** To obtain the correct self-energising action the shoe faces must contact the pivot pins at the top edges only. The shoes should have .040" to .060" clearance from the lower edge of the pivot pin flats. Slacken the locking stud and move the pivot pin in the required direction to adjust this clearance. Do not remove material from the brake shoe end.

(c) **Glazed Linings.** If this condition occurs, the linings must be de-glazed by filing, or replaced and the drums thoroughly cleaned with a solvent, e.g. Carbon Tetra-Chloride.

(d) **Grabbing of Brakes.** This tendency will usually only be apparent when reversing. If new linings have been fitted, two corrective measures can be adopted (1) by adjusting the brake linkage until the brakes drag slightly when moving forward, and (2) by blocking the camshaft bearing block springs by tightening the lock nuts.

Another source for this condition could be wear in the slots of the camshaft bearing block. Once this conditions occurs, the camshaft drops until the roller of the front shoe engages the reverse lobe on the cam and this causes the drag of the front shoe to compound the cam to lock the rear shoe. If measures (1) and (2) fail to correct the defect, remove the bearing blocks and build up the upper edge of the slots as necessary to reduce the clearance.

## BRAKE CONVERSION

**Caution:** The brake conversion must be carried out in its entirety.

### PREPARATION

The procedure should be thoroughly read before commencing the operation.

When modifying early tractors, it will be necessary to replace the round brake shoe pivot pins (20485) with pins (30227) which have flats on their outer ends.

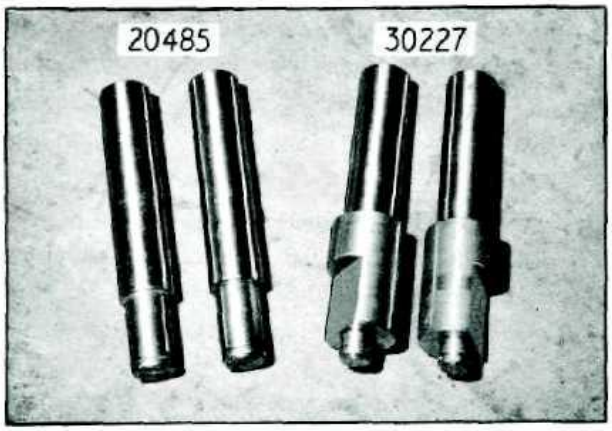



**Fig. N.6 — Brake Shoe Pivot Pins.**

To reset the brake shoe pivot pins, a special spanner and setting template are required. Fig. N7.

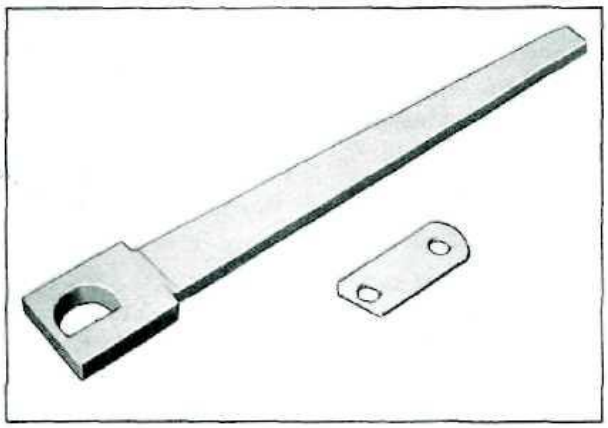


**Fig. N.7 — Pivot Pin Special Spanner and Setting Template.**

The existing brake linkage, camshaft bracket (20582) back plate (cast integral with the final drive housing), brake shoe retainer (20486), retainer spring (20495), retainer nut (14085), brake shoe pivot pin (30227), pivot pin setscrew (1304) and pivot pin circlip (20431) are all re-used.

### PROCEDURE

1. Dismantle the rear wheels, cast centres or brake drums, wheel hubs, brake shoes, brake camshafts and bearing blocks.

2. Check the braking surface on the cast centre or brake drum. A very fine finish is required to ensure efficiency and reduce noise.

3. Modify the existing back plate on the final drive housing by drilling and tapping the bearing block mounting holes 5/8" UNF.
***Caution:*** *Reasonable accuracy must be maintained.* (If drilling facilities are not available, tap the 17/32" dia. holes, 9/16" UNF, file to the bottom of the thread and tap 5/8" UNF).

4. Loosen the setscrew locking the brake shoe pivot pin and turn each pivot with the special spanner so that the flat on the pivot pins is exactly parallel with the flat on the setting template.

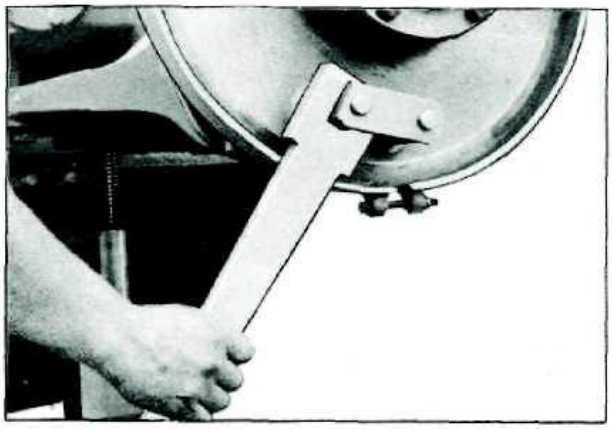


**Fig. N.8 — Setting Pivot Pins to Template.**

5. Fit the camshaft bearing blocks (31048). It may be necessary to relieve the casting to obtain clearance for the screw locknut. Smear the sliding faces lightly with grease and adjust the screws until the bearing block can just be moved by hand in both directions with no binding. Tighten the locknuts (4307) and fit the camshafts (31028/9) and the brake linkage, inserting sufficient washers between the outer bracket (20582) and the circlip (20431) to take up any camshaft end float.

6. Check the fit of the lined shoe in the drum. Using two levers, hold the centre and one end of the lining against the drum. The clearance at the other end of the lining must be .005"-.010". Hand fit as necessary.

7. Fit the brake shoes, links, existing circlips, existing retainer studs and retaining springs. Note the following:—

(a) The front shoe must be towards the engine irrespective of whether a forward or reverse differential is fitted.

(b) One washer is placed inside and one outside the shoe on the retaining stud.

(c) The camshaft must not foul on the shoe casting before seating the roller. If adjusting the camshaft end float does not remedy the condition, relieve the brakeshoe, removing the minimum of material necessary to give clearance.

(d) Check that there is clearance of .050"-.080" between the heel of the shoe and the pivot pin measured at the bottom edge of the flats.

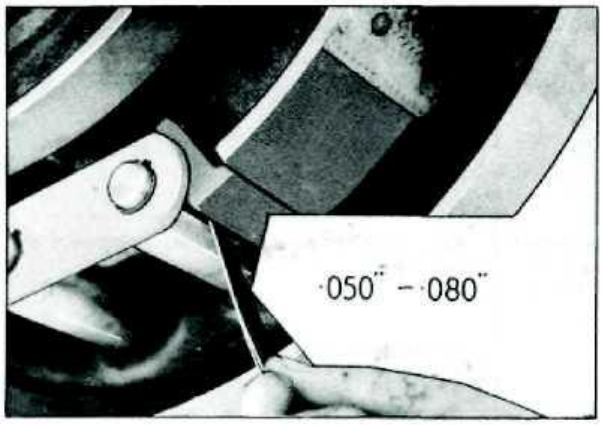



Fig. N.9 — Brake Shoe Heel Clearance.

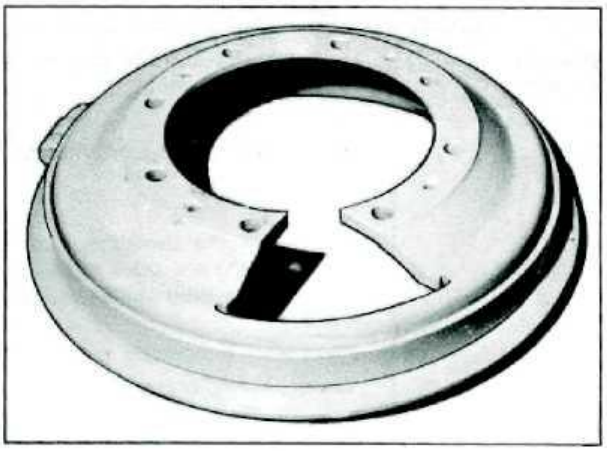


Fig. N.10 — Brake Check Cutaway Brake Drum.

(e) Operate the linkage to check for binding.

8. Replace the wheel hubs and brake drums. To enable a thorough check to be made of the assembled parts and their operation, a cutaway brake drum as shown in Fig. N10 can be used.

**Important:** The drums and shoes must be scrupulously clean as even slight traces of grease will permanently effect the braking efficiency.

Re-assemble the wheels, correctly adjust the brakes, and road test the tractor.

A brake trouble shooting chart is below.

| Trouble | Cause | Action |
|---|---|---|
| **Brake Drag** | Weak shoe retainer springs. | Replace. |
| | Camshaft bearing block adjusted too tightly or seized. | Adjust and lightly grease if necessary. |
| | Eccentric or out of round drums. | Re-machine. |
| | Brakes adjusted too tightly. | Re-adjust. 1" minimum free pedal movement with up to 2½" to suit the operator. |
| | Shoes misaligned laterally. | Add or reduce the washers between shoe and retaining stud. |
| **Brakes Erratic or Grabbing** | Pivot pins out of adjustment or incorrectly set. | Re-adjust using setting template. |
| | Drum out of round or eccentric. | Re-machine. |
| | Excessive toe and heel contact of linings. | Hand fit to give from .005" to .010" clearance. |
| | Water in contact with lining particularly the woven type. | Rough up the lining then run with brakes lightly applied until efficiency is restored. |
| **Low Frequency Brake Squeal or Noise** | Lining not firmly attached to shoe. | Fit relined shoe. |
| | Out of round or eccentric drums. | Re-machine. |
| | Weak shoe retainer springs. | Replace. |
| | Nut loose on axle shaft. | Tighten nut and lock screws. |
| | Pivot pins incorrectly set. | Check, using setting template. |
| | Glazed linings. | Removing glazing or replace lining. |
| | Shoes contacting drum at toe and heel. | Hand fit to give from .005" - .010" clearance. |
| | Poor machined finish in drums. | Smooth off with fine emery paper on a shaped wooden block. |

| | | |
|---|---|---|
| **Poor Brake Efficiency** | Faulty lining contact due to warped or misaligned shoes. | Correct or replace shoes. |
| | Tapered drums. | Machine drums. |
| | Excessive crowning on shoes. | Hand fit to give from .005" to .010" clearance. |
| | Grease on linings. | Fit relined shoe. |
| | Centres of the camshaft and roller pins out of line more than 1/16" due to run-off when drilling camshaft bearing block holes. | Rework bearing block slots to correct the condition. |
| | Pivot Pins incorrectly set. | Re-adjust using setting template. |
| | Wrong lining material. | Use only genuine Chamberlain replacements. |
| | Faulty machining on pivot face of shoe. | Rework or replace. |
| | Brakes require readjustment. | Re-adjust. 1" minimum free pedal movement with up to 2½" to suit the operator. |
| | Cam brake block too tight preventing shoes properly centralizing. | Re-adjust. |
| | Worn block ferrules allowing too much vertical movement of cam. | Replace ferrules. |
| | Glazed linings. | Remove glazing or fit relined shoe. |

# PLESSEY HYDRAULIC SYSTEM

This system, as used on early Champion and Canelander tractors, consisted of a Plessey hydraulic pump, a control valve, an oil reservoir and connecting hoses.

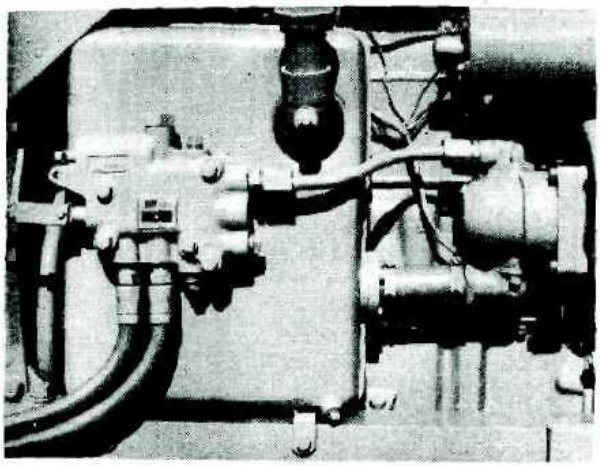


Fig. O.1 — Plessey Double Acting Hydraulic (Champion).

**Pump:**

The spur gear type pump is engine mounted and driven by the engine timing gears, making the system live when the engine is running, regardless of engagement or dis-engagement of the main tractor clutch. The drive is transmitted through a gear keyed to a tapered shaft integral with the pump drive gear. The body also contains the driven gear and shaft, both shafts being supported by alloy bearing bushes retained in the body. Axial hydraulic loading of these bearings maintains high volumetric efficiency by limiting the side clearance between the gear and bearing faces to an amount sufficient only to maintain a satisfactory oil film between the surfaces. The pressure loading is achieved by porting pump outlet pressure to an area on the rear surfaces of the bearings. The area under pressure is controlled to apply an axial hydraulic load towards the pump gear thus loading the whole pump assembly against the bottom of the body bores.

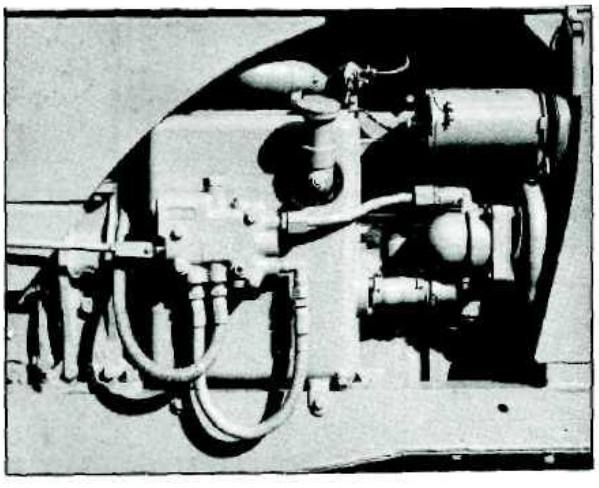


Fig. O.2 — Plessey Single Acting Hydraulic (Canelander).

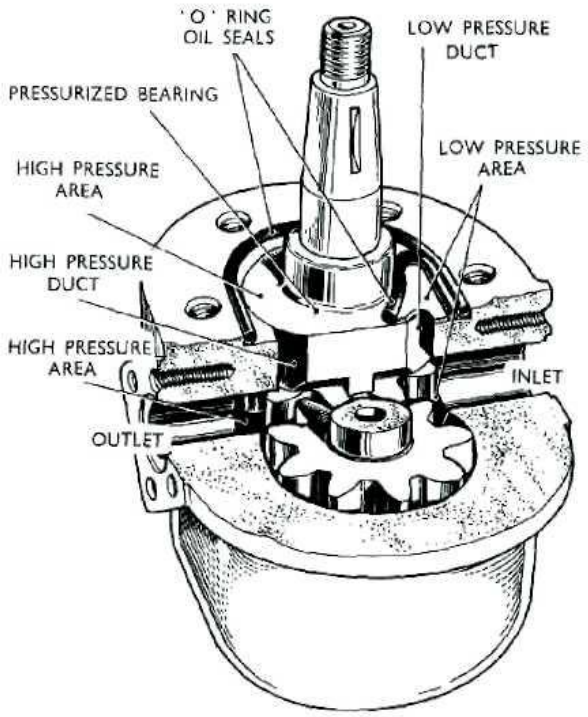



Fig. O.3 — Plessey Pump.

A smaller area on the inlet side of the pump is ported to inlet pressure and the area is proportioned to impart a true axial thrust to the bearings and to avoid the tendency for them to tip and prevent full face contact with the gears.

Synthetic rubber cord rings are used to separate the high and low pressure areas and to seal the joint between the pump body and cover. Accurate bearing alignment is achieved by location in a common bore, and pressure loading eliminates control of side clearances by shimming for selective assembly of components and provides a means of automatically taking up wear on the side faces of bearings and gears during the life of the pump.

The inlet and outlet connections are sealed to the body by "O" rings and the 5/8" diameter outlet hole should be uppermost.

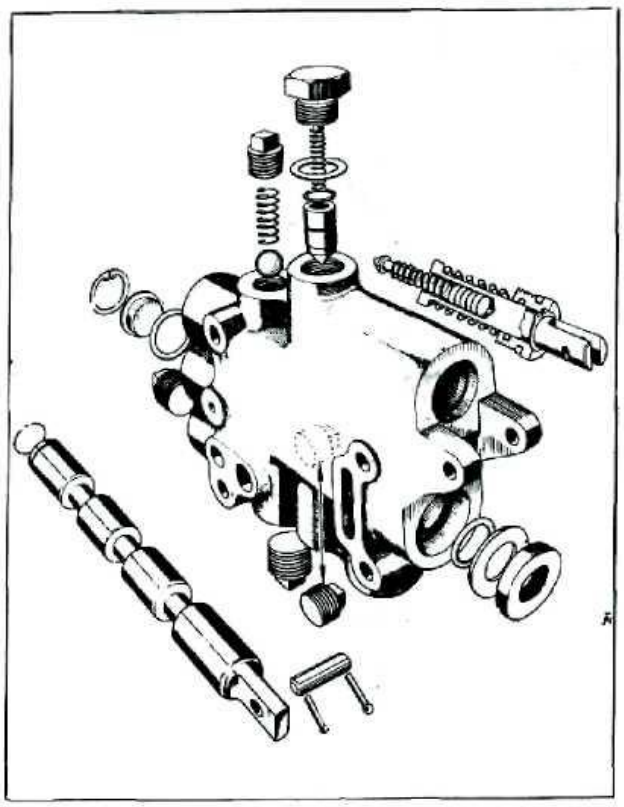


Fig. O.4 — Moore Control Valve (Exploded View).

**Valve:**

The valve unit, mounted on the side of the reservoir, contains a spool valve, a ball by-pass valve, and a plunger valve which operates as a relief valve in conjunction with a 1,000 p.s.i. bleed valve. The spool valve may be either double acting (Champion) or single acting (Canelander) and the housing has ports to receive oil (supplied from the pump through a copper pipe), two cylinder connections (one of which reconnects with the plug at the front end of the valve for single acting), two external connections and mounting face drilling for by-pass of supply oil, relief valve discharge, spool valve bleed and the two external connections.

The spool valve is a precision fit in the ground bore of the housing and is fitted with a circlip to prevent it being accidentally withdrawn through the rear of the valve. The spool is sealed at its forward end by a plug and "O" ring and at its rear end by a lip type seal. Original bleed valves had provision for the external control of the system pressure, but this was deleted in later units. The two external connections are provided for the supply and return for a separate system.

**Reservoir:**

Two sizes of hydraulic reservoir have been used, each incorporating a suction pipe and strainer connected to the pump by a low pressure rubber hose. The valve is mounted on a machined face on the reservoir.

**Hoses:** .

Two hoses lead to the rear of the tractor where they are connected either to quick release couplings for trailing implement operation or the Mk1 three point linkage cylinder located under the nearside of the fuel tank.

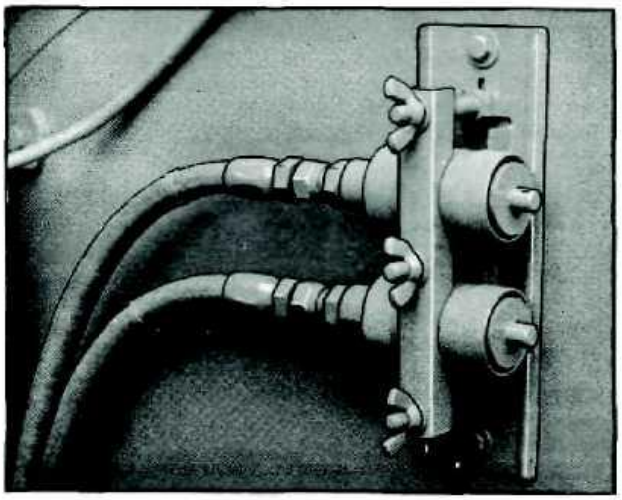


Fig. O.5 — Hoses and Quick Release Couplings.

**Controls:**

The valve spool is connected to the operating lever by a rod onto which two springs are fitted. These springs serve to return the rod and the spool valve to the central or "hold" position when the lever is released.

**SPECIFICATIONS**

| | |
|---|---|
| Make of pump | – Plessey. |
| Capacity | – 11.4 G.P.M. at 2,000 r.p.m. |
| Rotation | – Anti-clockwise. |
| Delivery pressure | – 1,000 p.s.i. |
| Oil recommendation | – Straight Mineral Oil SAE30. |
| Make of control valve | – Malcolm Moore. |
| Reservoir capacity (at correct oil level) | – Orig. 1.75 gall. approx. Current 2.75 gall. approx. |
| Type of hose | – Cotton cover single wire braid. |
| Size of hose | – $\frac{3}{8}$" orig., $\frac{1}{2}$" current. |
| Fittings | – M. & F. |
| Length of hose | – 7'6" O/A. |
| Coupling | – P.B.R. break-away. |

## MAINTENANCE

Fill the hydraulic tank to 2" below the top of the tank and start the engine, operate the valve and inspect for signs of oil leakage.

The recommended oil is a straight mineral of high quality with a viscosity of approximately SAE30.

Check oil level daily, and top up as necessary. It is recommended that the tank be drained and cleaned after the first 250 hours of operation and at every subsequent 1,000 hours. If the oil shows signs of contamination before these hours are reached, it should be drained and replaced. Whilst the oil is drained, remove and clean the suction filter and inspect the condition of the suction hose. This operation will be facilitated by removing the suction elbow from the pump, using an "Allen" wrench. Exercise care to avoid damage to the suction elbow "O" ring seal.

## OPERATION

Immediately the engine starts, a cycle of operation commences in the hydraulic system and continues until the engine is stopped or the control valve actuated.

As the pump revolves, oil is drawn from the reservoir through the strainer into the pump housing. The oil pressure is raised as it passes through the gears and is conveyed to the inlet connection on the control valve. Portion of both the pump inlet low pressure oil and the outlet high pressure oil is ported to the rear of the pump bearings to effect an axial hydraulic bearing load.

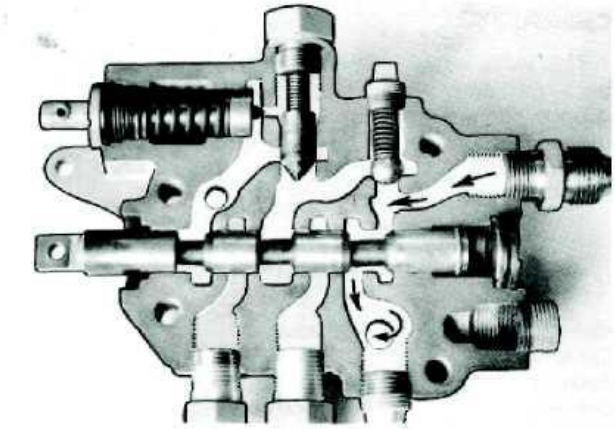


Fig. O.6 — Control Valve (Neutral).

When the oil enters the control valve, it flows past the neutral groove in the spool and back to the reservoir through matching holes in both the valve and reservoir. The cycle continues until the spool is moved to either the raise or lower positions. This movement matches the spool with the appropriate gallery and outlet, and the oil flows via the hoses to the breakaway couplings or the three point linkage.

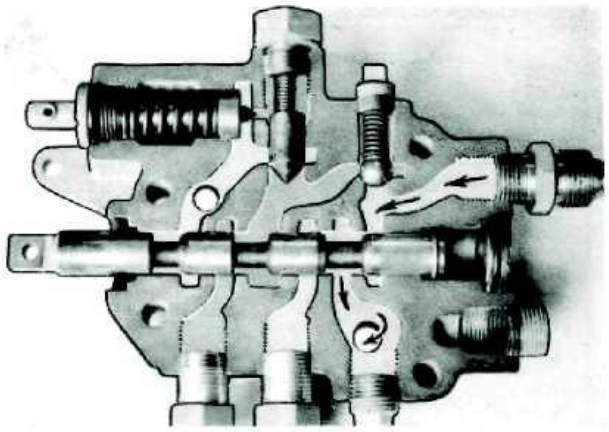


Fig. O.7 — Control Valve (Cylinder port open before return port closed).

The spool valve lands are dimensioned and chamfered to ensure that the pump supply is not completely blocked when the spool valve is moving from "hold" to either "raise" or "lower" i.e., the passage to the cylinder port is opened before the "return to tank" port is closed. To prevent oil escaping from the cylinder connection and returning to the tank during this period (resulting in the implement dropping when moving the control to or from the "raise" position), the by-pass ball valve has been incorporated. This valve opens against a light spring to allow oil from the pump to flow to the cylinders, but is held against its seat by the pressure in the cylinder line until the spool valve has restricted the flow of pump oil to the tank sufficiently to exceed the line pressure.

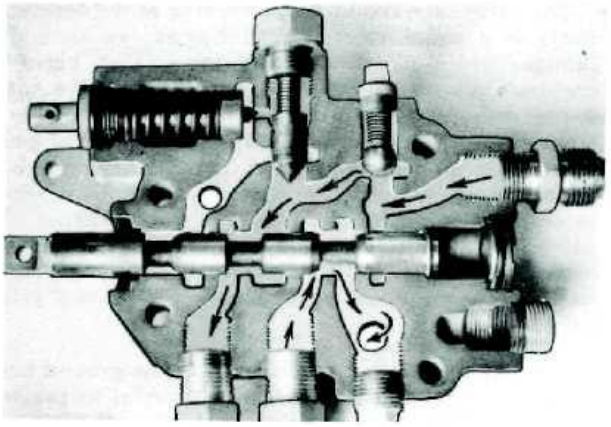


Fig. O.8 — Control Valve (Ball valve open to "raise").

The vertical **plunger valve** is fitted with a piston ring, but has a very small hole through its conical face. This hole allows oil to fill the cavity above the valve and the entire area is subjected to the system pressure. As there is no pressure difference on the plunger valve, it is held on its seat by its spring and oil is prevented from escaping to the tank via the relief valve discharge porting from below the valve by the conical seat and from above the valve by the piston ring.

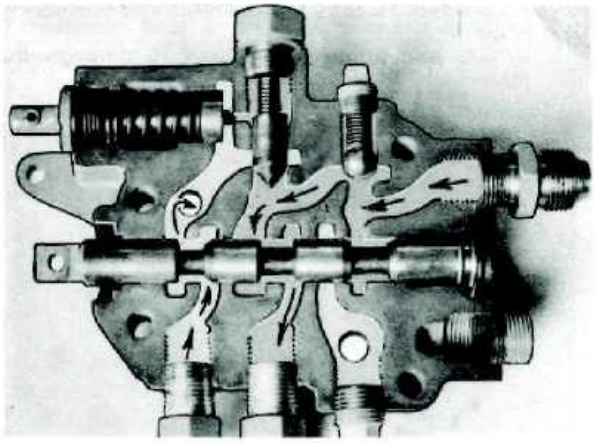


Fig. O.9 — Control Valve (Ball valve open to "lower").

In the event of system pressure exceeding the spring loading on the **bleed valve** it opens and allows oil from above the plunger valve to escape to the tank. As a result, the plunger valve is lifted from its seat by the system pressure and allows a full volume flow to escape direct to the tank without passing the bleed valve. With the system pressure relieved, the bleed valve closes and oil passes slowly to above the plunger valve through the small hole in its head and allows the valve to return slowly to its seat. The system being retarded in this manner eliminates relief valve "squeal" and reduces wear on the valve seats to a minimum.

## TROUBLE SHOOTING

| Symptom | Cause | Remedy |
|---|---|---|
| Unit drops before lifting. | 1. Cavitation due to pump starvation caused by: | |
| | (a) Inlet screen blocked. | Remove and clean. |
| | (b) Inner core of hose connecting reservoir and pump separated. | Replace hose. |
| | (c) Incorrect oil. | Replace with clean oil, correct grade. |
| | (d) Insufficient oil. | Top-up. |
| | 2. By-pass valve not seating due to: | |
| | (a) Dirt between ball and seat. | Clean the components. |
| | (b) Damaged seat. | Rework or replace valve assembly. |
| | (c) Spring tension. | Replace spring. |
| Slow lift accompanied by relief valve chatter. | 1. Overload. | Lift within the capacity of the system. |
| | 2. Damaged plunger or bleed valve seat. | Rework or replace control valve assembly. |
| | 3. Plunger or bleed valve spring tension. | Replace spring. |
| | 4. Pressure hose partially blocked. | Check and clean or replace as necessary. |
| Slow lift without relief valve chatter. | 1. Cavitation due to pump starvation. | See above. |
| | 2. Hole in plunger valve blocked. | Remove and clean. |
| | 3. Normal wear and tear on pump. | Remove and clean. |
| Overheating | 1. Overload. | Lift within capacity of system. |
| | 2. Cavitation. | See above. |

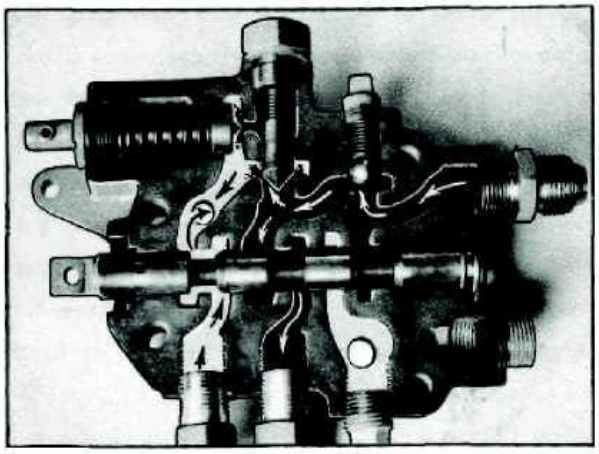


Fig. O.10 — Control Valve (Bleed valve open).

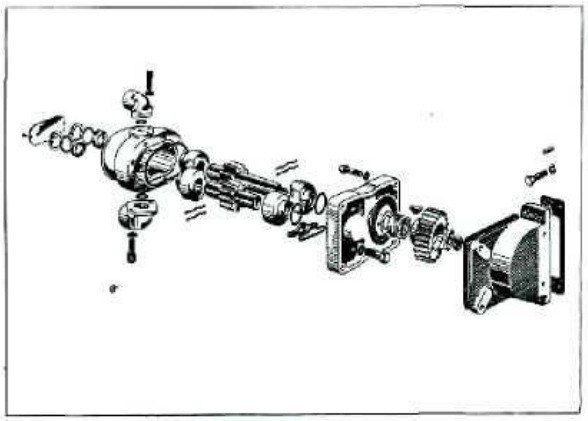


Fig. O.11 — Plessey Pump (Exploded View).

**HYDRAULIC PUMP:**

**To Remove:**

(1) Drain the hydraulic reservoir.

(2) Remove the inlet and outlet connection 'Allen' screws, or disconnect and remove the outlet pipe assembly and the inlet hose.

(3) Remove the four setscrews securing the pump to the driving gear housing and remove the pump. The locating ring 22293 may be tight in the housing and backward jerking of the pump may be necessary to enable the driving gear to dislodge it from its position. Do not use levers to pry the pump free as these may damage the alloy parts.

To Remove the Drive Gear: —

(1) Ease back the tab washer securing the drive gear; hold the gear firmly and remove the shaft nut.

(2) Remove the gear from the shaft by means of an extractor. If no extractor is available, support the gear firmly and force the shaft from it by a sharp blow with a lead hammer or similar tool being careful not to damage the thread.

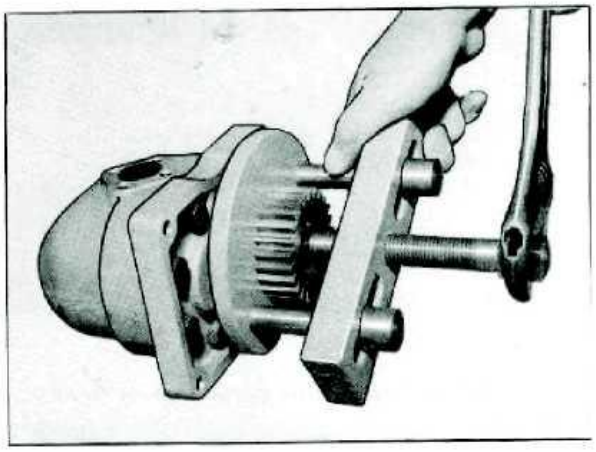


Fig. O.12 — Removing Pump Drive Gear.

**To Dismantle:**

(1) Remove eight screws around the pump cover.

(2) Lift off the cover.

(3) Remove the top bearings.

(4) Lift out the gears, noting the position of the driving gear.

(5) Remove the bottom bearings.

(6) Detach the nameplate and remove the circlips and seals.

(7) Remove the circlip and seals from the pump body cover.

**Inspection:**

All components must be perfectly clean and a clean work-bench should be available. Care should be taken that any cleaning solvent does not attack the rubber components. Kerosene or petrol is recommended.

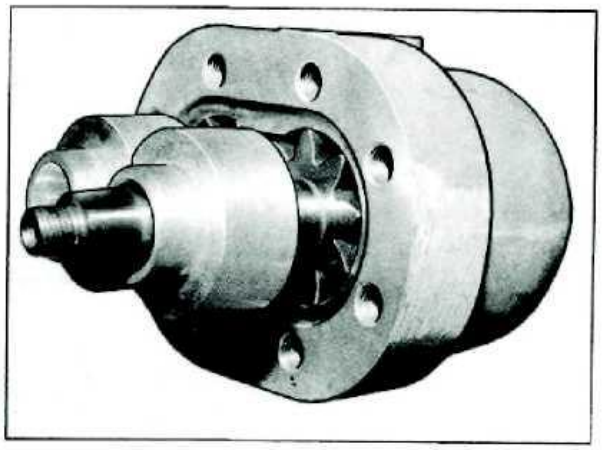


Fig. O.13 — Pump Re-assembly.

Check the following points: —

(1) The body bores and "O" ring recesses should be free from burrs and burr marks.

(2) Bearings should be free from burrs and bruises, particularly in bores and on flats. Oil grooves on bearing faces should be free from foreign matter.

(3) Gear faces and journals should be free from corrosion and bruise marks.

(4) Shaft seal must be free from damage on the sealing lip.

(5) It is necessary, usually, to renew all rubber sealing rings and shaft seal.

**Re-assembly:**

(1) Assemble the bottom bearings into the body. When used bearings are re-fitted, it will usually be possible to identify the correct bearings by observing the witness marks on the rear faces where the bearings have engaged the bottom of the pump body. The bearings should be held together with the flats in engagement and the locking wires in position, the two bearings being offered into the mouth of the body bores with one bearing slightly in advance of the other. They will slide freely to the bottom of the bore. Rotate them in the direction of rotation of the pump driven gear, and press home the uppermost bearing.

(2) Assemble the pump gears.

(3) Inject a little oil into the pump.

(4) Fit the top bearings, rotate them in the same direction as the bottom bearings.

(5) Fit the cover "O" ring together with the relief plate and "O" ring. Care should be taken that the relief plate is assembled on the inlet side of the pump.

(6) Replace the pump cover taking care not to damage the seal.

(7) Fit screws and washers and tighten evenly and securely.

(8) Assemble the drive gear to the pump shaft. This should be offered by hand, not tapped into position. Lock the tab washer.

(9) Assemble the seals and nameplate to the base of the body.

(10) Turn pump by hand to ensure no binding occurs.

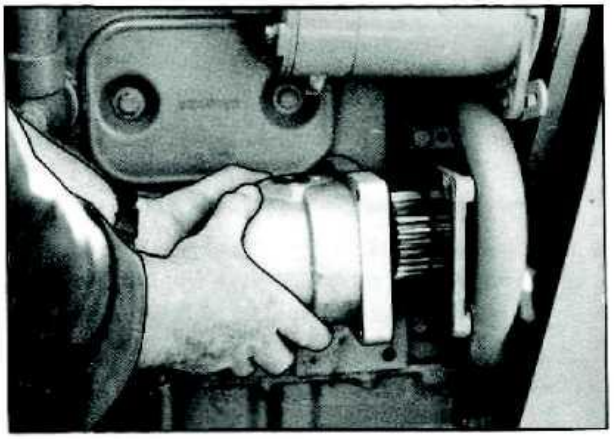


Fig. O.14 — Installing Pump.

**Installation:**

Re-assembly of the pump to the engine is a reversal of the dismantling procedure with the following points noted: —

(1) The outlet or smaller hole must be uppermost.

(2) The locating ring is correctly installed in the driving gear housing before the bolts are finally tightened.

(3) The tractor engine is not started before the hydraulic system is filled with oil.

**CONTROL VALVE:**

**To Remove:**

(1) Drain the reservoir below the bottom of the valve.

(2) Disconnect the pump to valve pipe.

(3) Remove the two hoses. Where these are fitted to a three-point linkage ram, it will be necessary to first disconnect them from the ram to avoid hose distortion.

(4) Remove the control rod to spool clevis pin.

(5) Remove the four bolts holding the valve to the reservoir mounting pad and remove the valve.

**To Dismantle:**

The plunger valve and by-pass valve can be removed by removal of the retaining plugs on the top of the control valve.

Removal of the circlip on the end of the valve allows the blanking plug to be removed and the spool withdrawn.

**Inspection:**

Note the following points:—

(1) As the spool and body are a matched pair, renewal of one of these parts necessitates the renewal of the other.

(2) Stickiness of the spool in the housing can be overcome by lapping, but care must be taken that the parts are completely clean and free from the lapping medium before re-assembly.

(3) Scoring of the spool or body will affect the serviceability of the assembly and necessitates renewal of the parts.

(4) Closely inspect the seating of the bleed plunger and by-pass valves as these will materially contribute to poor operation of the system.

If any doubt exists regarding the serviceability of any of the parts, renew them.

**Re-assembly:**

Re-assembly is a reversal of the dismantling procedure with absolute cleanliness the keynote.

**HOSES:**

The hoses should not be subjected to twisting as this weakens the casing allowing them to fail at this weak point. Chafing should also be avoided for the same reason.

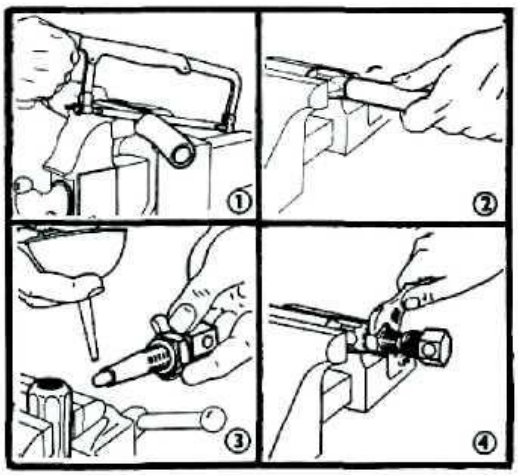



Fig. O.15 — Use of P.B.R. Fitting Tools.

The early 3/8" hoses were not equipped with reusable end fittings as are the later hoses. Fitting tools are available, and using these proceed as follows to replace the fittings:—

(1) Cut the hose to length.

(2) Place the socket in vice. Screw hose counterclockwise until it bottoms. Back off 1/4 turn.

(3) Push the nipple on to the assembly tool and oil the nipple thread and the inside of the hose liberally.

(4) Screw the nipple into the socket and hose clockwise by using a spanner on the hexagon. Tighten the nipple until it is in contact with the socket, then withdraw the assembly tool.

**P.B.R. COUPLINGS:**

These fittings are designed to allow a quick and easy method of connecting and disconnecting the hoses without loss of oil. Air is also prevented from entering the system when re-connecting. They are mounted on a special bracket at the rear of the tractor, the bracket being designed to hold the sleeve whilst any extra pull on the hose disconnects it before any damage is done.

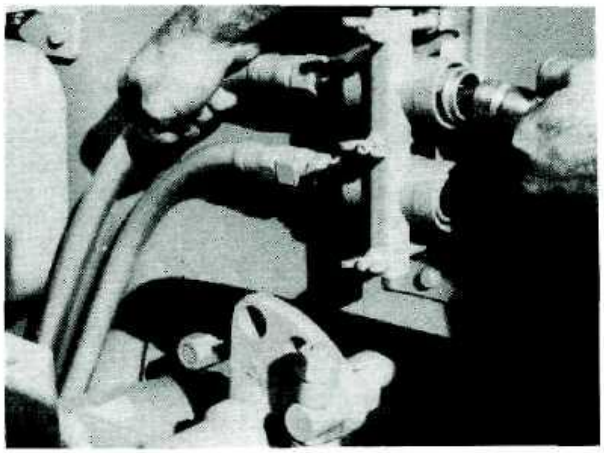


Fig. O.16 — Disconnecting P.B.R. Couplings.

When working, the nozzle is kept in position by protruding balls locking in a groove in the nozzle. The action of releasing is to slide the body inside the sleeve until the balls match an oversize section allowing the nozzle to unlock and slide free. Sealing of the coupling is accomplished by the use of an "O" ring inside the body through which the removable nozzle must pass.

If possible, disconnecting with high pressure in the line should be avoided as this causes a pressure build-up and makes re-connecting difficult. The control valve must be in the neutral position when re-connecting.

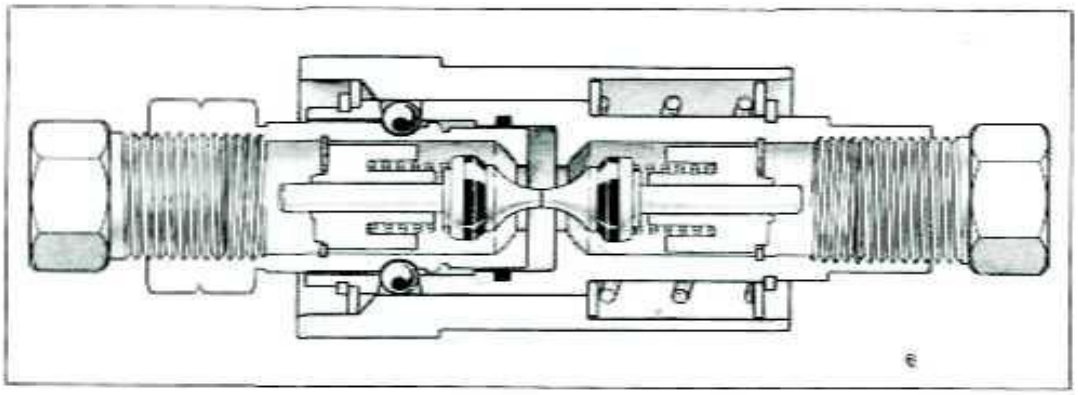


**Fig. O.17 — Sectioned P.B.R. Coupling.**

When the coupling is disconnected, a spring causes the valves to close thus sealing against loss of oil. As the hoses are reconnected, the protruding ends of both valves meet and the valves are held off their seats allowing the oil to flow.

Replacement or reconditioning of the valves may be accomplished by the removal of the retaining circlip whilst the sealing "O" ring can be replaced by removing the unserviceable item and rolling the new one into the retaining groove. (Do not stretch the "O" ring before fitting as it will not return to its correct size.)

# VICKERS POWER PACK

The Vickers Hydraulic Power Pack, as fitted to Chamberlain Tractors, is used to transmit power through hydraulic oil under pressure to operate either three point linkage equipment or hydraulically controlled trailing implements. The compact Power Pack combines a vane type pump, relief valve, operating valve, oil tank and oil filter, all in one unit.

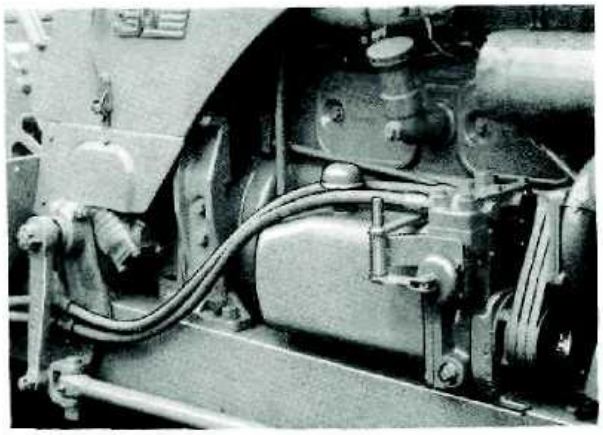


Fig. O.18 — Vickers Power Pack (Double Acting).

The Power Pack is available as a double or single acting unit, double acting being used with trailing implements, while single acting is used in conjunction with Mark II three point linkage. Adequate oil for single acting operation is contained in the 1½ gallon reservoir. Conversion from double to single acting can be effected as described on Page O.13 in this section.

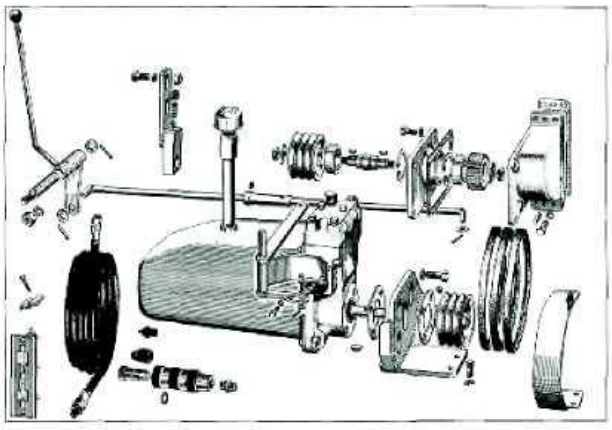


Fig. O.19 — Power Pack Drive (Exploded View).

**Caution:**

Double acting hydraulics must not be used to operate Mark II three point linkage equipment as undue stresses would be imposed on the linkage and equipment.

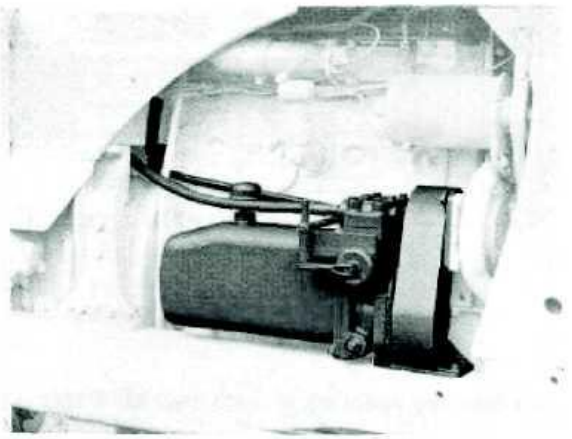


Fig. O.20 — Vickers Power Pack (Single Acting).

The flange mounted Power Pack is driven by three vee-belts fitted between the pump pulley and a pulley and drive connected to the offside front of the tractor engine. This drive is continuous whilst the engine is operating making the hydraulics live regardless of engagement or disengagement of the main tractor clutch.

**Controls:**

A control lever is attached to the operating valve which is spring loaded to return to neutral, a force of approximately 25 lbs. being required to overcome the spring.

On single acting units a spring loaded ball engages in a notch cut in a sleeve attached to the operating rod. This arrangement serves to retain the Power Pack spool valve in the "lower" or "float" position once the operator has moved the control to this position. When the ball is not located in the slot, the Power Pack mechanism will return the control to the central or "hold" position.

Vickers hydraulics can be adapted to earlier Champion tractors, but it will be necessary to: —

(a) Drill and tap three holes in the tractor chassis for the Power Pack mount.

(b) Drill two holes in the bulkhead to take the detent block.

(c) If the unit is to operate Mark I three point linkage equipment it will be necessary to replace the 1500 p.s.i. relief valve with a 1,000 p.s.i. valve (P/N14518).

**Hoses:**

For single acting hydraulics, one hose leads to a three point linkage cylinder located beside the near-side of the fuel tank while double acting hydraulics have two hoses leading to the rear of the tractor where they are connected to quick release couplings for trailing implement operation.

**Quick Release Couplings:**

These are of the P.B.R. type and are designed to allow a quick and easy method of connecting and disconnecting the hoses without loss of oil.

## SPECIFICATION

| | |
|---|---|
| Make of Power Pack | – Vickers |
| Capacity | – 5.2 G.P.M. at 1,600 R.P.M. |
| Rotation | – Anticlockwise (viewed from front of tractor) |
| Delivery pressure | – 1,500 p.s.i. |
| Oil recommendation | – High Viscosity Index oil containing anti-oxidant, anti-rust and anti-foam additives. Viscosity 43-76 centistokes at 100°F. Check the oil recommendation chart. |
| Reservoir oil level | – 1½-1-¾" below the top of the filler boss. |
| Reservoir capacity | – 1½ gallons. |
| Type of hose | – Cotton covered single wire braid. |
| Size of hose | – 3/8". |
| Fittings | – M. & F. |
| Length of hose | – 8'6" O/A. |
| Coupling | – P.B.R. Break-away. |

## MAINTENANCE

Fill the hydraulic oil tank to 1½ - 1¾" below the top of the filler boss. Check the oil level daily and top up as necessary. It is recommended that the tank be drained and cleaned after the first 250 hours of operation and at every subsequent 1,000 hours. If the oil shows signs of contamination before these hours are reached, it should be drained and replaced. Before coupling a trailing implement to the tractor, check the implement hydraulic system, flush out and, if necessary, dismantle and clean should contaminated or heavy oil be present as this will adversely affect the Power Pack when the system is operated. Occasionally check the belt tension and adjust it so that there is approximately ½" of hand pressure movement.

## OPERATION

A cast aluminium oil reservoir housing the vane type rotary pump unit is bolted to the face of the pump body and uses a cork gasket as an oil seal. The pump slotted rotor is driven by the unit drive shaft and a vane in each slot slides radially as the rotor revolves. Centrifugal force causes the vanes to follow the inside cam contour of a hardened and ground ring which is so shaped that two opposing pumping chambers are formed.

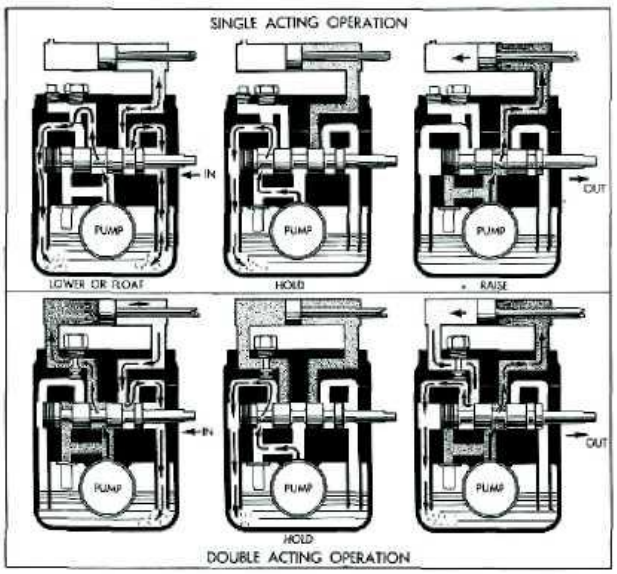



**Fig. O.21 — Schematic Power Pack Operation.**

Inlet flow is received through the kidney slots of the pump head and enters that portion of the cam-formed pumping chambers in which the cavity between the rotor and the cam is enlarging. The flow is carried along by vane action, and is expelled under pressure from that portion of the cam cavity which is diminishing. Pressure oil is ported through the kidney slots of the pressure plate and into the pressure passages of the body and spool valve.

The floating pressure plate, which is continuously subjected to system pressure, automatically takes up leakage as pressure increases.

Because the pump vanes are initially ejected by centrifugal force, it is essential when starting that the minimum drive speed be held to 600 R.P.M. until the pump is primed and pressure built up.

A spring loaded, poppet type, relief valve is teed into the high pressure circuit and functions when system pressure reaches the setting of the valve. Fluid relieved from the circuit through the valve is dispelled into the reservoir.

The valve action is produced in the powerpack by a sliding spool which is precision fitted in the body bore; spool lands and bore grooves port the hydraulic fluid into desired passages determined by the position of the spool. The schematic diagram illustrates the operation of the single and double acting systems. The spool parts have been re-arranged to clarify the systems; in practice the return flow does not come in contact with the end of the spool as shown.

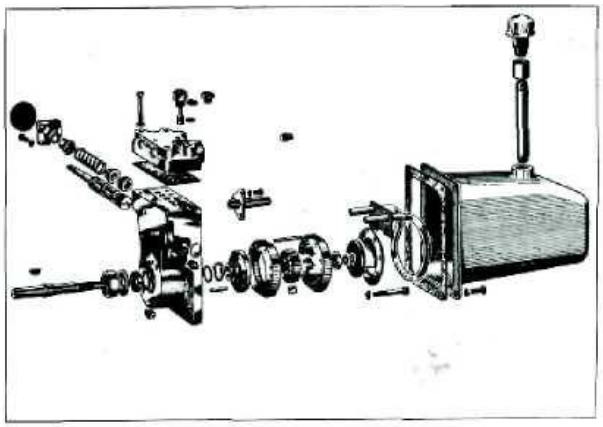


Fig. O.22 — Power Pack (Exploded View).

## OVERHAUL

**To Remove:**

(1) Remove the belt guard P/N 25628 if fitted.

(2) Slacken the power pack mounting bolts and remove the three vee belts.

(3) Remove the hand lever to control arm link split pin and washer.

(4) Remove the hose or hoses being careful not to excessively bend them as this may cause internal structural damage.
Cover the ends to prevent the ingress of dirt.

(5) Slacken the power pack pulley grub screw and remove the pulley.
**Caution:** If the pulley is tight, use a puller as the use of levers may damage the shaft retaining circlip and the damage will not be apparent unless the power pack is dismantled.

(6) Remove the power pack mounting bolts and lift the pack clear being careful not to spill the oil from the hose or breather holes.

**To dismantle:**

(1) Prepare a clean working area and thoroughly clean the outside of the power pack.

(2) Remove the breather and drain the oil.

(3) Remove the four retaining bolts and the reservoir.

(4) Remove the two Allen screws securing the oil return tube and remove the tube. The other six Allen screws may now be removed with no obstruction.

(5) Lift the baffle plate and screen clear and remove the shaft retaining circlip. Note any shims fitted beneath the circlip.

(6) Remove the pump head and the cam ring. The rotor and vanes are now exposed and particular note should be made of their position so that they can be assembled in the correct manner.

(7) The pressure plate and wave washer can now be removed from the rear and the shaft and bearing removed from the front.
Carefully note the position of the front bearing spacer as incorrect assembly of this item affects the reassembly of the pump.

(8) The removal of the three screws allows the relief valve to be removed from the back face of the power pack body.

(9) Six bolts retain the top cover which can be lifted clear when these are removed.

(10) Remove the spool cover and boot which enables the spool to be withdrawn. Care should be taken with this operation as the spool and body are a matched pair and burring or grooving of either component necessitates the replacement of both. If the circlip is removed and the bushes and spring disassembled from the spool, carefully note the position of the outer bush as incorrect assembly of this item will seriously affect the spool operation.

**Inspection:**

Carefully examine all components and if any doubt exists regarding their serviceability, replace them. Check that the vanes are a free fit in the rotot slots. If any binding occurs, carefully hone the high spot removing no more material than the high spot.

The pump head and pressure plate faces may be surface ground if worn, but must be thoroughly cleaned before re-assembly or rapid wear and damage will take place.

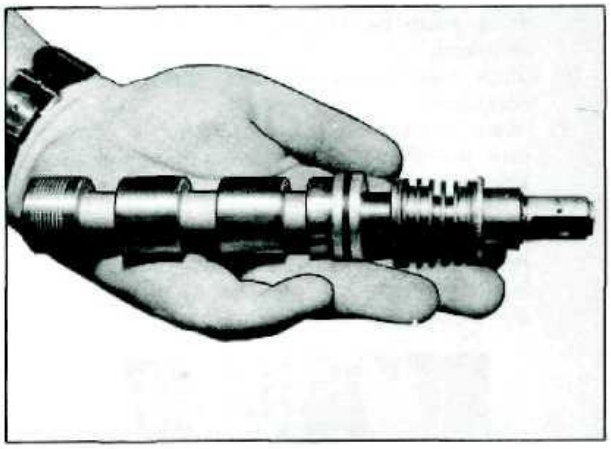


Fig. O.23 — Power Pack Spool (Note outer bush assembly).

**Re-assembly:**

Reassembly is a reversal of the dismantling procedure with the following points noted:

(1) New seals, 'O' rings, gaskets and shaft retaining circlip should be fitted after each dismantling.

2) The spool outer bushing must be fitted with the longest distance from the shoulder towards the spool cover.
3) The front bearing spacer is fitted with the inwardly dished side towards the bearing and the seal with the lipped edge towards the inside of the pump.
4) When assembling the cam ring slope it towards the spool cover and boot when viewed from the rear of the pump for left hand rotation.

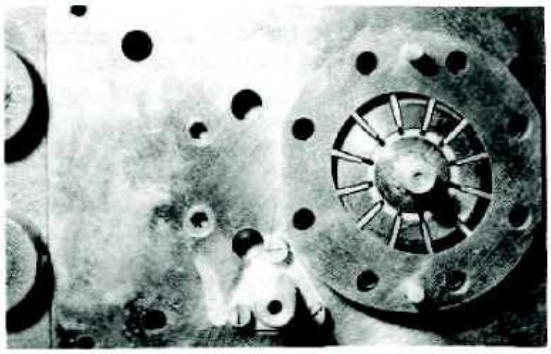


Fig. O.24 — Cam and Rotor Assembly.

Note that early type rotors also had sloping grooves which should be assembled similarly to the cam ring whilst the later type has straight grooves. Vanes having only one chamfered edge should be assembled with this edge trailing. Incorrect assembling of the cam ring and rotor will result in seizure of the pump due to lack of oil.

5) Fit a new circlip to the end of the shaft. If new parts have been included the shaft end float must be checked and a shim fitted if required.
6) Check that the relief valve spring is in good condition.
7) When reassembly of the pump is completed, turn the shaft in the correct direction of rotation to ensure that there is no binding of the parts.
8) After refitting the pump to the tractor, do not neglect to fill with the correct oil before starting the engine as operation of the pump without oil will result in seizure.

Fig. O.25 — Belt Adjustment.

**Conversion—Single to Double Acting Hydraulics:**

The following parts are required for the conversion:
Double Acting Plug (High head) and 'O' Ring.
One extra Hydraulic Hose.
Quick Release Couplings, Mounting Bracket and Reducing Nipples.

(1) Remove the single acting plug (1/4" high head) from the top cover of the power pack. Replace it with the double acting plug and 'O' Ring. Take care to avoid damaging the 'O' Ring.
(2) Remove the retainer, spring and plug from the detent block.
(3) Remove the square head plug from the power pack body and replace it with the hydraulic hose.
(4) Fit the quick release couplings and brackets to the O.S. mudguard. Use the existing mudguard mounting bracket bolts and locations. Add the reducing nipples to the forward end of the coupling.

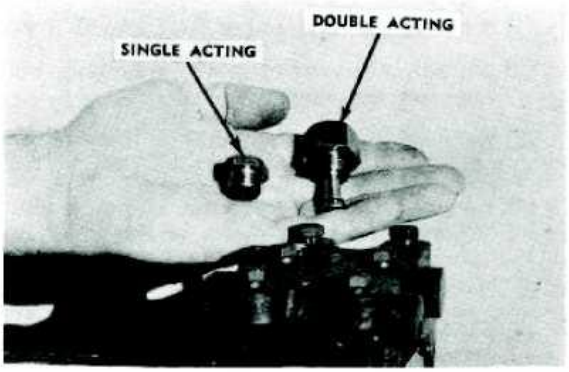



Fig. O.26 — Conversion Plugs.

**Conversion—Double to Single Acting Hydraulics:**

The following parts are required for the conversion.
Single Acting Plug (1/4" high head).
Square Head Plug.
Detent Ball, Spring and Retainer.

(1) Remove the double acting plug—(high head) and "O" Ring from the top of the power pack cover and replace it with the single acting plug.

(2) Remove the inside (nearside) hydraulic hose and replace it with the square head plug in the power pack body. Connect the remaining hose to the elbow of the 3-point linkage hydraulic cylinder.

(3) Add the ball, spring and plug to the detent block. Loosen the sleeve locking grub screw. Push the hand control lever fully forward. Hold the lever in this position and align the sleeve detent with the ball. Lock the sleeve to the link rod with the grub screw.

Hoses and P.B.R. couplings used in this system are covered at the end of the Plessey Hydraulic System.

# VICKERS POWER STEERING

The power steering system provides effortless steering for Industrial Champion tractors used in heavy industrial applications. The system comprises a vane type pump, a booster cylinder, hoses connecting the pump and booster and a drag link to connect the booster to the pitman arm. A lug welded to the chassis anchors the booster while the booster rod socket locates in the stub axle drag link, special stops welded to the lower steering column bracket prevents the steering box from 'bottoming' in either direction.

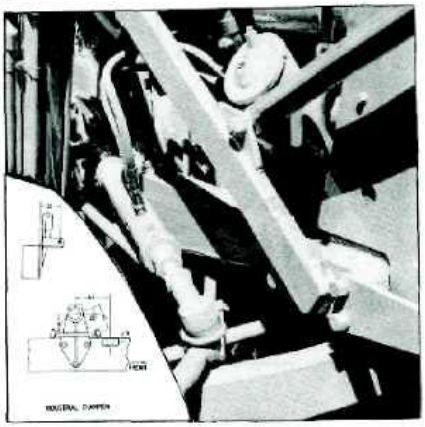


Fig. O.27 — Mounted Pump and Booster Cylinder.

**Pump:**

The power steering pump, used to supply fluid flow for the operation of the booster, is of the balanced vane, constant delivery VT16 type with integral volume control, relief valve and oil reservoir. Delivery of oil is at a minimum rate of 1.0GP.M. at 500 r.p.m. with a maximum of 3.00 p.m. at 2000 r.p.m. The pump is geared directly to the engine camshaft on the offside front of the block and has a pressure relief valve setting of 750 p.s.i.

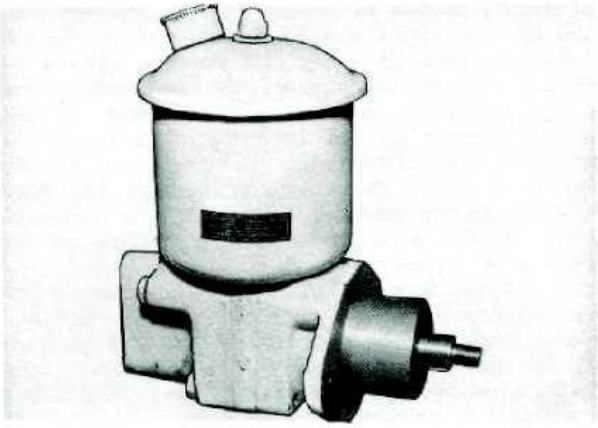


Fig. O.28 — Steering Pump.

The unit consists principally of a body, cover, cam ring, rotor and vanes, pressure plate and flow control valve. The vanes, contained within the rotor slots and driven in rotation with the cam shaped contour of the ring, are responsible for the development of fluid flow. The flow control valve, which incorporates an overload relief valve, controls this developed flow.

**Booster Cylinder:**

The booster cylinder utilises hydraulic pressure from the engine driven pump to facilitate the steering action. It has a 2" cylinder bore with a maximum piston stroke of 8½" and a rated thrust capacity of 1500 lbs. at 600 p.s.i. pressure. The anchor socket is fixed to the piston rod whilst the stub axle drag link arm socket is screw adjusted with locknuts for correct adjustment of the assembly. A ball stud protruding from under the cylinder body connects with the pitman arm drag link. Two hose fittings on the top of the cylinder are used to connect to the pump.

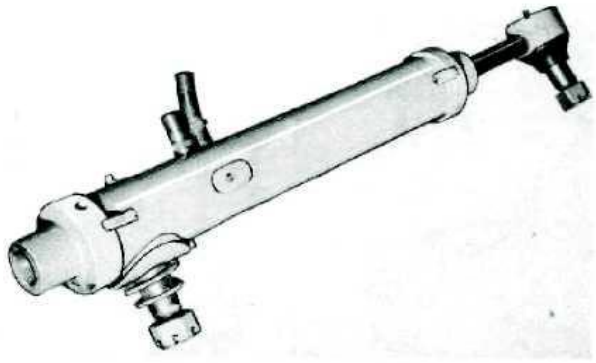


Fig. O.29 — Booster Cylinder.

**SPECIFICATIONS**

| | |
|---|---|
| Make of pump | – Vickers. |
| Capacity | – 1.00 p.m. at 500 R.P.M. min. |
| | – 3.00 p.m. at 2000 R.P.M. max. |
| Rotation | – Anti-clockwise. |
| Relief Valve Pressure | – 750 p.s.i. |
| Reservoir Capacity (on Tractor) | – Approx. 1 pint. |
| Oil Recommendation | – Automatic Transmission Type A. |
| Make of Booster | – Vickers. |
| Cylinder Bore | – 2". |
| Max. piston stroke | – 8½". |
| Lubrication | – Chassis Grease. |
| Type of hose | – Cotton Cover single wire braid. |
| Size of hose | – 3/8". |
| Length of hose | – 2'3" O/A. |
| Fittings | – M. & F. |

**MAINTENANCE**

Check the fluid level daily and top up as necessary. As the pump will be operating and the oil circulating when ever the engine is running, check the oil regularly. The level should be within ½"-1/4" from the base of the filler plug boss with the

steering booster in the neutral position. It is recommended that the tank be drained and cleaned after the first 250 hours of operation and at every subsequent 1000 hours. If the fluid shows signs of contamination before these hours are reached it should be drained and replaced.

Service the lubricating points daily and check the hydraulic system for leaks and tighten up where necessary. Periodically examine the hydraulic hoses for chafing caused by rubbing against metal parts.

## PUMP OPERATION

The unit depends on the tractor engine as a source of rotary mechanical power in order to produce fluid flow. Inlet through ports in the pump body is created by a partial vacuum set up by the action of the pumping cartridge (cam ring, rotor and vanes). This flow is directed through the cartridge to the pressure port in the cover and on to the booster. The developed oil flow is monitored by a flow control valve.

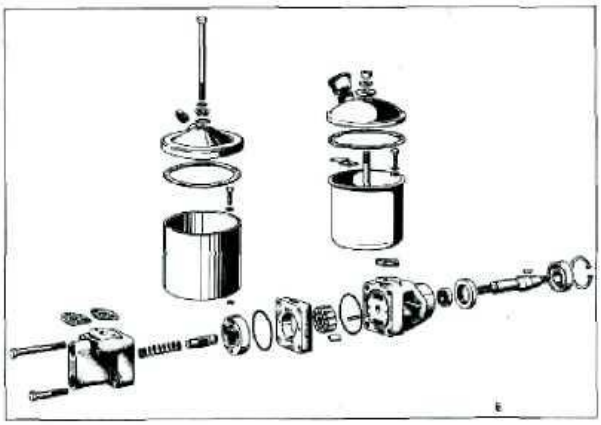


Fig. 0.30 — Pump (Exploded View).

Inside the cam ring, the slotted rotor is driven in an anti-clockwise direction by the unit drive shaft. A vane in each rotor slot slides radially to contact the cam shaped contour of the pump ring. Centrifugal force and fluid pressure behind the vanes causes them to follow the inside cam contour of the ring. Inlet flow is received in the pumping chambers through the kidney slots of the pump body and enters that portion of the cam cavity in the pumping chambers between the rotor and ring. The flow is carried along by the vane action, and is expelled from that portion of the cam cavity which is diminishing. This action is continuous, regardless of pressure restrictions imposed at the pump outlet. The inlet flow is divided within the pump body such that oil enters the cam cavity at two points 180 deg. apart. Oil is expelled at two points the same distance apart. In operation, this condition results in opposed pumping chambers and it is this opposed position of chambers both inlet and outlet, that produces the hydraulic balance of the pump.

**Controlled Flow Action:**

Control of this developed oil flow is accomplished by a combined flow control and relief valve (18) through (23). In general, this valve limits the amount of the flow from the pump and, by means of its internal construction, fluid in excess of the amount required to perform the work is relieved into the return circuit flow to tank.

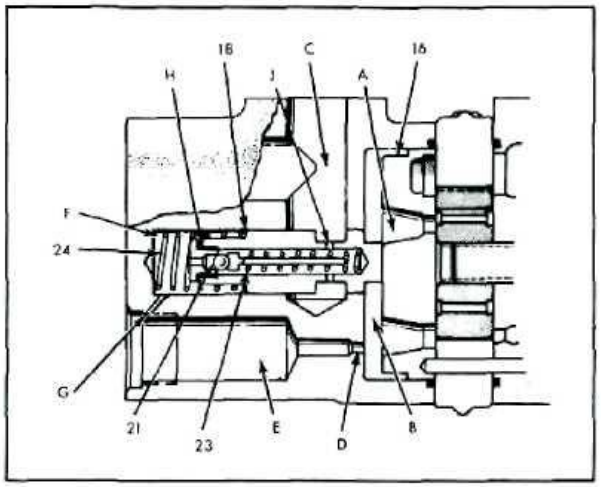



Fig. 0.31 — Flow Control and Relief Valve (Section View).

**Flow Control Operation:**

A. As the name implies, the flow control valve is used to relieve excess pressure as it may occur at the outlet of pressure port (e). Oil in excess of system requirements is ported into the return circuit flow via passage (c). This is accomplished through the action of sliding spool (18), in the following manner: Oil expelled from the pumping chambers flows through the kidney slots (a) in pressure plate (16) into pressure chamber (b), through orifice (d) and out pressure port (e) to system.

B. When tractor wheels are not being turned, sliding spool (18) is in the closed position blocking passage (c). The spool is held in "closed", or neutral position by force of spring (24). As flow volume increases, pressure acts against the head end of the spool forcing the oil in spring chamber (f) out through passage (g). As the force of spring (24) is overcome, the spool retards, throttling excess oil into the return circuit flow through passage (c). Since these pumps are designed to deliver oil in excess of circuit requirements, this throttling position of the spool is its normal operating position.

C. If pump flow is blocked, a high pressure condition develops in the circuit. This pressure is transmitted back through outlet port (e) and passage (g) into spring chamber (f) and drilled passage (h). As pressure overcomes the force of spring (23), ball check (21) is unseated and oil flows past the ball, through passage (h) and through drilled passages (j) to passage (c). The sudden drop in pressure in spring chamber (f) causes the spool to move to wide open position and oil flows freely from chamber (b)

to passage (c). When pressure returns to normal, relief valve ball (21) reseats and spool (18) returns to either closed or throttling position.

The entire cycle is represented schematically in figure 0.32 the positions of the control valve while idling, during normal operation, and when causing excessive pressure build up, being shown.

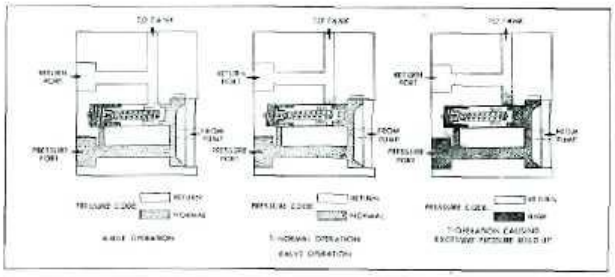


Fig. O.32 — Schematic Action of Valve.

A secondary function of the control valve is to hold the pressure plate against the pump cartridge parts until system pressure builds up sufficiently to assume this function.

## PUMP OVERHAUL

1. **Disassembly:** Before proceeding with the disassembly, drain all oil from the unit.

### A. Cover End:

(1) Turn out screw (1) and remove lockwasher (2) and washer (3). Lift reservoir cover (6) from reservoir and separate bolt guide (4) from cover. Slip off gasket (5) from bolt guide. Remove reservoir screws (8) and separate reservoir (9) from the pump.

(2) Remove gaskets (12). Turn out the cover mounting screws and separate cover (15) from the remainder of the unit. Removing the cover will provide access to pressure plate (16). Remove it along with sealing ring (17).

(3) Flow control valve (18) is located within the cover and may be removed from its bore to reach spring (24). The relief valve, which is an integral part of the flow control valve, is factory pre-set for the proper pressure rating. Since this is so, it is not recommended that it be disassembled.

(4) Pull locating pins (25) from ring (26) and remove the ring. The sealing ring between the ring and body (29) is the same as (17), the one used between the ring and cover (15). Note the position of the cam contour before removing the ring. Slide vanes (28) from their slots in the rotor and pull rotor (27) from the end of the drive shaft. Note the position of the ring and vanes during disassembly so that they may be properly reassembled.

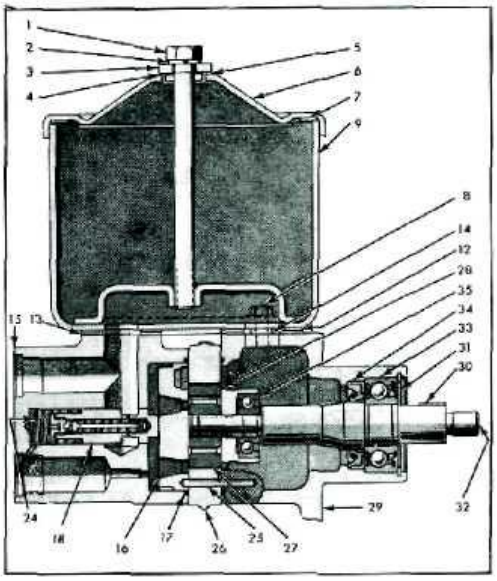



Fig. O.33 — Section through Pump.

### B. Shaft End:

This end of the pump must be opened to gain access to the bearings and the oil seal. Disassembly may be accomplished as follows: Lift key (30) from its seat in the drive shaft. Remove snap ring (31) that holds outboard bearing (33) in position. Next, carefully remove the drive shaft by gently tapping on the rotor end of the shaft with a soft nosed hammer. The same result may be obtained by standing the unit on its end (rotor end of the shaft down) and pressing downward on pump body (29). When doing this, place a wooden block under the shaft to protect splining.

### C. Drive Shaft Bearings and Shaft Seal:

(1) Before proceeding further with disassembly, it should be noted that drive shaft bearing (33) is a press fit on the shaft and that bearing (35) is also pressed into a recess provided in the pump body. Wash these bearings thoroughly in a clean solvent and test each one for wear. Rotate each bearing, applying as much pressure to the outer races as is necessary to determine whether the balls or races have become pitted or cracked. Check for looseness. A small amount of end play is permissible; however, an excessive amount for any one bearing will require its replacement.

(2) To remove bearing (33), place bearing and shaft in an arbor press and support the bearing by using a length of pipe with a diameter such that it will contact the inner race of the bearing. Press the shaft down through the bearing.

(3) Shaft seal (34) is pressed into its seat in the body to insure against leakage. Check oil seal diameter on drive shaft for possible scoring marks. If any are found, both seal and shaft must be replaced.

(4) To remove the seal, insert a hooked tool through the shaft bore, catch the under side of the seal and pull out.

(5) Removal of inboard bearing (35) may be accomplished best with a bearing puller applied through the shaft bore of the pump body and contacting the outer race of the bearing. The same result may be achieved by tapping this bearing out with a drift inserted from the cover end.

2. **Inspection, Repair or Replacement:**

**Note**: Wash all parts except seals in clear mineral oil solvent and lay them aside for inspection. Replace all old seals with new ones at reassembly.

A. Pump Cartridge: The pump cartridge consists of ring (26), rotor (27) vanes (28) and the two seals (17). Check the finished faces of the pump cartridge for roughness or irregular wear. Check the rotor slots with vanes inserted for excessively loose fits. Vanes must slide freely but snugly in rotor slots. Inspect cam ring contour and vane contact surfaces for deep scoring. If heavy scoring is noted, pump cartridge parts, may be removed with crocus cloth or a hard Arkansas stone.

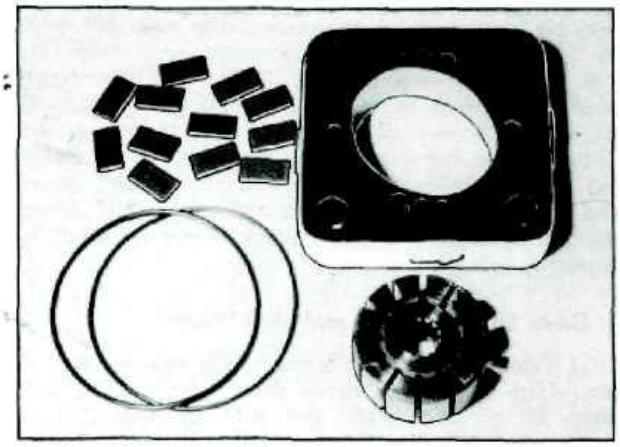


*Fig. O.34 — Pump Cartridge.*

B. Pressure Plate: Inspect the machined contact face of the pressure plate for scoring. This face may be repaired by lapping if total depth of cut needed to clean up the surface does not exceed .005.

C. Flow Control Valve: Insert valve in its bore location in the pump body. There should be no evidence of binding. The valve O.D. may be polished with crocus cloth to assure smooth movement. However, if deep scoring is noted on the valve surface, the pump body valve bore will be similarly scored necessitating replacement of both of these parts. Machining or touch up is not recommended due to the close tolerance dimensions involved.

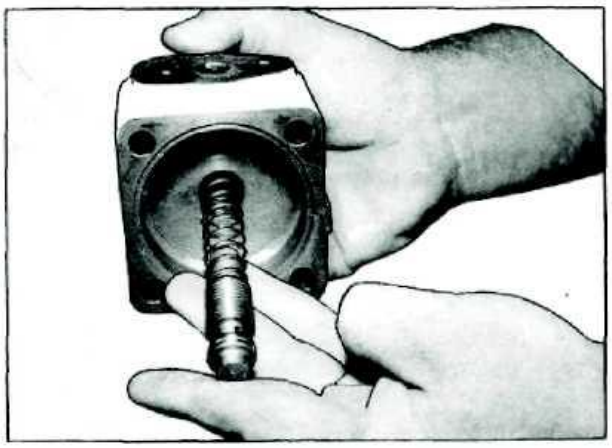


*Fig. O.35 — Flow Control Valve.*

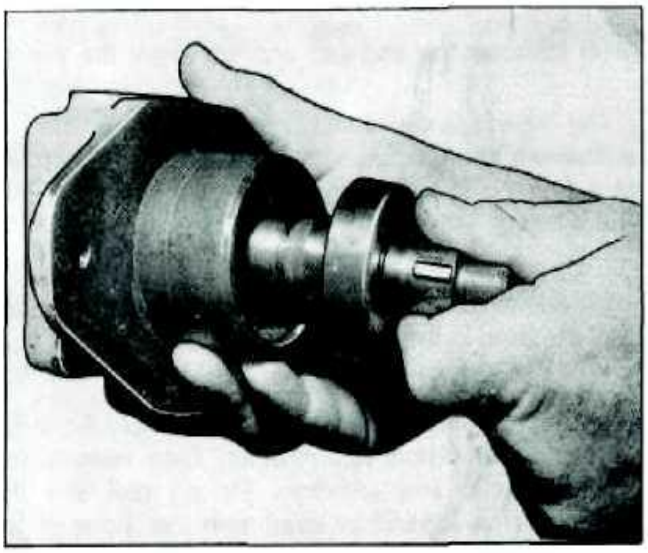
D. Bearings: After thorough cleaning, turn the outer race of the bearings while exerting finger pressure against the inner race to detect roughness. Pitted, cracked, or scored races or balls will require bearing replacement.

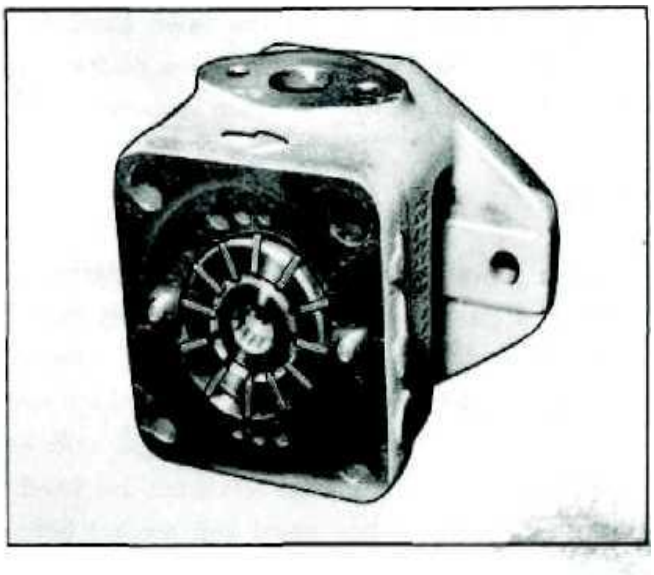
E. Shaft seal and Drive Shaft. Replace the shaft seal at each overhaul to prevent oil leakage around the shaft. Check the O.D. of the drive shaft at the point of contact with sealing lip of the shaft seal for scoring or excessive wear. Do not install a new shaft seal for use with a worn or scored shaft as this practice will invite pump leakage. Replace the damaged shaft with a new one.

3. **Reassembly:**

**Note:** Prior to reassembly, immerse all parts in clean hydraulic oil. This will facilitate reassembly and also lessen the possibility of tearing or cutting replacement seals.

A. Drive Shaft Bearings and Shaft Seal: Assemble bearing (33) in its proper location on shaft (32). Seat bearing (35) in its location in the housing. Be certain that both bearings are properly seated. This best may be achieved with the aid of bearing driver that contacts the inner race of bearing (33) and the outer race of bearing (35). When seating bearing (33) take the precautions necessary to prevent damage to the splines on the rotor end of the drive shaft. Install shaft seal (34) in its location in the housing. The sealing lip must face inward, that is, toward the cover end of the pump.





Movement of the steering wheel causes the booster control ball stud to operate the valve spool which causes the oil to flow as shown in the diagrams and the wheels to turn in the direction required.

**Caution:**

When power steering is fitted to a tractor, the front axle steering stop setscrews and nuts must be removed and pitman arm stops fitted, otherwise damage may be caused to the steering linkage when the full thrust of the booster forces the stub axle against its stop. The pitman arm stops are fitted to restrict the steering box travel and prevent bottoming.

## OVERHAUL

An exploded view of the cylinder is included in this section, but any overhaul necessitating the dismantling of the valve assembly should only be carried out in a workshop equipped with the correct type of testing facilities.

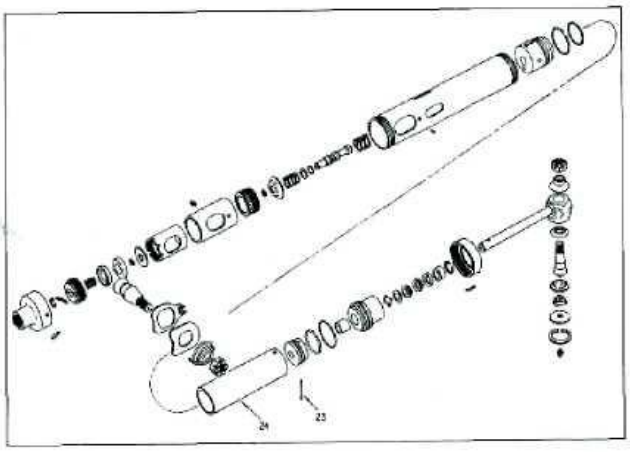


**Fig. O.39 — Booster Cylinder (Exploded View).**

Should an oil leak be apparent in the cylinder, it is advisable to replace all seals.

To replace the seals proceed as follows:

(1) Prepare a clean work area and thoroughly clean the cylinder.

(2) Cut through the piston end cylinder cap locking piece with a hack saw.

(3) Remove the two hose adaptor nipples.

(4) Unscrew the end cap and withdraw the piston.

The inner cylinder and valve body will usually be withdrawn at the same time but if this is not the case, tapping of the outer cylinder on a piece of wood will dislodge these parts.

(5) Remove the valve body from the inner cylinder and the inner cylinder from the piston.

(6) Remove the piston rollpin, the piston from the rod, and the piston rod retainer, then remove the retainer circlip and withdraw the oil seal and the packing. (This operation need only be done if an oil leak at this point has been apparent).

(7) Remove the "O" rings and thoroughly inspect all parts including the cylinder bore and piston ring. Replace if necessary.

(8) Clean all parts and fit the new "O" rings.

(9) Lubricate the dismantled parts, and reassemble in the following order: —

(a) Fit the packing and seal to the retainer and then fit the circlip. Slide the retainer onto the piston rod making sure that the packing is correctly seated.

(b) Install the piston on the rod and fit the roll pin.

(c) Slide the inner cylinder onto the piston ensuring that the two holes in the end of the cylinder are towards the end cap.

(d) Fit the valve body to the inner cylinder and install in the outer cylinder ensuring that the valve body locates correctly on the spool and that the hose adaptor holes are facing the correct port.

(e) Tighten the end cap and lock with spotweld.

(f) Fit the hose adaptors in their correct position.

(The bent adaptor nipple fitted nearest the piston rod).

10. Fit the cylinder to the tractor, connect the hoses (the bottom pump connection linked with the cylinder adaptor nearest the piston rod) and fill the pump with the correct grade of oil to within ½-¼" from the base of the filler plug boss with the steering booster in the neutral position.

11. Operate the power steering and check for oil leaks.

# TROUBLE SHOOTING CHART

| Trouble | Probable Cause | Remedy |
|---|---|---|
| Pump not delivering oil. | Cam ring and rotor assembled incorrectly. | See reassembly instructions for pump cartridge. |
| | Pump drive shaft disengaged or sheared. | Remove pump; determine damage to cartridge parts (see disassembly instructions); replace sheared shaft and needed parts. |
| | Flow control valve stuck open. | Disassemble pump and wash control valve in a clean solvent. Return valve to its bore and slide it back and forth. No stickiness in movement should occur. If a gritty feeling is noted on the valve O.D. it may be polished with a crocus cloth. Avoid removal of excess material or rounding of valve edges during this operation. Do not attempt to polish the valve bore. Wash all parts before reassembly of pump. Fill system with clean oil per prescribed recommendations. |
| | Vane or vanes stuck in rotor slots. | Disassemble pump, examine rotor slots for dirt, grime or small metal chips. Clean rotor and vanes in a good grade solvent (mineral oil or kerosene) reassemble parts and check for free vane movement. |
| | Oil viscosity too heavy to pick up prime. | Use fluid of the proper viscosity as recommended. |
| Noisy pump operation. | Pump intake partially blocked. | Drain system completely; flush to clear pump passages. Flush and refill system with clean oil as per prescribed recommendations. |
| | Air vent for oil tank clogged or dirty strainer. | Remove filler cap and clean air vent slot. Check strainer in tank for clogged condition. Drain, flush and add clean oil to system. |
| | Air being drawn into pump return connection. | Pump must receive air-free oil or pump will be noisy. Drain system, tighten all hose connections. Clean or replace filter, add clean oil of the proper viscosity. |
| | Leaking shaft seal. | Check pump shaft seal and replace if sealing lip has been damaged. Check for scoring of shaft at seal contact area. Replace faulty shaft. |

# THREE POINT LINKAGE

## DESCRIPTION

Two models of three point linkage have been fitted and are designated Mk. I and Mk. 11.

**MK. 1 Linkage:**

This unit is designed to operate in conjunction with Plessey Double acting 1,000 p.s.i. hydraulics and incorporates a 12" stroke x 3" bore double acting cylinder which is mounted through a slot provided in fuel tanks fitted to Champion Tractors to serial Nos. DM 2003 and Ind. 355.

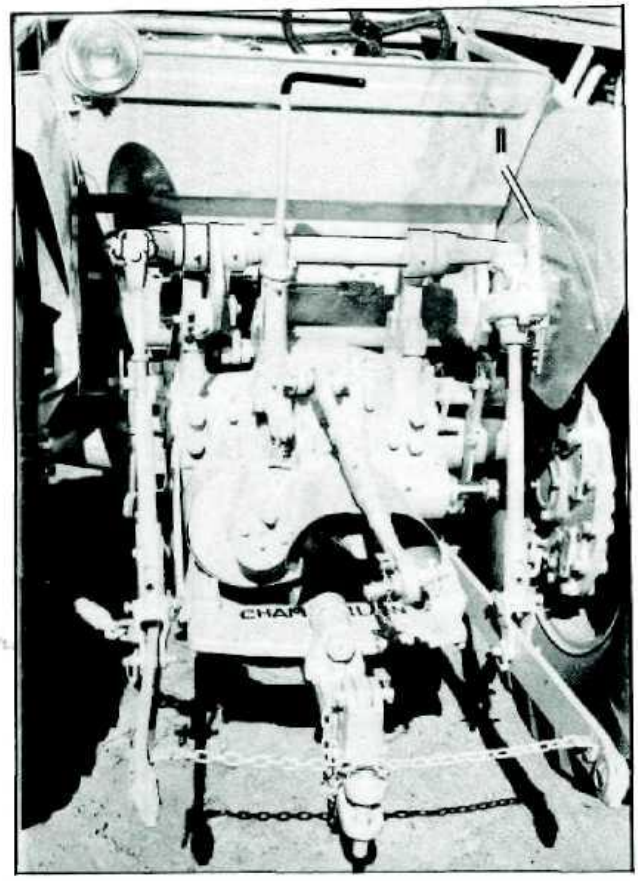


Fig. P.1 — Mk. I Three Point Linkage.

The cylinder is anchored to a bracket attached to the nearside Chassis member by two studs and chambered nuts and the piston rod is connected to a lever on the 3 T.P.L. rock shaft. The hydraulic system does not include a "float" position but a pin coupling the cylinder lever to a quadrant on the rock shaft may be removed to allow the linkage to float within the limit set by an adjustable depth setting screw attached to the quadrant. Slotted holes are also provided in the lower link lift arms to allow small float movements.

Lateral levelling adjustment is provided on the off-side lift arm in the form of a geared levelling box, and the top link includes a turnbuckle to allow longitudinal levelling.

Sway chains are provided to restrict side movement of the linkage and these couple the lower links to lugs attached to the tractor final drives. Early units had these lugs offset slightly to hold the links firmly in the raised position, but allow a small side movement in the working position. This was later modified due to damage caused when the linkage was lifted after the sway chains were fully tightened in the working position. The lugs are now positioned to maintain, as near as possible, a constant tension throughout the lift range.

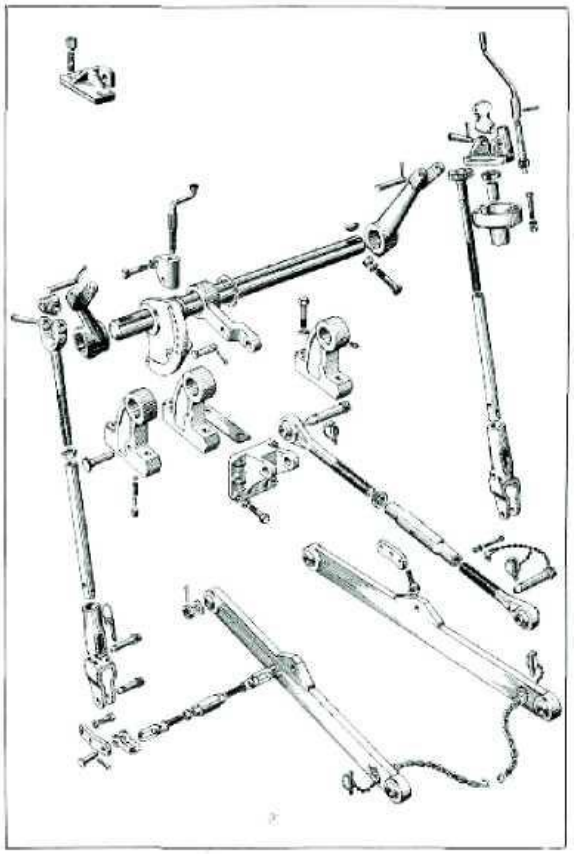


Fig. P.2 — Mk. I T.P.L. (exploded view).

Three brackets attach the rock shaft to the differential housing on this linkage as the double acting hydraulic system can be used to impose a downward thrust on the implement. This downward thrust imposes heavy loads on the linkage and implement as well as reducing the tractor's traction.

A locking pin is provided to hold the linkage in the fully raised position for transport and safety chains are provided to couple the lower links when no implement is attached.

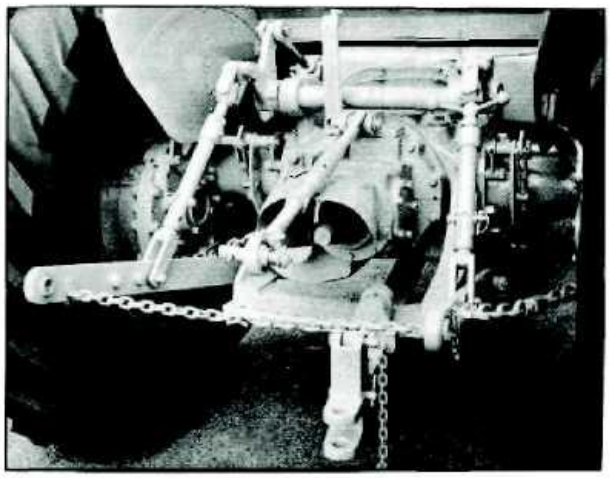


Fig. P.3 — Mk. II Three Point Linkage.

**MK. 11 Linkage:**

This unit is designed to operate with Vickers 1,500 p.s.i. single acting hydraulics and incorporates a 12" stroke x 2-3/4" bore single acting cylinder which is mounted beside the shortened fuel tank fitted to Champion tractors from serial Nos. DM 2004 and Ind. 356, all Crusader tractors and Canelander tractors. As this shortened fuel tank is 1" deeper, it cannot be fitted to earlier Champion tractors unless the later seat frame and fuel tank shield are also fitted. The unit is similar to the Mk 1 in that it consists basically of three links with the single upper link incorporating a turnbuckle and the two lower links coupled by adjustable lift arms to the rock shaft mounted above the differential housing. The lateral levelling is obtained by adjusting the screw on the offside lift arm. Three radial handles are provided for this purpose.

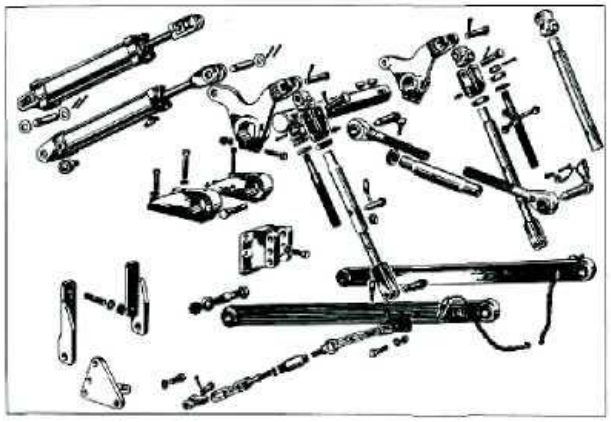


Fig. P.4 — Mk. II T.P.L. (exploded view).

The linkage incorporates only slotted lift arms holes as float provision, as the hydraulic system prevents damage or appreciable loss of traction due to the linkage resisting an upward thrust from the attached implement. The hydraulic system has three positions: raise, hold and float.

**Raise:**

Oil under pressure from the pump is directed to the rear of the cylinder piston to contract the cylinder and raise the linkage. Air from the front of the piston is expelled through the cylinder breather.

**Hold:**

In this position oil is prevented from entering or leaving the cylinder and the linkage will not lower unless leakage occurs in either the piston or gland seals, the hose or the valve spool. However, an upward thrust on the linkage of only 25 lbs, (in addition to that required to overcome friction) will reduce the pressure on the oil in the cylinder sufficiently to vaporise it and allow the cylinder to contract and the linkage to lift, thus preventing severe loss of traction or damage to the linkage and implement.

**Float:**

In this position oil is able to flow freely between the cylinder and the reservoir and the weight of the implement, combined with the suction of the tillage tools, keeps the implement at a working level controlled by the implement depth setting. In the event of the tractor rear wheels dropping into a depression, the resultant upward thrust on the linkage causes oil to enter the cylinder to allow the implement to lift.

**SPECIFICATIONS**

| | | | |
|---|---|---|---|
| Make | – Own. | | |
| Type | – Mark 1 Double acting.<br>Mark II Single acting. | | |
| Category | – Category 2 Standard.<br>Category 1 Optional. | | |
| Maximum Lift Force | – Approx. 3,000 lbs. | | |
| Maximum Lift Height (screws fully contracted) | D.M.<br>– 39½" | Cr.<br>38" | H.C.<br>41" |
| Lowered Linkage Ground Clearance (screws fully extended) | – 5½" | 4" | 9" |
| Height of Lift (screws in set position) | – 25" | 25" | 23" |
| Diameter of Upper Link Ball Hole | – Category 2 1.000".<br>Category 1 .750". | | |
| Diameter of Lower Link Ball Hole | – Category 2 1.115".<br>Category 1 .870". | | |
| Lubrication | – Chassis Grease. | | |
| Make of Cylinder | – Mark I Malcolm Moore.<br>Mark II Own. | | |
| Cylinder Bore | – Mark I 3".<br>Mark II 2¾". | | |
| Length of Stroke | – 12" | | |
| System Operating Pressure | – Mark I 1,000 p.s.i.<br>Mark II 1,500 p.s.i. | | |

## MAINTENANCE

Grease nipples are provided in each of the rock shaft brackets and also in the levelling screws. These require servicing with chassis grease every 50 hours of three point linkage operation.

The levelling box on Mark 1 linkage should have the cover removed periodically and the grease renewed.

## OPERATING ADJUSTMENTS

Should a tractor be fitted with a belt pulley unit, it will be necessary to remove the pulley before using the three point linkage equipment. To remove the pulley, unlock and remove the slotted nut from the pulley shaft, then, using a suitable puller picking up on the two tapped holes in the pulley, withdraw the pulley from the shaft. Remove, or tape in position, the pulley key and smear the exposed shaft with grease to prevent corrosion.

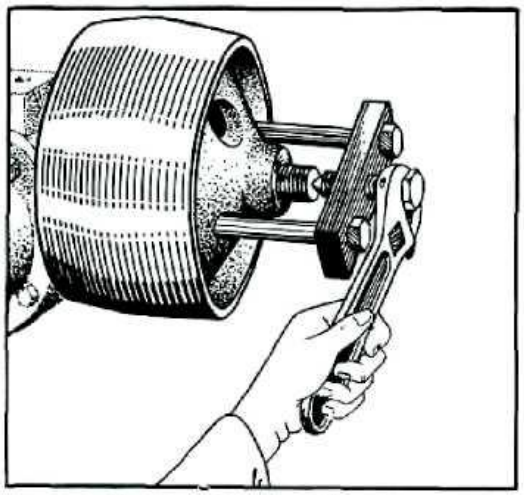


Fig. P.5 — Removing Belt Pulley.

The adjustable lift arms have two pin positions. One position gives a fixed length so that the machine is held rigidly to its work and the second position allows a degree of float so that if the attached machine is fitted with wheels, it will follow the ground contour giving an even depth of work.

Fig. P.6 — Lift Arm Pins in Slotted Holes.

The top link incorporates a turnbuckle allowing longitudinal levelling of the implement while lateral levelling is by means of the device on the offside lift arm.

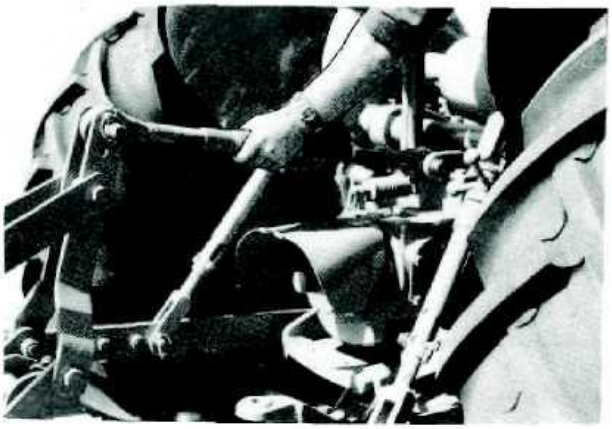


Fig. P.7 — Longitudinal Levelling of an Implement.

The sway chains fitted between the lower arms and the final drives are used to hold the implement rigid during transport and to allow a controlled amount of side float when working.

When adjustment of the chains has been made, the linkage should be raised and lowered to check that the chains are not over-tensioned at any point in the operating range.

## FITTING INSTRUCTIONS

It is presumed that the tractor is already equipped with hydraulics or that a hydraulic kit, together with fitting instructions, has been obtained.

Early Champion tractors having a long fuel tank require Plessey hydraulics and Mark 1 three point linkage.

Some Champion Tractors, fitted with the short fuel tank, have not been provided with a cylinder anchor lug on the nearside chassis member. Therefore it will be necessary to obtain the lug, P/N 21961, and weld it to the chassis as shown in the illustration, to be used with Mark 11 linkage.

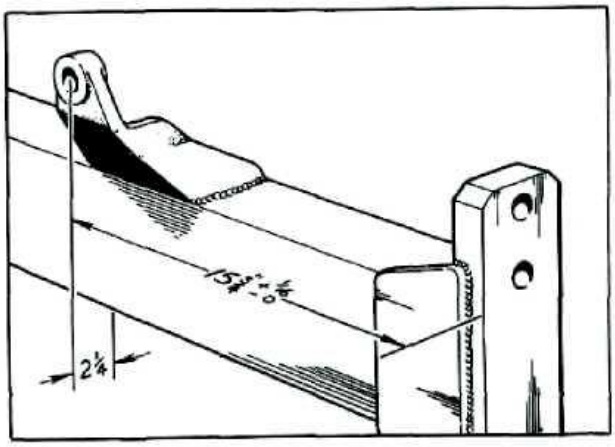



Fig. P.8 — Mk. II Anchor Lug Specifications.

**Recommended Fitting Procedure:**

1. On early tractors, move the rear light and bracket from the offside to the nearside to allow room for the levelling box.

2. Thoroughly clean the top pads on the differential housing, the bores in the rock shaft brackets and the bearing surfaces on the rockshaft. Grease the bearing surfaces and slide the brackets onto the shaft.

Bolt the brackets to the differential housing observing the following:—

(a) On Mark 1 linkage the centre bracket is attached to the nearside holes of the centre pad, the quadrant is in line with the slot in the fuel tank and the bracket fitted with the transport plunger is assembled to the nearside.

(b) On Mark 11, the bracket containing the transport plunger is fitted to the offside.

(c) On both linkages, check for rockshaft bind. Should binding occur, check which bracket is at fault and realign using packing shims if necessary.

3. Fit the keys to the rockshaft and assemble the bellcranks (Mark II) or lift arms (Mark 1). The wedging open of the clamp slots in these components will facilitate assembly. Do not tighten the clamp bolts.

4. Remove the nearside portion of the fuel tank shield and fit the cylinder. The breather and elbow should be fitted to the appropriate ports in the Mark 11 cylinder, as shown in the diagram, before attaching to the anchor lug.

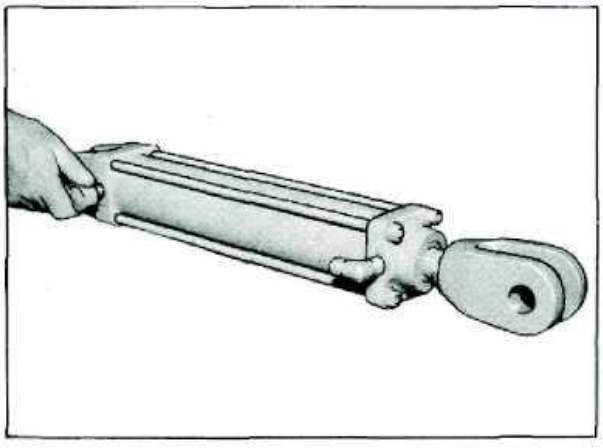


**Fig. P.9 — Mk. II Cylinder Breather and Elbow.**

For Mark 1 assembly, the cylinder hose connections are towards the front and facing the offside of the tractor. Two studs are provided on which to mount the cylinder bracket and these should be screwed in to the tapped holes provided in the nearside of the chassis and the bracket attached to the cylinder and mounted on the studs.

5. Attach the cylinder to the quadrant. (On Mark 1 linkage it will be necessary to remove the raised portion of the head of the pin provided if a P.T.O. unit is fitted). Centralise the rock shaft allowing 1/16"-1/8" end float before tightening the bellcrank or lift arm clamp belts.

6. Attach the hose or hoses to the cylinder. For Mark 11 operation, the hose is fitted to the rearmost port of the cylinder. Due to the confined area in which to work on Mark 1 Cylinders, it is necessary to firmly attach one hose to the lower port in the cylinder before fitting the hose connecting nipple to the upper port. This nipple must also be removed before removal of the lower hose can be effected.

7. Fit the component parts comprising the lifting rods to the bellcrank or lift arm.

The plain lift arm is fitted to the nearside and the level adjusting link (Mark 11) or the rod and levelling box (Mark 1) are assembled to the offside.

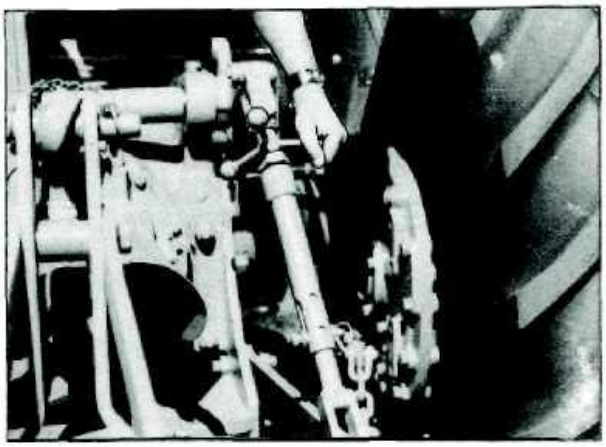


**Fig. P.10 — Mk. II Lateral Levelling Adjustment.**

8. Fit the top link to either the fork on the P.T.O. control tower or to the upper of the three holes in the link anchor bracket.

9. If the lower link pivot pins are not already assembled into the base of the drawbar bracket, assemble and lock in position with locknuts. On some early tractors it may be necessary to tack-weld the pivot pins in position as there is insufficient clearance for the locknut to be fitted.

10. Clean and oil the pivot pins and fit the two lower links (the safety chains are towards the rear of the tractor). Pin the lift links to the lower links, on Mark 11 linkage using the hole nearest to the tractor.

11. Assemble the sway chains and attach them to the lower arms and final drives.

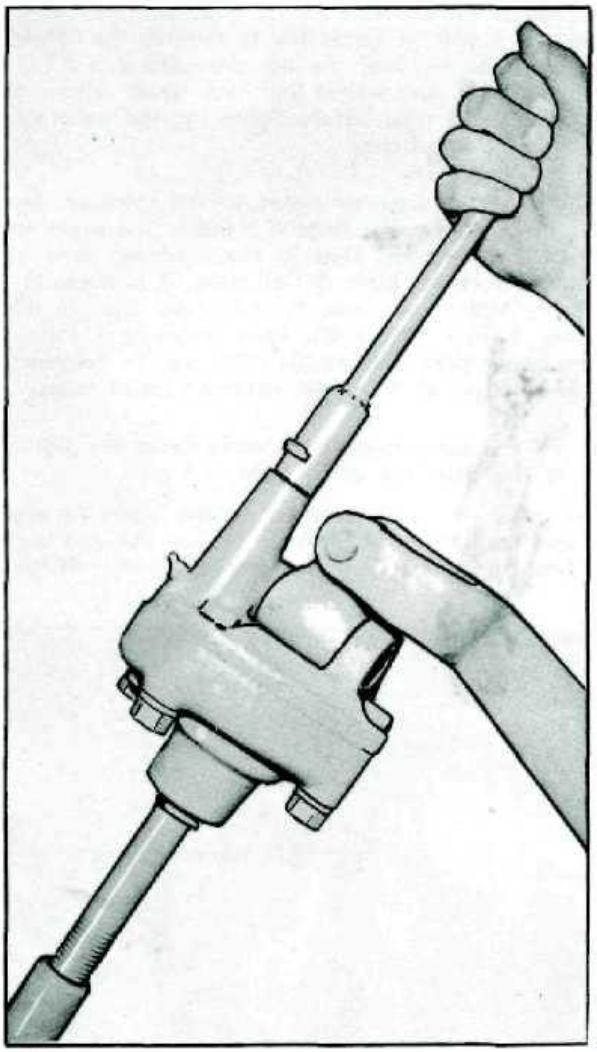


Fig. P.11 — Mk. I Lateral Levelling Adjustment.

Attach the three point linkage drawbar (if fitted), connect the safety chains and adjust the sway chain turnbuckles.

Fig. P.12 — T.P.L. Drawbar.

## HYDRAULIC CYLINDERS

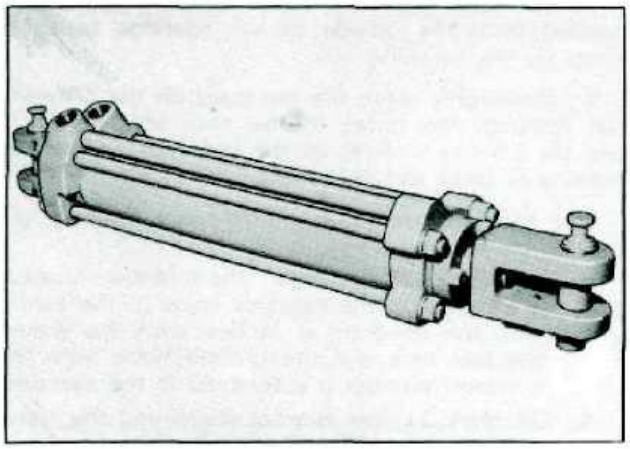


Fig. P.13 — Malcolm Moore Cylinder.

Early Champions and Canelanders used a Malcolm Moore 12" x 3" cylinder in conjunction with Plessey hydraulics while later Champions, Canelanders and Crusaders use a 12" x 2¾" Chamberlain manufactured cylinder with Vickers hydraulics.

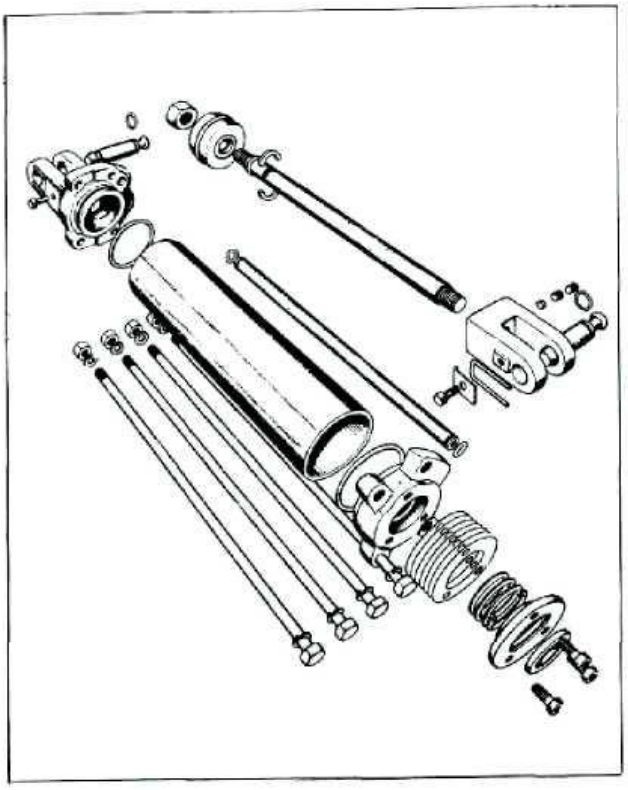


Fig. P.14 — M.M. Cylinder (exploded view).

The Malcolm Moore cylinder has both hose connections fitted to the integral fork and end casting and has a transfer tube for conveying oil to or from the further end. Four bolts clamp the cylinder body and the transfer tube between the two ends and sealing is by "O" rings. The piston is clamped to the piston rod by packing pieces and a nut, with an "O" ring seal between the shaft and piston and "Shamrock" seal ring between the piston and cylinder body. The protruding piston rod is fitted with a fork, locked in position with two grub screws, and the piston rod seal is composed of 'Chevron' type packing pieces and a dust seal, shims being provided under the end cover for packing piece adjustment.

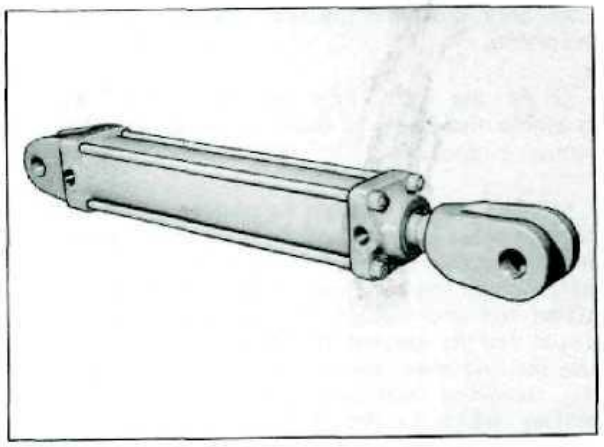


Fig. P.15 — C.I.L. Cylinder.

The Chamberlain cylinder has a hose connection in each end piece, one hole being fitted with a breather for single acting operation. Four tie rods clamp the cylinder body between the ends and "O" rings make the seal. The piston is clamped to the piston rod by a nut, with an "O" ring sealing between rod and piston, and an "O" ring and two leather back-up rings sealing between the piston and cylinder body. The protruding piston rod is fitted with a screwed fork and locknut with an "O" ring and oil seal making the rod to gland cap seal.

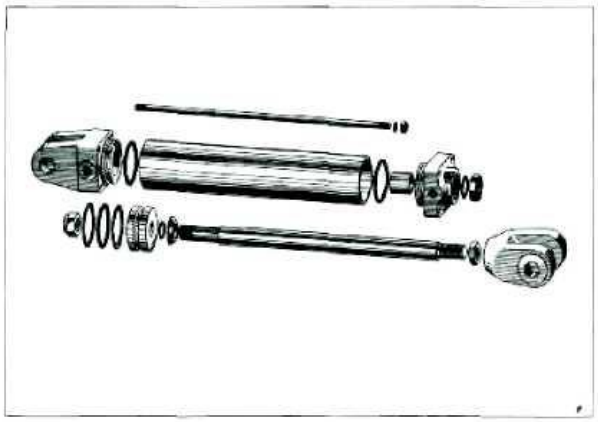


Fig. P.16 — C.I.L. Cylinder (exploded view).

**Maintenance:**

The cylinders should be removed and flushed out each time the hydraulic system oil is renewed. Any oil leaks must be repaired immediately they become apparent. On Malcolm Moore cylinders, an oil leak at the piston rod protruding end may be overcome by the removal of an end cover shim but, a leak at this point on the Chamberlain cylinder, requires renewal of the oil seal and the "O" ring.

When refilling and checking hydraulic system oil levels, the single acting or Mark II linkage should be in the lowered position while the double acting or Mark 1 linkage should be in the raised position. In both cases, operate the hydraulics and recheck the oil level after adding oil.

**Trouble Shooting:**

If cylinder "creep" is experienced with Mark I linkage, the cylinder piston seal may be faulty, but the hydraulic system should be checked as detailed in the Hydraulic Section before dismantling of the cylinder is considered.

Leakage of the cylinder piston seal on Mark 11 linkage will be evident by the presence of oil at the breather.

**Dismantling:**

(1) Prepare a clean working area and thoroughly clean the outside of the cylinder.

(2) Remove the breather (Mark 11) and make sure that all oil is completely drained.

(3) On Malcolm Moore cylinders (cylinder 1) loosen the grub screws and remove the fork. On Chamberlain cylinders (cylinder 11) slacken the locknut and remove the fork.

(4) Remove the clamping bolts or tie rods and remove the gland cap.

(5) The piston can now be withdrawn.

(6) Remove the cylinder body from the hinge cap.

(7) On cylinder 1 the packing can be dismantled by removal of the three setscrews.

**Inspection:**

Thoroughly clean all parts and inspect. Check the cylinder bore and piston for scoring. If any doubt exists regarding the serviceability of any part, renew. It is recommended that all seals be replaced at overhaul.

**Re-assembly:**

(1) Fit the packing to the piston. The synthetic packing material is not fully elastic and will not return to the original size if overstretched.

Early Chamberlain cylinders had an aluminium piston using an "O" ring without leather backup rings. These pistons can be reworked to the specifications shown in Fig. P.17 so that the back up rings can be used.

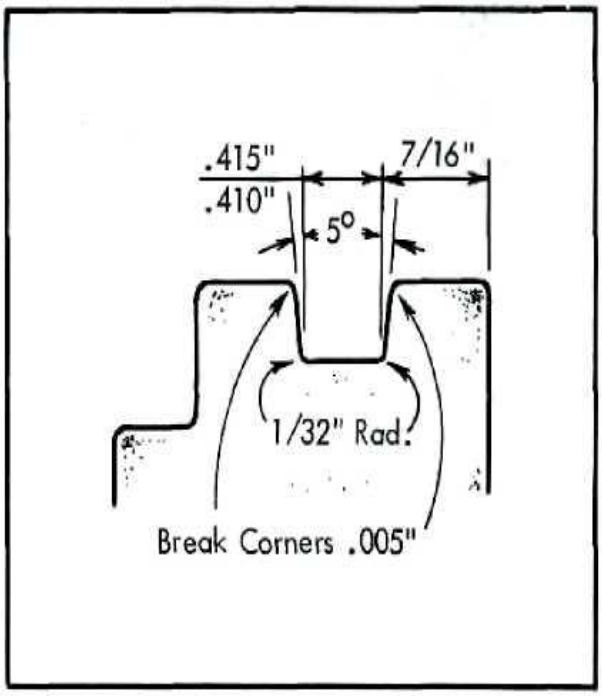



**Fig. P.17 — C.I.L. Aluminium Piston Rework.**

The back up rings should be fitted in the following manner:—

(a) Soak the rings in light oil or water for 30 minutes to soften.

(b) Install the rings on either side of the "O" ring on the piston. Do not cut the leather rings. Install them so that the flesh side of the leather is next to the "O" ring.

(c) After installation, dry out the leather rings for 10-15 minutes at 180°F. to shrink them back to size.

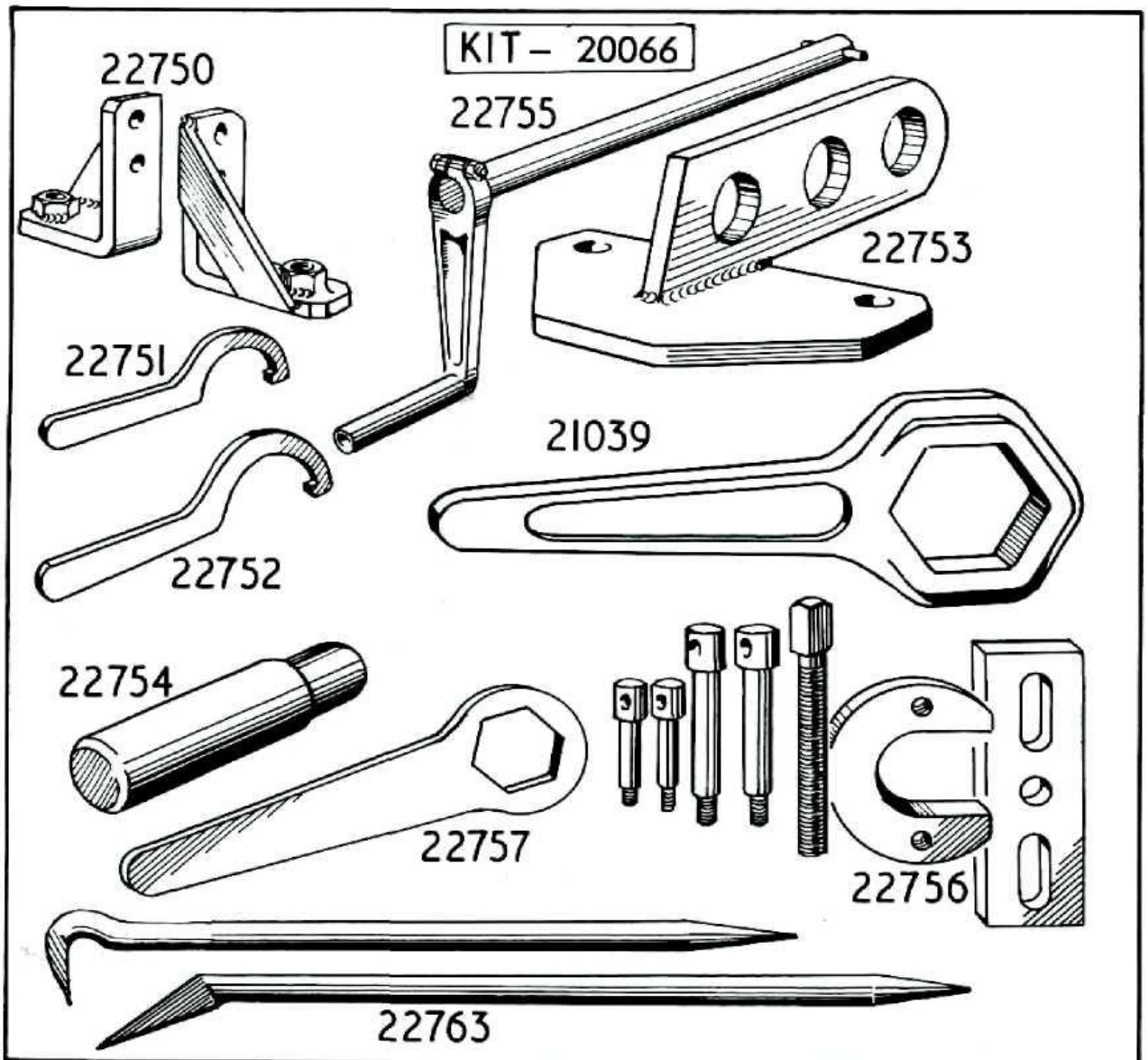
(2) Insert the piston in the cylinder body. Check from both ends that the seal is seating correctly on the piston.

(3) Fit the "O" rings to the end pieces and assemble the body to them ensuring that the seals remain in position.

(4) On cylinder 1 install the packing pieces with the concave sides inwards and fit the end cover and dust seal using the specified number of shims. Do not fully tighten the setscrews. Assemble the fork to the piston rod and tighten the end cover, moving the piston rod to prevent the packing seizing the rod. Use the end cover shims to correctly adjust the packing, removing them one at a time to give the best sealing which is indicated by the packing being squeezed solid without binding the shaft.

(5) On cylinder 11, install the piston rod sealing "O" ring and the oil seal then fit the locknut and fork.

(6) Install the cylinder on the tractor and operate the hydraulic system, checking for cylinder oil leaks.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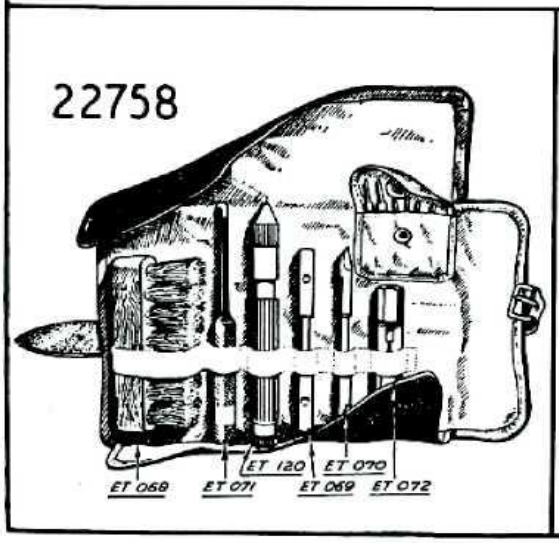
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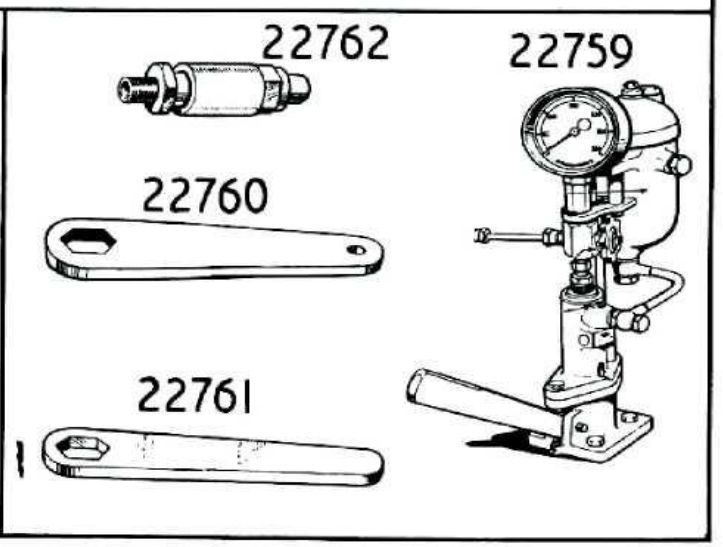
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# SPECIAL TOOLS & EQUIPMENT

| | |
|---|---|
| **22750** | Brackets — Engine Front Supporting |
| **22751** | C - Spanner 1½" |
| **22752** | C - Spanner 2" |
| **22753** | Lifting Tool — Differential |
| **22754** | Dummy Pilot — Clutch Plate |
| **22755** | Crankhandle — Engine |
| **22756** | Puller — Steering Wheel, Pitman Arm & Belt Pulley. (Included in T 1053 - 40 KA Kit). |
| **22757** | Spanner — Crank Dog |
| **21039** | Spanner — Rear Axle Nut |
| **22758** | Cleaning Kit — Atomisers |
| **22759** | Testing Pump — Atomiser |
| **22760** | Spanner — Nozzle Holder Cap Nut |
| **22761** | Spanner — Nozzle Cap Nut |
| **22762** | Flushing Tool — Atomiser |
| **22763** | Pinch Bars (T 342 - 40 KA Kit) |
| **20066** | CHAMPION Service Kit comprising P/Ns. 22750 - 22751 - 22752 - 22753 - 22754 - 22755 - 22756 - 22757 - 22763 - 21039. |