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Part 1.

FERRET, MKS 1 AND 2

FIELD REPAIR

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INTRODUCTION

1. The stripping and assembly sequences detailed in this instruction have been found by trial to be the most suitable for field conditions. It is essential to keep these sequences.

2. Certain modifications have been introduced since production started which have not been incorporated in earlier vehicles. Where this results in two sequences for similar jobs, both sequences are given.

NOTES: 1. The abbreviations LH and RH used in this instruction refer respectively to the left- and right-hand sides of the vehicle as viewed from the driver's seat facing front.

2. Where this instruction refers to the engine, No 1 cylinder will be that nearest the radiator.

3. Details are given of a number of tools for local manufacture, these have all been made and used during the preparation of this instruction.

4. The jointing compounds mentioned during the assembly of various components throughout these instructions are as follows:-

Compound	Uses	Part No
(a) Jointing compound (Shellac based)	For face and gasket joints, oil and gastight seals, cylinder head gaskets, etc.	H1/HAA 0459
(b) Bostik 'C'	An adhesive compound for use on metal to metal waterproof joints, hull plates, etc.	H1/HAA 0444
(c) Bostik 'B'	Compound, glazing, for use on glass to metal or glass to rubber watertight joints	H1/8030-C10-1091
(d) Bostik 299A	Compound, jointing, for use on rubber to metal watertight joints	H1/8030-C10-1092
(e) Bostik 772	Compound, jointing, for use on electrical equipment, gasoline, oil and waterproof	H1/8030-C10-1093
(f) Silicone (Compound DC4)	A sealing and preservative compound for rubber, for use in electrical equipment, non-adhesive	LV6/MT1 1311

REMOVAL, REPLACEMENT AND ADJUSTMENT OF MAJOR ASSEMBLIES AND COMPONENTS

ENGINE B.60 NO 1, MK 6A

GENERAL

5. The six cylinder dry sump engine has a compression ratio of 6.4 : 1, and develops 96 b.h.p. (net) at 3,300 r.p.m. Dry weight including fluid flywheel, 812 lb. When it is necessary to remove the engine from the hull, it will be removed complete with radiator, fan assembly, oil tank, gearbox and transfer case. Dry weight of complete unit as at Fig. 1, 1,428 lb.

Removal of engine

- 6.(a) Drain the coolant.
- (b) Remove the engine compartment top coverplate, hull cross-tube and louvre plate, disconnect the rear lights and remove the rear hull plate.
- (c) Drain the fuel tank.
- (d) Release both escape hatches for easy access to the hull.
- (e) Remove all seats, air cleaner, batteries, battery boxes, wireless set cradle, gearbox coverplates and propeller shaft tunnels from the fighting compartment.
- (f) Remove the battery leads and clips and disconnect the fuel pipes.
- (g) Disconnect the fuel gauge leads, remove the fuel tank filler neck and the air trunk to the carburetter.
- (h) Disconnect the starter motor leads at the starter, and remove the distribution box complete with its leads from the hull plate.

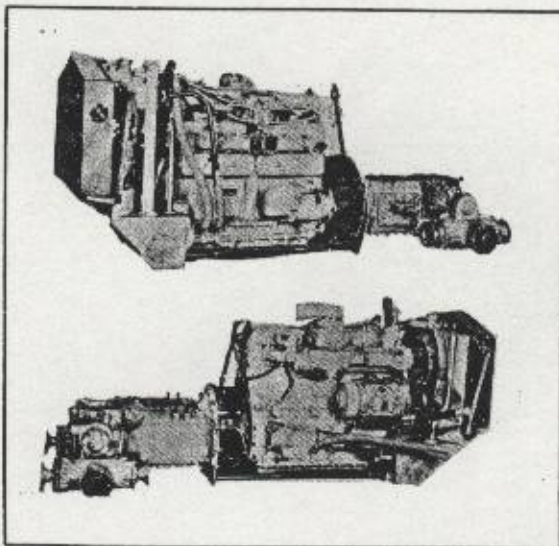


FIG. 1 - POWER UNIT

TOP - RH SIDE BOTTOM - LH SIDE

- (j) Disconnect the fuel tank breather pipe and remove the four bolts securing the fuel tank. Lift the fuel tank forward and out through the top of the fighting compartment.
- (k) Disconnect all four propeller shaft couplings at the transfer case bevel boxes.
- (l) Disconnect the speedometer drive at the transfer case, the gear selector rod at the RH side of the gearbox, the forward and reverse lever at the bottom LH side of the transfer case and the gear change rod at the LH side of the gearbox.
- (m) Remove the two engine steady plates and disconnect the accelerator rod at the bell-crank.
- (n) Remove the tachometer drive from the RH side of the engine, disconnect the coolant temperature bulb at the cylinder head. Remove the exhaust pipe, manifold to hull plate.
- (o) Disconnect the oil hoses at the filter and remove the filter complete from its bracket.
- (p) Detach the oil cooler from its bracket on the hull and secure it with cord to the engine.
DO NOT disconnect the hoses.
- (q) Disconnect the generator leads at the socket and the hand throttle and choke control at the carburetter.
- (r) Remove the four screws securing the rear engine mounting bracket, which is beneath the crankshaft pulley. Slacken off the coolant drain hose clips.
- (s) Remove the bolts securing the aluminium baffle plates between radiator assembly and hull sides; leave these attached to the radiator. Release the overflow pipe clip.
- (t) Lift the complete unit approximately 12 inches from the hull floor by means of a three point sling. Mark both trunnion caps and transfer bevel cases with correlating marks for correct replacement.

NOTE:- The trunnion bushes are mounted eccentric to the cap.

- (u) Remove the trunnion caps and withdraw the power unit through the rear of the hull.

Operations to be carried out with the engine removed

7. The following servicing operations will be carried out whilst the engine and gearbox are out of the vehicle:-

- (a) Check the cylinder head nuts for tightness and the inlet and exhaust valve tappet clearances.
- (b) Check the sump adaptor plate bolts for tightness.
- (c) Remove and service the fuel pump.
- (d) Should the engine have done considerable mileage, drain the oil tank, remove the inspection plates and examine for sludge. In the event of sludge being present, disconnect the hoses, remove the tank from the engine and thoroughly clean with gasoline NOT kerosene. Renew the face joint gaskets and replace the inspection plates with jointing compound. Refill with clean engine oil.
- (e) Check the timing case bolts, lubricating pipes and unions.
- (f) Check the security of the crankshaft damper and starting handle dog.
- (g) Inspect the starter motor mounting bolts.
- (h) Check the coolant hoses for serviceability, particularly the two beneath the radiator; these must be renewed if in a doubtful condition.
- (j) Check the fan assembly bolts and fan coupling nuts for tightness, examine the drive belts for tension and wear and renew if necessary.
- (k) Check the induction manifold nuts.
- (l) Inspect all controls bolted to the hull floor.
- (m) Check the fluid coupling for leaks.
- (n) Examine the two rear bevel boxes and shaft couplings.

Replacement of engine

- 8.(a) Before replacing the engine slacken off the exhaust manifold nuts.
- (b) Place the bottom half of the transfer case trunnion bearer blocks in position and locate them with their own bolts, this will positively locate the power unit in the trunnion bearers.
- (c) Replace the engine in the reverse order to para 6. Fit a new exhaust pipe flange gasket, and tighten the exhaust manifold nuts after the exhaust flange bolts have been tightened.

New or reconditioned engines

9. Engines are supplied less the following parts, which, when it is desired to change an engine, should be inspected for serviceability. If replacement is necessary these should be demanded in addition to the engine assembly, otherwise these existing parts are to be utilized on the replacement engine:-

- Dynamo
- Dynamo pulley
- Dynamo mounting bracket, straps and cradle assembly
- Dynamo adjusting bracket and strut assembly
- Driving belts
- Dynamo oil pipes
- Dynamo oil pipe adaptors and banjo bolt
- Dynamo oil pipe bracket and clips

NOTE:- When fitting a replacement engine remove the float chamber cover from the carburetter and take out the transportation piece (where fitted).

*Exhaust valve guides**General*

10. Normally the exhaust valve guides will not require renewal between overhauls. Should however one or more exhaust valve guides require renewal due to damage caused by valve spring or valve stem breakage, or other causes, the guides can be renewed without removing the engine from the vehicle as follows:-

- (a) Disconnect the batteries.
- (b) Drain the coolant.
- (c) Remove the engine coverplate and the hull crosstube.
- (d) Remove the cylinder head (see VEH N 403/1-1.).
- (e) Remove the exhaust manifold and 'Y' pipe.
- (f) Remove the valve tappet chamber covers.
- (g) Mop up the engine oil lying in the chamber and plug all oil return holes with clean rag to prevent anything dropping into the sump.
- (h) Remove the exhaust valve springs, wedges, packing and washers and lift out the exhaust valves.
- (j) Remove the tappet screw and locknut, lift out the tappet and plug the bore with clean rag.

NOTE:- Should more than one guide require renewal, complete the operation on each guide and replace the-tappet.

Removal (Fig. 2)

11. Manufacture locally a drift to the dimensions given in Fig. 3. Using a copper hammer with light to moderate blows on the drift will give best results and the guide will come out easily and without fear of damage to the cylinder block.

Renewal (Fig. 4)

12. New guides will be pressed in with the tool shown in detail at Fig. 5. This is made of mild steel and manufactured locally.

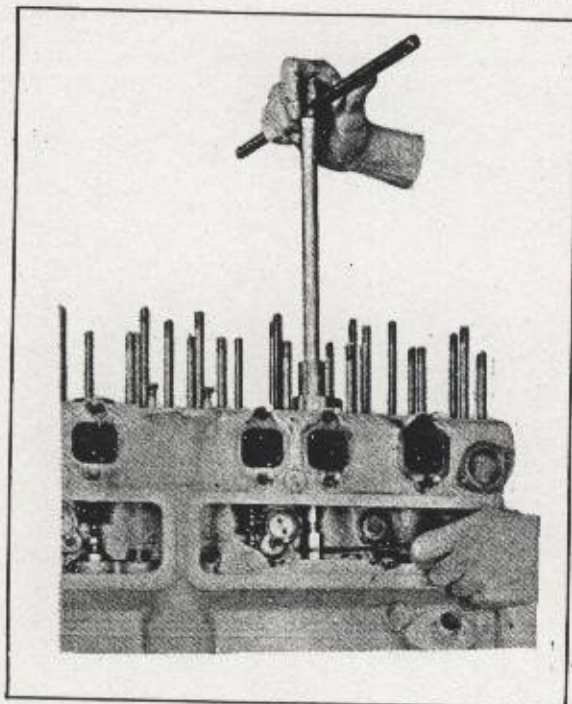


FIG. 2 - EXHAUST VALVE GUIDE
REMOVAL

- (a) Insert the new guide into the cylinder block from the tappet chamber; it can be pushed in with the fingers for approximately 1/4 inch.
- (b) Place the large collar in the exhaust valve seat, push the bolt down through the collar and new valve guide and thread the nut on the bottom of the bolt.

NOTE:- A 3/8 inch plain washer inserted between the bolt head and large collar will assist in drawing the new guide up tight.

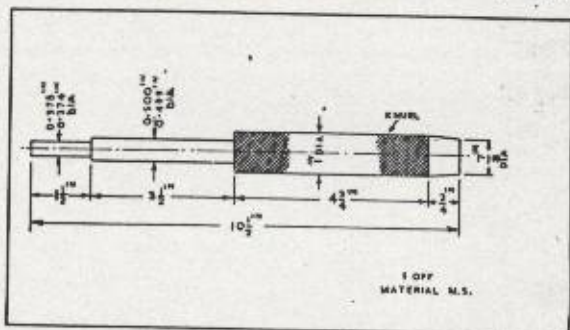


FIG. 3 - TOOL, REMOVING, EXHAUST
VALVE GUIDE (LOCAL MANUFACTURE)

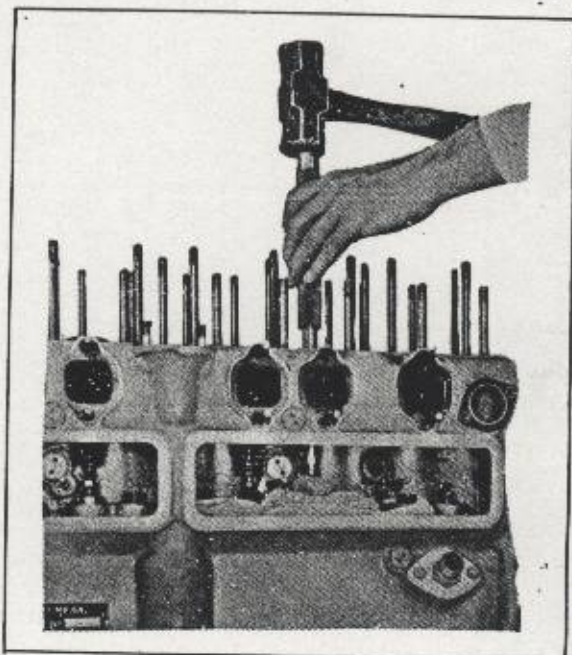


FIG. 4 - EXHAUST VALVE GUIDE
REPLACEMENT

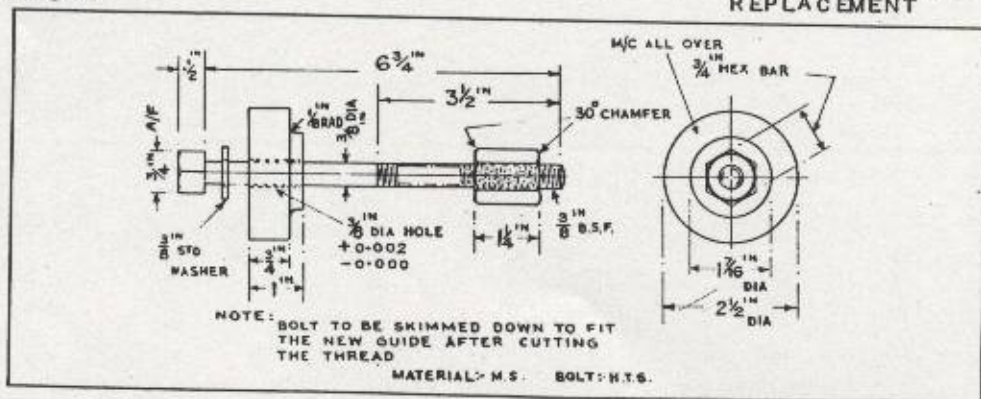


FIG. 5 - TOOL, REPLACING, EXHAUST VALVE GUIDES (LOCAL MANUFACTURE)

- (c) Ensure the new guide is fully home, by seeing that the guide collar is butting up to the cylinder block. Remove the pressing tool, but leave in the rag plugging the tappet bore.
- (d) Mask the bottom of the tappet chamber with clean rag and ream out the new guide with 'Reamer, exhaust valve guide, FV 143188'.
- (e) Carefully remove the rag containing the swarf and the rag plugs from the tappet.
- (f) Renew the exhaust valve and lap it in.
- (g) Replace the tappet, tappet adjusting screw and locknut, valve stem packing, washers, springs, collars and wedges.
- (h) Replace all other components in the reverse sequence to sub-para 10 (a) to (f).

NOTE:- To recondition the valves. see VEH N 403/1-1.

LUBRICATION SYSTEM

Engine oil pump

13. The two pumps (pressure and scavenging) are within the same assembly casing. Both are of positive gear type running at half crankshaft speed.

Removal (Fig. 6)

14.(a) Remove the engine from the vehicle, see para 6.

(b) Drain the oil from and remove the reservoir.

(c) Remove the sump.

NOTE:- The sump should be removed with the engine in a normal upright position, otherwise the residual oil in the sump will be thrown over the interior of the crankcase.

(d) Remove the distributor head (NOT the distributor base assembly). Turn the crankshaft until No 1 piston is on T.D.C. compression by the flywheel marking, and the rotor arm opposite No 1 H.T. segment. Remove the distributor base assembly from the engine.

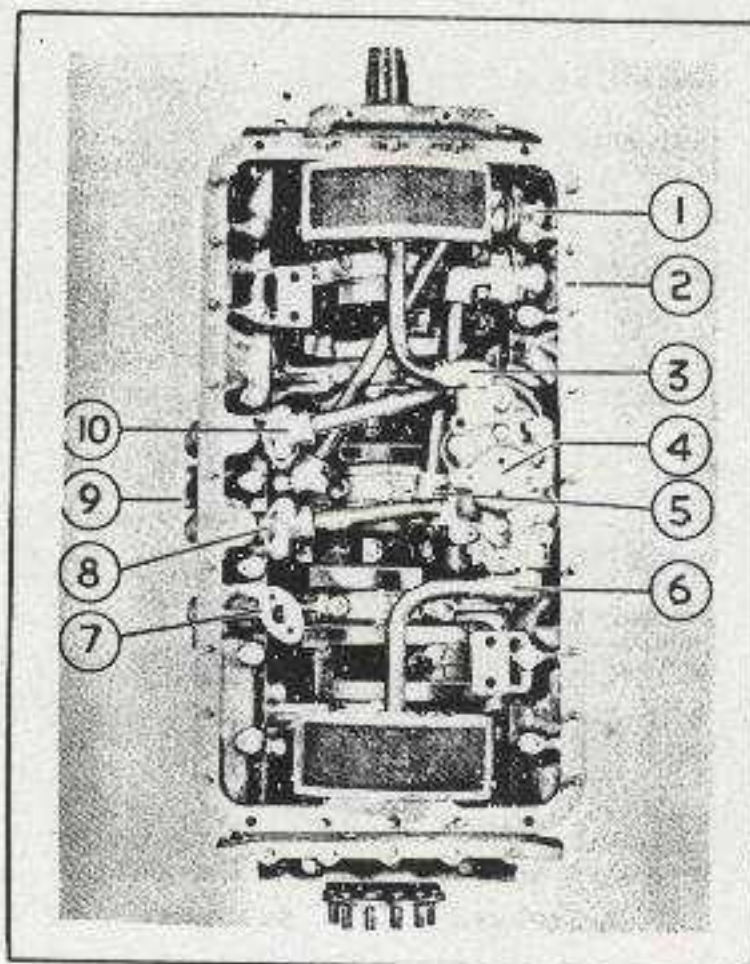
(e) Remove the nuts securing the two gauze filters.

(f) Referring to Fig. 6, disconnect the two elbows (9) and (11). Disconnect both elbows of the delivery pipe, pump to filter (2) and remove the pipe. This will give access to the two nuts securing the pump assembly to the crankcase. Lift out the pump and the distributor drive shaft.

(g) Remove the scavenger delivery pipe (9) from the scavenge pump body and the suction pipe (11) from the pressure pump body. Pull out the two pipes (3) and (6) suction scavenge from the pump body.

Skew gear, timing

15. Viewing the skew gear driving oil pump, from the top, it will be seen that the gear has fifteen teeth. The slot for the distributor shaft is opposite a tooth on one side and between two teeth on the opposite side of the gear and this is important as it



1. Delivery, filter to relief valve
2. Delivery, pump to filter
3. Scavenge suction, front
4. Scavenge pump, base
5. Pressure pump, delivery elbow
6. Scavenge pump, suction rear
7. Blanked off
8. Scavenge delivery to cooler and tank
9. Relief valve
10. Suction, tank to pressure pump

FIG. 6 - ENGINE B.60 (DRY SUMP) - OIL PUMP CONNECTIONS

has a direct bearing on the ignition timing, see Fig. 7. Turn the skew gear until the tooth opposite the slot is facing the front of the pump, Fig. 8, ie, the timing case end. Now turn the skew gear clockwise (viewed from the top) 45 degrees, place the shaft driving distributor on the gear and enter the assembly into the cylinder block. The meshing of the two skew gears, ie, oil pump and camshaft will cancel out the 45 degrees advance given to the oil pump skew gear. With the pump in position, view the blade of the distributor shaft from the top of the cylinder block, the blade must be in line with the engine as at Fig. 9. Should the timing be one tooth out, it will be obvious and the timing must be done again.

Replacement

16. Ensure that the crankshaft has not been disturbed from the setting given in para 14(d), otherwise the ignition timing will be incorrect.

- (a) Bolt the pump to the crankcase, replace all the internal piping.
- (b) Renew the sump gasket sealing it with jointing compound.
- (c) Examine the oil reservoir for sludge.

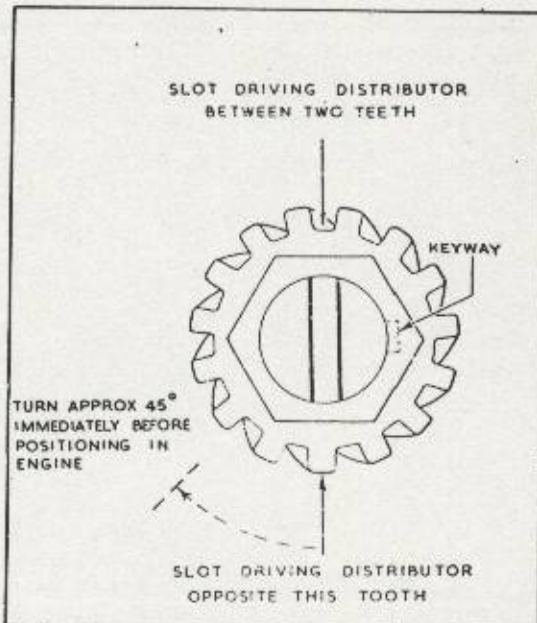


FIG. 7 - SKEW GEAR - DRIVING OIL PUMP AND DISTRIBUTOR

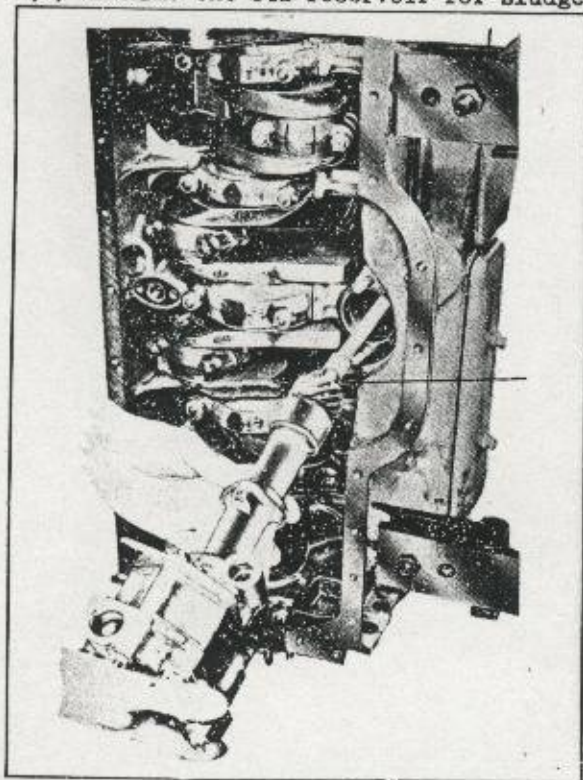


FIG. 8 - OIL PUMP REPLACEMENT - PUMP DRIVE ADVANCED 45° AND DISTRIBUTOR DRIVE SHAFT IN POSITION

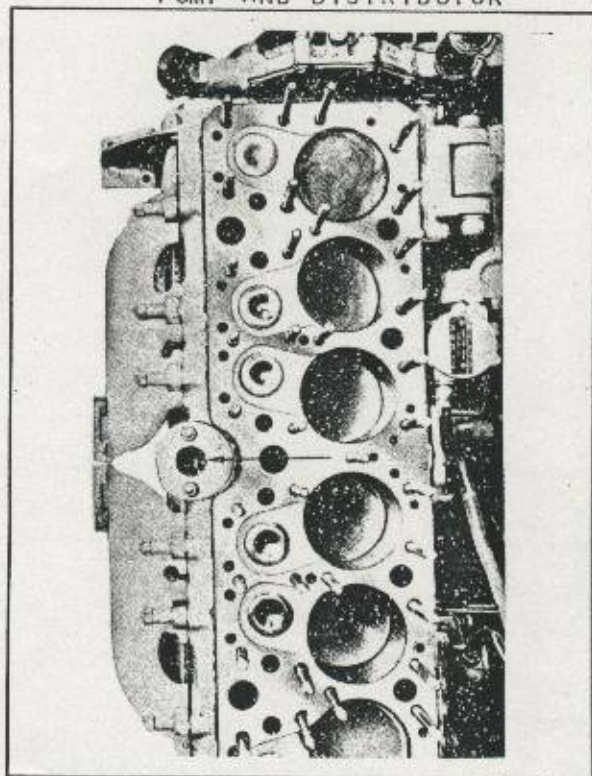


FIG. 9 - OIL PUMP REPLACEMENT - CORRECT POSITION OF DISTRIBUTOR SHAFT BLADE

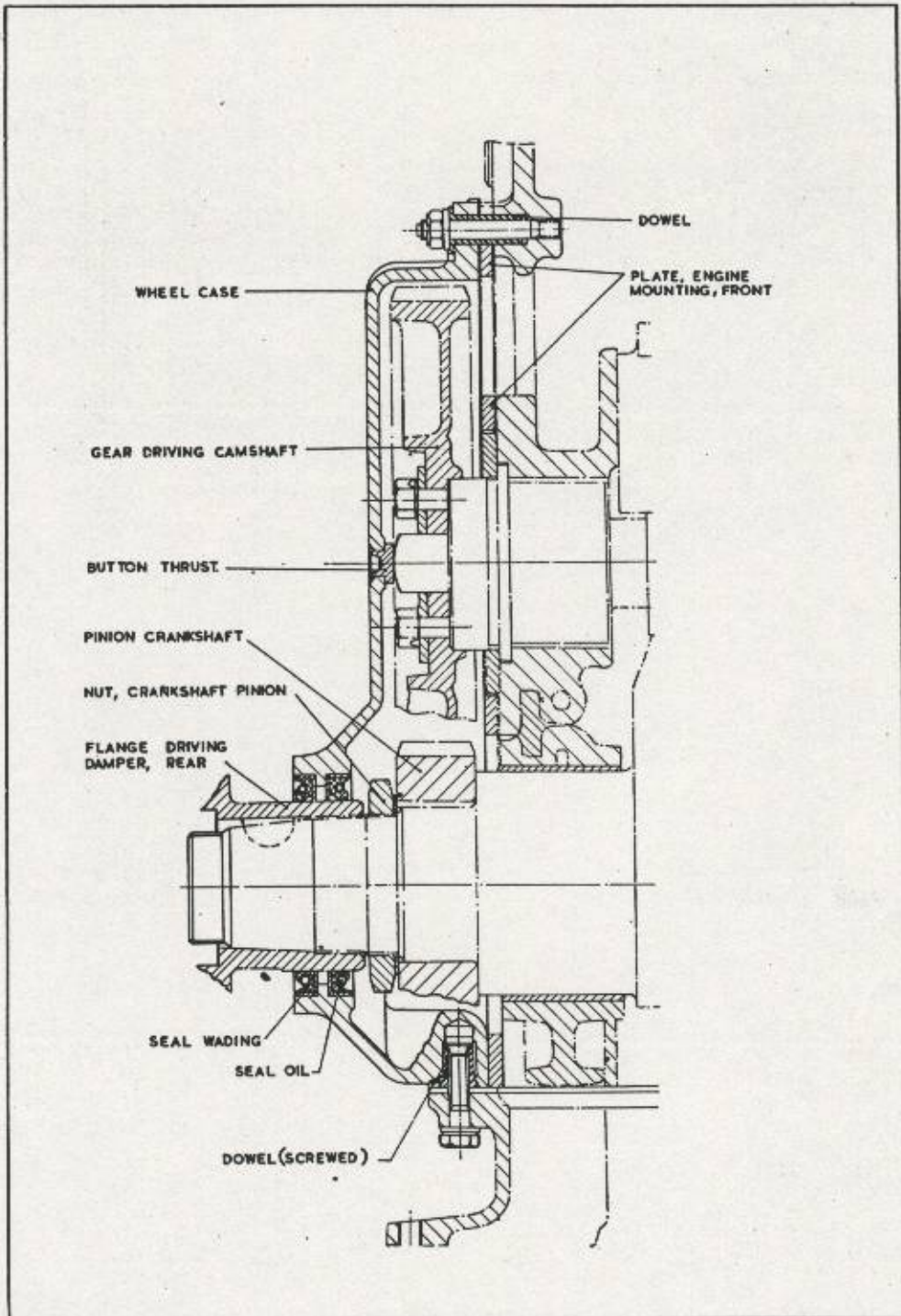
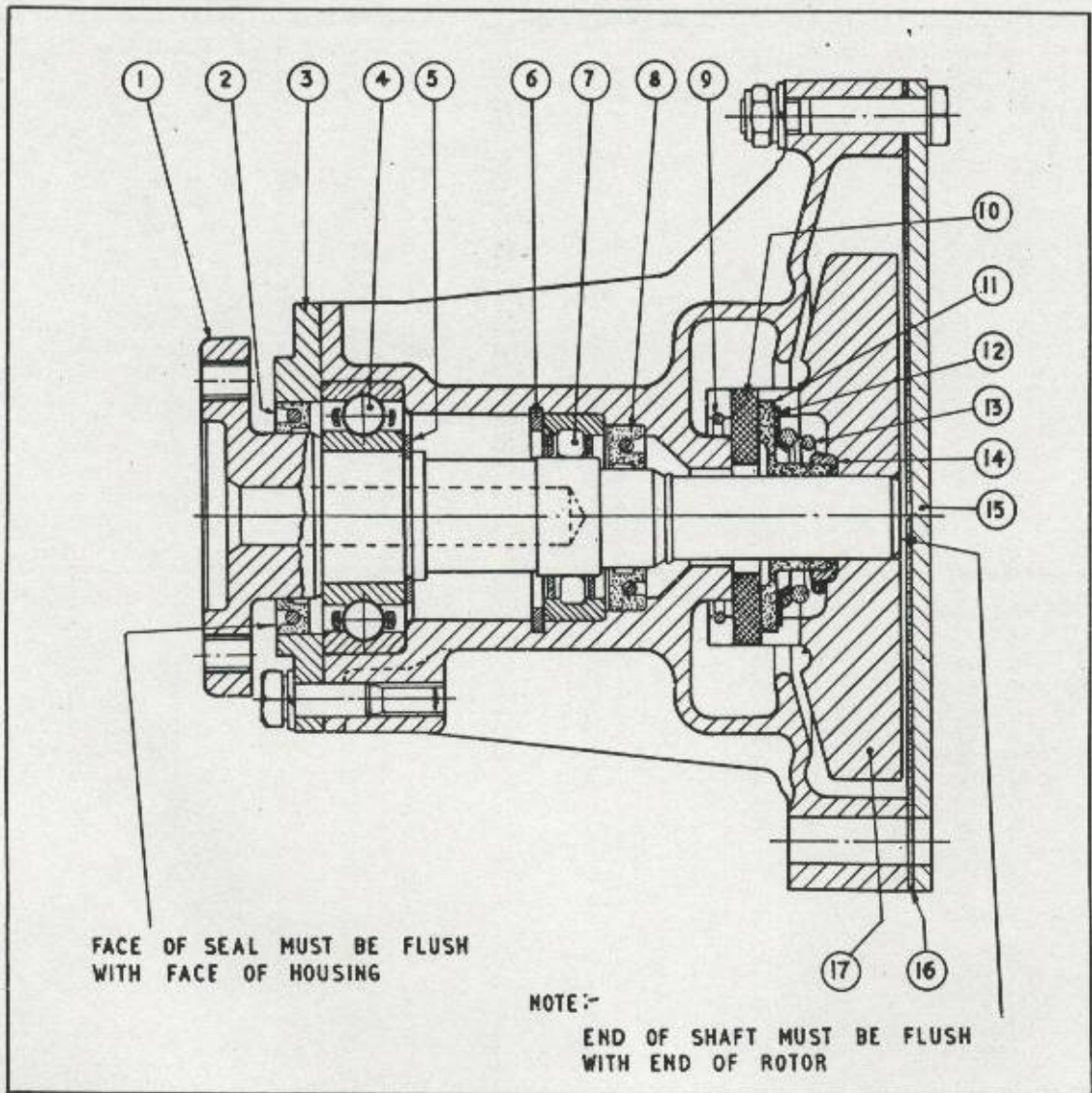


FIG. 10 - TIMING WHEEL CASE - OIL SEALS



- | | |
|--|---------------------------|
| 1. Shaft, coolant pump | 10. Gland-ring, carbon |
| 2. Seal, oil, 1.25 x 1.75 x 0.25 inch | 11. Seal, rubber |
| 3. Housing, oil seal | 12. Housing, seal, rubber |
| 4. Bearing, ball, 25 x 52 x 15 mm. | 13. Spring, pump, seal |
| 5. Circlips, Seeger, ext., 25 mm. | 14. Ring, retaining, seal |
| 6. Circlip, Seeger, int., 1.678 inch | 15. Plate, backing, pump |
| 7. Bearing, roller, 17 x 40 x 12 mm. | 16. Joint, backing, plate |
| 8. Seal, oil, 0.75 x 1.377 x 0.25 inch | 17. Rotor |
| 9. Spring ring, rotor | |

FIG. 11 - COOLANT PUMP - GENERAL ARRANGEMENTS

- (d) Refit the oil reservoir to the engine. Connect all external hoses ensuring they are tight. Fill the reservoir with three gallons of engine oil.
- (e) Ensure that the piston of No 1 cylinder is still at T.D.C. compression stroke, refit the distributor and replace the engine in the reverse sequence to para 6.
- (f) Before refitting the oil filter to the vehicle, remove the bowl and fill to within two inches of the top with engine oil with the filter element in position. Replace the bowl.
- (g) Before connecting up the oil filter to the engine, prime the pump through the delivery hose (pump to filter) with approximately 1/4 pint of engine oil.

Oil seals, timing wheel case

17. Two oil seals are employed to seal the timing end of the crankcase, the inner one sealing the crankcase against loss of lubricating oil and the outer against ingress of water. These are further reinforced by grease being forced between them. Both seals are pressed into the timing wheel case with their rubbing contacts on the rear driving flange of the crankshaft damper (see Fig. 10). It is not necessary to remove the engine from the vehicle to renew these seals.

18. Removal:-

- (a) Remove the air louvre, rear hull plate and radiator (see VEH N 403/1-1).
- (b) Remove the plate, locking, starting dog.
- (c) Remove the large hexagonal nut and tapered bush.
- (d) Remove the starting handle dog.
- (e) Withdraw the crankshaft damper assembly using 'Extractor, FV 143191'.
- (f) Disconnect the oil pipe to the timing gears and the wading seal grease pipe at their unions.
- (g) Remove the timing wheel case.
- (h) Renew both oil seals, the inner seal with its lip towards the timing wheels, the outer seal with its lip facing the damper.

19. Replacement:-

- (a) Lightly grease with grease LG-280 both oil seals on their inner diameter. Refit the timing wheel case to the engine.
- (b) Reconnect the oil feed and the wading seal pipes.
- (c) Examine the rear driving flange of the damper for ridging or scoring. The flange may be machined but must be finally polished smooth. The oil seal rubbing face should not be reduced by more than 0.005 inch diameter.
- (d) Ensure that the Woodruff key is a good push fit with 100 per cent contact and lightly grease with grease LG-280 the rear flange oil seal contact.
- (e) Insert the driving flange of the damper into the outer oil seal. Screw the starting handle dog on to the crankshaft and drive the damper home square and tight by means of the dog nut.

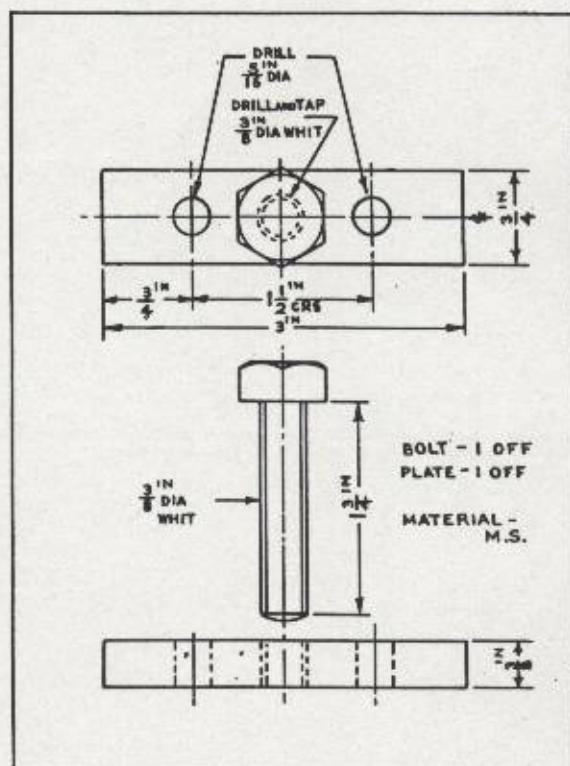


FIG. 12 - COOLANT PUMP - TOOL,
REMOVING ROTOR FROM PUMP SHAFT
(LOCAL MANUFACTURE)

- (f) Replace the tapered bush and nut and the plate, locking, starter dog.
- (g) Replace the radiator, rear plate and louvres.

Workshop special tools

- 20. W 6513 Compressor, exhaust valve spring
- FV 143184 Spanner, exhaust tappet
- FV 143188 Reamer, exhaust valve guide
- FV 143191 Extractor, crankshaft damper

COOLING SYSTEM**COOLANT PUMP**

Removal/Replacement, see VEH N 403/1-1.

21. Dismantling (Fig. 11):-

- (a) Remove the pulley.
- (b) Remove the backplate.
- (c) Remove the pump rotor. This is a press fit on the shaft and will be removed by means of a tool manufactured locally, see Fig. 12.
- (d) Remove the wire circlip, carbon gland ring, spring, rubber seal and the two brass support rings.
- (e) Remove the front oil seal housing bolts. Withdraw the pump spindle complete with housing, bearing and oil seal.
- (f) Remove the bearing circlip from the shaft. Fit the extractor (FV 143211) over the flange and press out the shaft.
- (g) Remove the circlip from the pump body. Withdraw the roller bearing and oil seal.

22. Reassembly:-

Replace in the reverse order, noting the following points:-

- (a) Renew all gaskets, oil seals, water seals, including carbon gland ring and the rotor.
- (b) Ensure that the radius on the end of the shaft is smooth before pressing on the oil seal, or rubber water seals.
- (c) When pressing the rotor on the shaft ensure that the thrust is being taken by the flanged end of the shaft and not by the alloy housing.

NOTE:- The rotor is of cast iron and must have an interference fit requiring a pressure of 800 lb/sq. in.

FAN ASSEMBLY**23. Removal:-**

- (a) Remove the radiator assembly in accordance with VEH N 403/1-1.
- (b) Slacken the V-belts at the generator adjusting bracket.
- (c) Remove the two self-locking nuts securing the layrub coupling to the water pump pulley.
- (d) Remove the six nuts securing the fan assembly to the engine oil sump casing.
- (e) Lift the fan assembly clear of the vehicle.

24. Replacement:-

Replace in the reverse order.

25. Dismantling (Fig. 13):-

- (a) Remove the layrub coupling and the fan hub.
- (b) Remove the bolt retaining fan bearings.

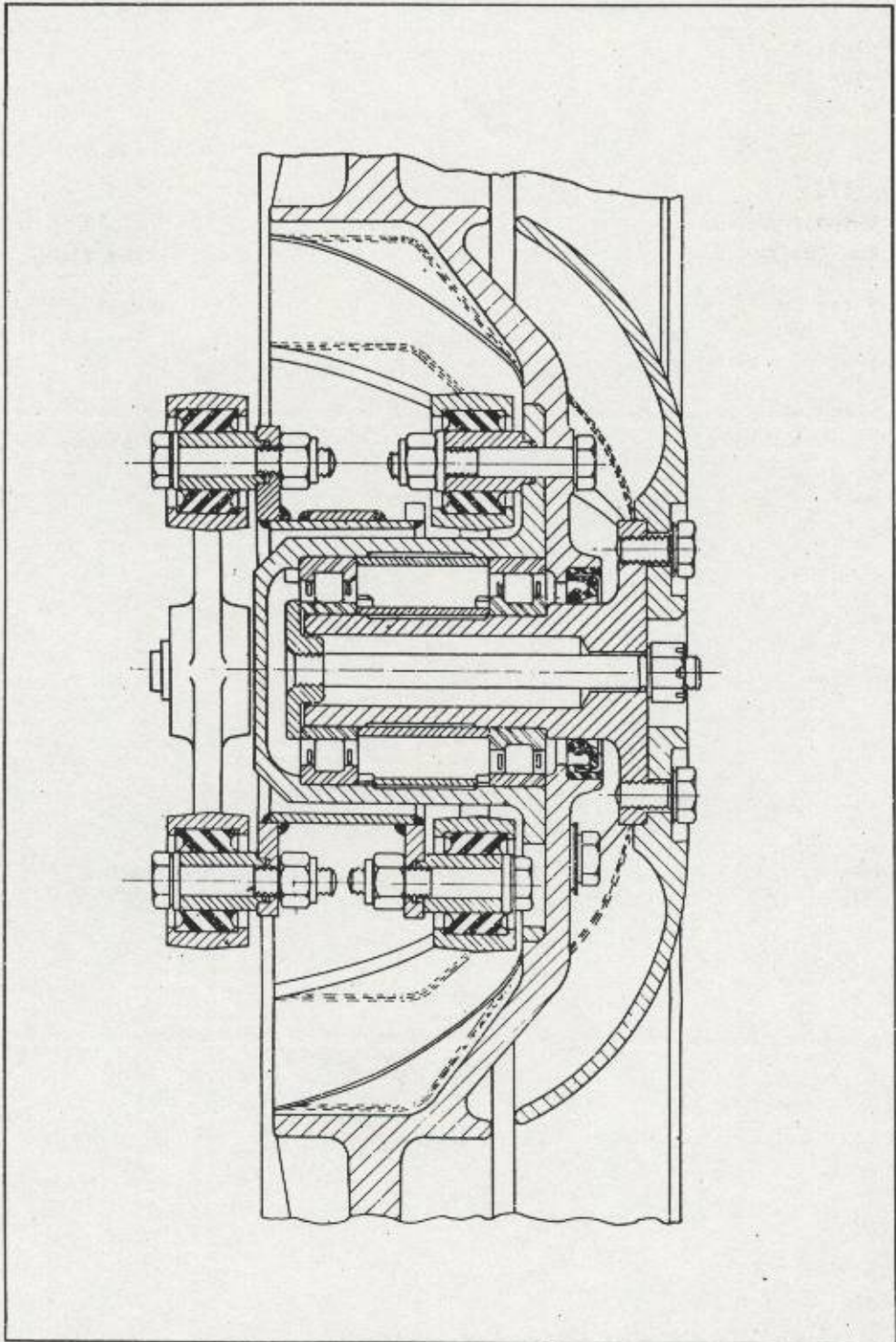


FIG. 13 - COOLANT FAN - GENERAL ARRANGEMENT

- (c) Withdraw the two roller bearings and distance piece. It will be necessary to use a puller for the bearings.
- (d) Remove the fan shaft from the cowl.
- (e) Press the oil seal out of the fan centre.

Examine the bearings and the oil seal in accordance with GEN O 050 and VEH A 163-3.

26. Reassembly:-

- (a) Fit the oil seal to the fan centre.
- (b) Place the bearing shaft through the fan centre with its bolting flange at the back.
- (c) Lay the fan on a bench with the bearing shaft vertical and place a flat block of wood, or metal, under the shaft.
- (d) With a suitable piece of tube drive the roller bearings on to the shaft (not forgetting the distance pieces).
- (e) Replace the centre bolt, tighten the nut and replace the split pin.
- (f) Replace the bearing hub and the layrub coupling, tighten the screws and turn over the tab washers.
- (g) Insert the fan assembly into the cowl, line up the threaded holes of the bearing shaft flange with the six holes in the cowl centre, replace and tighten the screws.

Fan balancing (Fig. 14)

27. Should the fan blades become damaged, but repairable, the fan should be given a static balance test after repair. Do not remove metal from the blades to balance the fan. Holes should be drilled and tapped on the 'light' side and brass plugs screwed in to the tappings. The plugs should be just proud each side of the blade to allow for peening over and finally smoothing down with a file. Centre punching the plugs to key them in, is not recommended due to the softness of the aluminium blades; 1/8 inch to 3/8 inch diameter brass rod will be found suitable for balance plugs. Finally chuck the fan in a suitable lathe and if necessary skim the blade tips to prevent fouling of the cowl. Only the smallest amount necessary should be machined off otherwise the efficiency of the fan will be impaired.

Workshop special tools

28. LV3/RR FV 143211 Extractor, coolant pump bearing.

TRANSMISSION

FLUID FLYWHEEL

(Remove the gearbox, see para 35).

29. Dismantling, Figs. 15, 16 and 17:-

- (a) Remove the circlip from the rear casing oil seal housing and the washer adjusting. Drain the oil.
- (b) Remove the six studs securing the oil seal housing, insert three extractor screws and draw off the seal housing.

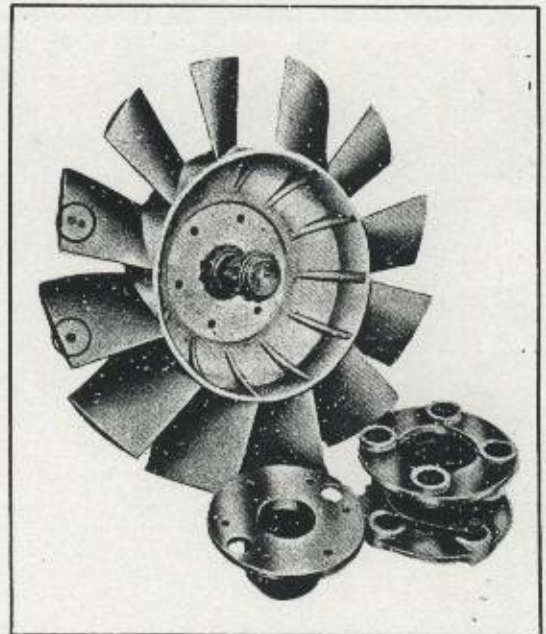


FIG. 14 - FAN BALANCING -
SHOWING BRASS PLUGS

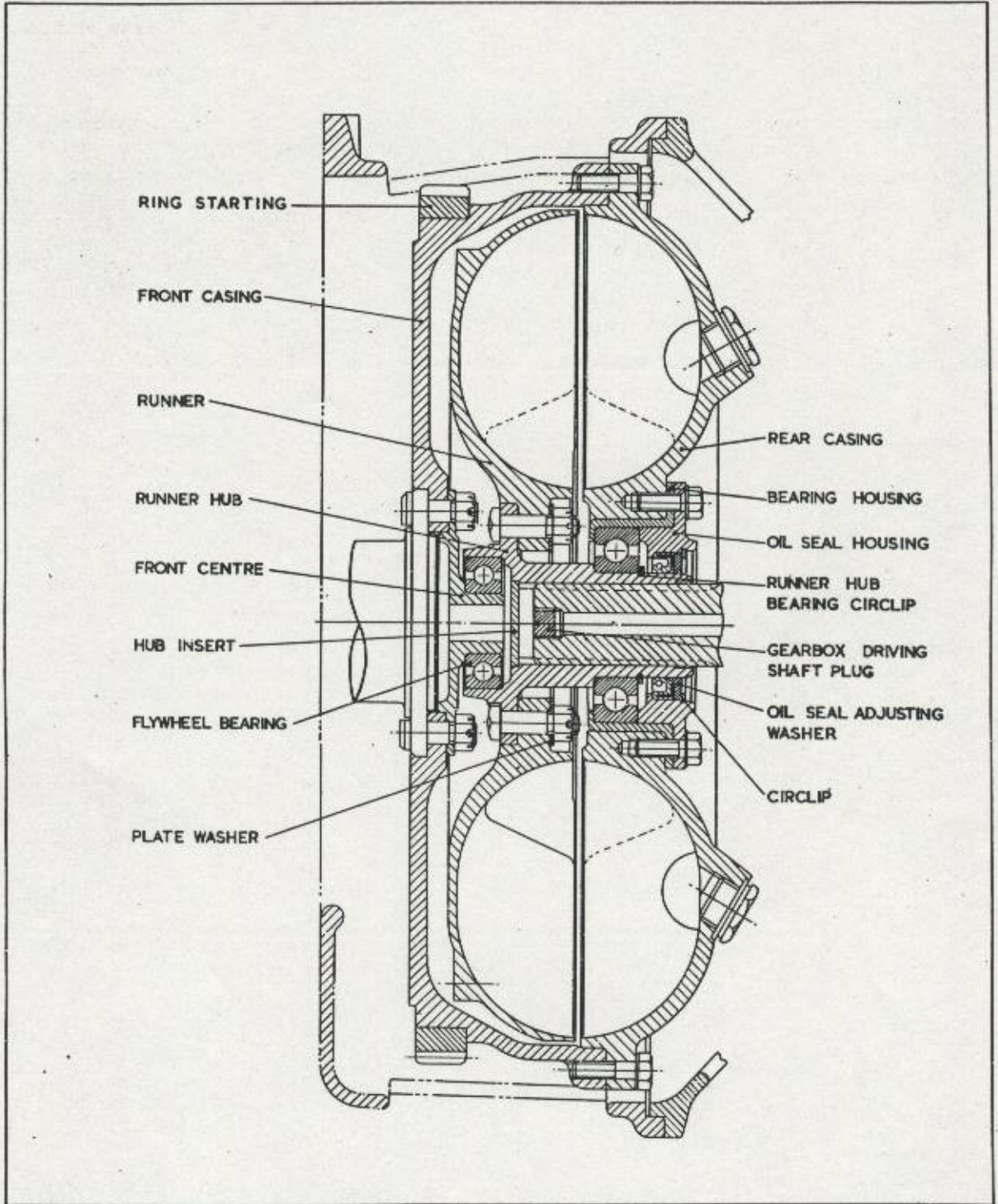


FIG. 15 - FLUID FLYWHEEL - GENERAL ARRANGEMENT

- (c) Remove the inner circlip locating the rear bearing. Remove the screws securing the rear casing and extract the casing complete with runner and hub using three 5/16 U.N.C. screws.
- (d) Remove the rear bearing and housing from the rear casing.
- (e) Remove the split pins and nuts to separate the flywheel runner from the runner hub. This exposes the whole of the fluid flywheel assembly.

30. Reassembly:-

Replace in the reverse order noting the following points:-

- (a) When the oil seal is being replaced, ensure that the circlip groove has no protruding sharp edges or burrs, as this will damage the oil seal on entry. It is advisable to run a half-round scraper around the inside of the housing. Soak the new oil seal in oil OM-13 and insert wet.
- (b) Washers adjusting oil seals are available in three sizes, 0.120, 0.130 and 0.145 inch. Select the washer which, when fitted with the circlip, will give a slight nip to the seal.
- (c) When mating the front and rear casings, renew the paper joint and use jointing compound on both sides.
- (d) Use jointing compound on the following face joints: front casing to crankshaft, oil seal housing and rear bearing housing.

OIL SEAL

31. Renewal:-

- (a) Drain the oil and remove the screws securing the oil seal housing. Using the extractor holes in the housing flange (5/16 UNF), remove the housing complete with circlip, adjusting washer and oil seal. Remove the circlip from the housing and tap out the adjusting washer and oil seal.
- (b) Examine the runner centre for scoring at the position of the oil seal and for worn bearings. The latter can be ascertained by spinning the centre and listening for any sound of roughness. There should be less than 0.002 inch movement at the centre when moved from side to side. Should the centre be scored or the bearings worn, renew in accordance with paras 32 and 33.
- (c) With the centre and bearings satisfactory, thoroughly clean the oil seal housing. Ensure that the circlip groove is free from burrs, dip the new seal in oil OM-13 and press into position within the housing. Clean the flange of the bearing housing and coat with jointing compound.
- (d) Refit the oil seal housing, taking care not to damage the oil seal as it passes over the centre spigot. Replace screws and tighten evenly.
- (e) Replace the adjusting washer and circlip. Replace the oil.
- (f) Before replacing the engine, check over the points listed in para 7.

RUNNER CENTRE AND BEARINGS

32. Removal:-

- (a) Drain the oil from the fluid flywheel.
- (b) Remove the screws securing the rear casing and using extractor bolts (5/16 UNC), remove the rear casing complete with runner.
- (c) Remove the oil seal housing complete with oil seal, adjusting washer and circlip.
- (d) Remove the bearing circlip, support the outer flange of the casing on wooden blocks and tap the runner centre through the bearing.
- (e) Support the bearing housing at its rear flange and tap the bearing out of the housing. No attempt should be made to remove the housing from the rear casing. The housing is pressed into the casing and then machined to receive the bearing. Should the bearing housing be defective, renew the rear casing complete.

- (f) Remove the eight bolts, nuts and plate washer, securing the centre to the runner. Drive the centre from the runner and extract the front bearing from the centre. Should the bearing remain on the front centre, pull the bearing from the spigot in situ; DO NOT remove the centre from the flywheel.

33. Replacement:-

Replace in the reverse order to removal noting the following points:-

- (a) When fitting the centre to the runner, press the centre into place carefully and do not allow to tilt or metal sheared from the edge of the counterbore may fall between the mating faces and throw the centre out of alignment.
- (b) Check that the insert is in place in the runner centre. The inserts are rolled into place during production and tested to 80 lb/sq.in.
- (c) With a scraper, give a slight lead to the leading edge of the oil seal housing beyond the circlip groove.
- (d) Having fitted the runner assembly to the rear casing and before fitting the oil seal, hold the rear casing in a vice and spin the runner. It should rotate quite freely.
- (e) Three thicknesses of adjusting washers are available for the oil seal, 0.120, 0.130 and 0.130 and 0.145 inch. Fit the washer that gives a slight nip to the oil seal with the circlip in place.
- (f) Use a new joint for the rear casing and coat the flanges with jointing compound. Immediately prior to fitting the oil seal housing, coat the bearing housing flange with jointing compound. Jointing compound should not be used on the oil seal.

Starting ring

34. Renewal:-

Proceed as for sub-para 29(a) to (e), remove split pins, nuts and flywheel bearing front centre. Remove flywheel.

- (a) Remove the six securing screws from the starting ring, heat slightly around the ring and tap off.
- (b) The replacement rings are 0.010 inch interference fit with the casing. Heat in boiling water for a few minutes, drop over the casing and allow to cool. Ensure that the ring is against the shoulder.
- (c) When cold, drill and tap new holes mid-way between the existing holes and refit securing screws. Screw in securely and as a precaution against unscrewing, lightly mark with a centre punch at the position of the screwdriver slot.
- (d) When replacing the front casing to the flywheel flange carefully line up the off centred (2^o) bolt hole with the corresponding holes in the flange. This ensures that the T.D.C. marking is in its correct position relative to the crankshaft.

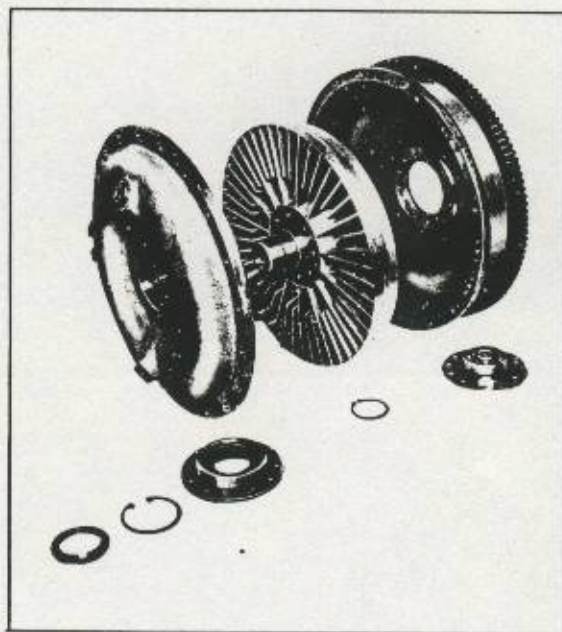


FIG. 16 - FLUID FLYWHEEL -
REAR

GEARBOX AND TRANSFER BOX

35. Removal:-

- (a) Remove the front and rear roof plates.

- (b) Remove the gunner's seat, wireless set baseplate, gearbox coverplate and bracket.
- (c) Remove the air cleaner.
- (d) Disconnect the battery leads, remove batteries and battery boxes.
- (e) Remove the battery leads, clamps, and wireless set bearer bracket.
- (f) Remove the floor sideplates and crew seats.
- (g) Disconnect and remove fuel filter outlet pipe.
- (h) Remove the LH front propeller shaft tunnel.
- (j) Disconnect the gear selector rod at the gearbox.
- (k) Remove the RH propeller shaft tunnel.
- (l) Disconnect all four propeller shaft couplings at the transfer case bevel boxes.
- (m) Disconnect the LH front propeller shaft at the front end and remove from the hull (this is necessary as it cannot be moved to one side as in the case of the other three).
- (n) Remove the clip and fuel line from the gearbox. Loop up the cables which pass over the bell housing.
- (o) Disconnect the gear change rod at the gearbox and the forward and reverse rod at the transfer case.
- (p) Remove the engine steady brackets.
- (q) Remove the transfer case mounting bracket caps, lift the unit slightly at the gearbox end and pack up the engine for support.
- (r) Remove the gearbox bell housing nuts (the two bottom nuts can be removed with a ring spanner).
- (s) Sling the gearbox assembly, slide it clear of the flywheel and lift out through the top of the fighting compartment.

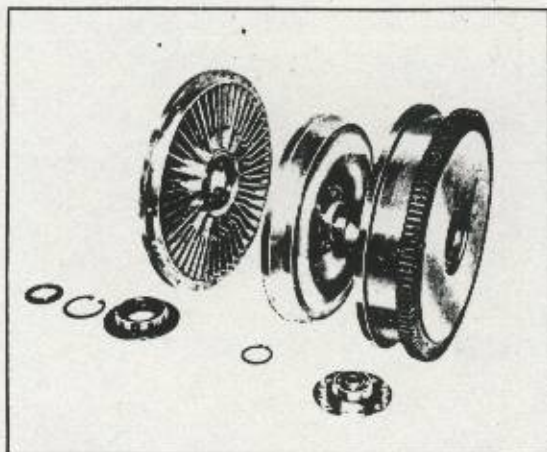


FIG. 17 - FLUID FLYWHEEL -
FRONT

36. Replacement:-

- (a) Examine the fluid flywheel for leaks at the oil seal, see para 31.
- (b) Lower the gearbox in through the top of the fighting compartment, line up the splines of the input shaft and push in until the gearbox front plate meets the gearbox support plate, tighten the nuts.
- (c) Remove the packing from under the engine and lower the gearbox end into the trunnion bearers, replace and tighten the caps.
- (d) Replace the engine steady brackets and re-set the rubber pads. Reconnect the forward and reverse rod, the gear change rod and the gear selector rods.
- (e) Replace the cables and fuel line over the bell housing and secure them with their clips.
- (f) Replace the LH front propeller shaft and couple up all four shafts at the transfer box output bevel boxes. Refit the front propeller shaft tunnels.
- (g) Replace the fuel lines to the filter. Refit the floor sideplates and crew seats.
- (h) Replace the battery leads, wireless set bearers, battery boxes and batteries. Reconnect the batteries.
- (j) Replace the gearbox coverplate, wireless baseplate, air cleaner and gunner's seat. Connect the air cleaner hose and refit the front and rear roof plates.

BEVEL BOXES

37. Removal (Fig. 18):-

It will be necessary to remove the engine when removing the rear bevel boxes, see para 6.

- (a) Disconnect any electrical accessories on the adjacent wing. Remove the wing.
 - (b) Jack up the vehicle and place skidding under the hull. Remove the road wheel.
 - (c) Drain the bevel box.
 - (d) Pull the handbrake hard on, place the jack under the hub and lift the suspension high enough to remove the bump pads. Lower the suspension, the initial compression is now out of the spring. Release the handbrake.
 - (e) Disconnect the spring seat control levers, remove one lubricator and cap from the spring seat pin and knock out the pin.
 - (f) Remove the spring top bracket, lift out the spring complete with seat and shock absorber.
 - (g) Disconnect the handbrake cable clip and remove the expander unit from the brake backplate. Should it be a front wheel station, disconnect the outer steering ball joint.
 - (h) Support the hub and remove the bottom lubricator and swivel pin cap. Disconnect the small flange coupling mid-way between the inner and outer tracta joints. Remove the wheel hub and outer tracta joint.
 - (j) Remove the eight screws securing the bevel box from outside the hull.
- NOTE:- It is not necessary to remove the suspension links from the hull.
- (k) Disconnect the propeller shaft at the flange coupling. Remove the bevel box complete with the inner tracta joint from inside the hull.
 - (l) Pull the inner tracta joint out of the bevel box housing complete with its sliding (cork) seal.

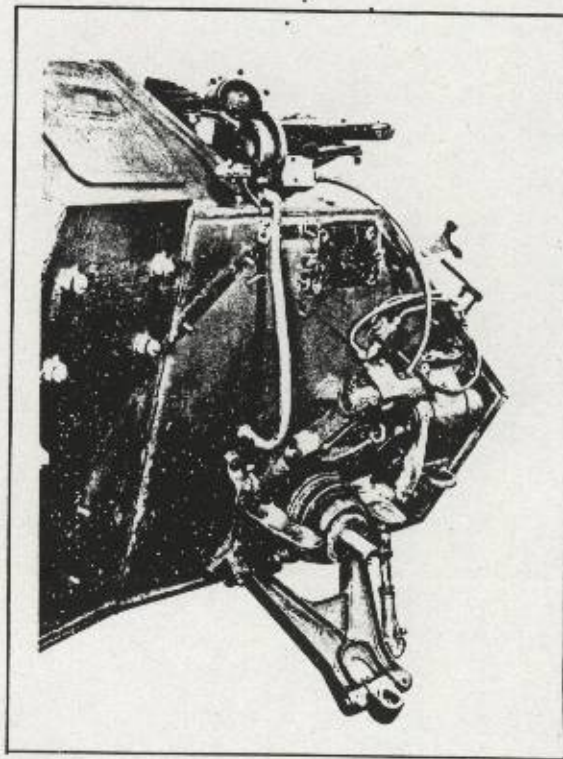


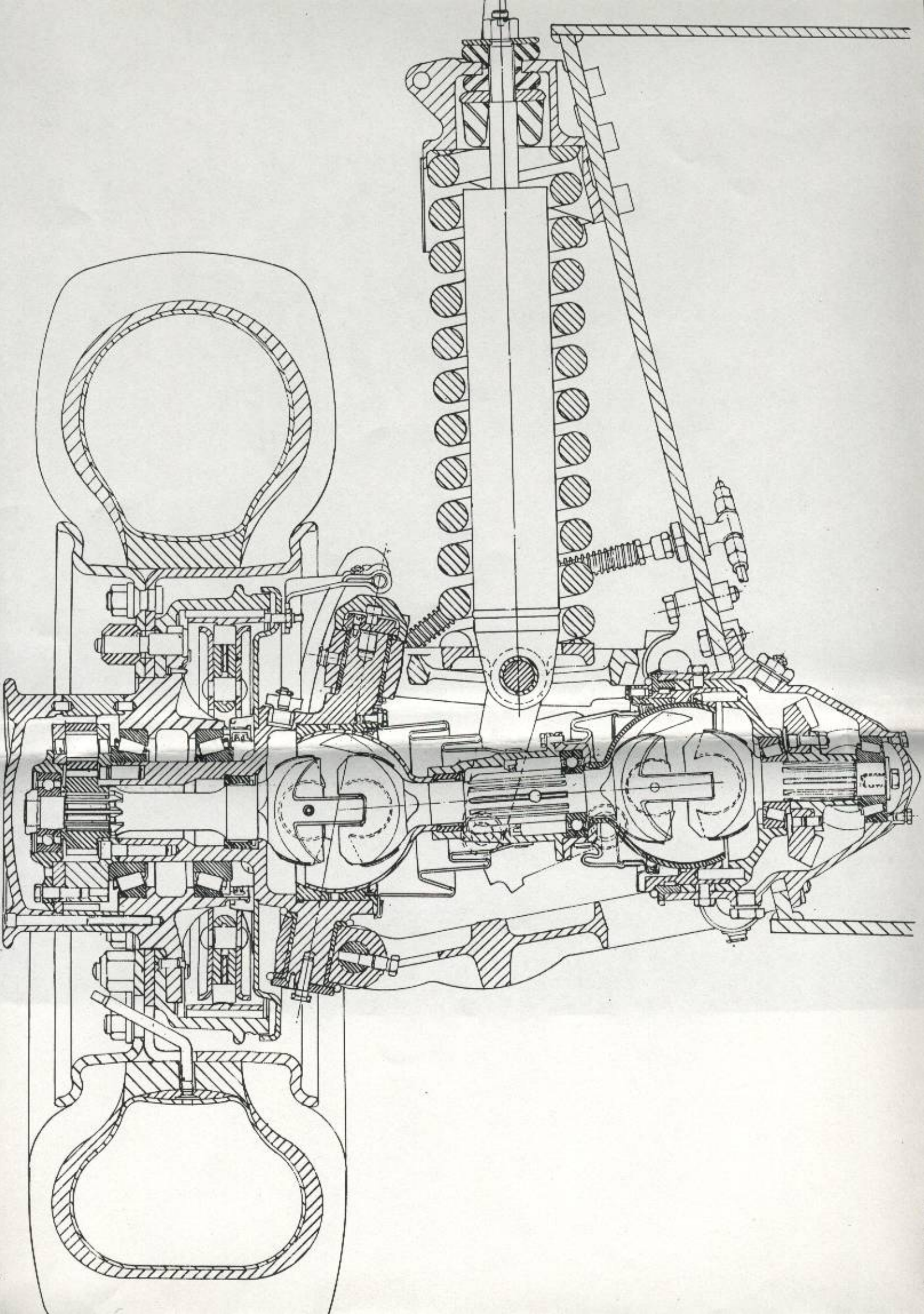
FIG. 18 - BEVEL BOX - REMOVAL

38. Replacement:-

- (a) Remove the sliding seat from the inner tracta housing. Renew the cork seal (joint to the top). Press it into the bevel box, using a smear of grease LG-280 for lubricant.
- (b) Lightly smear the face joint of the cork seal housing with Bostik 'C' and replace the large rubber 'O' ring. Insert the inner tracta housing into the bevel housing and bolt up the gaiter ring to the cork seal housing face.
- (c) Clean the bolting faces of the hull and bevel box, smear with Bostik 'C'. Replace the bevel box complete with inner tracta joint, by inserting it in the hull aperture from inside. Replace and tighten the eight screws. Reconnect the propeller shaft.
- (d) Replace the bevel box drain plug and refill with three (3) pints of oil.
- (e) Replace the hub and outer tracta assembly.

NOTE:- When engaging the splined shaft of the outer tracta assembly with the splined sleeve of the inner assembly, ensure that they are in alignment before

Fig 19 - Final Drive - General Arrangement



engagement, or the oil seal within the outer tracta shaft housing will be damaged. Push the outer assembly up to the flange, and replace the screws.

- (f) Refit the top and bottom links to the hub assembly.
- (g) Replace the spring, seat and shock absorber assembly. Lift the hub by means of a jack and replace the bump rubbers.
- (h) Refit the brake expander unit, handbrake cable clip, steering rod ball joint (if applicable), wing, electrical accessories, road wheel, in that order. If it is a front wheel station check the wheel alignment for 1/8 inch toe-in.

NOTE:- It will not be possible on later models to remove the outer steering ball joints in the usual manner due to the fitting of a modified form of brake adjuster. Two alternative methods of disconnecting the steering rods may be used:-

First method:-

- (i) Remove the split pin and slacken the nut of the ball pin (outer ball joint).
- (ii) Using a lead hammer, slacken the ball pin taper in the steering arm and remove the nut.
- (iii) Remove the circlip in the top of the ball joint housing and withdraw the top cup and ball pin.

Second method:-

- (i) Jack up the vehicle to lift the road wheel clear of the ground.
- (ii) Slacken off both nuts (LH and RH threads) locking the steering rod to the ball joints.
- (iii) Screw the rod out of both ball joints.

The first method will not upset the front wheel toe-in. Should however the ball pin tapers be difficult to move, carry out the second method.

AXLES

Tracta joint inner

39. Removal (Figs. 18 and 19):-

- (a) Disconnect the wiring of any accessory, ie, lamps, horn or smoke dischargers mounted on the adjacent wing, pull the wires through the wing grommets and leave them hanging from the junction box.
- (b) Remove the wing.
- (c) Place chocks under two of the other wheels.
- (d) Jack the vehicle up and place sufficient skidding under the hull to keep the road wheel clear of the ground with the suspension in its lowest position. Remove the road wheel.
- (e) Pull the handbrake hard on, place a jack under the wheel hub and jack up until the top suspension link is well clear of the bump pads, remove the rubber pads and lower the hub. This will take all compression out of the coil spring. Drain the adjacent bevel box. Release the handbrake.
- (f) Place a wad of rag or cotton waste between the rubber gaiters and the top suspension link, otherwise the top link will drop and damage the gaiter on removal of the spring seat pin.
- (g) Disconnect the spring seat control linkage, remove the lubricator and end cap from the spring seat pin and drive out the pin.
- (h) Remove the screws securing the spring, top bracket, lift the spring clear of the hull complete with top bracket, shock absorber and spring seat.
- (j) Disconnect the handbrake cable clip and remove the brake expander unit from the brake backplate. If it is a front wheel station disconnect the steering at the outer ball joint. See note at the end of para 38.
- (k) Support the hub, remove the dowel screw and one lubricator from the bottom link outer pin, knock out the pin and push the bottom link down as far as it will go. Remove the cap squares from the top link outer pin and push the top link up as far as it will go.

- (1) Remove the six 1/4 UNF hex. hd. screws from the flanged joint of the housing. Pull the hub away from the hull. The assembly will come away leaving the inner tracta housing within the bevel box.

- NOTES:-
1. The inner tracta joint housing is a sliding fit within the bevel box and takes up the lateral movement of the drive due to the vertical movement of the road wheel when running. To remove the inner tracta joint housing, pull it straight out.
 2. Do not unscrew the large serrated locking ring as this will upset the meshing of the bevel box gears.
 3. Keep all tracta joints mated.

40. Dismantling:-

- (a) Remove the four hex. hd. screws and pull off the seat, sliding inner tracta housing.
- (b) Remove the small hose clip on the gaiter, slacken off the larger one and pull the gaiter over the small flange. Remove the tracta oil seal housing.
- (c) Punch the 'Mills' pin out of the splined shaft sleeve, pull off the sleeve and remove the tracta fork.
- (d) Press the ball bearing out of the housing, inner tracta fork, and the oil seal out of the housing, inner tracta oil seal.

41. Reassembling:-

- (a) Replace the drain plug and ensure that the gasket is serviceable. Renew the cork seal, see para 38(a).
- (b) Press the ball bearing into the housing, tracta fork, pass the fork shaft through the bearing, slip on the splined sleeve and secure it with a new 'Mills' pin.
NOTE:- Under no circumstances will 'Mills' pins be replaced. They will always be renewed.
- (c) Renew the rubber gaiter, apply Bostik 299A to the smaller gaiter end, pull the gaiter over the coupling flange from the splined end and secure it with the hose clip.
- (d) Press a new oil seal into its housing, fit the gaiter to the oil seal housing with a smear of Bostik 299A between them, bolt up the tracta housing to the bevel box with the oil deflectors in the housing to the top.
- (e) Fill the bevel box which includes the inner tracta joint with three (3) pints of oil.

42. Replacement:-

- (a) Pull the top suspension link down to the horizontal position, lift the spring and shock absorber into position, pass the spring seat control levers between the top link arms and nut up loosely. Secure the top spring bracket to the hull, drive the spring seat pin through the link arms, replace the end cap and lubricator and tighten the spring seat control nuts.
- (b) Lightly grease the outside of the splined sleeve, with grease LG-280. This will assist the oil seal of the outer tracta housing to slide on without damage. Offer up the hub and outer tracta assembly, ensuring that the inner and outer tracta shafts are in alignment as the oil seal must slide over the sleeve at the same time as the splines engage. Push on as far as it will go and secure with the six 1/4 UNF screws. Lift the hub and secure it to the outer link cross-pin with the cap squares.
- (c) Swing the lower suspension link up and drive in the bottom link pin. Replace the screwed dowel and lubricator.
- (d) Replace the brake expander unit. Should any difficulty be experienced in engaging the expander unit levers remove the brake drum and spring the shoes apart. Reconnect the handbrake cable clip and the outer steering ball joint, if applicable.
- (e) Refit the wing, remake the electrical connections, replace the road wheel and remove the skidding.

Tracta joint outer

43. Removal (Figs. 19 and 20):-

- (a) Jack the vehicle up and place skidding under the hull lifting the road wheel just clear of the ground. Remove the road wheel.
- (b) Jack up the hub until the top suspension links are well clear of the bump pads. This will facilitate the removal of the six 1/4 UNF hex. hd. screws at the flange joint of the two tracta shaft housings.
- (c) Lower the hub and remove the jack.
- (d) Remove the expander unit from the brake backplate and release the handbrake cable clip. Should it be a front wheel station disconnect the outer ball joint of the steering rod.
- (e) Remove the hex. hd. dowel screw and knock out the trunnion pin of the lower suspension link. Support the hub and remove the two cap squares of the upper link trunnion.
- (f) Pull the hub and outer tracta joint away from the vehicle.
- (g) Remove the hub cap, stand the assembly vertical and allow the hub to drain, to ensure the correct quantity of lubricant on refilling.
- (h) Remove the hose clip on the inner end of the gaiter and four 1/4 UNF screws securing the housing oil seal. Pull the outer tracta housing out of the hub assembly.

44. Dismantling:-

Push the tracta fork out of its housing and remove the gaiter and the oil seal. Press out the small oil seal which fits over the inner tracta shaft sleeve, take out the circlip, remove the needle roller bearing and cage from within the neck of the outer tracta housing.

45. Reassembling:-

- (a) Replace the hub cap, stand the hub assembly in a vertical position, tracta joint (slotted and spigotted) upwards. Stand the outer tracta fork upright and engage it with the spigot.
- (b) Push the needle roller cage down the housing and secure it with the circlip. Insert the rollers into the cage with a liberal smear of grease LG-280 to prevent them becoming misplaced.
- (c) Insert the rollers into the cage with a liberal smear of grease LG-280 to prevent them becoming misplaced.
- (d) Pass the housing over the shaft of the outer tracta fork taking care not to dislodge the needle rollers. Fit the tracta shaft housing in the hub carrier. Fit the housing, oil seal, and gaiter and secure with the four screws. Seal the small end of the gaiter to the housing with Bostik299A and replace the hose clip.

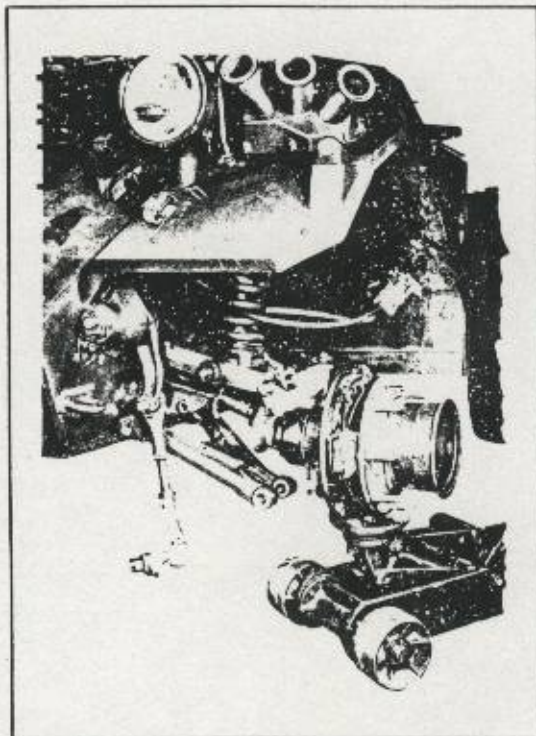


FIG. 20 - TRACTA JOINT OUTER -
REMOVAL

- (e) Fill the outer tracta housing (which includes the hub) with one and a half ($1\frac{1}{2}$) pints of oil.

46. Replacement:-

- (a) Push the lower suspension link down as far as it will go, and lightly grease with grease LG-280 the inner tracta shaft sleeve to assist the oil seal in sliding over it.
- (b) Support the hub by a sling, engage the outer shaft splines with the sleeve. Ensure that the outer assembly is in alignment with the inner assembly otherwise the oil seal may be damaged. Push the outer assembly on to the inner as far as it will go. Replace and tighten the six flange screws.
- (c) Engage the trunnion with the upper suspension link and secure with the two cap squares.
- (d) Swing the lower suspension link up, knock in the trunnion pin and secure it with its dowel screw.
- (e) Replace the brake expander unit, handbrake cable clip and the steering ball joint (if applicable).

NOTE:- Should the brake expander levers prove difficult to insert, remove the brake drum and prize the shoes apart adjacent to the expander tappets, press the levers in.

- (f) Replace the road wheel and remove the skidding.

IMPORTANT. Note: Should the steering arm be removed from either of the front hub swivels, ensure that the $\frac{7}{8}$ inch long screw is replaced on the top hole of the triangular bolting plate. The other two bolts are $1\frac{1}{2}$ inches long, and if fitted to the top tapping will damage the housing, tracta joint.

Road wheel hubs

47. Dismantling (Fig. 19):-

Jack up, remove the road wheel brake drum and dismantle the hub in the following sequence:-

- (a) Pull the brake shoes out of their carriers and collect the pivot pins and springs.
- (b) Remove the hub cap.
- (c) Remove the drive shaft nut and tab washer.
- (d) Remove the outer bearing housing (5/16 UNF extractor screws).
- (e) Remove the annulus hub reduction.
- (f) Remove the shims, sun wheel and spacer.
- (g) Remove the planet, hub reduction gear.

NOTE:- The 'Unbrako' screws securing the planet gear are locked by means of small copper slugs driven down holes parallel and adjacent to the screw heads. Should any difficulty be experienced in removing the screws, drill the slugs with a slightly smaller twist drill approximately $\frac{3}{16}$ inch deep. The slugs will then collapse on turning the screw head, see Fig. 21.

- (h) Remove the hub, roller bearings, shims, distance piece oil seal, oil seals and the distance piece roller bearings.
- (j) Disconnect the handbrake cable clip and remove the brake expander unit from the brake backplate. Slacken the brake adjuster right back, remove the carrier return springs and lift out the carriers. Remove the screws and lift off the brake backplate.

- (k) Disconnect the housing, outer tracta oil seal and cup gaiter.
- (l) If it is a front wheel station remove the outer steering arm with the ball joint.
- (m) Remove the trunnion caps from the upper suspension link pins, remove the setscrew and one lubricator and tap out the bottom trunnion link pin.
- (n) Pull away the carrier hub, take out the hub tracta fork, remove the circlip and withdraw the bearing (needle) tracta fork.

48. Reassembly (Fig. 22):-

Examine the hub tracta fork for scoring or bluing at the fork end (suggesting inadequate lubrication). Should this be apparent renew the tracta fork and the needle bearings as these also will be damaged. Examine the splines of the shaft for distortion.

- (a) Replace the needle bearing cage in the hub and secure it with its circlip. Fill the cage with needle rollers and a liberal smear of grease LG-280. This will keep the needle rollers in position.
 - (b) Replace the carrier hub (or swivel hub in the case of a front wheel station) by connecting the bottom trunnion to the lower suspension links. Swing the carrier hub up and replace the top trunnion caps.
 - (c) Replace the brake backplate and reposition the shoe carriers. Replace the stronger of the two pull-off springs first (this spring is adjacent to the expander unit). The second spring can then be easily replaced.
 - (d) Place the bearing spacer on the hub carrier and push it right up to the flange with its chamfer outwards.
 - (e) Press both roller bearings and cups into the hub bearing. Replace the oil seal distance piece followed by the two oil seals. These are positioned with their lips facing each other. See Gen O 050 on roller bearings and VEH A 163-3 on the fitting of oil seals.
 - (f) Slide the hub bearing on to the carrier, place the planet carrier in position, without the shims and tighten the screws. This will draw the roller bearings up and into position. Remove the screws and withdraw the planet carrier. Now insert 0.050 inch in shims, replace the planet carrier and tighten the screws. The planet carrier should now stand proud of the outer roller bearing cone. Measure this amount with feeler gauges. Remove the planet carrier and reduce the shimming by the amount gauged. Shims are available in the following sizes: 0.004, 0.010 and 0.048 inch.
- NOTE:- It may be necessary to commence with more than 0.050 inch shimming on some hub assemblies. This is a good average figure to commence with on a trial and error basis.
- (g) Ensure that the 'Unbrako' screws securing the planet carrier are extra tight. Insert a slug down each of the small holes beside the screw heads and spread each slug with a centre punch to lock the screws, Fig. 21.
 - (h) Place the annulus hub into position.

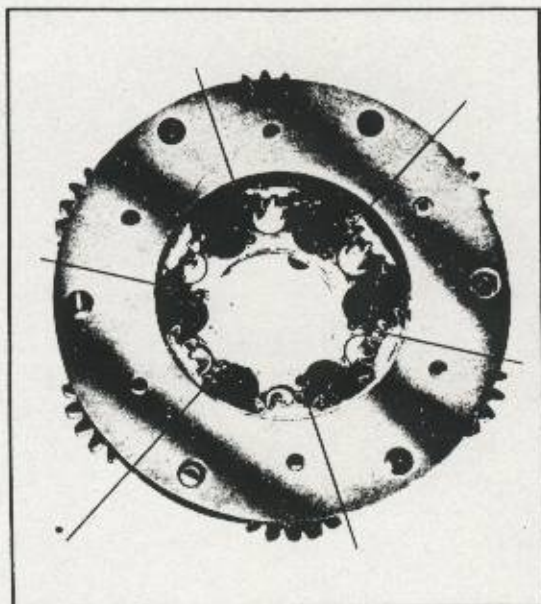


FIG. 21 - PLANET HUB REDUCTION GEAR - SLUGS LOCKING SCREWS

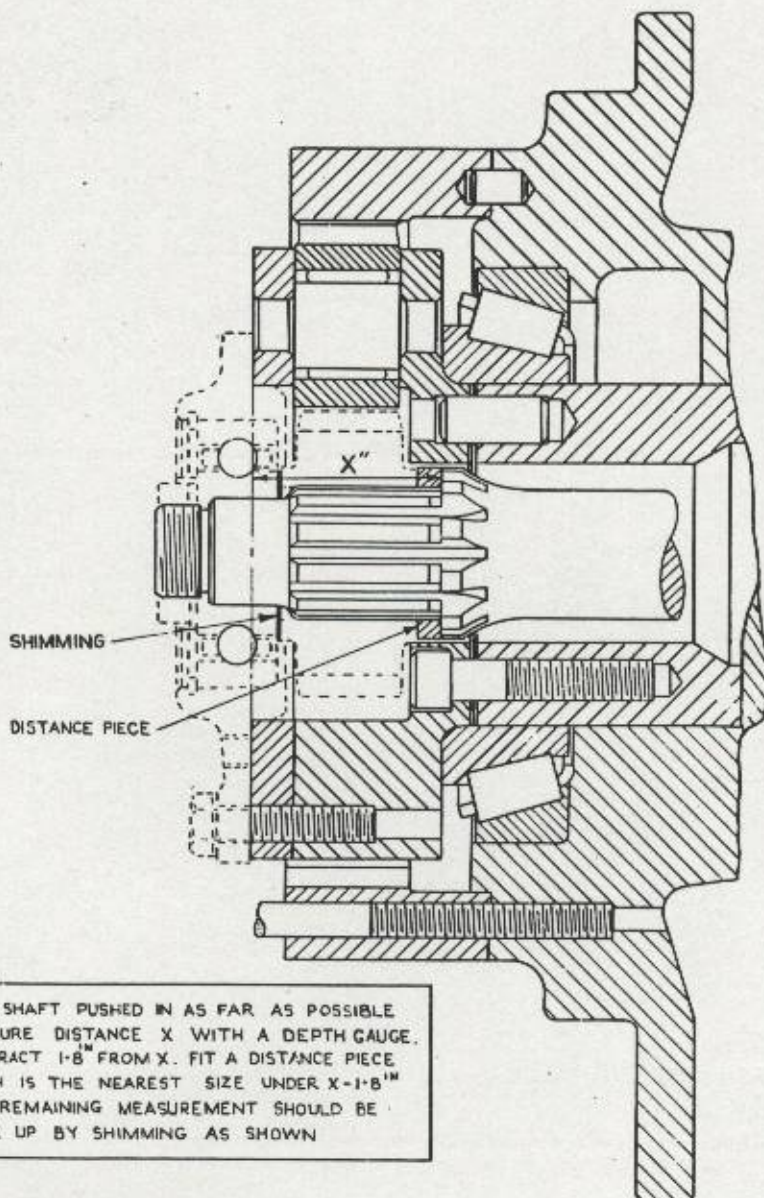


FIG. 22 - HUB REDUCTION - FINAL DRIVE ADJUSTMENTS

(j) The spacer which fits over the splined end of the tracta fork must now be fitted in accordance with Fig. 21. These spacers are available in the following sizes:-

- (i) LV9/ASC FV 50965/1 Spacer, hub, 3/8 inch.
- (ii) LV9/ASC FV 50965/2 Spacer, hub, 7/16 inch.
- (iii) LV9/ASC FV 50965/3 Spacer, hub, 1/2 inch.

(k) Replace the ball bearing in the housing, hub bearing, outer and secure it with the circlip. Place the bearing and housing on the shaft. Fit the correct amount of shims followed by the bearing housing, six outer securing screws, tab washer and shaft nut.

(l) Replace the cover, hub reduction gear.

(m) Reconnect the steering arm with ball joint, brake expander unit, handbrake cable clip and the housing outer tracta oil seal.

(n) Refill the outer tracta joint and hub with one and a half (1½) pints of oil.

(o) Replace the brake drum and adjust the brakes in accordance with VEH N 403/1-1. Replace the roadwheel.

49. Renewal of road wheel studs:-

Dismantle the hub in accordance with para 47 (a) to (g). Draw the hub off the carrier with the outer roller bearing. DO NOT disturb the inner bearing or oil seals. The wheel studs are held and locked in position by means of the ring retaining wheel studs, the ring being riveted to the hub by eight 1/8 inch csk. hd. iron rivets snapped over on the inside. Whenever wheel studs require renewing the ring retaining studs will be removed from the hub by shearing the snap heads on the inside of the hub. Under no circumstances will the retaining ring be forced open to allow the insertion of a single stud, otherwise it will remain buckled and will foul the brake assembly when the wheel is revolving. After renewing any damaged studs, shape up the ring retaining with a hide or wood mallet, replace over the studs and secure with eight new rivets.

SUSPENSION

DISMANTLING

50. Jack up the hull and remove the following from the vehicle:-

- (a) Road wheel;
- (b) Spring and shock absorber, see para 37;
- (c) Outer tracta assembly, see para 43.

REMOVAL OF LINKS

51. To remove the suspension links it is necessary to remove only one bracket, suspension link. Should it be a rear wheel station, knock the pins out of the bracket nearest the rear hull plate and remove the inner bracket complete with the links. Similarly, if it is a front wheel station turn the steering hard over and knock the pins out of the link brackets nearest the steering lever, remove the inner bracket complete with links, suspension. Knock out the pins remaining in the links and release the attached bracket. All pins can now be checked with their respective bushes for wear.

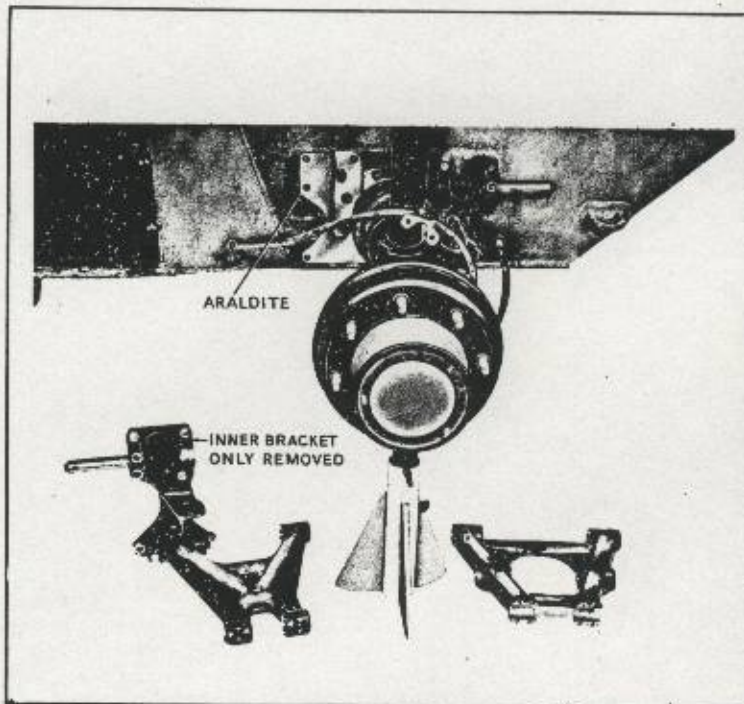


FIG. 23 - SUSPENSION LINKS - REMOVAL

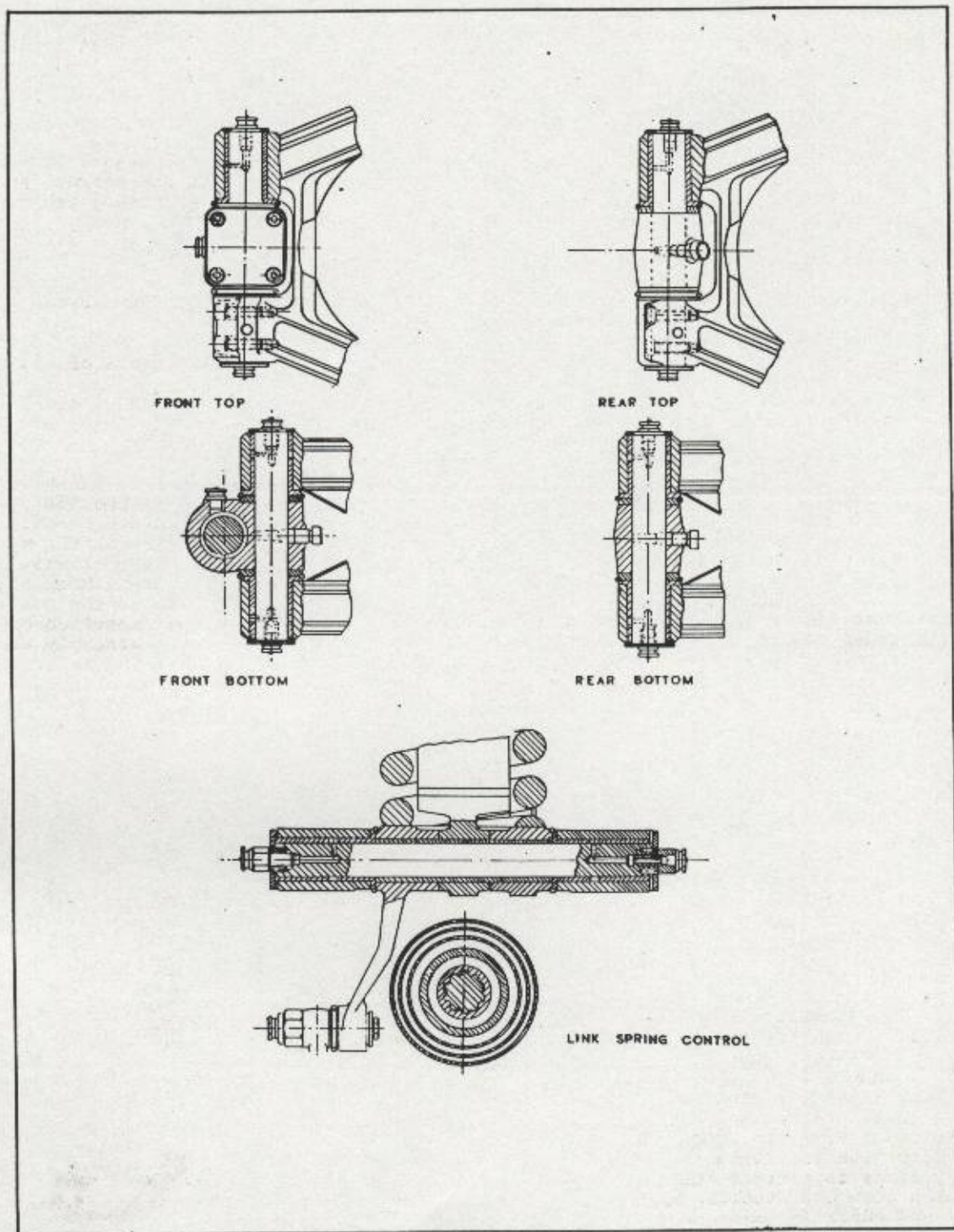


FIG. 24 - SUSPENSION PINS AND BUSHES - PART AND SECTIONAL VIEWS

Link bushes

52. Removal:-

Remove the old bushes by either pressing or punching them out of the links. Discard all the pins of the unserviceable bushes.

53. Renewal (Fig. 24):-

New bushes will NOT be driven in, they will be pressed in. If a suitable press is not available a large bench vice will press the bushes in satisfactorily. All the bushes in the link arms are in pairs except the top link outers. To ensure that all bushes are in correct alignment the pilot and bush shown at Fig. 25 will be manufactured locally and used with an expanding reamer, Fl/FA 16170.

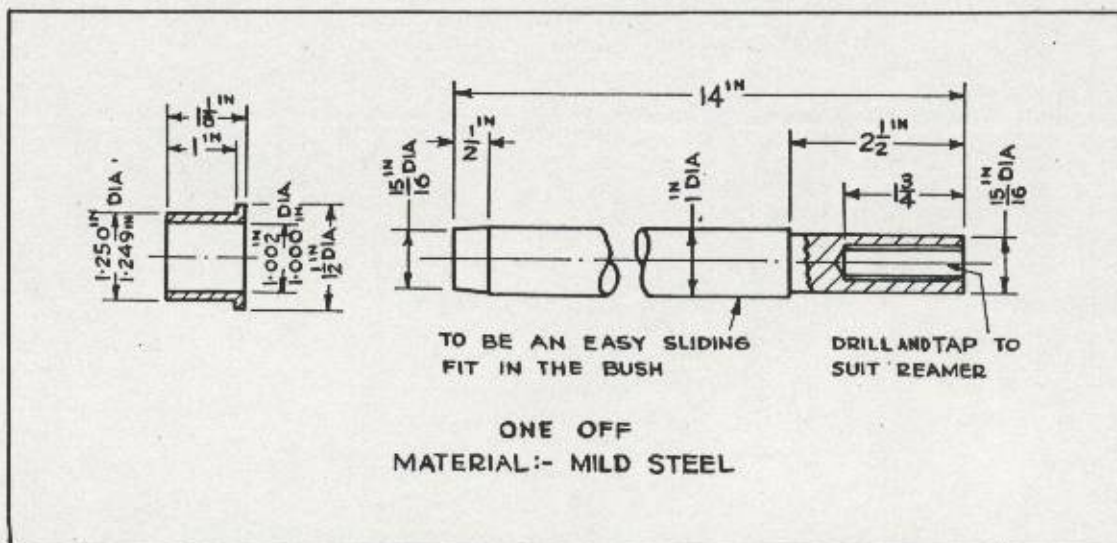


FIG. 25 - PILOT AND PILOT BUSH - REAMING SUSPENSION LINK BUSHES
(LOCAL MANUFACTURE)

- Press one pair of bushes into one arm of the link (one from either side).
- Insert the pilot bush in the opposite arm, pass the pilot through and screw it on to the reamer (Fig. 26).
- Ream the bushes to an easy push fit for the new pin.
- Remove the pilot bush and press in a pair of new bushes in the opposite arm.
- The pilot will now be guided by the first two bushes reamed at (c) so allowing the second pair of bushes to be reamed in alignment with the first pair (Fig. 27).
- When replacing the outer trunnion bushes clamp both the bush to be reamed and the pilot bush down tight by the caps before reaming.
- Remove any swarf that has lodged in the lubricant space between the paired bushes.

REPLACEMENT OF LINKS

54. Attach the bracket (which was removed from the hull) to the links by means of the pins. Smear the bolting face of the bracket with Bostik 'C' and bolt the bracket up to the hull slightly slack. This will allow the bracket to line up with the other link bracket (which was left bolted to the hull). When all the bracket pins are driven home, tighten all bracket screws, replace the lubricators and grease with LG-320. The links should move freely without binding or slackness.

REASSEMBLING SUSPENSION

- 55.(a) Renew the oil seal within the outer tracta shaft housing.
- (b) Lightly grease the inner tracta shaft sleeve with grease LG-280 to assist the oil seal to slide over the sleeve.
- (c) Offer the outer tracta joint and hub up to the inner tracta splined shaft, carefully engage them and feed the oil seal gently over the chamfered end of the inner tracta shaft.
- IMPORTANT. Note:** The inner and outer tracta shafts must be aligned with each other for assembly otherwise the oil seal mentioned in sub-para (a) will be damaged.
- (d) Push the outer tracta assembly home and bolt up the tracta housing flange joint at the centre.
- (e) Fit the top and bottom links to the trunnions.
- (f) Replace the shock absorber, spring and spring seat assembly, brake expander unit, steering rod (if applicable), wing, wiring and accessories and roadwheel. If the steering has been disconnected, check the front wheel toe-in in accordance with VEH N 403/1-1.

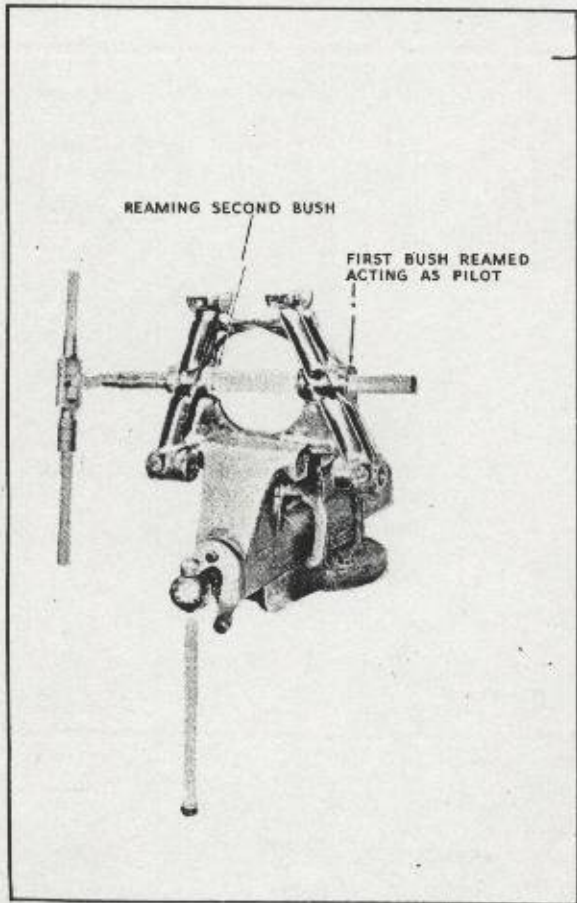
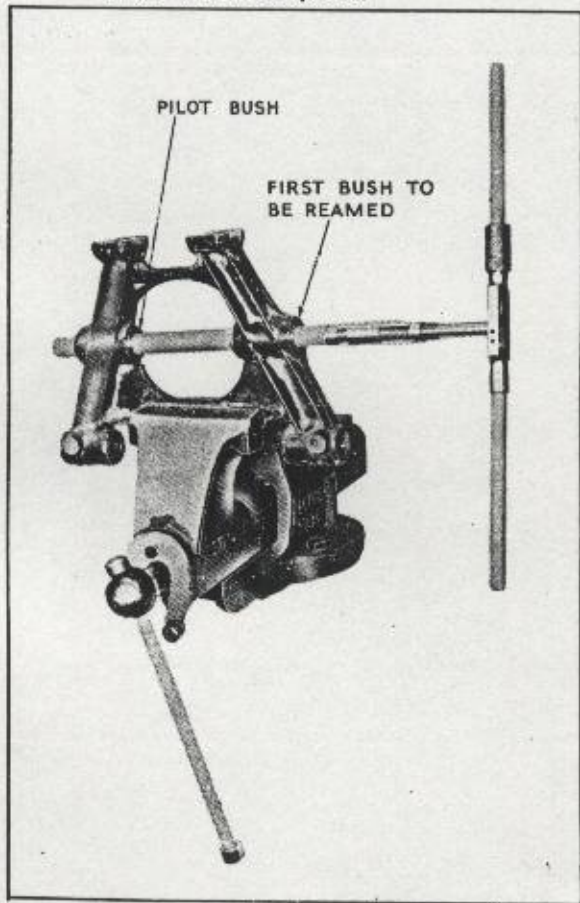


FIG. 26 - LINK BUSHES - LINE
REAMING - FIRST OPERATION

FIG. 27 - LINK BUSHES - LINE
REAMING - SECOND OPERATION

NOTE:- When link brackets are removed from the hull, the hard plastic material adhering to the hull side will NOT be removed. This material, known as 'Araldite', is put on by the vehicle manufacturers, its function being to fill in slight irregularities of the armour plate and present a flat bolting surface to the suspension brackets.

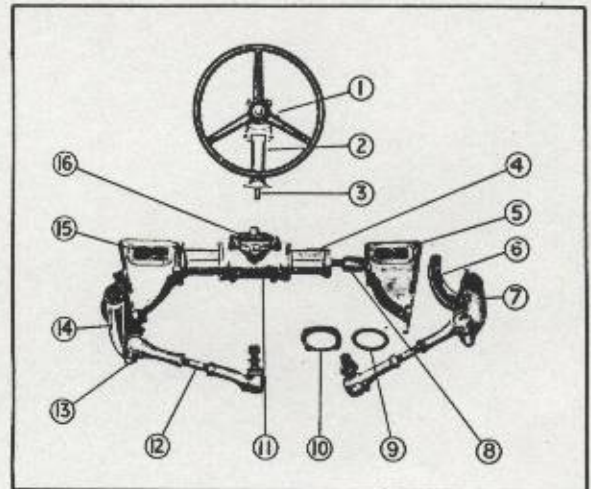
STEERING**STEERING GEAR****Removal:-**

- 56.(a) Drain the lubricant from the steering gear by removing the plugs from the base of the LH and RH inner steering lever casings.
- (b) Remove the cap nut and apply a small wheel puller to the steering wheel. This is mounted on a tapered shaft.
- (c) Disconnect the batteries. Detach the speedometer and tachometer cables at the instrument panel. Disconnect the hand throttle control and break all electrical connections at the snap couplings.
- (d) Remove the instrument and ignition panels.
- (e) Remove the four small access plates from the inner steering lever casings (LH and RH); remove the split pins and push out the link fork pins.
- (f) Disconnect the steering rods at the inner ball joint, remove the studs securing the outer steering lever casing and remove the casing complete with inner and outer steering levers from the hull.
- (g) Remove the six hex. hd. screws supporting the steering column. Lift the steering gear out of the hull.

Note:- Removal of the steering levers, inner and outer, is fully described in VEH N 403/1-1.

Dismantling to sub-assemblies (Fig. 28):-

- 57.(a) Steering wheel shaft - Remove the four screws and pull out the steering wheel shaft housing. Secure the shimming to the assembly.
- (b) Steering column - Remove the filler plug from the recirculating ball housing, turn the steering gear over and drain the lubricant. Replace the plug. Remove the four screws at the base of the steering column, gently tap the joint with a hide mallet and lift the column upwards to clear the splined shaft from the lower bevel wheel. Lift out the lower bevel wheel, complete, with its housing and bearing. Retain the shimming to this assembly.



1. Box, steering, bevel, upper
2. Column, steering
3. Shaft, steering column
4. Housing, extension
5. Casing, steering lever, inner, RH
6. Steering lever, inner
7. Casing, steering lever, outer
8. Link, recirculating shaft
9. Seal, rubber, steering case
10. Housing, seal
11. Housing, recirculating ball
12. Rod, steering, LH
13. Socket, steering rod
14. Steering lever, outer
15. Link, fork end, pin
16. Gear, bevel, steering, lower

FIG. 28 - STEERING GEAR LAYOUT

- (c) Recirculating ball housing - Remove the casing steering lever inner, RH and LH. Remove the housings and the extension steering links RH and LH retaining the shimming to both housings.

Dismantling to components (Figs. 29 and 30):-

- 58.(a) Steering wheel shaft assembly - Remove the Woodruff key, hold the shaft housing in the hand tap the shaft through with a hide mallet from the keyway end and press off the small ball bearing with the oil seal. Remove the two locknuts and press off the larger ball bearing carefully supporting the bearing housing as this is aluminium. Remove the bearing from its housing. To facilitate removal, immerse the housing in hot water for a few minutes.
- (b) Steering column assembly - Remove the four inverted screws from beneath the box, steering bevel flange and remove the box. Tap the splined end of the shaft driving the pinion, bearing and housing, out through the top of the column. Remove the locknuts, bearing and housing in a similar manner to sub-para (a). Remove the locknuts from the lower bevel pinion quill, press out the pinion and remove the bearing from the housing.
- (c) Recirculating ball housing assembly - Hold the housing over a clean container, pull the shaft recirculating out (either end) and allow the anti-friction balls (57) to drop into the container. Under no circumstances will the race recirculating ball be driven, tapped, or pressed from the housing. Normally a vigorous shake will slacken the roller race cups. Should they remain tight in the housing place the housing in hot water for a few minutes, then remove the roller race cups, race recirculating, rollers and cones.

Reassembly

59. **IMPORTANT. Notes:** 1. It is possible to assemble three components incorrectly, any of which may not be apparent until the complete assembly has been bolted into the hull. These are:-
- The race circulating can be assembled right to left and will give reverse steering.
 - The recirculating shaft must be replaced so that its transfer port face is at the top when the assembly is fitted in the hull.
 - The anti-friction balls are fed into the three centre ball runs only when replacing the shaft, the two outer runs are blind, having no transfer port.
2. This steering gear must be assembled with the minimum of backlash in the bevel wheels and pinions, but with complete freedom of movement. Therefore, ensure that all components are clean and dry, examine the face joints of all the aluminium castings for burrs or bruises. When fitting shims ensure that they are flat for upon these depend the fitting and meshing of the bevels and pinions. The ball, roller bearings and the recirculating balls may be lightly oiled with OEP-220; proceed as follows:-
- Press the roller bearings and cones on to each end of the race recirculating ball, insert the race into the housing with its bevel wheel to the right hand side, fit a roller bearing cup to both ends, and centralise the recirculating race in the housing. These two roller bearings must be pre-loaded to 0.002 inch by means of the shimming as follows: Fit LH and RH housing extension, steering links to the recirculating housing with 0.040 inch shims in both sides to commence with, check the recirculating housing for free rotation without endfloat (this may require more or less shimming). Remove or replace the shims as near as possible by an equal amount at both joints until this condition is attained. Then remove one 0.002 inch shim from the LH side. Leave the LH housing extension off.
 - Turn the recirculating housing to the vertical position with the RH housing extension to the bottom. Insert the recirculating shaft into the housing from the top and feed 19 balls into each of the second, third and fourth grooves in the shaft, pushing the shaft down into the housing as each groove becomes full (see Fig. 31).

1. Roller, steering link (4)
2. Bush, steering link (8)
3. Lever, steering, outer
4. Link (fork end)
5. Pin, joint, link to shaft
6. Lever, steering, outer
7. Bush, steering link
8. Pin, joint, link to lever
9. Link
10. Plate, inspection (4)
11. Seal, rubber (2)
12. Housing, seal
13. Housing, extension LH
14. Shaft, recirculating ball
15. Bearing, taper roller (2)
16. Race recirculating, incl bevel wheel
17. Ball, steel, anti-friction, 1/4 incl dia (57)
18. Bevel wheel including race
19. Housing, recirculating ball
20. Housing, extension RH
21. Casing, steering lever, inner RH
22. Ring, sealing hull
23. Casing, steering lever, outer RH
24. Lever, steering outer, RH

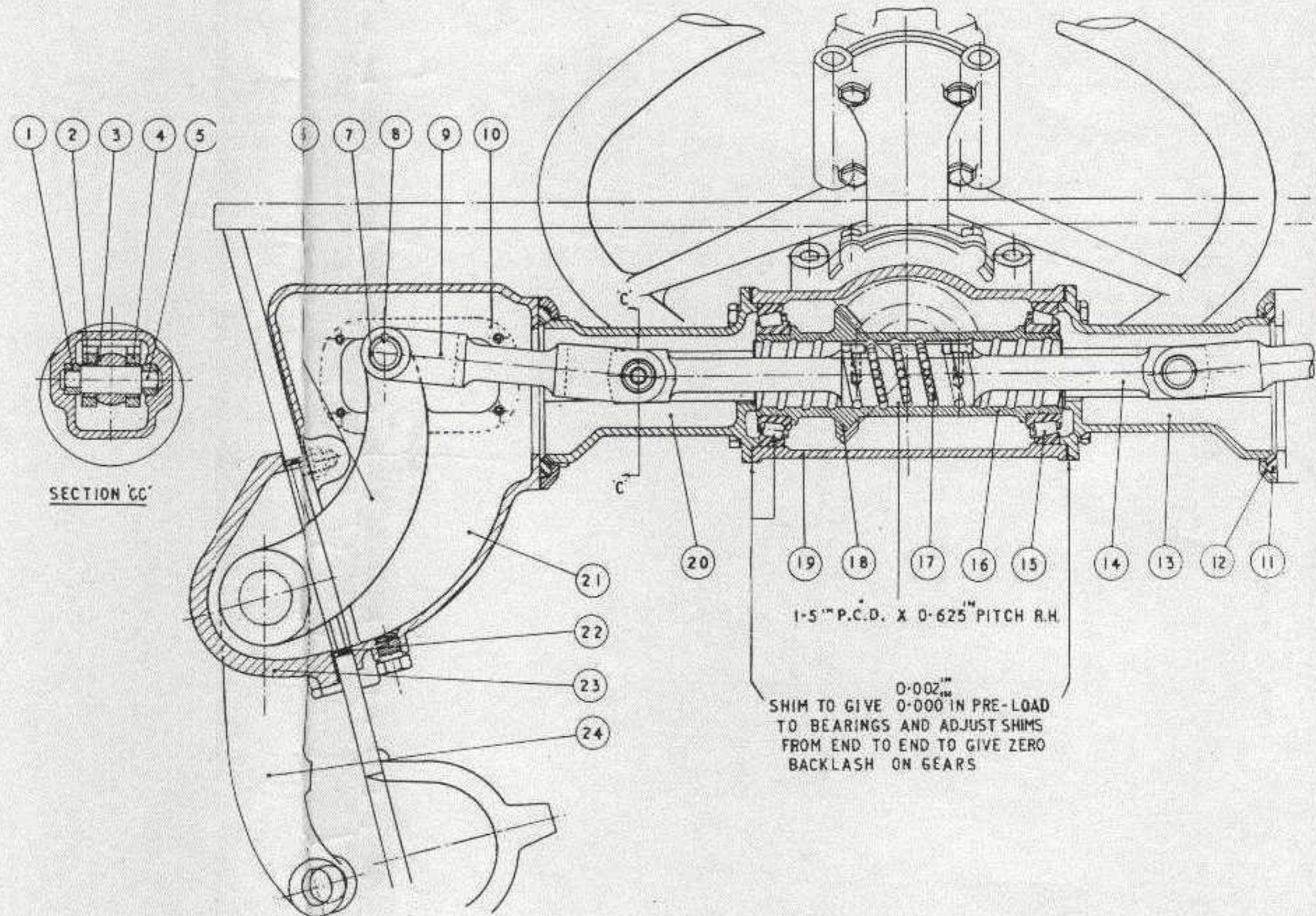


FIG. 29 - STEERING GEAR - GENERAL ARRANGEMENT - FRONT ELEVATION

1. Wheel, bevel, steering, lower
2. Bearing, ball
3. Housing, bearing, shimmed
4. Nut, locking, bearing (2)
5. Column, steering
6. Shaft and pinion, steering column
7. Seal, oil
8. Nut, locking, bearing (2)
9. Bearing, ball, column
10. Housing, bearing, shimmed
11. Box, steering, bevel
12. Plug, filler
13. Gear, bevel, upper with shaft
14. Housing, bearing, shimmed
15. Bearing, ball, 1-3/8 in. x 3 in. x 11/16 in.
16. Bearing, ball, 1 in. x 2-1/4 in. x 5/8 in.
17. Seal, oil
18. Key, woodruff No 11
19. Cap nut
20. Housing bearing
21. Plug, filler
22. Port, transfer, recirculating ball
23. Bevel wheel, race recirculating

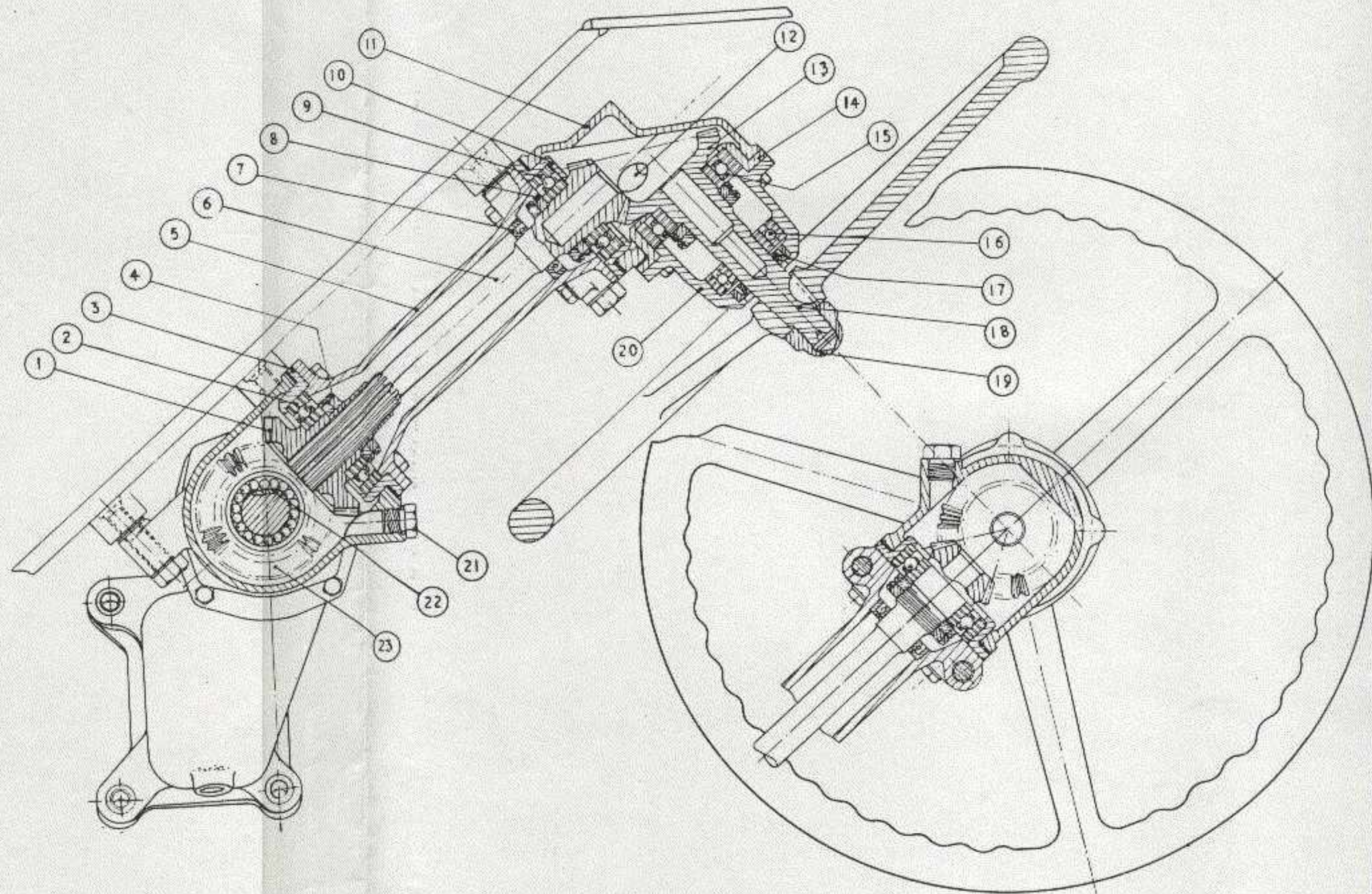


FIG. 30 - STEERING GEAR - GENERAL ARRANGEMENT - END ELEVATION

- (c) Pass the fork end of a steering link through the LH extension housing (this was not refitted, see sub-para (a)). Apply jointing compound to both faces of the joint, slip the selected shims on the flanged face side of the housing extension, connect the link fork end to the recirculating shaft, place the rollers on the fork pin and slide the extension into position. Tighten the screws. Reverse the position of the recirculating housing and fit the RH link, pin, rollers, shims and extension housing.
- (d) Press the ball bearing of the gear bevel lower, into its housing. Press the bearing and housing on to the lower bevel gear, replace and tighten the locknuts. Place the bevel gear in position in the top of the recirculating gear housing with a total of 0.020 inch shimming between the face joint. Reduce this shimming by trial and error (using four slave screws with plain washers) until the two gears mesh freely with a minimum of backlash. Remove the slave screws, apply jointing compound to the joints and place the steering column in position. Tighten the setscrews.
- (e) Steering column: Renew the oil seal in the top of the steering column with the skirt of the seal to the top. Assemble the bearing housing and locknuts to the steering column shaft pinion as sub-para (d). Place the shaft in the column ensuring that the splines do not damage the oil seal and engage the splines with the gear bevel steering lower. Place 0.015-0.020 inch of shims on the flange of the shaft pinion housing followed by the box steering bevel. Replace and tighten the four inverted screws. For the final adjustment of the shims, see sub-para (g).
- (f) Steering wheel shaft: Press the larger of the two ball bearings into its housing. Press this bearing with its housing up to the shoulder of the steering wheel shaft gear, fit the two locknuts and tighten. Renew the oil seal in the shaft housing, the skirt facing inward. Press the small ball bearing in behind the oil seal. Remove any sharp edges from the Woodruff key seating, press the shaft through the housing and apply jointing compound to the face joints before they meet.
- (g) Place 0.015-0.020 inch shimming on the steering wheel shaft flanged joint, replace and tighten the securing screws. Adjust the shimming at the steering wheel shaft and the column shaft joints by trial and error until there is free movement without backlash. When this is achieved, dismantle both shim joints, apply jointing compound, reassemble and tighten the screws. Fit the Woodruff key and replace the steering wheel.

Test

60. Bolt the steering assembly to the angle-plate (as shown in Fig. 32) but with the steering column in the horizontal position and the housing, recirculating ball, vertical. Hang a 56 lb. weight on the lower link fork end. Draw the weight up by turning the steering wheel, release the wheel and the weight should go to the bottom (in 12-15 seconds) turning the steering wheel through the recirculating ball mechanism. Should the weight fail to turn the steering gear unaided, check the gear for tightness, paying particular attention to the meshing of the gear wheels.

Replacement

- 61.(a) For ease of replacement remove the box, steering bevel upper, complete with steering wheel from the column.
- (b) Slacken off the housings, rubber seals, and the LH and RH inner lever steering casings.
- (c) Position the steering gear in the hull and secure temporarily with two bolts at the top and bottom gear housings.
- (d) Insert the ring sealing. This goes in the hull aperture. Smear the bolting face on the hull side and face joint of the casing, outer lever, with Bostik 'C'. Replace the shims (if any). Bolt up the outer and inner lever casings tight. Carry out the same procedure on the opposite side.

- (e) Replace all the bolts securing the top of the column and the housing, recirculating ball, to the hull and tighten. Replace the box, bevel upper complete with steering wheel, sealing the joint face with sealing compound.
- (f) Tighten the housings rubber seals on the housing extensions. Refit the link fork end pins and replace the coverplates to the casing levers inner.
- (g) Fill the bevel box, upper and the housings, recirculating ball, each with one and a half ($1\frac{1}{2}$) pints of oil.
- (h) Replace the instrument and switch panels.
- (j) Check the front wheel alignment in accordance with VEH N 403/1-1.

WORKSHOP SPECIAL TOOLS

62. FV 51456 Spanner 'C' steering locknuts.

ELECTRICAL SYSTEM

STARTER MOTOR NO 1, MK 1 AND NO 1, MK 2

(Removal/Replacement - see VEH N 403/1-1).

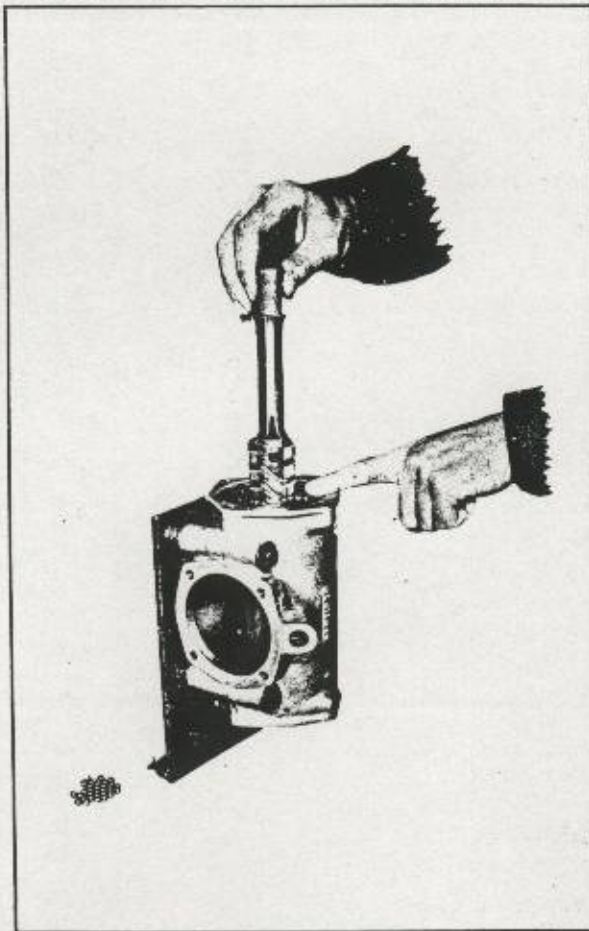


FIG. 31 - STEERING GEAR - ASSEMBLING
RECIRCULATING SHAFT, BALLS AND NUTS

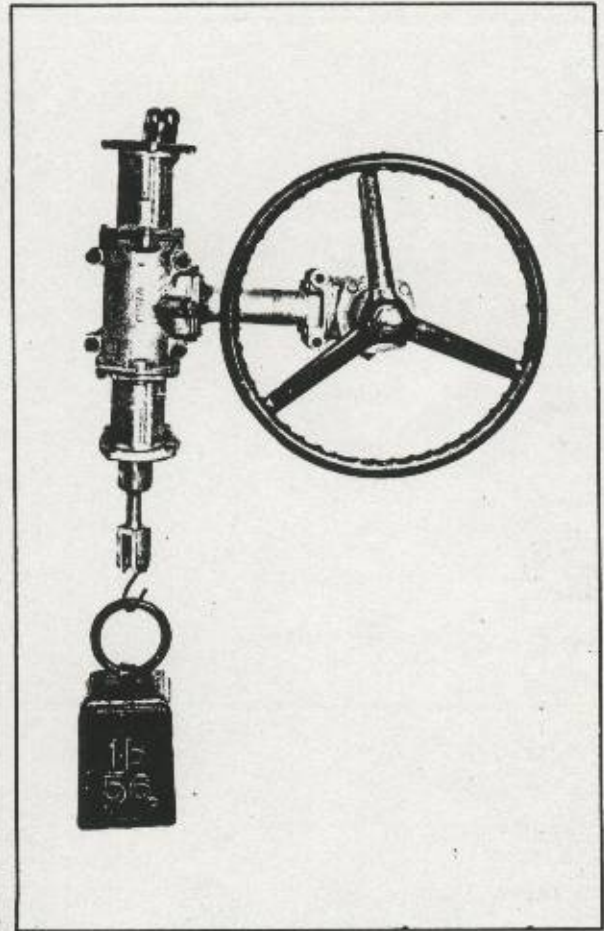


FIG. 32 - STEERING GEAR -
TEST RIG

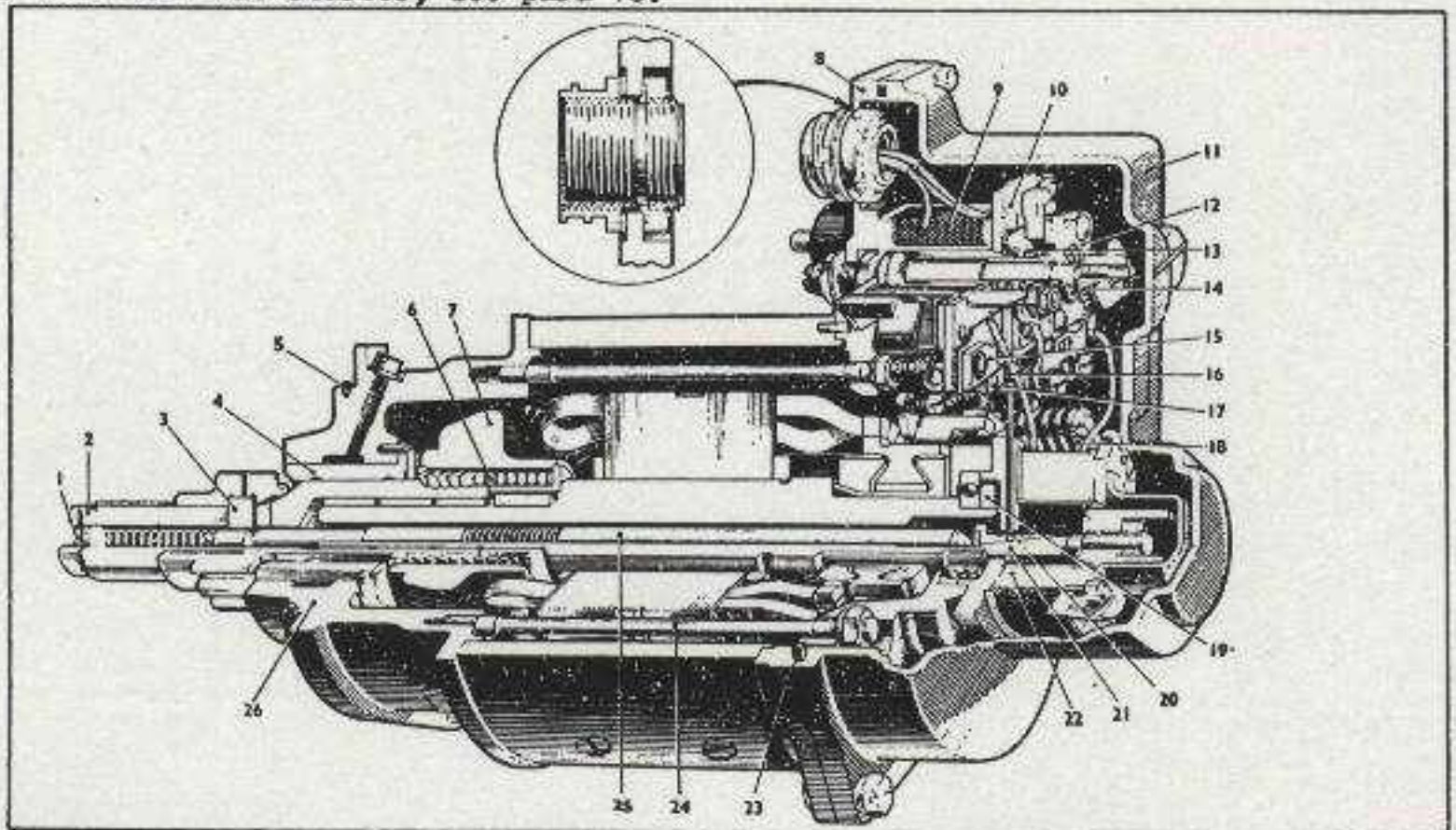
Solenoid switch**63. Removal (Fig. 33):-**

- (a) Remove the commutator end (C.E.) cover.
- (b) Disconnect the heavy and light engagement coil leads. Disconnect the short lead from the negative terminal.
- (c) Remove the ring nut from the plug on the terminal plate and push the plug through the plate.
- (d) Remove the nut from the special slotted screw located between the main terminals, and withdraw the switch.

64. Replacement:-

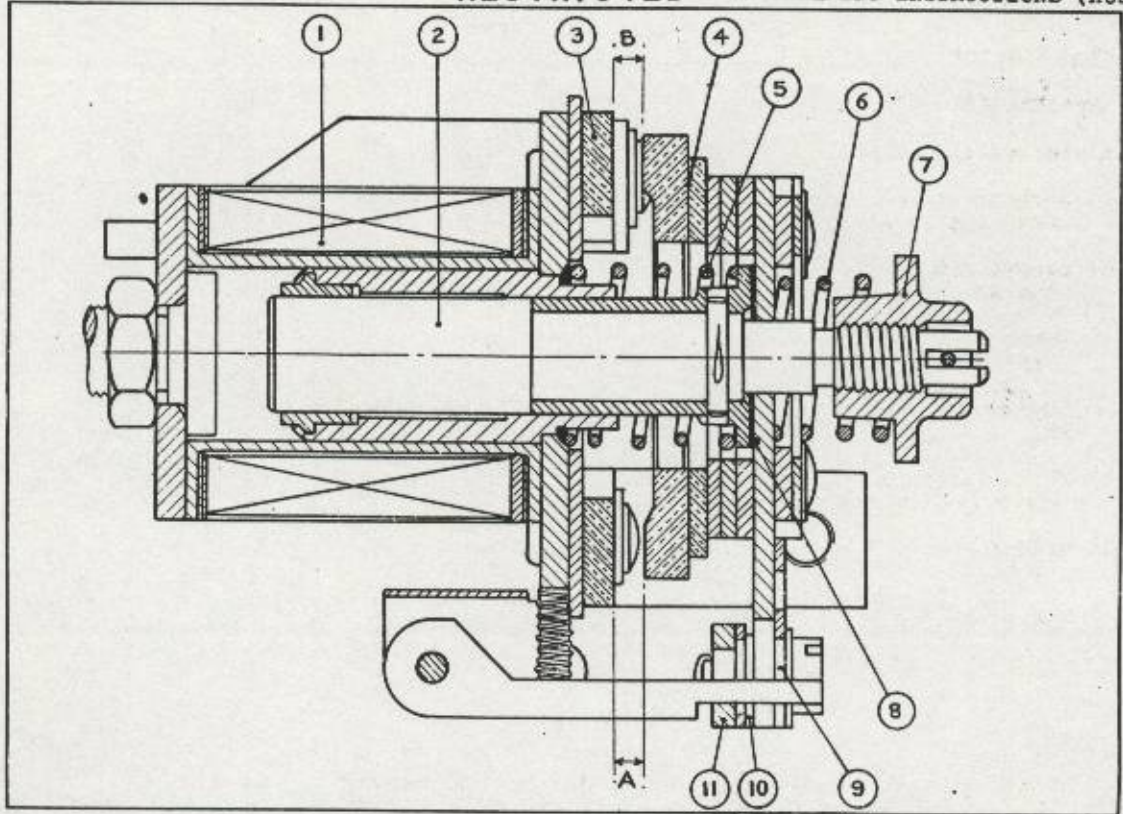
Replace in the reverse order noting the following points:-

- (a) Place the rubber sealing ring of the special screw in the recess of the terminal plate before replacing the switch. Apply a little silicone sealing compound.
- (b) Ensure that the trip pin is in position within the engagement solenoid yoke before replacing the switch.
- (c) Seal test the starter, see para 78.



- | | | |
|-------------------------|-----------------------------|---------------------------------|
| 1. Retaining plug | 10. First contact | 18. Heavy engagement coil |
| 2. Retaining pin | 11. C.E. cover | 19. Shaft nut |
| 3. Pinion key | 12. Moving contact assembly | 20. Trip pin |
| 4. Bush, bearing | 13. Return spring | 21. Trip plunger |
| 5. Sealing ring | 14. Contact spring | 22. Light engagement coil |
| 6. Drive spring | 15. Second contact (fixed) | 23. Sealing ring |
| 7. Hub | 16. Trip lever spring | 24. Tie-rod |
| 8. Commutator end-plate | 17. Trip lever | 25. Pinion engagement mechanism |
| 9. Switch coil | | 26. D.E. plate |

FIG. 33 - STARTER MOTOR NO 1, MK 2 - GENERAL ARRANGEMENT



1. Coil, switch solenoid
2. Armature
3. Contacts, fixed
4. Contacts, moving
5. Spring, return, contact
6. Spring, contact

7. Nut, retaining
8. Washers, packing, armature
9. Adjusting plate
10. Washers, packing, trip lever
11. Trip lever stop

FIG. 34 - STARTER NO 1, MK 2 - STARTER SWITCH ASSEMBLY

65. Dismantling (Fig. 34):-

- (a) Remove the split pin, nut and spring from the switch armature.
- (b) Remove the two locknuts and coned nuts. Take off the moving plate contact, armature, spring and packing washers. Collect the small spring from beneath the trip lever.

66. Checks to be carried out:-

- (a) Examine the fixed and moving plate contacts. Should the contacts be badly burnt, renew the complete unit. Reface contacts that are slightly burnt.
- (b) Test the solenoid coil (resistance 2.5 ohms).
- (c) Lightly lubricate the armature with grease XG-271.
- (d) Ensure that the free length of the trigger spring is 3/8 inch.

67. Reassembly:-

Reassemble in the reverse order to para 65. When replacing the contact spring retaining nut, screw the nut down until it just touches the spring, then give the nut a further 1/2 to 3/4 turn. Insert the split pin and adjust as follows:-

- (a) Adjust gap 'A' by varying the number of 'Washers packing trip lever' so that gap is 0.7 mm minimum when gap 'B' is closed and trip lever is engaged with trip lever stop.
- (b) When first contact is closed by hand and trip lever is engaged with the stop, there must be 2.3 to 2.6 mm further armature movement to bring the armature fully home. If necessary adjust by varying the number of 'Washers packing armature'.

NOTE:- 1. The trip lever stop group should not normally require dismantling. Fig. 35 shows the correct assembly sequence of this unit.
2. Seal test the starter, see para 78.

Motor

68. Dismantling:-

- (a) Remove the solenoid switch, see para 63.
- (b) Remove the cap and the front plate of the engagement solenoid.
- (c) Withdraw the solenoid coils and the three insulating washers.
- (d) Remove the solenoid body complete with the engagement armature and trip plunger. Tilt the motor and withdraw the thrust rod spring with buffer rod and push-rod.
- (e) Disconnect the two links connecting the brush boxes. Wedge the brushes in the boxes with the brush springs.
- (f) Slacken the locking screw in the split nut on the armature shaft (C.E.) and remove the nut.
- (g) Remove the four tie-rod nuts at the C.E. plate and the four socket screws at the drive end (D.E.) housing. Remove the D.E. housing with the drive assembly. Tap out the armature with a hide mallet.

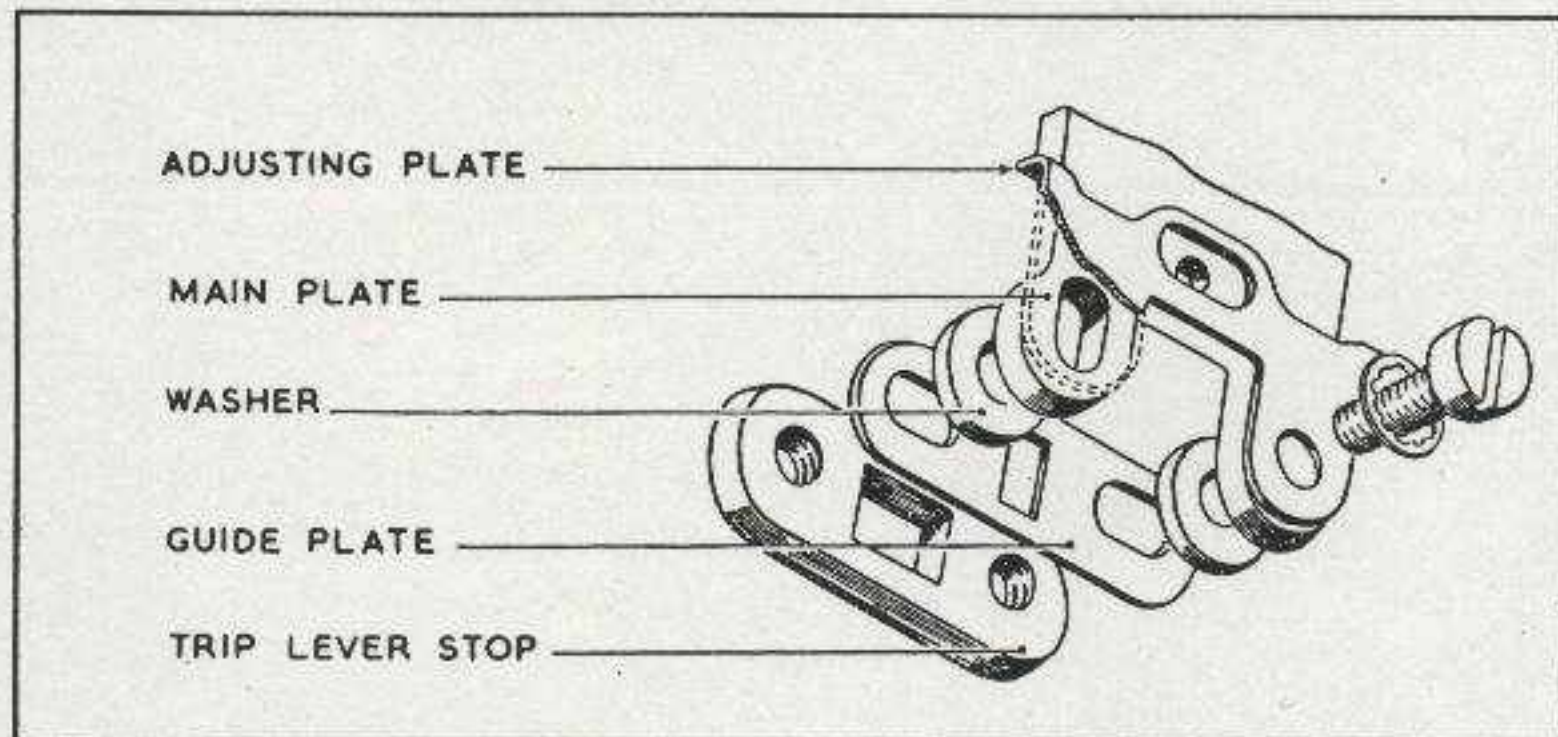
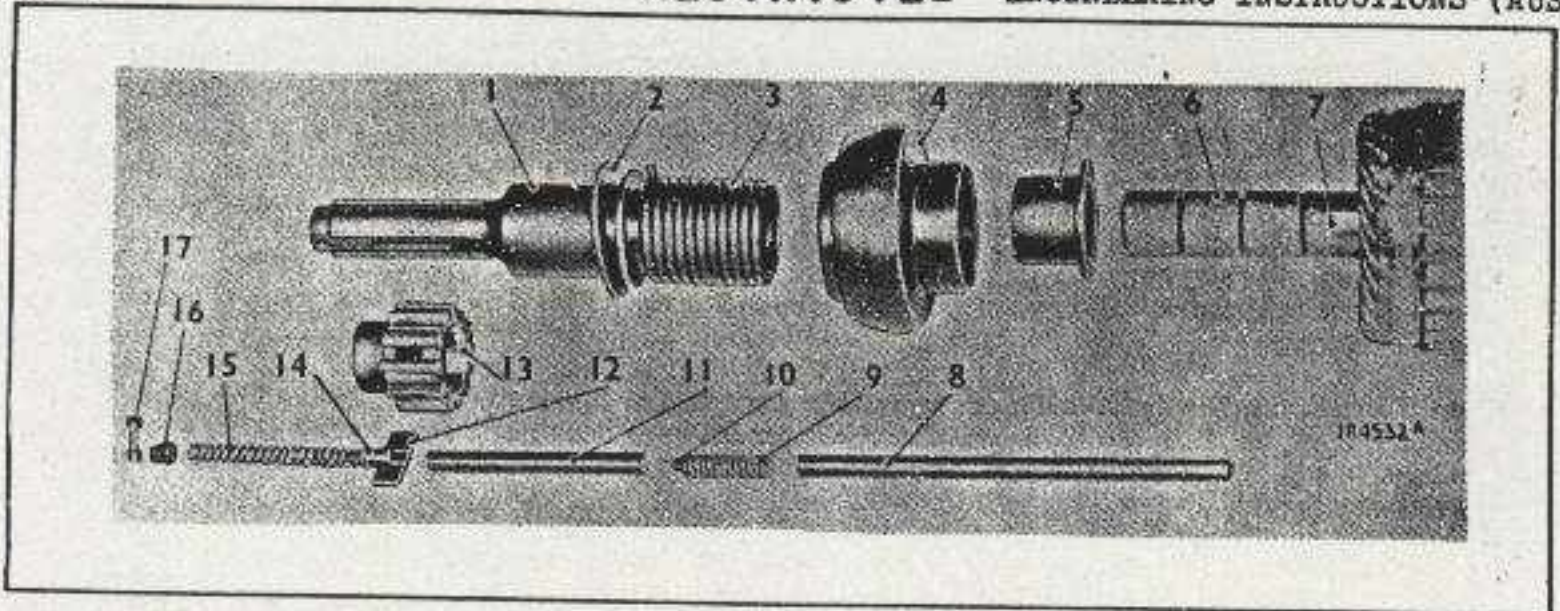


FIG. 35 - STARTER NO 1, MK 2 - TRIP LEVER STOP GROUP ASSEMBLY



- | | | |
|---------------------|-------------------------|--------------------|
| 1. Pinion sleeve | 7. Retaining sleeve key | 12. Key |
| 2. Thrust washer | 8. Thrust rod | 13. Pinion |
| 3. Drive spring | 9. Buffer spring | 14. Spring pad |
| 4. Hub | 10. Buffer rod | 15. Return spring |
| 5. Retaining sleeve | 11. Push-rod | 16. Retaining plug |
| 6. Oilite bush | | 17. Retaining pin |

FIG. 36 - STARTER MOTOR NO 1, MK 2 DRIVE - PINION ENGAGEMENT MECHANISM

69. Check the following:-

- (a) Security of brush boxes.
- (b) Freedom of brushes in their boxes.
- (c) Brush spring pressure (replace if below 1 lb.).
- (d) Test the field and engagement coils for shorts or broken circuits.
- (e) Armature connections for thrown solder.
- (f) Commutator for pitting and wear.
- (g) The bushes at the D.E.

70. Reassembly:-

Reassemble in the reverse order to para 68 noting the following points:-

- (a) Quarter fill the C.E. ball bearing with grease XG-271. Lightly grease the push-rods, buffer rod end spring and D.E. bushes with the same lubricant.
- (b) Apply Bostik 772 to the face joints of the yoke.

Driving end (Salisbury drive)

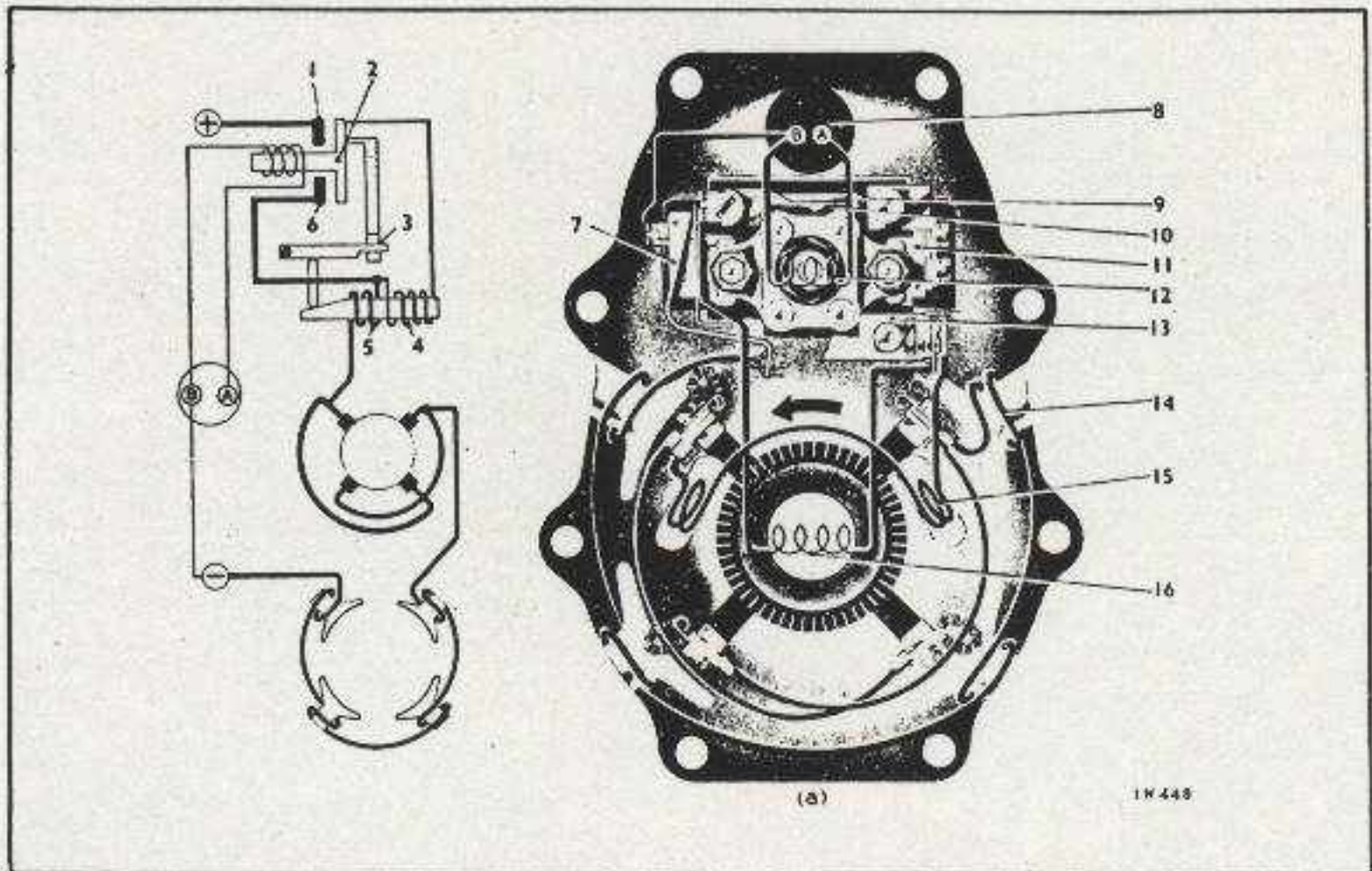
71. Removal:-

Note:- The driving end can be removed without disturbing the armature, brush gear, or engagement solenoid; but the switch assembly must be removed as it masks the nut of the top tie-rod.

- (a) Remove the C.E. cover.
- (b) Remove the switch assembly (para 63).
- (c) Remove the four tie-rod nuts at the C.E. plate and the four socket screws at the D.E. housing.
- (d) Remove the D.E. housing with drive assembly.

72. Replacement:-

Replace in the reverse order.



- | | | |
|----------------------------|-----------------------------|---------------------------|
| 1. First contact | 7. Negative terminal | 13. Second contact plate |
| 2. Moving contact assembly | 8. Plug | 14. Field coil |
| 3. Trip mechanism | 9. First contact plate | 15. Heavy engagement coil |
| 4. Light engagement coil | 10. Moving contact assembly | 16. Light engagement coil |
| 5. Heavy engagement coil | 11. Positive terminal | |
| 6. Second contact | 12. Switch coil | |

(a) View from commutator end

FIG. 37 - STARTER MOTOR NO 1, MK 2 - CONNECTION DIAGRAM

73. Dismantling (Fig. 36):-

- (a) Push the plug into the splined shaft, remove the pin, withdraw the plug and spring, push the key out of the pinion wheel and remove the pinion.
- (b) Grip the hub in the left hand and with the right hand twist the shaft clockwise and pull. This will separate the four components of the drive.

74. Reassembly:-

Lubricate all components with grease XG-271. Replace the drive spring on the pinion sleeve by twisting clockwise. Enter the spring into the hub engaging the spring tang in the slot of the hub. Press in the retaining sleeve. Insert the drive in the D.E. housing.

NOTE:- Ensure that the thrust rod, buffer spring with rod and push-rod are in position in that order within the armature shaft. Seal the D.E. housing with Bostik 772 and seal test the starter in accordance with para 78.

Mechanical adjustments

75. Pinion wheel position:-

The distance from the engagement end of the pinion to the face of the D.E. flange must be within 1.862 to 0.885 inch. Adjust by means of the locknut and screw within the solenoid armature at the C.E.

76. Switch trip adjustment:-

Press the switch moving contact against the trip lever stop. Push in the engagement solenoid armature until the switch is released by the trip lever. Release should occur when the solenoid armature projects 0.118 to 0.197 inch (3 mm to 5 mm) from the front plate. To reset the trip lever (see Fig. 35):-

- (a) Slacken off the trip lever stop screws.
- (b) Adjust the guide plate horizontally to hold the lever in line with the pin.
- (c) Set the trip lever stop by moving the adjusting plate vertically (using a small pin punch) until the switch trips at the armature setting given above. Tighten the screws.

Electrical tests (Fig. 37)

- 77.(a) Switch - Energize the switch coil with a current not exceeding 6A. The plunger should be pulled through its complete travel. Should the plunger movement cease when the fixed and moving contacts make, ie, without having completed its full travel, it indicates that either the plunger follow through is excessive or the spring retainer nut has been over-tightened.

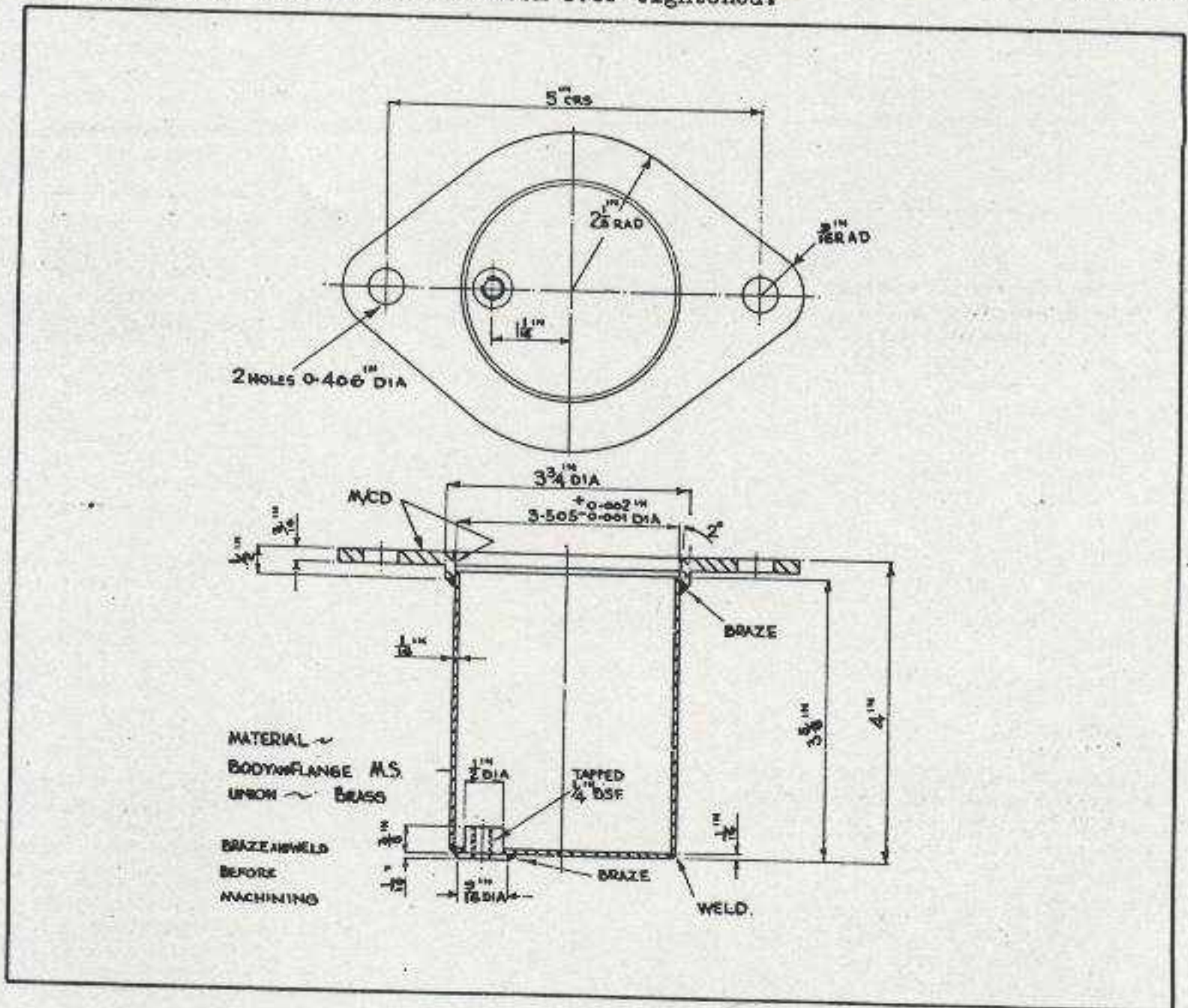


FIG. 38 - STARTER MOTOR NO 1, MK 2 - COVER, SEAL TESTING, DRIVING END (LOCAL MANUFACTURE)

NOTE:- On starter motors No 1, Mk 1 not incorporating Mod No 3, the current required for complete travel of the plunger must not exceed 4.9A.

Test the insulation between contacts and frame.

(b) Motor:-

- (i) Test the insulation resistance between the 'neg' terminal and the carcass using a 500V Megger. The insulation resistance should not be less than one megohm.
- (ii) Run the motor on no load from a 24V battery. After 15 seconds the current should not exceed 40-45A with a terminal voltage of 23V. The speed should be 4,500 r.p.m. (approx). The pinion should not be released from the engagement position until the current is less than 55A.
- (iii) With the pinion locked against rotation, the current draw should be 600A with a P.D. across the terminals of 15.5V. Under these conditions the drive spring should not slip. The locked torque test should be taken as quickly as possible to avoid overheating the windings.
- (iv) Re-check the switch tripping position and repeat tests (ii) and (iii) should it be necessary to re-set the switch.

Seal test

78. After the starter has been bench tested, fit the seal cover (Fig. 38) on the driving end flange. Using outfit 'A' seal testing, pump up to 6 lb/sq.in. and immerse the assembly in water for 15 minutes, the pressure must not fall below 5.75 lb/sq.in.

STARTER MOTOR NO 1, MK 2/1

(Removal/Replacement - see VEH N 403/1-1)

Solenoid switch

79. Removal:-

- (a) Remove the commutator end (C.E.) cover.
- (b) Disconnect the main field coil, auxiliary field leads and the positive terminal connection from the switch.
- (c) Remove the switch plug from the C.E. plate.
- (d) Disconnect the switch lead from the brush connection.
- (e) Remove the switch securing nut located between the main terminals and withdraw the switch.

80. Replacement:-

- (a) Replace in the reverse order, applying silicone sealing compound to the sealing washers of the switch plug, switch stud and C.E. cover.
- (b) Seal test the starter, see para 78.

81. Dismantling (see Fig. 39):-

- (a) Remove the armature nut and withdraw the nut locking plate, catch plate, insulating bush, flat spring, moving contact, adjusting washers and the return spring. Note the number and thickness of adjusting washers.
- (b) Remove the coil spring from beneath the trigger.
- (c) Withdraw and clean the moving contact. If badly pitted or burnt, renew or reface. See Fig. 39(a).

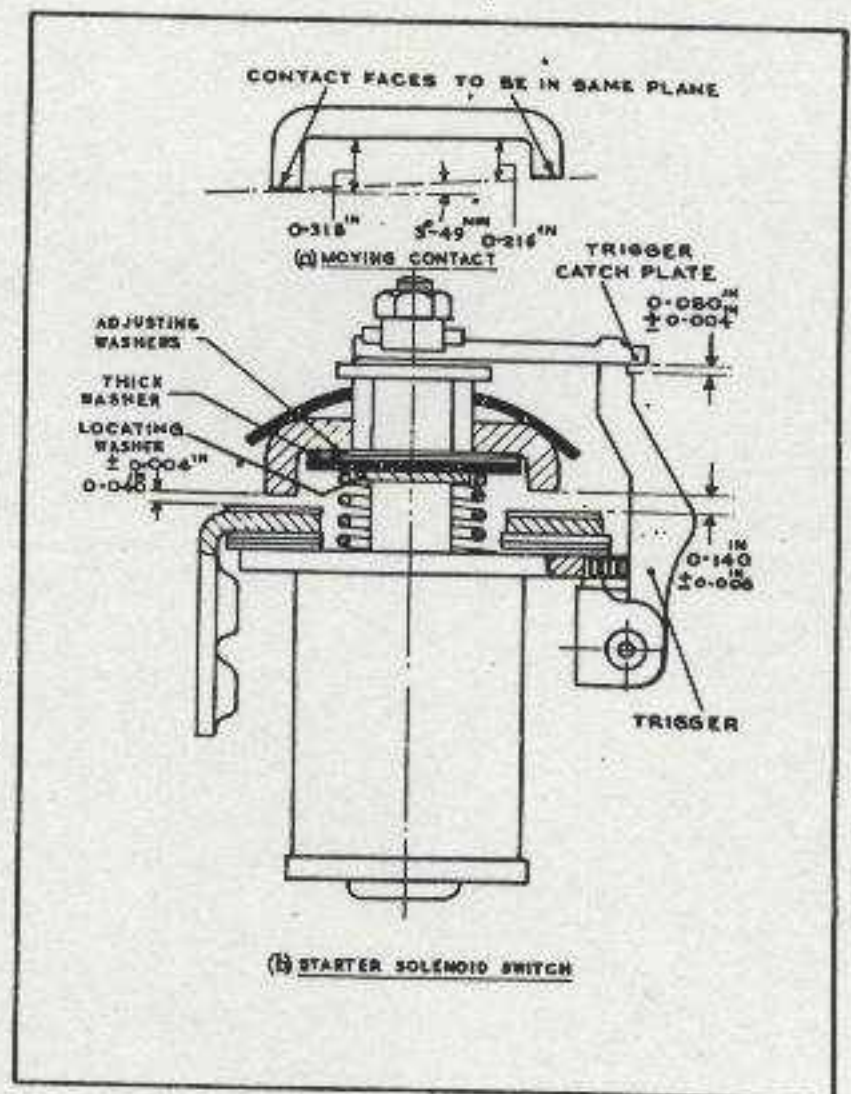


FIG. 39 - STARTER MOTOR NO 1,
MK 2/1 - SOLENOID SWITCH SETTING

NOTE:- Limit of refacing, 0.015 inch.

- (d) Clean the fixed contacts. Reface or renew burnt or pitted contacts.
NOTE:- New contacts must be faced by skimming after fixing to the contact plate.
- (e) Check the trigger spring and armature return spring. Armature return spring: pressure of 2 lb 14 oz to 3 lb 8 oz when compressed to a length of 1/2 inch. Trigger spring: free length 13/32 inch.
- (f) Check the resistance of the solenoid coil (approximately 8 ohms).

82. Reassembly:-

Reassemble in the reverse order, applying a thin film of grease XG-271 to the plunger and contact surface of the flat spring.

- NOTES:-
1. Replace the moving contact so that the greater gap is adjacent to the trigger.
 2. Replace the armature washers (see Fig. 38 (b)) and adjust the contact gaps to the limits shown. Adjusting washers are supplied in thickness of 0.004, 0.008 and 0.012 inch. The thick washer or locating washer must not be removed to obtain correct adjustment.
 3. Check the trigger gap, see Fig. 38(b) and adjust by bending the trigger catch plate.

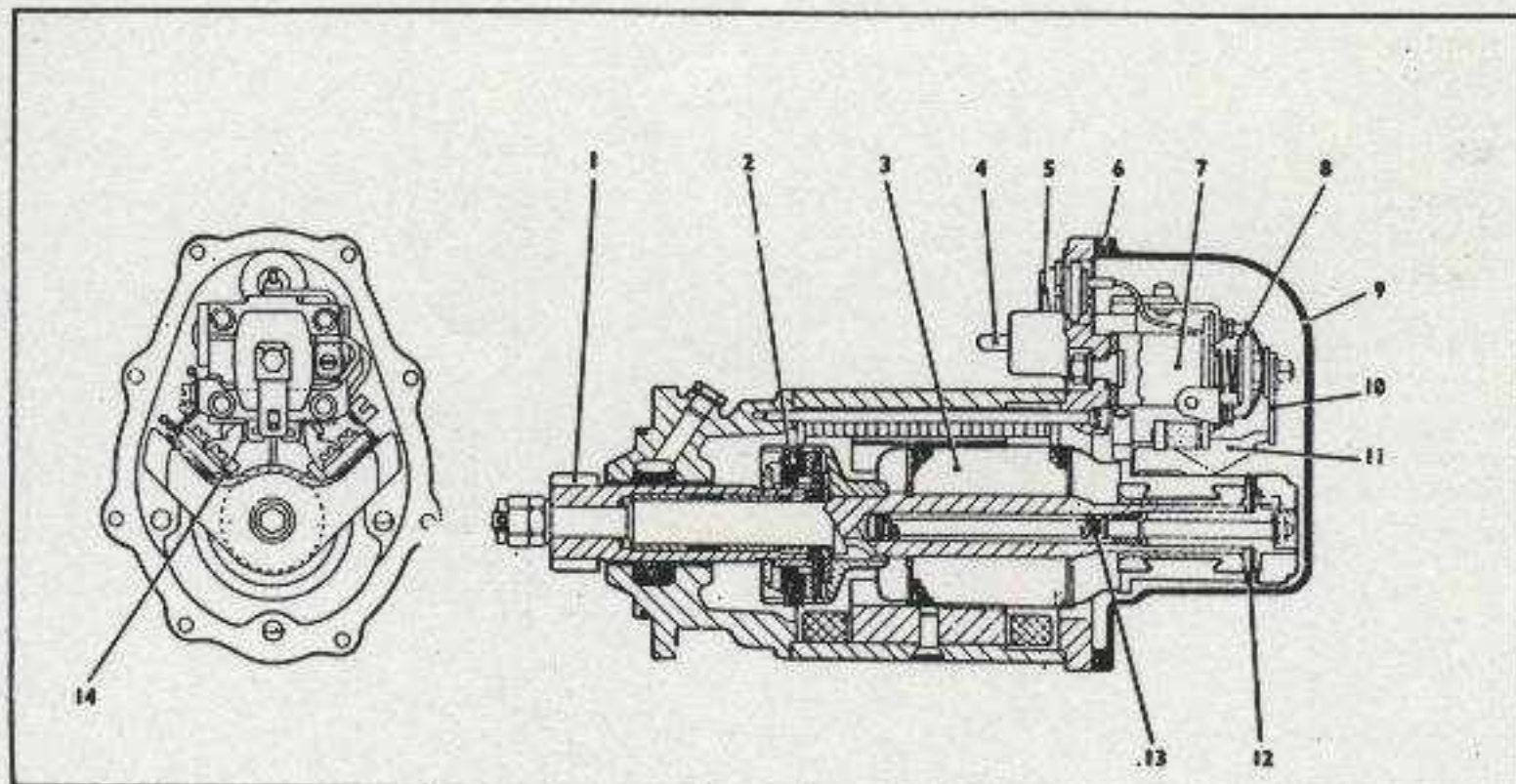
83. Checks after reassembly:-

- (a) Pressure to overcome return spring in the 'off' position must be between 2 lb 10 oz and 3 lb 14 oz.
- (b) Force to overcome total spring pressure when both contacts have closed must be between 14½ and 17½ lb.
- (c) Force to overcome spring tension of trigger applied at peak of tripping face with the switch in the 'off' position must be between 7 and 10½ oz.
- (d) When trigger is tripped at 12 to 15V, the switch must make on both contacts.
- (e) Apply 48V to the switch for a few seconds. The trigger should prevent the second contacts from making. Faulty assembly or rounding of the trigger stop will cause the trigger to slip.

Motor

84. Dismantling (Fig. 40):-

- (a) Remove the solenoid switch, see para 79.
- (b) Wedge the brushes in their boxes with the brush springs.
- (c) Remove the armature plunger nut.
- (d) Remove the tie-rod bolts from the C.E. end and withdraw the armature with the D.E. shield.
- (e) Remove the pinion nut, washers, pinion, the thin washer and pinion spring. Withdraw the pinion with care to avoid damage to the pinion lubricator pad.
- (f) Remove the D.E. shield from the armature and withdraw the clutch assembly.
NOTE:- Do not remove the clutch housing from the armature shaft.
- (g) Should dismantling of the clutch be necessary, withdraw the two pressure plates, the back ring shims and rear brass clutch plate. Lever out the spring ring and remove the remaining clutch plates and the two initial pressure springs.
- (h) Remove the armature plunger using dismantling tool, LV6/MT4 SER 2.



- | | | |
|--------------------------|---------------------|-------------------------|
| 1. Pinion | 6. Seal, C.E. cover | 10. Trigger catch plate |
| 2. Clutch assembly | 7. Solenoid switch | 11. Trigger |
| 3. Armature | 8. Moving contact | 12. Tripping plate |
| 4. Main terminal | 9. C.E. cover | 13. Armature plunger |
| 5. Plug, solenoid switch | | 14. Brush box |

FIG. 40 - STARTER MOTOR NO 1, MK 2/1 - GENERAL ARRANGEMENT

85. Checks to be carried out:-

- Check the tightness of the brush boxes and renew defective brushes. Check that the pressure of the brush springs is 2 lb 10 oz to 3 lb 5 oz.
- Apply a volt-drop test to the armature and examine for thrown solder.
- Test the main auxiliary series and auxiliary shunt windings.
Resistance of auxiliary shunt winding: 1.80 ohms.
Resistance of auxiliary series winding: 2.56 ohms.
- Examine the pinion for wear. Apply grease XG-271 to the pinion and spring.
- Examine the clutch plates, pressure plates, sleeve and fibre thrust washer. Apply a thin film of grease XG-271 and reassemble the clutch.

- NOTES:-
- Assemble the brass and steel plates alternately commencing with a steel plate against the two initial pressure springs.
 - Replace the original shims between the rear brass clutch plate and the flat surface of the back ring.

- Reassemble the armature plunger, D.E. shield and pinion on the armature.

- NOTES:-
- Press in the lubricator pad when replacing the pinion.
 - Check the free movement of the pinion (1/16 to 3/32 inch with the nuts fully tightened).

- Clamp the armature and, with a radius arm on the pinion articulate the clutch (10 to 12 times). Place weights on the radius arm. The clutch should slip with a load of 80 to 100 lb.ft. Adjust by shimming between the rear clutch plate and the back ring. Articulate the clutch before each test.

86. Reassembly:-

Reassemble in the reverse order to sub-paras 84 (a) to (h).

- NOTES:-
1. Apply Bostik 772 to the face of the D.E. shield when replacing the armature in the carcass.
 2. Lubricate at the D.E. with oil OMD-60 (20 to 25 drops).

87. Testing:-

- (a) Test the insulation between the 'neg' terminal and the body: minimum resistance 1 Meg ohm.
- (b) Test the starter using a fully charged 24V battery.

Test	Approximate values		
	Current	P.D. across terminals	R.p.m.
1. Run on no load	55A	23.0V	4,000
2. Normal start (torque 16 lb.ft.)	380A	15.0V	1,300
3. Lock torque test	750A	9.0V	N11

NOTE:- Make test (3) quickly to avoid damage to the starter.

- (c) Seal test the starter, see para 78.

GENERATOR NO 2, MK 1 and NO 2, MK 2

(Removal/Replacement, see VEH N 403/1-1).

General

88. The generator is driven through an integral 2-speed epicyclic gearbox which automatically changes the speed of the generator armature at 2,000 r.p.m. (generator pulley speed). When the pulley speed is above 2,000 r.p.m. the armature speed is 1.545 times pulley speed. Under 2,000 r.p.m. pulley speed, the armature runs at 4.37 times pulley speed. The gearbox is force fed with lubricating oil from the main oil gallery of the engine, a restricting device controlling the flow to approximately 1/4 gallon per minute.

- IMPORTANT. Notes:-
1. A metal to metal oil seal of ground and mated parts is situated between the gearbox and armature. Under no circumstances will the seal be disturbed either by dismantling the gearbox further than that given in para 90, or by the removal of the armature. Special tools and jigs are required for the setting of the clutch pressure plate springs. Should the gearbox, oil seal, armature or field coils require attention, renew the generator.
 2. Should the generator be removed from the vehicle, or a new generator fitted, remove the hexagonal plug adjacent to the top oil feed elbow and prime the generator gearbox with 1/4 pint of engine oil immediately before starting the engine.

Oil leakage check

89. Examine the air outlet gauze on the top of the generator for traces of oil. If oil is present, remove the gauze and examine the internal surface, should there be more than a very light film of oil, the oil seal between the gearbox and generator is defective and the generator must be renewed.

Driving end bearings

90. Renewal (Fig. 41):-

Place the generator in a vertical position.

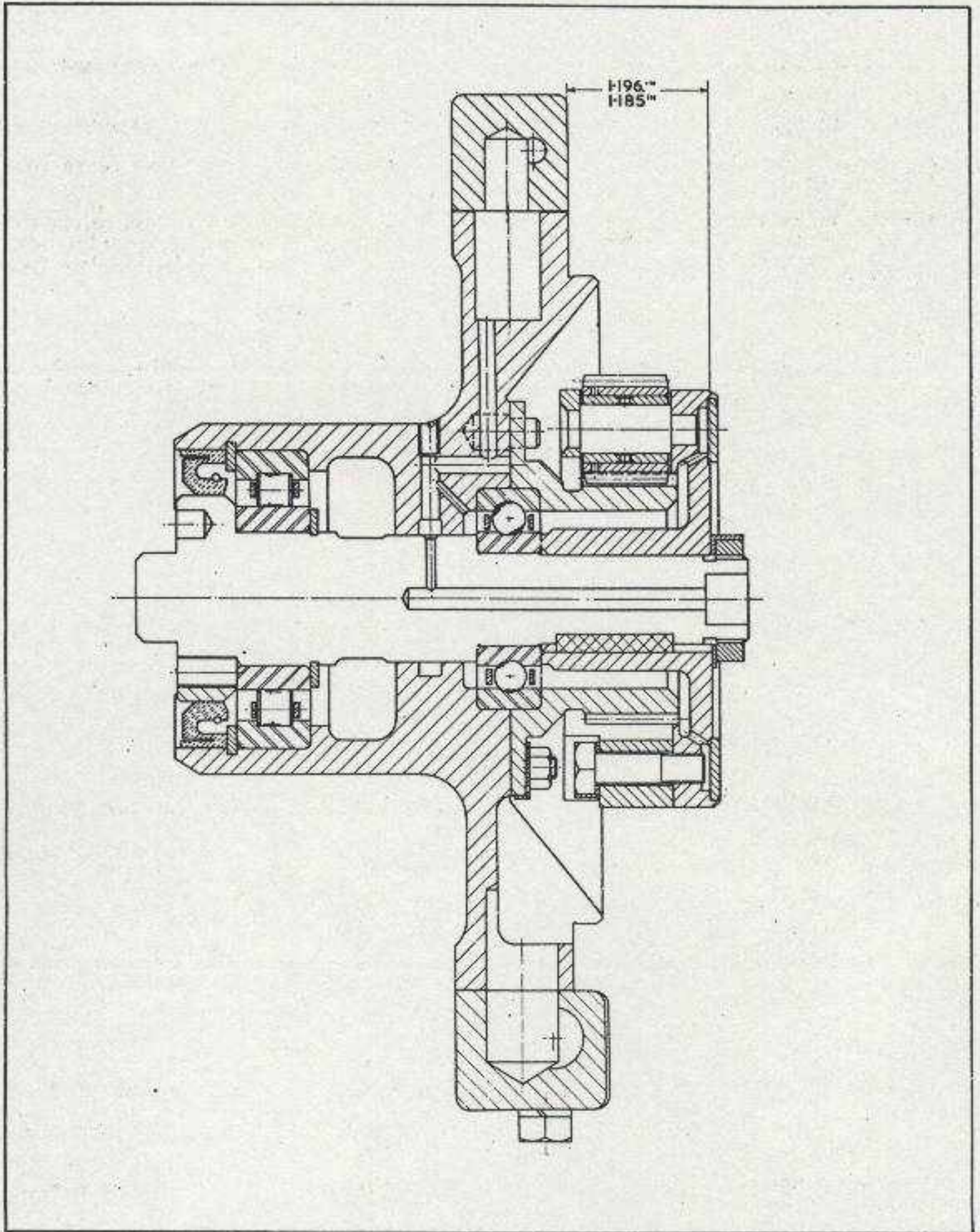


FIG. 41 - GENERATOR (TWO-SPEED) NO 2, MK 1 AND MK 2 - GENERAL
ARRANGEMENT SHOWING DRIVING END BEARINGS AND OIL SEAL

- (a) Remove the D.E. cover (this will come away with the input planet carrier and sun wheel). Collect the bush, oil delivery.
 - (b) Remove the nut and tabwasher securing the planet carrier to the input shaft. Withdraw the carrier.
 - (c) Remove the nuts securing the sun wheel to the D.E. cover and withdraw the sun wheel.
 - (d) The outer face oil seal will have to be removed externally and must be renewed. Remove the circlip.
 - (e) Tap the input shaft from the threaded end using a hide mallet. The shaft will come away from the D.E. cover complete with roller bearings and locating circlip leaving the ball bearing within the D.E. cover. To remove this bearing immerse the cover in hot water for a few minutes.
 - (f) Replace in the reverse order, sealing the face joint of the D.E. cover with Bostik 772.
- Note:-** Ensure that the oil delivery bush is in position before assembling the D.E. cover and input planet assembly otherwise serious lubrication trouble will result.

Brush gear

91. *Dismantling:-*

- (a) Remove the C.E. cover with sealing ring.
- (b) Remove the ventilating fan. Collect and note the amount of shims. Remove the shaft key.
- (c) Wedge each brush in its box with the brush spring. Disconnect the three internal lead connections to the brushes.
- (d) Mark the C.E. housing plate in relation to the frame. Remove the housing plate.
- (e) Remove the brush gear housing, at the same time easing the disconnected leads through the holes in the brush gear carrier plate.

92. *Reassembly:-*

Reassemble in the reverse order noting the following points:-

- (a) The leads from the field windings and plug to the brush connections must be fed through the holes in the insulated brush gear carrier plate.
- (b) Before replacing the C.E. cover, check the clearance between the rear of the fan and C.E. plate, using feeler gauges. If necessary, adjust with shims at the rear of the fan until the clearance is between 0.015 and 0.020 inch. The clearance between the fan blades and the C.E. cover must not be less than 0.010 inch.
- (c) Seal the face joints of the C.E. plate and the C.E. cover with Bostik 772.

Testing on the vehicle

- 93.(a) Remove the generator plug from the control panel. Bridge the pins 'A' and 'C'.
- (b) Select the 0-100/120V range of an instrument testing Avometer and connect the 'pos' terminal to the bridged connection and the 'neg' terminal to pin 'B'.
- (c) Start the engine and check voltage at the idling speed, this must be in the region of 24V.

IMPORTANT. **Note:-** To avoid damage to the field windings which are of low resistance (2.0-2.5 ohms), do not increase engine speed above idling.

Bench tests

94. **IMPORTANT Note:** The generator gearbox is supplied with two to four pints of oil per minute when fitted to the engine. To avoid overheating and damage during bench tests, running time must be kept to a minimum. The generator should only be tested for output. Under no circumstances will it be used on the test bench for resetting the panel generator.

- (a) Mount the generator on a 'Test Bench electric' with a suitable drive coupling and oil supply, see Figs. 42 and 43. Before testing, drive the generator at the lowest speed for approximately three to five minutes to allow the lubricant to circulate through the gearbox.
- (b) Increase the speed of the test bench to above 2,000 r.p.m. The gearbox must change speed at 2,100 r.p.m. $\pm 10\%$, i.e., the armature will now be turning at 1.545 times test bench speed.
- (c) On reducing the speed, the gearbox must cut in at 1,950 r.p.m. $\pm 10\%$, i.e., the armature will now be turning at 4.37 times test bench speed. Should the gear change take place outside the limits given above, replace the generator.
Note:- The high speed runs must be of short duration.
- (d) Check the generator gearbox for overheating.
- (e) Connect the generator for load test. Complete the field circuit (pin 'C') through the test panel to the generator 'pos' terminal.
- (f) Run the test bench up to 690 r.p.m. (armature speed 3,000 r.p.m.). The generator must deliver full load (i.e., 25A at 28.5V) with a field current not exceeding 4A.
- (g) Check for oil leakage, see para 89.

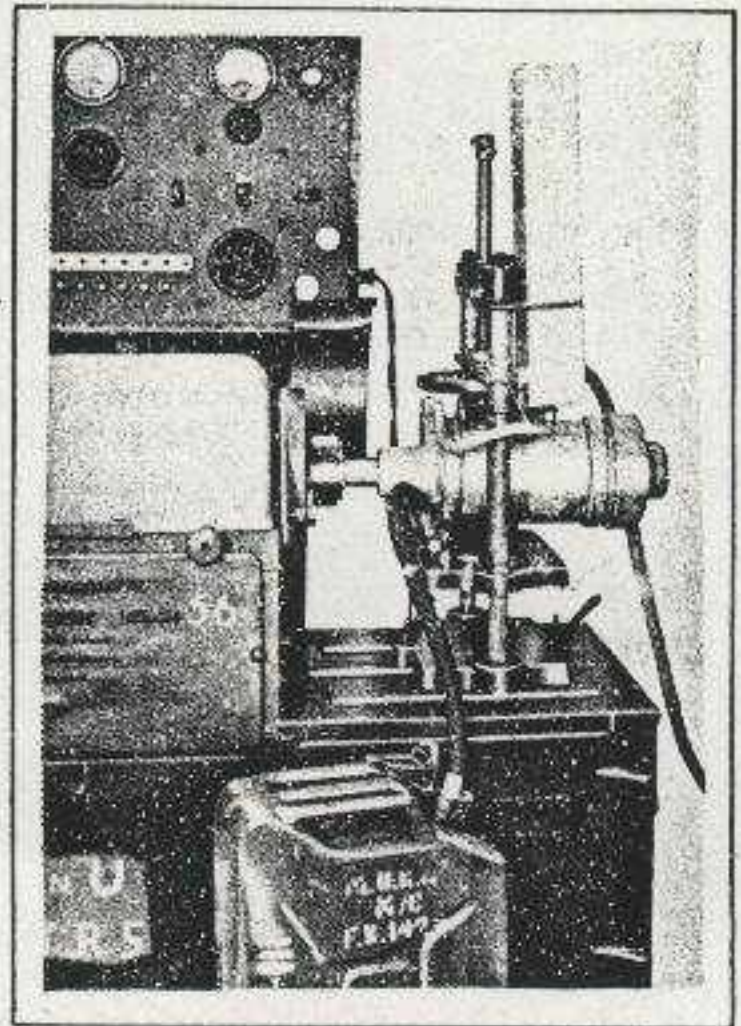


FIG. 42 - GENERATOR (TWO-SPEED)
TEMPORARY LUBRICATION OF THE
GEARBOX WHEN TESTING THE
GENERATOR FOR OUTPUT

PANEL GENERATOR NO 2, MK 1 (Figs. 44 to 47)

General

95. This panel is a current voltage control unit incorporating carbon pile regulation for use with generators No 2, Mk 1 and No 2, Mk 2. The panel comprises three sub-assemblies, the voltage and current regulator unit (VR1 and CR1), the resistor and capacitor group (R3, R4 and C1, C2), and the cut-out assembly (CO). The condensers C1 and C2 are located in a partitioned compartment beneath the tapped resistors R3 and R4. Mounted on the underside of the cut-out base are the under-volt relay (RL1), rectifier (MR1) and fixed resistor (R5). The cut-out is a POLARISED unit.

Out-out assembly96. **Removal:-**

Remove in order given: main cover, upper connections to the 3-way terminal block, base corner screws and cut-out assembly.

NOTE:- The cut-out must be carefully eased past the wiring surround.

97. Checks to be carried out:-

- (a) Pull-in voltage of differential coil (L0) is 0.75-1.75V and its resistance is 1.5 ohms.
- (b) Pull-in voltage of the under-volt relay (RL1) is 21V max and drop-out is 17V min. Its resistance is in the region of 370 ohms.
- (c) Resistance of fixed resistor (R5) is 95 ohms.
- (d) Cut-out is polarised, ie, the armature flicks in either direction when operated by hand. Polarity at contact end is South.

98. Replacement:-

Replace in the reverse order.

NOTE:- Insert the securing screws into the cut-out base before replacing the assembly in the panel.

Tapped resistors

99. Removal:-

- (a) Unsolder connections at band clips.
- (b) Loosen bracket holding screws.
- (c) Remove the nut securing the resistor tubes to the brackets and withdraw the studs.
- (d) Spring the brackets apart until the tubes are released.

100. Checks to be carried out:-

Resistances of R3 and R4 are 41 and 38 ohms respectively.

101. Replacement:-

Replace in the reverse order.

Carbon piles (Fig. 44)

102. Removal:-

- (a) Remove the small panel cover.
- (b) Record the armature to core air-gap measurements of voltage and current regulators.
- (c) Slacken locking screw (2) and remove the adjustable ferrule (4).
- (d) Insert $\frac{1}{2}$ inch dia rod through the centre of the carbon discs (1). Tilt the panel and allow the discs to slide down the rod.
- (e) Remove bracket (3) noting the insulation arrangement.
- (f) Withdraw the ceramic tube.

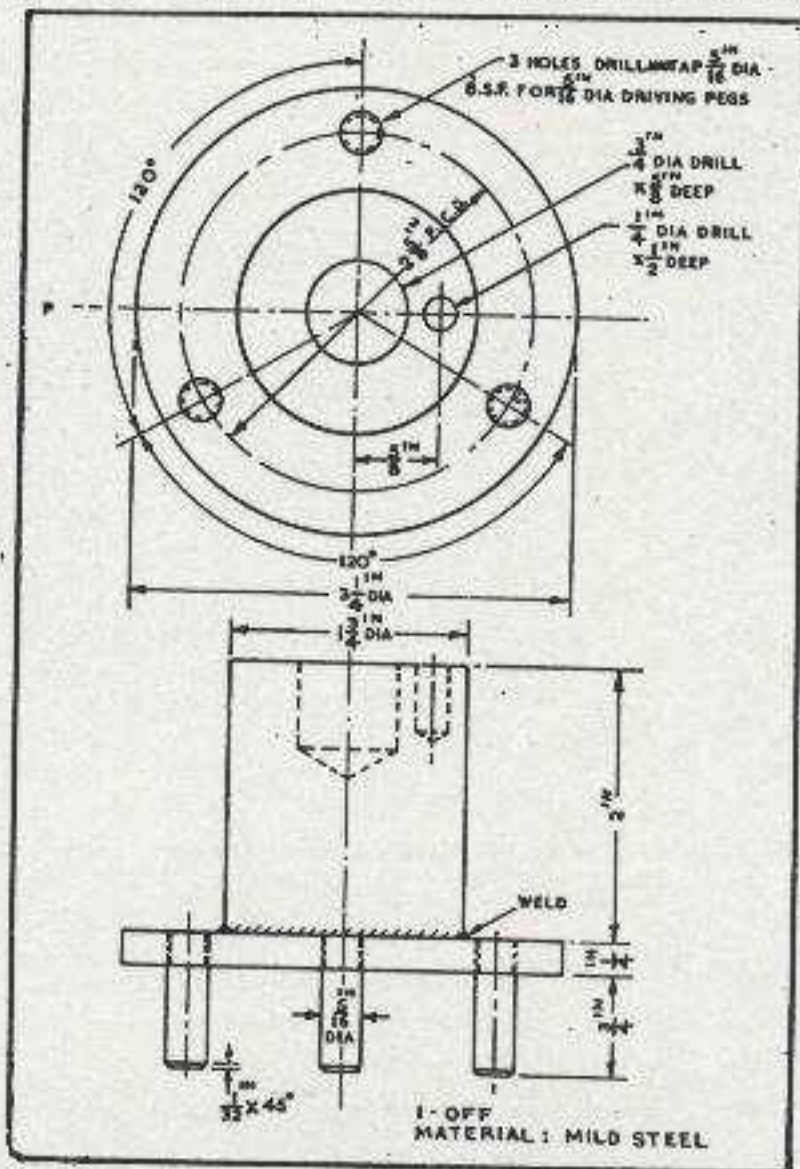
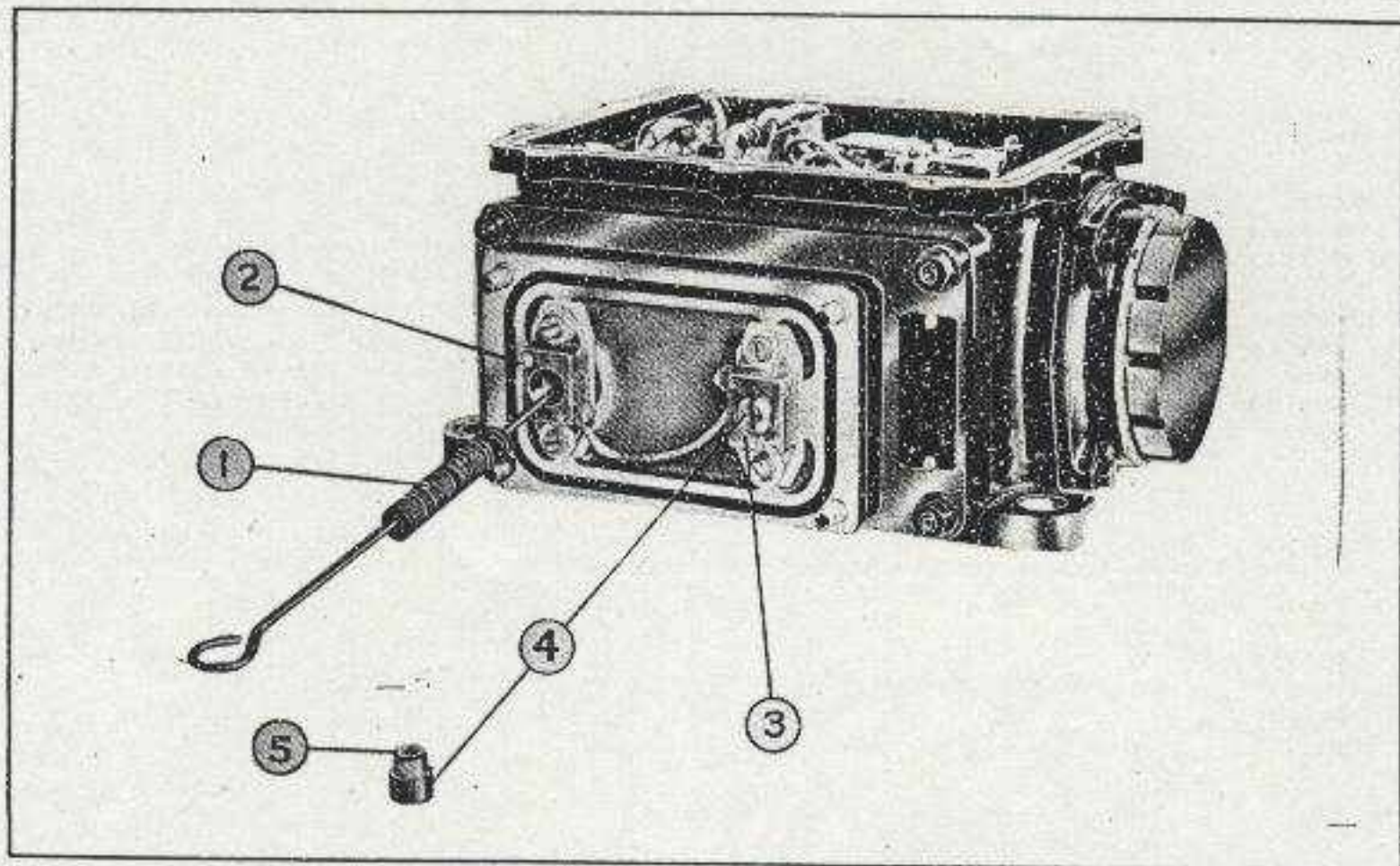


FIG. 43 - ADAPTOR - TWO-SPEED GENERATOR TO TEST BENCH ELECTRIC (LOCAL MANUFACTURE)



- | | |
|---|--------------------------------------|
| 1. Carbon pile | 4. Adjustable ferrule |
| 2. Screws locking adjustable ferrule | 5. Carbon insert, adjustable ferrule |
| 3. Bracket, adjustable ferrule, current regulator | |

FIG. 44 - PANEL GENERATOR NO 2, MK 1 - REMOVAL OF CARBON PILE

103. Checks to be carried out:-

- (a) Carbon dust between discs. Burning or pitting of discs. Voltage pile (R1) comprises a min of 25 thin and 26 thick carbon discs. Current pile (R2) comprises a min of 76 thin discs. Pile length of R1 and R2 is 1.5 inches.
- (b) Ceramic tube for cracks.
- (c) Surface of carbon inserts (5). Repolish with a fine grain (tissue) paper on a flat surface.

104. Replacement:-

Replace in the reverse order ensuring that the adjustable ferrule is screwed down until the air-gap recorded under para 102(b) is obtained. Recordings should not differ appreciably from 0.025 inch voltage unit and 0.027 inch current unit.

NOTE:- If pile renewal is due to hunting, screw in the ferrule a further one-eighth turn.

Tests and adjustments with No 2 Mk 1, and Mk 2 Generator

NOTE:- These must be carried out on the vehicle to ensure adequate lubrication to the generator, see para 94.

105. Out-out:-

- (a) Measure the no-load battery voltage.
- (b) Disconnect the current regulator (CR1) current coil connection (black band No 2)

from the terminal block, and insert an ammeter (30-0-30A).

- (c) Connect a voltmeter (BS1 Grade) between the current coil connection and the panel frame.
- (d) Start the engine and increase its r.p.m. until the cut-out contacts close. This must occur when the voltage exceeds the value of the battery recorded at (a) by 0.75-1.75V.
- (e) Decrease engine speed until the cut-out contacts open. Reverse current should be between 2-5A. Slight adjustments are effected by variation of the CO armature tail spring tension by the repositioning of the slotted plate. Larger adjustments are made by repositioning the stationery contacts. The armature air-gap at the contacts end should lie between 0.005-0.008 inch.

106. Voltage regulation:-

- (a) Connect a voltmeter as for cut-out testing, sub-para 105(c) and insert an ammeter (0-1A) range between the voltage coil (red No 2) lead and its normal connecting terminal.
- (b) Disconnect the battery socket from the generator panel and bridge sockets A and C.
- (c) Start engine and run through its speed range. The voltage must be controlled at $28.5V \pm 2\frac{1}{2}\%$.

Adjustments are made as follows:-

- (i) Remove the small panel cover.
- (ii) Start and run engine at 600 r.p.m.
- (iii) Slacken locking screw (2) Fig. 44. Screw the adjustable ferrule (4) slightly in and then out observing the effect on the voltmeter reading. Select the direction which causes the reading to fall and continue turning until it stops falling and then commences to rise again. Obtain the minimum or dip position and lock the ferrule with screw (2).

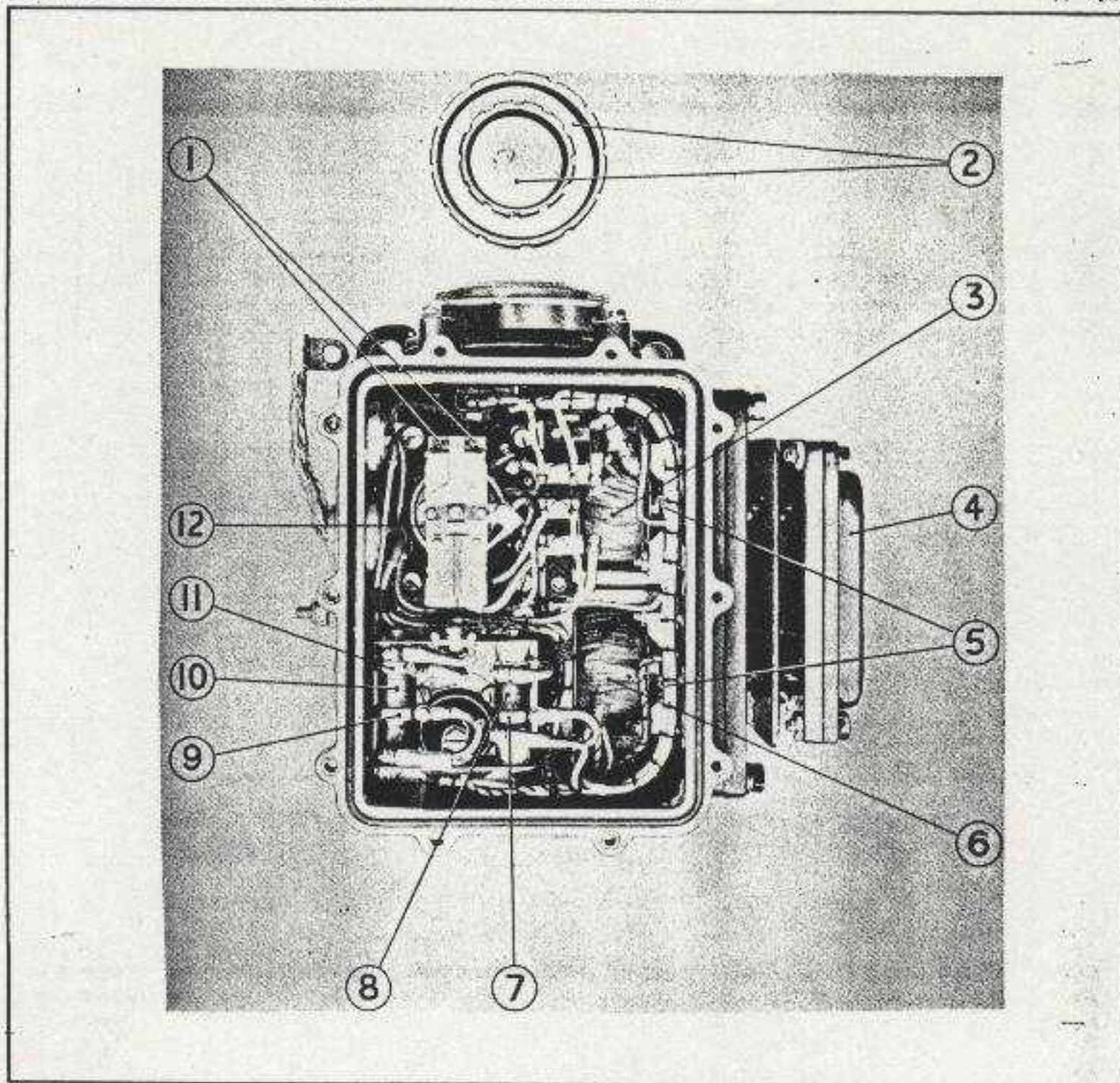
NOTES:- 1. "Dip" position affords optimum regulation.
2. Turning tool must accurately fit the adjustable ferrule slot.

- (iv) Slacken the band clip (9) Fig. 45 on the tapped resistor (R3) and adjust until the nominal controlled value is obtained. Tighten clip. The voltage coil current must be within the limits of 0.58-0.64A.
- (v) Remove A and C bridge and reconnect battery socket.

107. Current regulation:-

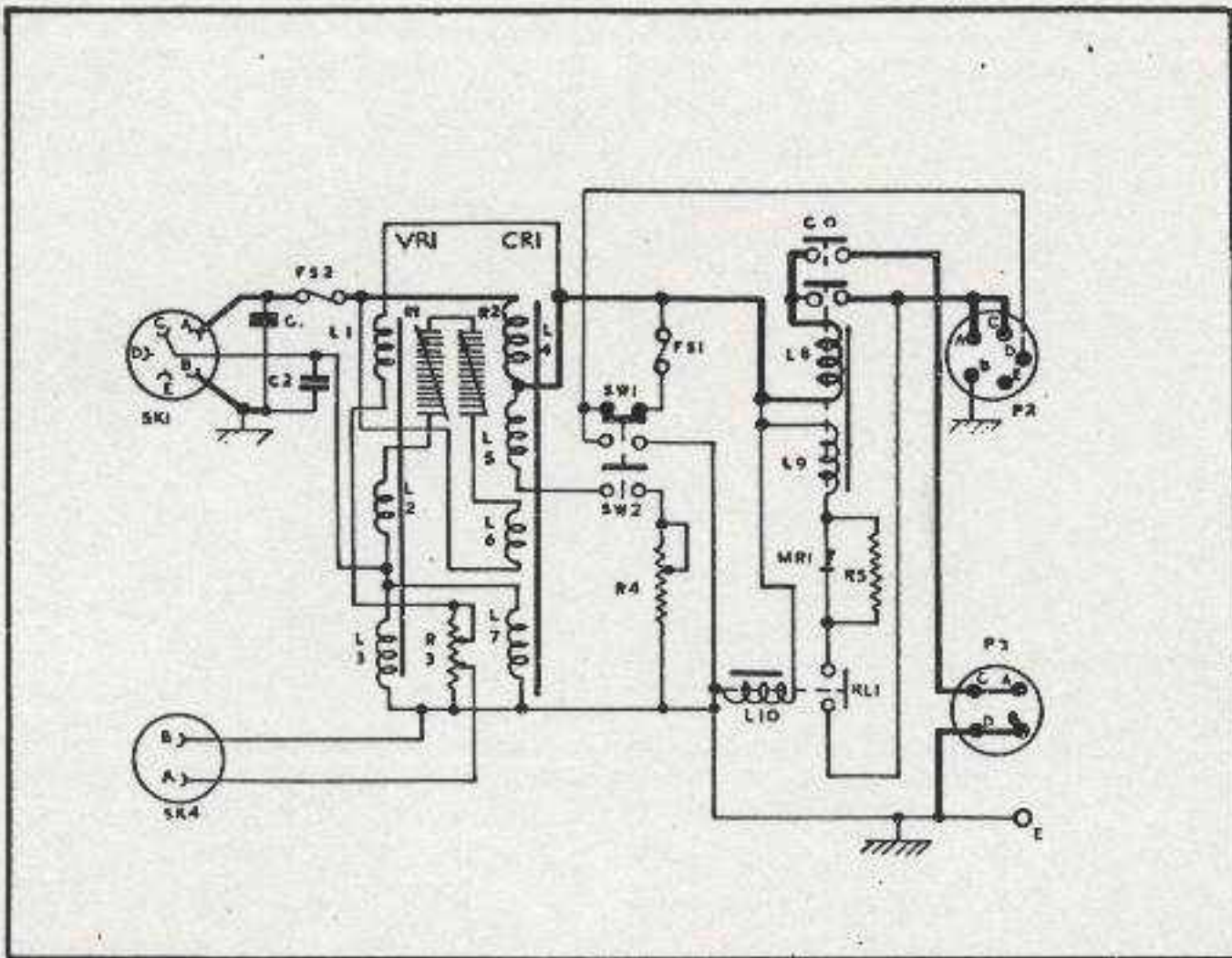
- (a) Connect the instruments as for cut-out testing sub-paras 105 (b) and (c).
- (b) With a variable load resistor (20A, 5.4 ohms) across the battery run engine at 600 r.p.m. Adjust output until a current value of 24-27A is reached with the current regulator inoperative.
- (c) Reduce load resistance until the pile of the current regulator is operating and controlling the current output at a reduced voltage of 27V. Stable control of current within the limits of 24-27A should be obtained with slight movement of the adjustable ferrule clockwise.

NOTE:- To obtain effective control it is essential to maintain pile compression.



- | | |
|--|---|
| 1. Screws, clamping, cut-out adjusting plate | 7. Adjustable clip, current limiting, for wading |
| 2. Wading caps | 8. Resistance, 38 ohms |
| 3. Current regulator coil | 9. Adjustable clip, voltage setting |
| 4. Cover, carbon pile regulators | 10. Resistance, 41 ohms |
| 5. Air-gaps, regulator armature to core | 11. Adjustable clip, battery thermal switch tapping |
| 6. Voltage regulator coil | 12. Cut-out assy (polarised unit) |

FIG. 45 - PANEL GENERATOR NO 2, MK 1 - MAIN COVER REMOVED



- | | | |
|--|---|------------------------------------|
| CO. Cut-out | L4. Current coil | R1. Carbon pile, voltage unit |
| C1. Capacitor 0.25 μ F | L5. Current limiting coil | R2. Carbon pile, current unit |
| C2. Capacitor 0.1 μ F | L6. Series coil, current unit | R3. Tapped resistor 41 ohms |
| CR1. Current regulator | L7. Stabilizer shunt coil, current unit | R4. Tapped resistor 38 ohms |
| E. Earth connection | L8. Series coil, cut-out | R5. Resistor 95 ohms |
| FS1. Fuse 5A | L9. Differential coil, cut-out | RL1. Under-volt relay |
| FS2. Fuse 25A | L10. Under-volt relay coil | SK1. Generator socket |
| L1. Voltage coil | MR1. Rectifier | SK4. Battery thermal switch socket |
| L2. Series coil, voltage unit | P2. Battery supply plug | SW1. SW2 wading switches |
| L3. Stabilizer shunt coil voltage unit | P3. WT battery plug | VR1. Voltage regulator |

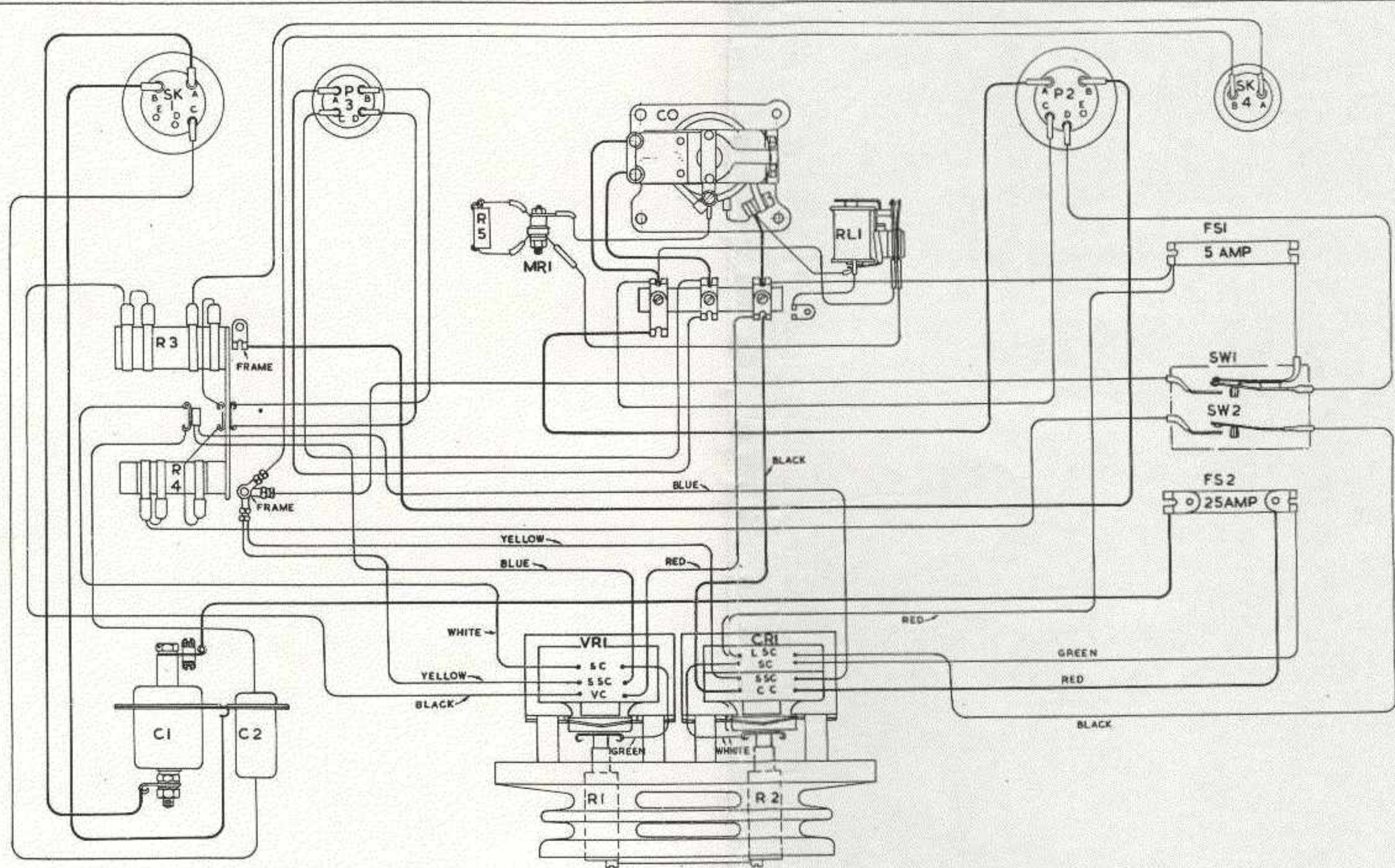
FIG. 46 - PANEL GENERATOR NO 2, MK 1 - CIRCUIT DIAGRAM (INCORPORATING MODIFICATION NO 1)

108. Regulation and stability tests:-

(a) Disconnect the battery socket and bridge connections A and C. Run the engine through its speed range and check that the output voltage is maintained within $\pm 2\frac{1}{2}\%$ of the nominal controlled value. Observe the voltmeter. To obviate the needle 'trembling' remove the pile and blow out dust between the carbon discs and repeat operation under sub-para 106(c).

(b) Reconnect the battery with a variable load resistor. Run the engine through its speed range with varied loads. The voltage must remain within the limits stated for loads up to the controlled max.

NOTE:- The battery must not be in a flat condition when making regulation tests.



CO. Cut-out
C1. Capacitor 0.25 μ F
C2. Capacitor 0.1 μ F
CR1. Current regulator
CC. Current coil
FS1. Fuse 5A
FS2. Fuse 25A
LSC. Limitation shunt coil
MR1. Rectifier

P2. Battery supply plug
P3. WT battery plug
R1. Carbon pile, voltage regulator
R2. Carbon pile, current regulator
R3. Tapped resistor 41 ohms
R4. Tapped resistor 38 ohms
R5. Resistor 95 ohms
RL1. Under-volt relay

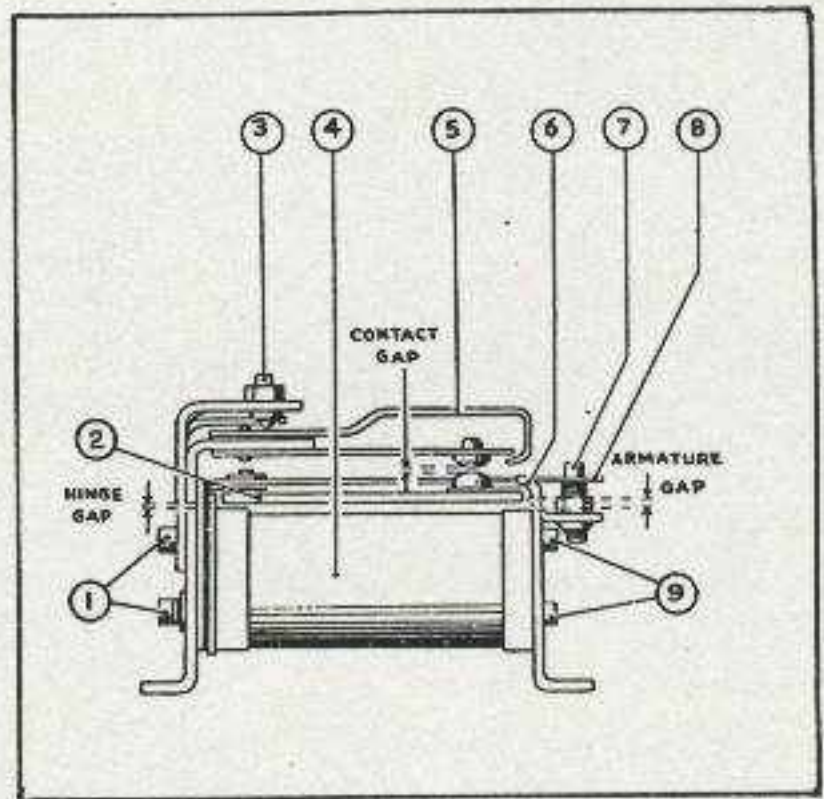
SC. Series coil
SSC. Shunt stabilizer coil
SK1. Generator socket
SK4. Battery thermal switch socket
SW1. Wading switch
SW2. Wading switch
VC. Voltage coil
VR1. Voltage regulator

FIG. 47 - PANEL GENERATOR NO 2 - WIRING LAYOUT

- (c) Start the engine and run up to 1,400 r.p.m. Adjust load so that the voltage is reduced to 27V. Between 600 to 1,400 r.p.m. the current must remain within the limits of 27 to 24A. Remove and blow out pile if ammeter needle 'trembling' occurs and repeat operation under sub-para 107(c). At 1,400 r.p.m. adjust load so that voltage is reduced to 27V. Switch load resistor in and out of circuit at least three times. Renew the panel if the regulator assy shows a tendency to instability.

109. Wading and battery thermal switch operation:-

- (a) Remove wading caps (2) (Fig. 32). The warning light will remain on.
- (b) Connect the instruments as for testing the cut-out, sub-paras 105(b) and (c).
- (c) Run the engine through its speed range. The generator should be limited to 6A and the voltage approx 2V below its normal setting. Adjustment is effected by moving band clip (7) (Fig. 45).
- (d) Replace wading caps.
- (e) Bridge socket connections A and B in socket SK4 (Fig. 46).
- (f) Run the engine through its speed range. The voltage should be 2V below the normal setting. Adjustment is effected by the movement of the band clip connection (11) (Fig. 45).



1. Securing screws, hinge endplate
2. Armature
3. Adjusting screw, contact gap
4. Core
5. Contact bracket
6. Endplate, contact end
7. Armature spring tensioning screw
8. Armature spring
9. Securing screws, contact endplate

FIG. 48 - BOX DISTRIBUTION NO 1,
MK 1 - CIRCUIT BREAKER SWITCH

DISTRIBUTION BOX NO 1, MK 1

110. Dismantling:-

- (a) Remove the baseplate.
- (b) Disconnect leads from insulated base and strip connectors adjacent to the heavy duty plug and socket connection.
- (c) Remove the four ch. hd. screws securing the insulated base, and remove the base with the circuit breakers.

111. Tests and adjustments, Fig. 48:-

(a) The circuit breaker adjustments:-

- (i) Air-gap between the armature and core at the hinged end. Loosen the securing screws on the endplate adjacent to hinge, set the gap, see sub-sub-para (vi), by moving the armature and tighten the screws.
- (ii) Air-gap between the armature and core at the contact end with the armature against the stop. Unscrew the contact gap adjusting screw. Slacken the securing screws of the endplate adjacent to the contact end. Set the gap, see sub-sub-para (vi) by raising or lowering the core. Tighten the screws.
- (iii) The coil should pull in the armature from its stop within a voltage range of 6.5-9.0V with the contacts separated one from the other. Adjust on the armature spring tensioning screw.

NOTE:- There is no means of adjustment on the early type of circuit breaker.

- (iv) Contact gap with armature held against core: Adjust the contact gap adjusting screw. See sub-sub-para (vi).
- (v) The bi-metal strip should just touch its bracket when the armature is against the core.
- (vi) Air gap settings:-

Type	Hinge gap	Air-gap	Contact gap
10A (Q5)	0.002-0.004	0.003 \pm 0.001	0.007-0.008
30A (Q3)	0.002-0.004	0.042 \pm 0.001	0.007-0.008

- (b) The 30A unit (Q3) is set to carry 35A continuously for 15 minutes without operating. At 60A it will operate within 15 to 50 seconds and at 100A four to six seconds. The 10A unit (Q5) is set to carry 11A for 15 minutes without operating, and at 20A it operates within 10 to 25 seconds.

112. Re-assembly:-

Reassemble in the reverse order.

- NOTES:- 1. Apply Silicone sealing compound on seal faces.
2. Test the sealing, see para 78.

SWITCHBOARD NO 1, MK 1

113. Dismantling:-

- (a) Unscrew the two bezels and withdraw the bulbs.
- (b) Remove the switch handles.
- (c) Remove the backplate from the body.
- (d) Unscrew the three ch. hd. screws holding the terminal and rotor base. Remove the nut securing the centre point of the dimmer switch to the cross connector strip and the small nut and screw securing the two vertical strip connectors.
- (e) Remove the switchboard housing by pressing on the switch spindles.
NOTE:- The ignition switch lock and panel switch remain in the housing. The ignition switch rotor will be held to the base by the pressure of the contacts on the barrel.
- (f) Remove the locking plate from the base of the lock. Remove the split ring and push the switch assembly out of the switchboard housing. Remove the plug from the side of the barrel, insert a pin punch into the hole, depress the spring-loaded plunger and remove the lock from the switch handle.
- (g) Remove the switch spindle sealing rings.

114. Re-assembly:-

Reassemble in the reverse order.

- NOTES:- 1. Apply Silicone sealing compound to all seals.
2. Test the sealing, see para 78.

SWITCH LOW-PRESSURE NO 1, MK 1

(Removal/Replacement, see VEH N 403/1-1).

115. Adjustment of contact points:-

- (a) Manufacture a clamp, see Fig. 49.
- (b) Cut out a gasket for the switch from 'Halite', cork sheet or similar material.
- (c) Mount the switch in the clamp.

- (d) Connect the unit to apparatus 'Workshop special tool Cat No WC 52765 Outfit 'A' seal testing', see Fig. 50.
- (e) Connect a 6V battery bulb in circuit to the switch terminals.
- (f) Pump the unit up to 10 lb/sq.in. pressure. The contact points will open and the light will be switched 'off'.
- (g) Allow the pressure to drop gradually. The contact point should make and the light switch 'on' at 7 lb/sq.in. pressure. Adjust the switch to cut out at 7 lb/sq.in.
- NOTES:-
1. Adjustment must be made against a falling and not rising pressure.
 2. The contact screw is self-locking and must be depressed with a screwdriver and turned.
 3. To raise the operating pressure turn the contact screw clockwise.

SPECIAL WORKSHOP TOOLS

- 116.(a) Starter No 1, Mk 1 and Mk 2
LA 85246 Spanner, solenoid armature hex locking nut
LA 71965 Spanner, solenoid armature ring locking nut
WC 52765 Outfit 'A' seal testing
- (b) Starter No 1, Mk 2/1
LV6/MT4 SER 2 Tool dismantling plunger.

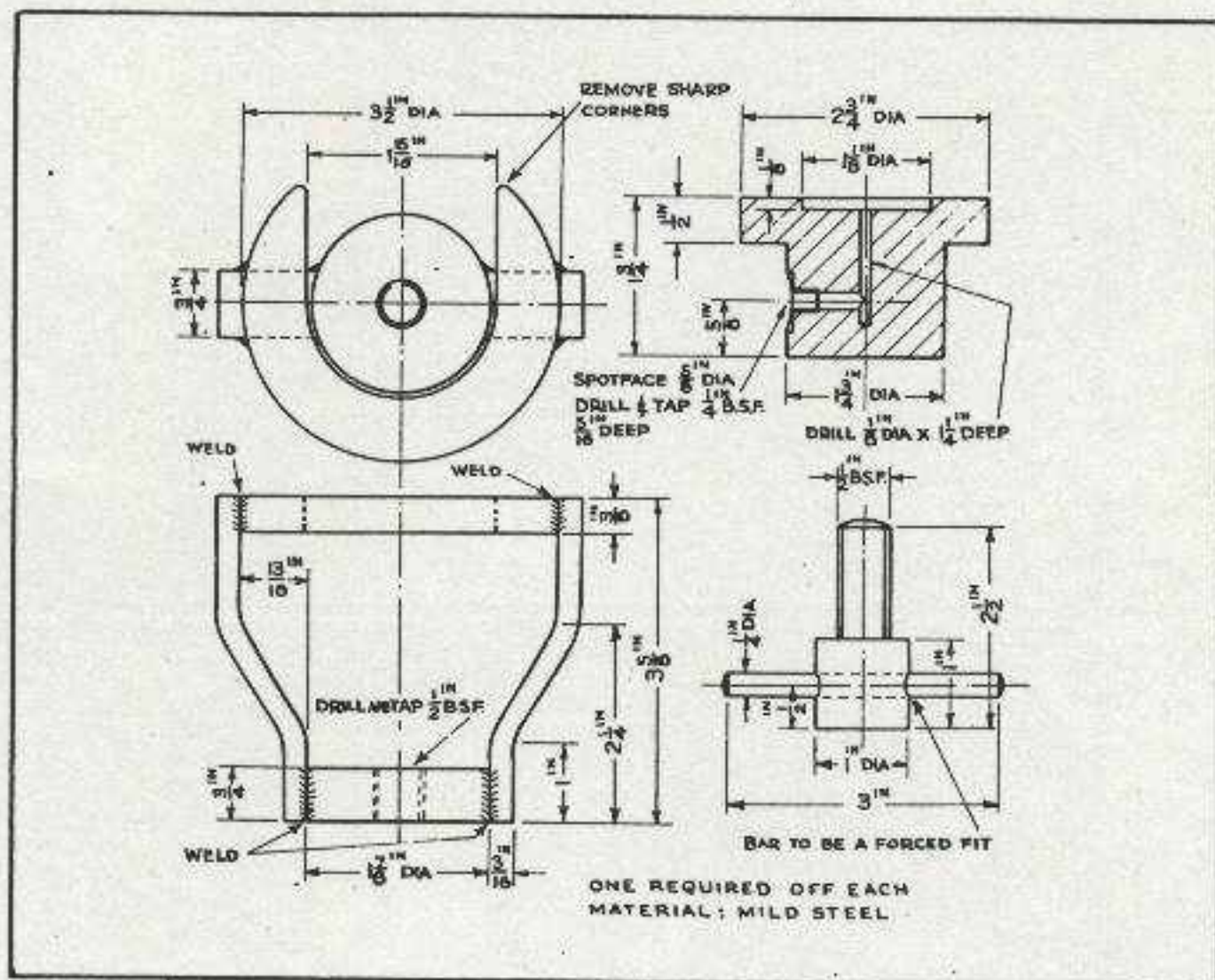


FIG. 49 - SWITCH, LOW-PRESSURE - CLAMP FOR PRESSURE SETTING CONTACTS
(LOCAL MANUFACTURE)