INSTRUCTION BOOK No. 46·4

GARDNER

REVERSING GEAR

3UC
TYPE 2

AND

REDUCING GEAR

TYPE 3

SERVICING AND MAINTENANCE INSTRUCTIONS

REVERSE GEAR No. ...

REDUCING GEAR No. .....

ENGINE No. ...

PRICE 10/-

SERVICING AND MAINTENANCE INSTRUCTIONS

FOR THE

GARDNER

No. 3 UNIT CONSTRUCTION REVERSE GEAR TYPE 2

AND

REVERSING — REDUCING GEAR TYPE 3

WITH

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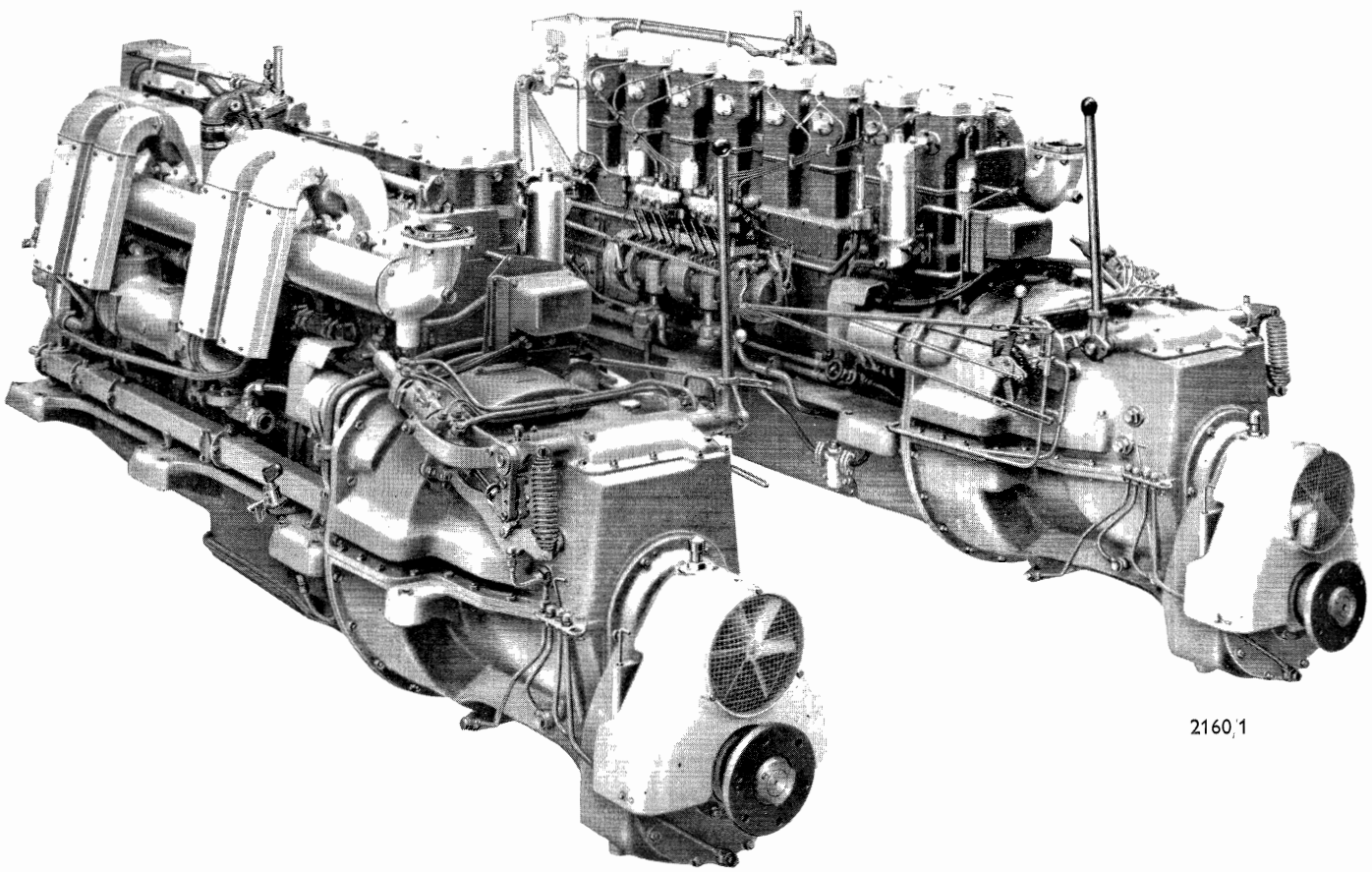

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Twin 8L3B engines equipped with 3UC Reversing and 3 : 1 Reducing Gears operated by Gardner Single Lever Hydraulic Mechanical Remote Control for gear and engine speed. Also visible is the sump emptying pipe arrangement for the reversing and reducing gear cases.

GARDNER

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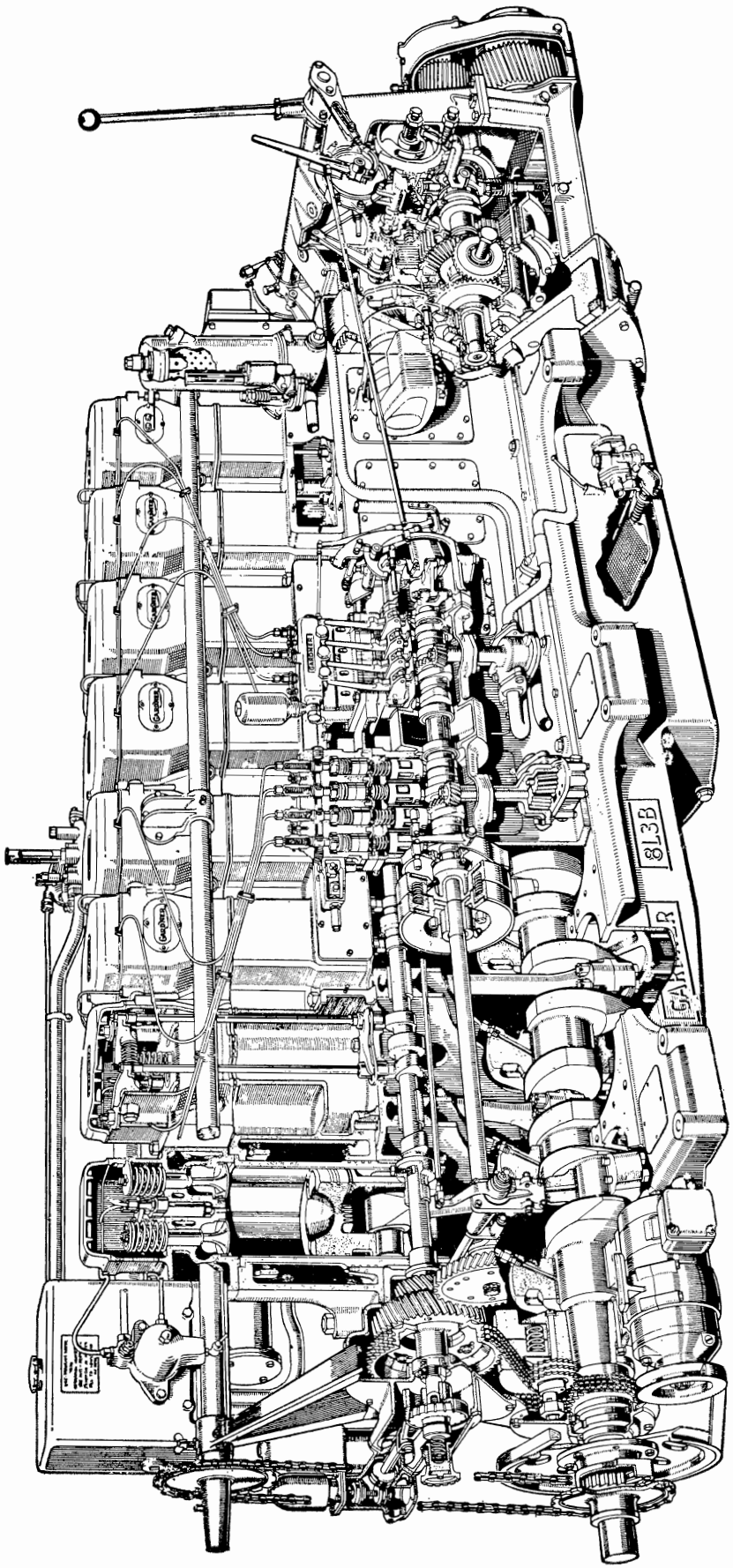
FOREWORD

THE data contained in this manual is based upon long experience and has been compiled in an endeavour to facilitate efficient and durable operation of our reversing and reversing-reducing gears. The instructions have been written specifically for the Type 2 reversing gear and Type 3 reducing gear, but additional information has been provided, which will enable the Manual to be used when servicing the earlier types of gear units.

To ensure prompt attention to enquiries or orders for spare parts it is imperative that the serial number of the engine should be quoted in all communications. The serial number will be found stamped on the upper surface of the crankcase adjacent to No. 1 cylinder on the fuel pump side of the engine.



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8L3B MARINE ENGINE WITH 3UC REVERSING AND REDUCING GEAR

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SECTION 1

Description and Maintenance

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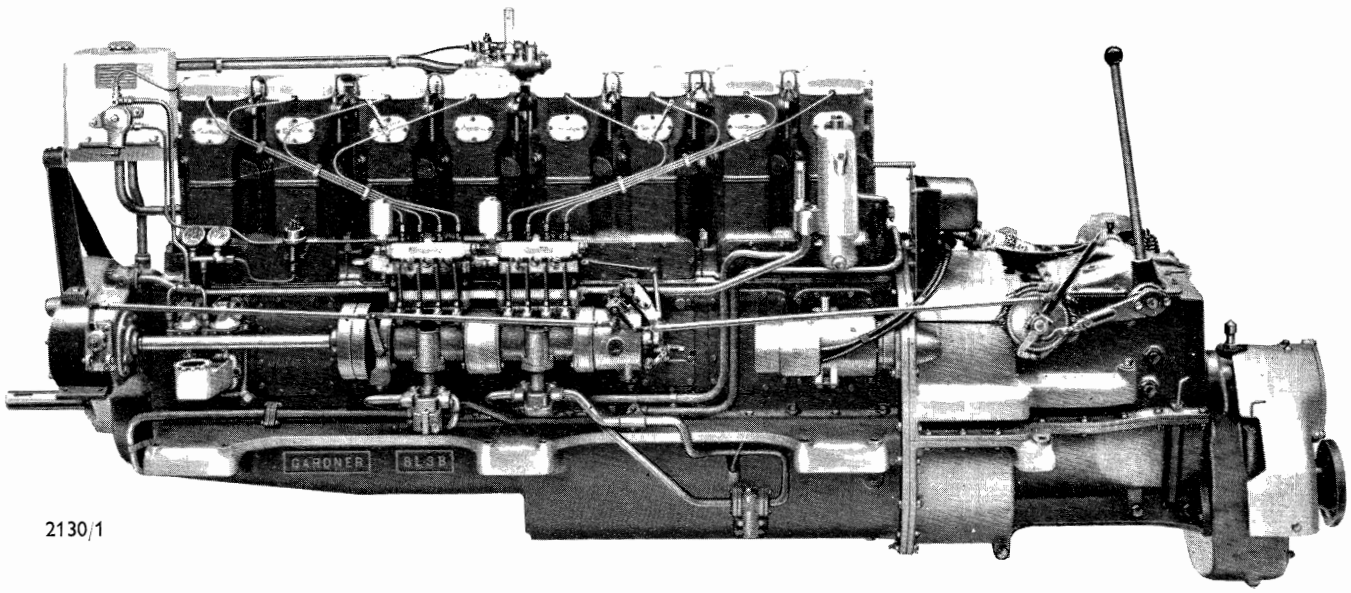
Assembling and Installation



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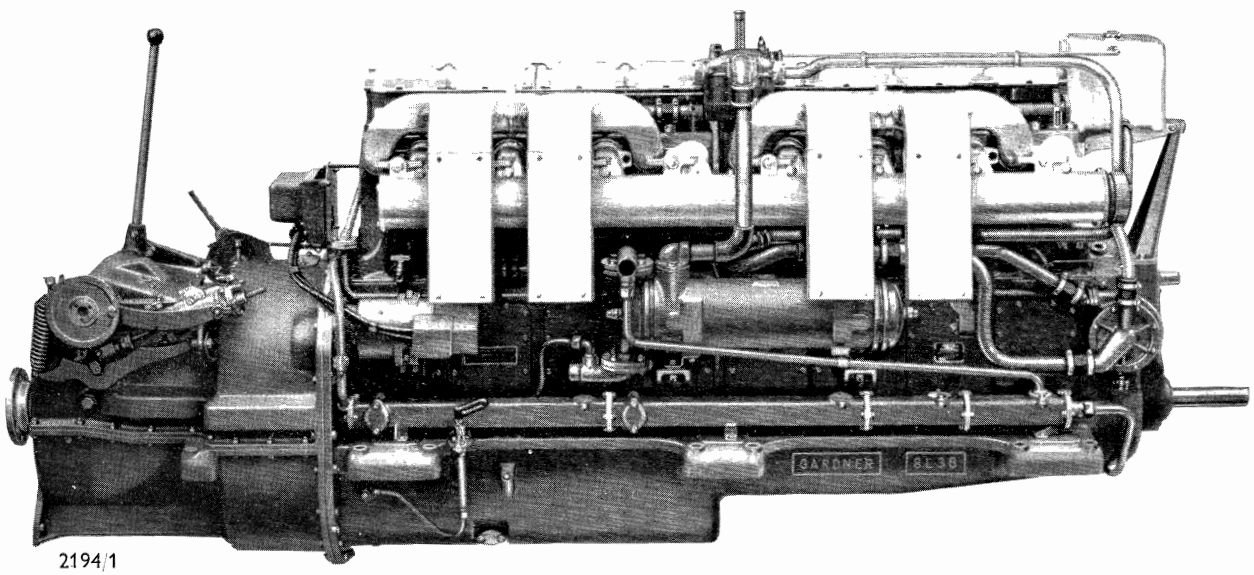
No. 3UC Reverse Gear Type 2 and Reducing Gear Type 3 fitted to an 8L3B engine. Showing fan and cowling for directing cooling air around the thrust bearings and reducing and reversing gear cases.



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8L3B engine with 3UC Reverse Gear arranged for direct drive to propeller shaft.

No. 3 Unit Construction Reversing Gear Type 2

and

Reducing Gear Type 3

INTRODUCTORY NOTES

The No. 3 U.C. reversing and reversing-reducing gear is constructed as a unit with the engine, securing permanent alignment, extreme rigidity, economy of weight and space and facility of installation.

The mechanical efficiency of the gear is of high order. When driving AHEAD it is not less than 99%. When driving ASTERN it is only slightly less, and continuous full power ASTERN can be demonstrated without distress or excessive temperature rise.

Lubrication of the reverse gear is effected by a self-contained pump system, isolated from the engine. All parts, including the locomotive type contracting brake used for ASTERN engagement and the ferrous/non-ferrous multi-plate AHEAD clutch, are continuously supplied by it.

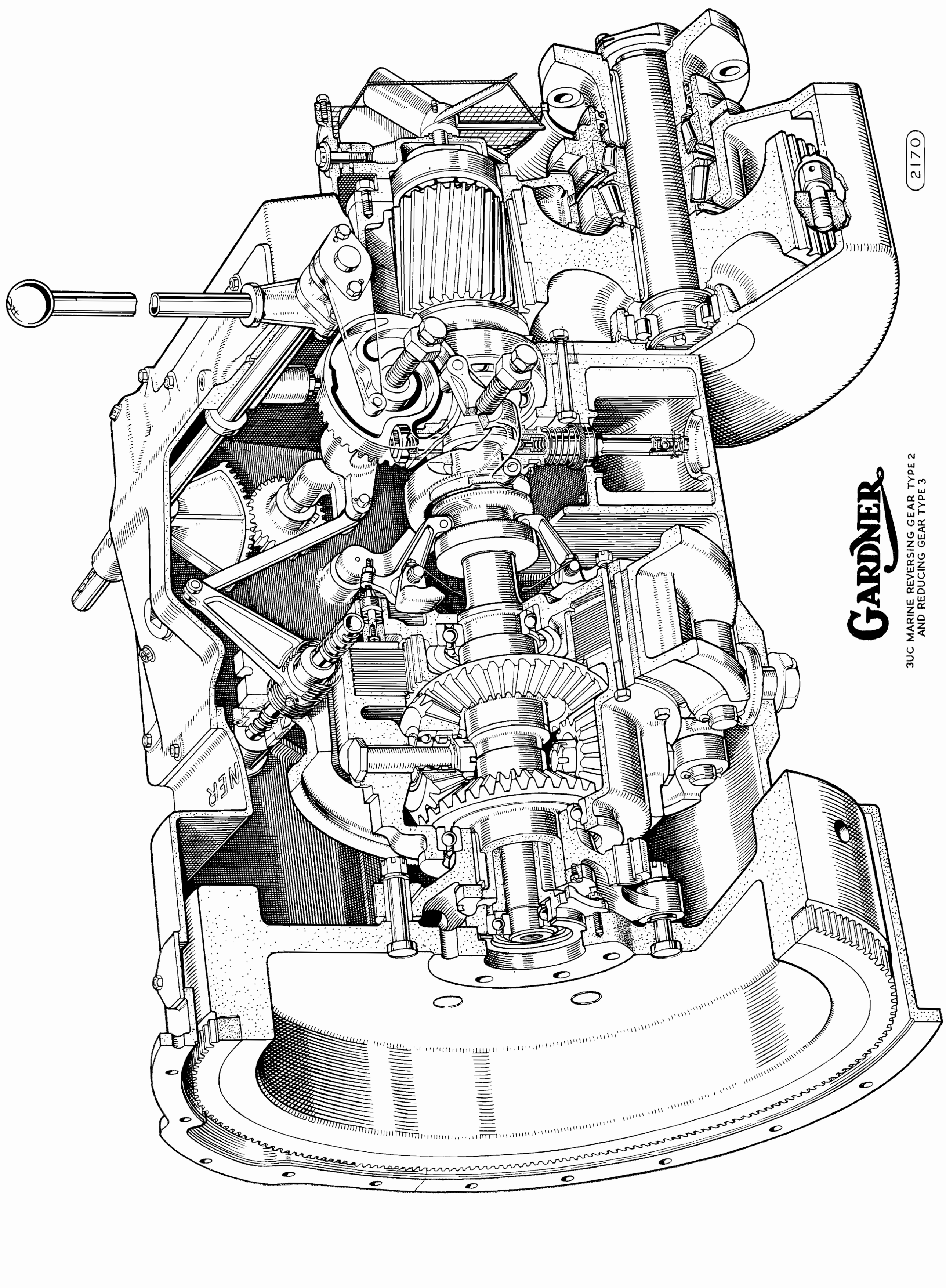
Permanently true alignment of the four ball and roller bearing mounted epicyclic bevel gears is ensured by a continuous main shaft which is relieved of any displacement due to torque reaction from the astern clutch, and there is provision for free thermal expansion of case and running gear independent of the engine crankshaft.

The reducing-reversing gear is adequately air cooled for all conditions by a small fan mounted on the output shaft. It is enclosed in a cast aluminium cowl which directs the cooling air around the thrust bearing, reducing gear case and the reverse gear case. Air thus circulated is additionally useful for bilge ventilation under the whole unit.

The design of the ahead and astern clutches incorporates large areas at large effective radii and secures long life, infrequent adjustment and low operating load. Engagement of clutches is smooth and entirely free from shock. The standard adjustment of clutch operating load is such that more than twice the torque of the engine can be transmitted without clutch "slip".

Ahead and astern propeller thrust is carried by adjustable double taper roller bearings having a design average useful life in excess of 60,000 hours. They are lubricated continuously from the gear case and protected by double synthetic rubber sealing rings on the output side.

The design of the reduction gear assembly embodies profile shaved, nitrogen hardened, moderate single helical tooth form gears, of low unit tooth load carried in high capacity bearings in rigid accurate mountings and secures extreme durability with inaudible operation. The load carrying capacity of the gears to British Standards is in excess of double the rated output of the engine.



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GARDNER
3UC MARINE REVERSING GEAR TYPE 2
AND REDUCING GEAR TYPE 3

LUBRICATING OIL SPECIFICATIONS

Reverse Gear.—The grade of oil used is the same as that recommended for the lubrication of the engine and for specification details, reference should be made to the appropriate Engine Instruction Book.

Reducing Gear.—It is recommended that an extreme pressure heavy gear oil of mineral base be used, to the following specifications:—

Viscosity Redwood No. 1	at 100°F. not greater than	3,500 secs.
	at 140°F. not less than	700 secs.
	at 200°F. not less than	160 secs.

Specific gravity about	·910 at 60°F.
Pour point not above	25°F.
Flash point (closed) not below	450°F.

Periodically, observe by dipstick that the oil remains fluid. Do not mix one make of oil with another.

The output shaft is equipped with an efficient dual seal, nevertheless it is desirable that the level of bilge water be kept to a minimum at all times.

If there is any indication that water may have entered the gear case, immediately drain and flush out repeatedly with engine oil until all traces of water have been removed. Run the engine for a period of approximately half a minute after each filling with flushing oil. Replenish with new heavy gear oil.

OIL-CHANGE PERIODS

Reverse Gear.—Drain and replenish the sump with fresh engine oil at intervals of 2,000 hours working. See para. 2 and 5.

Reducing Gear.—Drain and replenish the sump with fresh gear oil every four months; under normal working conditions. See para. 3.

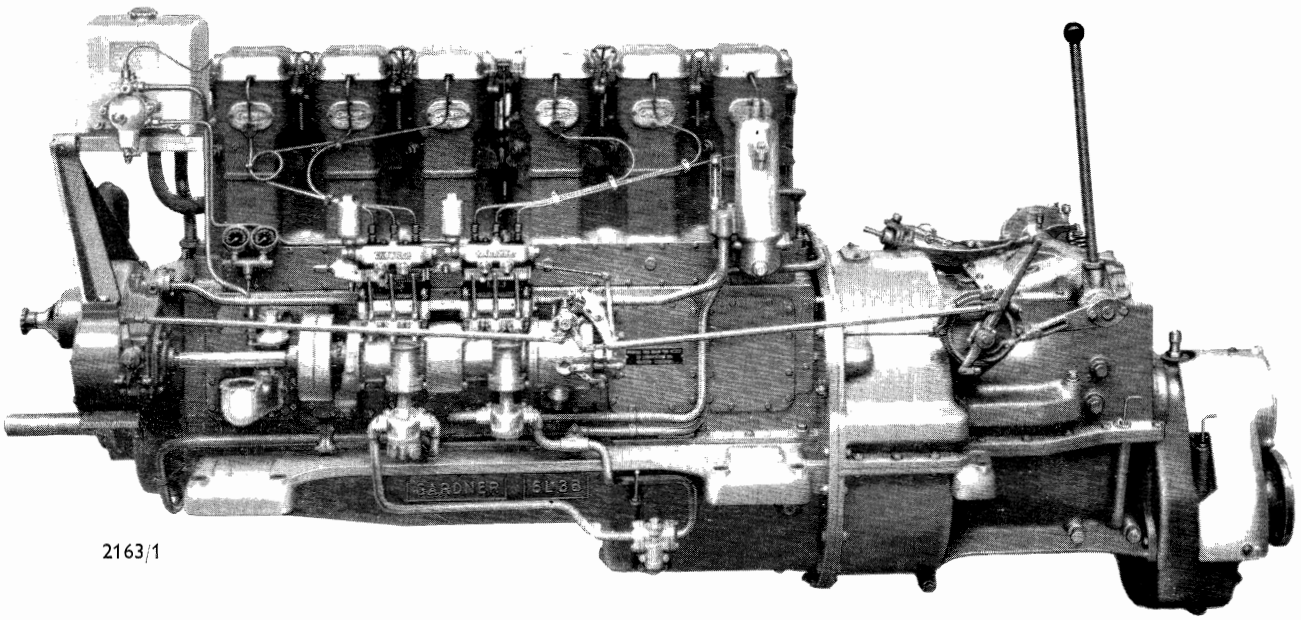
QUANTITY OF LUBRICANT REQUIRED FOR INITIAL FILLING (approx.)

Reverse Gear	Reducing Gear	
Quantity	Gear Ratio	Quantity
14 pints or 7·95 litres	2 : 1	6 pints or 3·41 litres
	3 : 1	7½ pints or 4·26 litres

CAUTION

DO NOT OVERFILL WITH OIL

This will cause overheating and loss of power.



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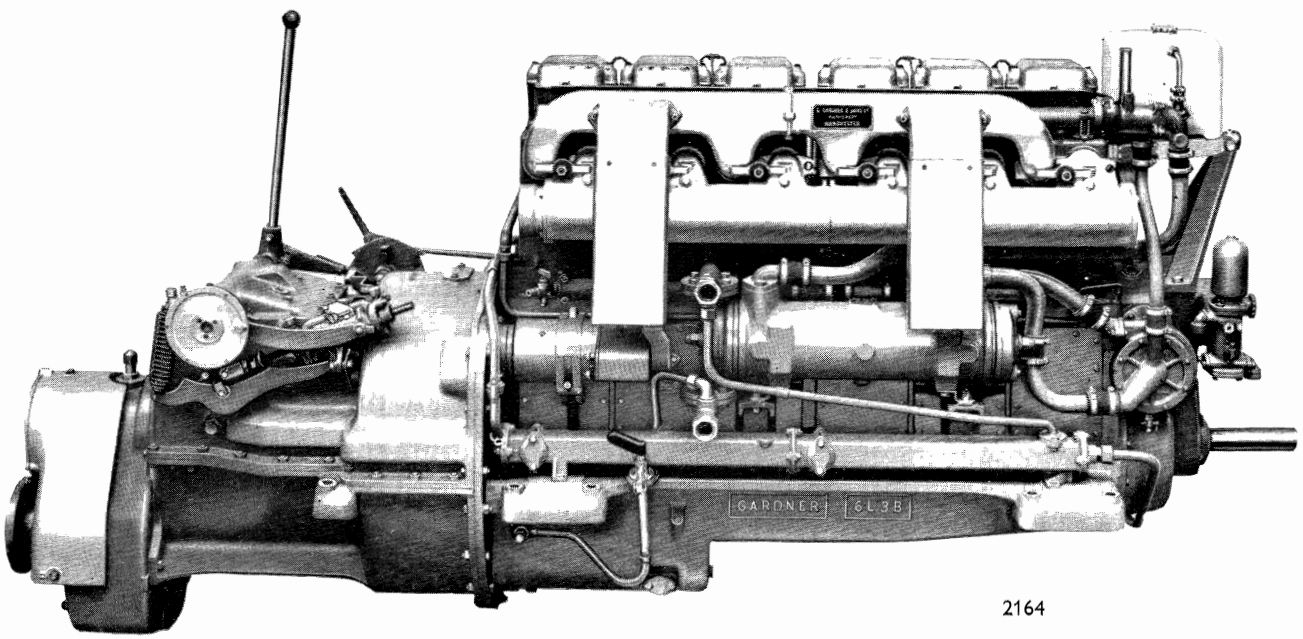

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6L3B Engine equipped with No. 3UC Reversing and Reversing Reducing Gears. Lower picture shows the Gardner Hydraulic Remote Control for reverse gear operation with "push-pull" cable pulley for gear position indicator, whilst above can be seen the interlocking of engine speed and reverse gear controls.

SECTION 1

DESCRIPTION AND MAINTENANCE

SECTION 1.

DESCRIPTION AND MAINTENANCE

1. **Lubrication System.**—At the aft end of the hollow main shaft of the reverse gear is mounted a ram pump, the lower half of which is submerged in the oil sump. This pump delivers oil to the hollow shaft from whence it is distributed by means of small radial holes to all the bearings and other working parts of the reverse gear. A small hole is also provided in the cap of the pump and this directs a fine jet of oil onto the mainshaft aft bearing.

   The oil, after lubricating the various parts, drains into the dirt sump and flywheel sump, where it is picked up by the flywheel and centrifuged into a trough which returns it to the main oil sump. This return oil flow may be observed through the filling plug orifice. A trough is provided on both sides of the gear case to cater for clockwise or anti-clockwise rotation of engines.

   Caution.—Since the oil pump is not in operation with the gear in the "Neutral" position it is not advisable to run the engine for prolonged periods without engaging either the "Ahead" or "Astern" clutches for a short period to ensure lubrication of the working parts.

2. **Sump Filling: Reverse Gear.**—Before filling the oil sump for the first time, the three drain plugs must be removed to ensure that the three sumps are quite empty. (See Fig. 2.)

   After replacing the three drain plugs, pour through the filling hole the correct amount of oil required by the gearbox. It will be noted, on completion, that the oil level is well above the upper mark on the dipstick. This level will fall after the engine has been run, due to some of the oil being transferred to the dirt sump and the flywheel sump as explained para. 1.

   If sump emptying pipes are fitted in lieu of drain plugs, the sump emptying pump should be connected to each pipe union in turn and the pump operated until satisfied that all oil has been extracted from each section of the gearbox.

   After draining has been completed the dust covers must be replaced on the pipe unions. (See Fig. 1.)

3. **Sump Filling: Reducing Gear.**—Remove the combined oil filler and breather from the top of the gear case and pour the required amount of oil through the filler orifice until the level reaches between the MAX. and MIN. marks on the dipstick.

   The oil must never be allowed to drop below the MIN. mark. Check regularly before running the engine when the gear is cold.

4. **First Running of Engine.**—When running the engine for the first time, or after prolonged periods of rest, set the engine speed at about 500 r.p.m. for two or three minutes with the "Ahead" or "Astern" clutch engaged. This will ensure a full distribution of oil to all the working parts of the reverse gear. Whilst the engine is still running the oil level will be found to be between the upper and lower marks on the dipstick.

   After this, the engine and gear may be put to work.

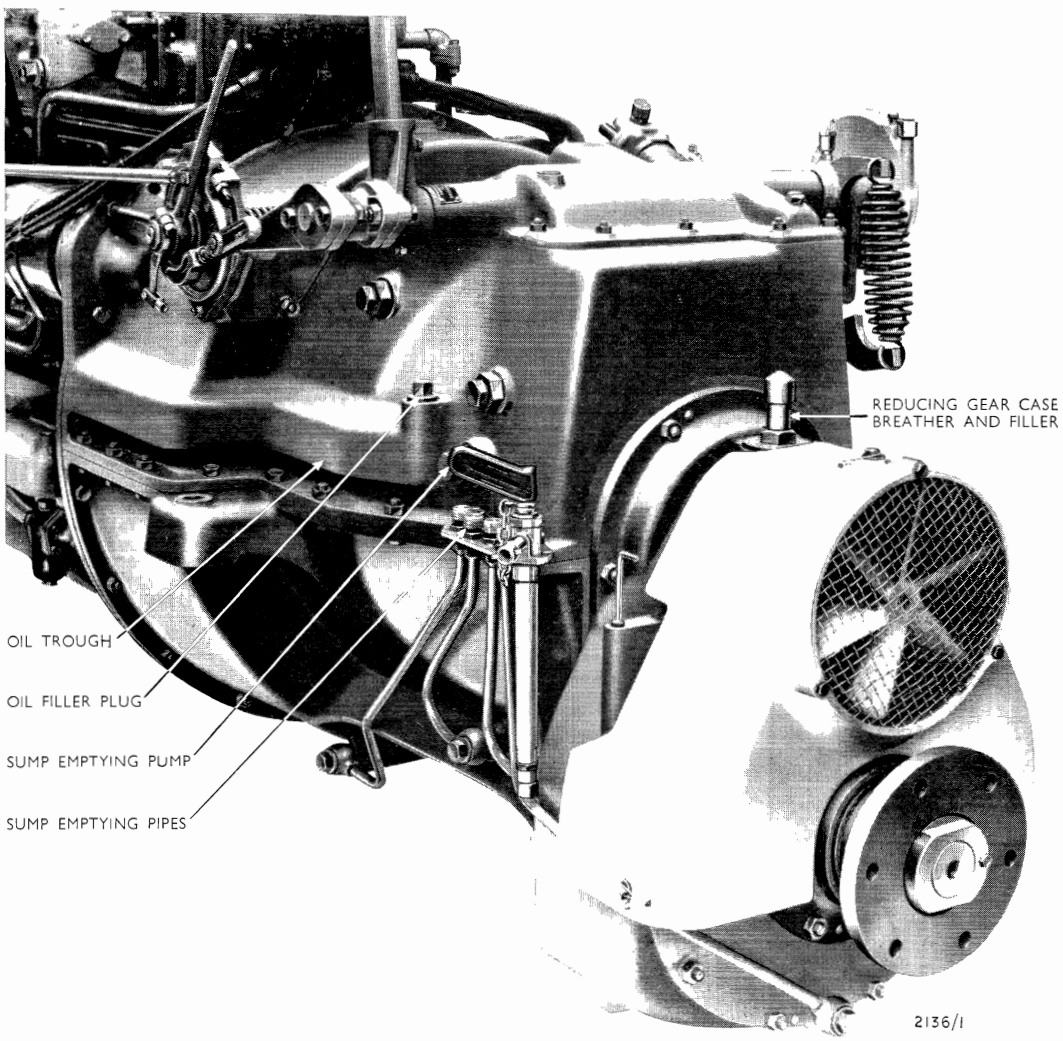
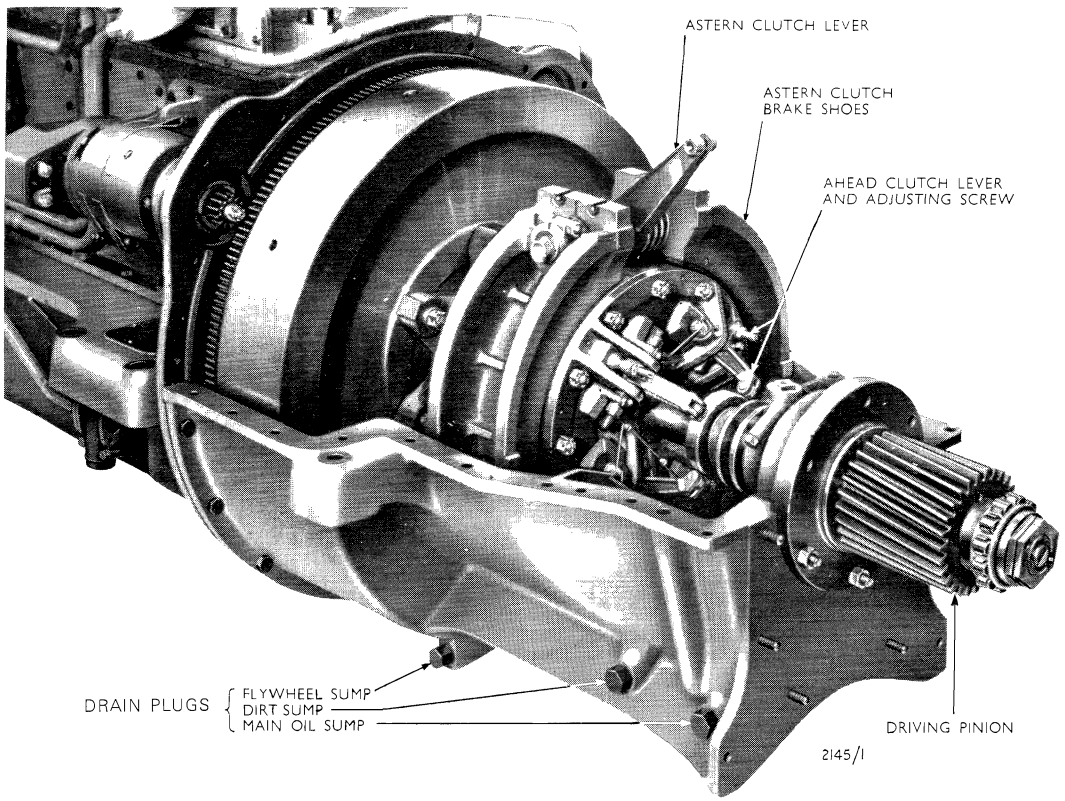


Fig. 1. Reversing and Reducing Gear Case Oil Filling and Draining Points



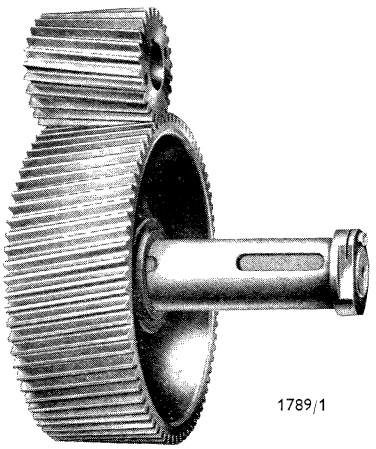


Fig. 2. 3UC Reverse Gear with upper half gear case removed, showing installation of running gear with Ahead and Astern clutches also inset a matched pair of 3:1 ratio Reducing Gears.

DESCRIPTION AND MAINTENANCE—*continued.*

5. **Maintaining Oil Level.**—With the reverse gear lubricating system, where the flywheel returns the oil to the main sump, it is not possible to give a definite oil level mark on the dipstick, because the oil level in the main sump varies according to the R.P.M. of the engine, and to the oil temperature in the gearbox. There are two lines on the dipstick, upper and lower, and if the gear case has been filled in accordance with para. 2, the oil level should be about $\frac{3}{8}$ in. below the upper line with the engine running at about 900 r.p.m. and the oil temperature about 90°F. (32°C.).

   Minimum Oil Level.—If the oil level falls below the lower mark or minimum level, with the engine running at 900 r.p.m. as above, oil should be added to the gear case to bring the level up to about half-way between the level marks.

   Excess Oil Level.—If, when running at 900 r.p.m. as above, and due to over filling, the oil-level reading is more than $\frac{7}{8}$ in. above the upper mark on the dipstick, the surplus oil should be drained from the sump.

   NOTE.—That it is undesirable to overfill, as the churning of this excess oil absorbs a little power.
   Maximum and Minimum Oil Level.—Finally, it may be said, that if the oil at any engine r.p.m. does not fall below the lower mark on the dipstick, there is sufficient oil in the gearbox. Also if the oil, at any engine r.p.m. does not rise more than $\frac{7}{8}$ in. above the upper mark, there is not an excess of oil in the gearbox.

6. **Lubricating Oil Pump.**—The pump has two rams or plungers, the lower being the pump ram submerged in the oil, and the upper being the balancing ram, which serves as a pressure relief valve and also feeds oil to the aft bearing. The ball suction valve is carried at the lower end of the pump body, and the ball delivery valve is carried in the upper end of the pump ram. Flats are provided on the pump ram so that it can be held in a vice or spanner when removing the screwed valve seats. A special screwdriver is provided in the tool kit for this purpose.

   With the pump submerged in the oil sump, it is extremely improbable that it will fail. Nevertheless it is prudent to check its action from time to time by observing the return oil flow through the filler orifice.

7. **Removal of Oil Pump.**—If the pump should fail, it must be removed from its shaft to find the cause of failure, and to do this, proceed as follows:—

   Place the gear lever in the "Neutral" position and remove the gear case cover. Disconnect the "Astern" clutch lever link from the cam plate shaft. Release the setscrew in the cam plate and slide the cam towards the crank as far as possible to disengage the bowl on the lower shaft. Unlock the nuts and release the pivot screws on each side of the case. The cam plate and its shaft can then be lifted out. Next rotate the main shaft until the pump eccentric lies with its maximum throw at T.D.C. Remove the two cap bolts of the pump, and take off the cap. Just above the gauze strainer will be found a knurled collar. If this is lifted upwards against the action of the spring and held upwards, the pump body can be lowered or disengaged from its shaft. When in this position, the pump can be moved sideways to clear the gear shaft, whilst lifting it from the gear case. When replacing the pump it is of vital importance that the pump body is replaced on the same side of the main shaft from which it was withdrawn. This will ensure that the oil hole in the cap is facing aft when the cap is reassembled. Note that the "Aft" marking must face to the rear.

   NOTE.—When replacing the cam plate shaft on reassembly, make sure that the cam plate bowl is in place on the lower shaft, before sliding the cam plate into its working position.

8. **Dirt and Flywheel Sump.**—This dirt sump is provided to trap any dirt particles that may collect from the wear of the clutch surfaces, etc. It is therefore advisable to drain this, and the flywheel sump, at intervals of say 1,000 hours, in order to remove any dirt that may have collected therein. The oil removed may be re-used after filtering. When draining this sump, take note of the oil quantity removed, and afterwards restore a similar quantity through the filling hole.

DESCRIPTION AND MAINTENANCE—*continued*

9. **Ahead Clutch.**—This clutch is of the plate type, having alternate sintered bronze and steel plates. Clutches fitted to 8L3B engines have nine sintered bronze plates and eight steel plates, whilst clutches fitted to the 6L3B engines and later L3 series engines have seven sintered bronze and six steel plates.

The plates are loaded by four clutch levers, each having an adjusting screw that transmits the pressure by means of spring plunger assemblies.

To accommodate the extra thickness of the four additional clutch plates on 8L3B engines, the collar on the plunger assemblies are shorter than those for the other engines. It is important, therefore, that the correct type of plunger assembly be fitted in each case otherwise the basic settings for the clutch levers will not be achieved. See Fig. 8 (Page 32).

Prior to the introduction of sintered bronze plates, L3 series engines were equipped with clutches containing 7 bronze plates and six steel plates $\frac{1}{8}$ in. thick and incorporated solid clutch pins with helical springs. These are no longer available and if replacement becomes necessary they can be exchanged as complete sets for the later $\frac{3}{32}$ in. sintered bronze and steel plates together with the appropriate plunger assemblies which have a longer collar to compensate for the reduced thickness of the new plates.

Replacement plunger assemblies are also available for use with the $\frac{1}{8}$ in. thick bronze clutch plates and in this event, are supplied with a shorter collar to accommodate the extra thickness.

If replacement of the original clutch springs is necessary, it is recommended that they be exchanged as complete sets and not singly.

The plunger assemblies are adjusted at the Works to a pre-determined loading which ensures that the pressure applied to the clutch plates is evenly shared by all four clutch levers.

This pre-loading is governed by the quantity and thickness of spring discs and by the special manner in which they are arranged on assembly. For this reason, the plunger assemblies are obtainable only as complete units and should not, *under any circumstances*, be disturbed or dismantled.

In the event of a plunger assembly being inadvertently dismantled, the following procedure must be adopted when reassembling to ensure that the designed loading is maintained.

The standard spring disc is ·032 in. thick and it is necessary before assembling the unit to measure with a micrometer the thickness of each disc in order to identify the non-standard discs which may have been incorporated in the original assembly for the purpose of obtaining the desired nip.

Having identified the non-standard spring discs, if any, assemble the discs on the plunger pin in four opposing groups of five discs each, ensuring that there is not more than one non-standard disc in any one group. Position the first group of five discs so that the outside edge abuts against the head of the plunger pin, followed by the second and subsequent groups, each reversed as shown in Fig. 3.

Having assembled the discs as illustrated, fit the plunger collar and check with a depth gauge that the end of the plunger pin is ·010 in. below the recess in the collar. This will ensure a ·010 in. nip on the discs with the setscrew fully tightened.

Finally, when fitting the setscrew, see that it is a stud fit in the plunger pin to prevent inadvertent loosening. Works practice is to apply a torque load of 50 lb. in. for final tightening when the setscrew head is within $\frac{1}{8}$ in. of contact with the pin.

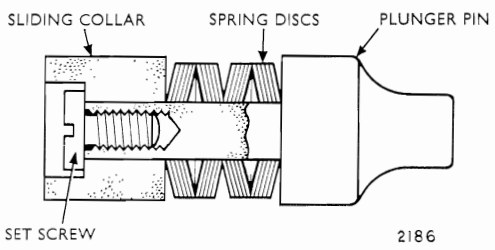


Fig. 3. Ahead Clutch Plunger Assembly

10. **Adjustment of Ahead Clutch** (Refer to Fig. 4).—Move the clutch collar so that the lever rollers rest on its smaller diameter. Withdraw the adjusting screws until the ends are flush with the inside face of the levers.

Move the clutch sleeve to bring the rollers into contact with its larger diameter. Turn each screw by hand until it exerts slight but definite pressure on each plunger assembly and lightly lock in position, taking care not to disturb the screw when doing so.

DESCRIPTION AND MAINTENANCE—*continued.*

Next move the clutch sleeve so that the rollers are again in contact with the smaller diameter. Then holding each screw in turn, unscrew the lock nut and screw the setscrew a further $1\frac{3}{4}$ turns inwards (estimating this by the screw driver slot) and firmly re-tighten the lock nut, taking care not to turn the screw when doing so.

If this procedure has been carefully followed, the levers will be adjusted equally. Do not adjust more than the $1\frac{3}{4}$ turns and when so adjusted it should require a pull of 95 to 100 lb. at 2 ft. radius of the operating hand lever to engage the clutch. The pull can be measured by a spring balance and cord looped round the hand lever.

When the reversing gear is fitted with a wheel control instead of hand lever proceed as directed above. When so adjusted it will require a pull of 68 to 72 lb. at a 5 in. radius of the hole in the operating hand wheel to engage the clutch. In this instance the load can be measured by looping the cord through the hole in the hand wheel rim.

CAUTION.—Do not exceed the loads specified above, it is unnecessary and might cause damage to the mechanism.

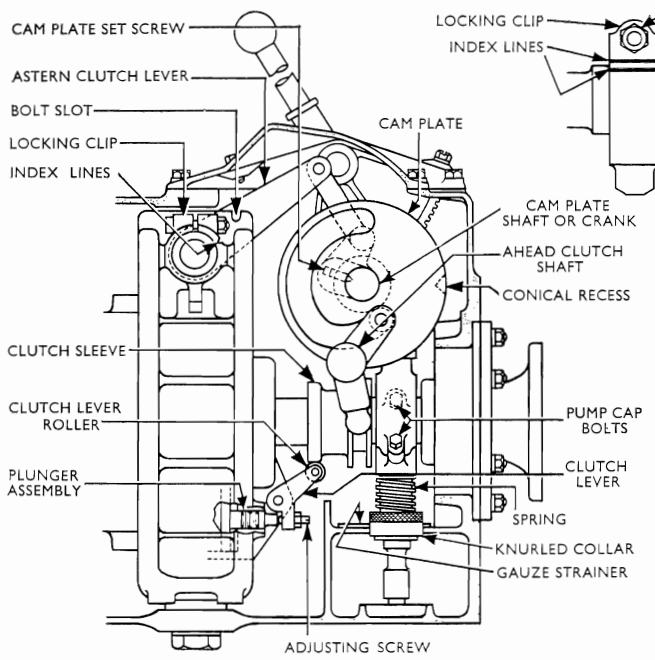


Fig. 4

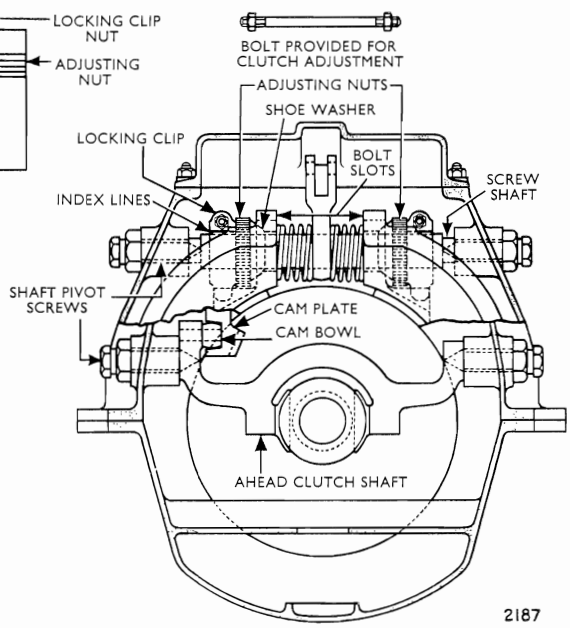


Fig. 5

11. **Astern Clutch or Brake.**—This clutch takes the form of a brake having a pair of cast iron brake shoes lined with friction fabric. The shoes are anchored and hinged at the bottom of the gearbox and their upper ends are contracted by means of a right and left hand screw shaft which is held endwise between two adjustable pivot screws in the upper part of the gearbox.
It will be seen from Fig. 5 that if the two adjusting nuts are set equally no disturbance of alignment of the rotating gearcase and mainshaft can take place. For this reason it is very important to adjust the two nuts so that the brake shoes make equal and simultaneous contact with the drum when contracted.

DESCRIPTION AND MAINTENANCE—*continued.*

12. **Preliminary Setting of Astern Clutch Brake Shoes.**—Put the gear into "reverse" and remove the gearcase cover. Slacken the bolts of the two locking clips (see Fig. 5) and unscrew the adjusting nuts clear of the shoes. Note that one has a right-hand and the other a left-hand thread. Insert the long bolt, provided in the tool kit, in the slots at the top of the brake shoes and lightly clamp the shoes on to the drum by tightening the nut and bolt. Turn one adjusting nut until it is in contact with the shoe washer and holding it in this position tighten the locking collar. Repeat the same operation on the other adjusting nut. With the two adjusting nuts equally positioned and the brake shocs centralised, final adjustment of the astern clutch can now be effected.

13. **Final Adjustment of Astern Clutch.**—Remove the bolt from the slots in the brake shoes and turn the cam plate until the astern clutch lever is in its highest position (see Fig. 4).

On each locking clip will be found two lines and the distance between these defines the amount of adjustment necessary to load the brake shoes. Make a mark with a scriber on both adjusting nuts to coincide with the *lower* line on each collar. Do this carefully.

Release the nut on one of the locking clips just enough to enable the adjusting nut to be prised round with a screwdriver. Engage the screwdriver in one of the slots and, using the brake shoe as a fulcrum, lever the nut round until the scribed mark coincides with the *top* line on the locking clip. Tighten the locking clip nut to the correct torque of 500 lb. in. and repeat the operation on the other adjusting nut.

This completes the astern clutch adjustment

On earlier 3UC gear units, a dot was used in place of the lower line, but the method of obtaining final adjustment is identical to that described above. **Do not exceed the above adjustment.**

The operating hand lever should require a pull of 85 to 90 lb. at 2 ft. radius to engage this clutch, when the reversing gear is cold.

When the gear is warm (about 110°F.) the above pull will be a little less, owing to the expansion of the brake shoes, but the clutch or brake will still carry its load.

When the reversing gear is fitted with wheel control proceed as directed in paragraphs 11, 12 and 13. When so adjusted it should require a pull of 62 to 66 lb. at the 5 in. radius of the hole in the hand wheel rim to engage the clutch, when the reversing gear is cold.

14. **Clutch Mechanism.**—The three shafts of this mechanism, i.e. the astern clutch screw shaft, the cam plate crank or shaft, and the ahead clutch shaft are carried by adjustable pivot screws, see Fig. 5. All three shafts are made so that they can be located endwise between their bosses on the gear case walls. To adjust these shaft pivots, proceed as follows:—

Unscrew the lock nuts, apply a little lubricant at the points of contact between pivot screws and shaft; Molybdenum Disulphide and Tallow is a good lubricant. Then holding the shaft in position with one hand, tighten one of the screws with the fingers of the other hand sufficiently to push the shaft end into contact with the inside face of the boss on the opposite side of the gear case.

Again using the fingers only, tighten the other pivot screw. With the shaft thus supported by the pivot screws adjust both screws to centralise the shaft between the two bosses, tightening with the fingers only. The shaft will now be a little stiff on its pivots, but the act of locking the nuts will withdraw the screw pivots a little and thus free the shaft. Hold the pivot screws with a spanner so that they cannot turn, when locking the nuts.

NOTE.—It is important that these shafts are closely adjusted, and at the same time, are free on their pivots. If not, the ahead clutch trunnion blocks will continue to rub on the face of the clutch sleeve after the ahead clutch is engaged.

15. **Lever Control Travel.**—The travel of the gear operating lever is limited by two adjustable stop screws, situated in the gear case cover. These abut against the ends of the operating quadrant when the lever is in the "Ahead" or "Astern" position. The stop screws are correctly adjusted before leaving the Works and should not require attention unless the original adjustment is disturbed during internal inspection of the gear, or in the event of excessive wear taking place after prolonged service.

DESCRIPTION AND MAINTENANCE—*continued.*

If, for any reason, the settings have been disturbed the control lever stop screws must be re-adjusted as follows:—

Slacken the lock nuts and unscrew the two stop screws. Push the gear lever forward to the limit of its travel; this will now be governed by the cam bowl striking the end of the recess in the cam plate. Hold the lever in this position and screw in the rear stop screw until it is in contact with the quadrant and a slight movement is felt at the end of the lever. Turn the screw a further quarter turn and tighten the locknut, taking care not to turn the screw whilst doing so. Repeat the operation with the gear lever in the astern position by adjusting the front stop screw in the same manner. The lever control travel will now be correctly set.

16. **Meshing of Internal Operating Quadrant.**—It is important that the quadrant on the handlever cross-shaft be meshed correctly with the pinion on the cam cross-shaft, so that the quadrant abuts against the stops, situated in the cover, in both "Ahead" and "Astern" positions. If the meshing is not correct either the Ahead or Astern clutch will not be fully engaged, in addition, the stopping of the lever or remote control mechanism (if fitted), will be transferred to the internal operating mechanism, which is not capable of withstanding the shock loads.
To ensure correct meshing of the quadrant, set the internal mechanism in the neutral position, with the line through the conical recess on the cam plate coinciding with the line on the top face of the casing. Before placing the cover in position, set the hand lever so that the line on the lever socket coincides with the line on the extended boss of the cover.
Check the meshing by noting that these latter lines are coinciding exactly when the Neutral locating plunger is fully engaged.

17. **Remote Control (if fitted).**—If a remote control of local or proprietary manufacture is installed for reverse gear operation, it is essential that a sufficient amount of travel be provided on the remote control lever to ensure full and complete engagement of both Ahead and Astern clutches.
Incomplete or partial engagement of these clutches will generate heat and induce rapid wear of the friction surfaces which is both undesirable and detrimental to the working parts of the gear.
It is strongly recommended therefore, that in the event of this type of control being fitted, the linkage or mechanism be so arranged that full movement of the internal operating quadrant is assured between its fore and aft stops in the gear case cover, and provision be made to incorporate adjustable stops for the remote control lever in order to avoid overloading the control linkage, with possible damage to the gear mechanism.
When adjusting the remote control linkage or mechanism it is essential that, with the remote control lever in the "Neutral" position, the datum line on the reversing gear cover coincides with that on the operating lever socket (refer to para. 16). With the linkage adjusted accordingly, the fore and aft stop screws for the remote control lever can then be adjusted to synchronise with those in the gear case cover.
It is advisable to periodically inspect the remote control linkage or mechanism for any lost motion which may arise due to wear of the working parts and which, if allowed to become excessive, would result in incomplete engagement of the clutches.

18. **Reducing Gears.**—These gears are matched in pairs and carry a number inside a blue circle. These numbers, which appear on both the large and small gear, lie at the same side. Works practice is to assemble the gears with the numbers facing aft.

Renewal of gears can only be effected in pairs. Under no circumstances must a new gear be matched with a worn one.

19. **Reducing Gear Seals and Glands.**—The aft thrust bearing housing of the reducing gear embodies duplex synthetic rubber seals to prevent rapid entry of bilge water in an emergency.
These seals are self-adjusting and do not require grease cup lubrication. Use oil-can occasionally on the aft seal.
It is important that the surface finish of the metal parts which operate within any of the synthetic rubber seals must be of the highest quality and free from any bruises, scratches or imperfections.
Earlier L3 type reducing gears were provided with a packed gland to prevent entry of water.
With this type of seal, the gland nuts should be followed up regularly but not tightened sufficiently to generate heat. Use gland grease cup daily, applying a water insoluble mineral base grease.

DESCRIPTION AND MAINTENANCE—*continued.*

20. **Dismantling of Reverse Gear.**—Should this be required at any time, the main shaft and rotating gear assembly can be withdrawn by removal of the following:—

    1. Cooling Fan and cowling
    2. Reduction gear and case } when fitted.

    If subsequent dismantling of the complete running gear is anticipated, it is advisable at this stage to slacken the driving pinion retaining nut, using the engine as a brake by engaging the ahead clutch.

    Caution.—When dismantling the Direct Drive Reverse Gear, the propeller shaft coupling must be withdrawn by inserting three $\frac{5}{16}$ in. B.S.F. draw-bolts in the holes provided in the boss of the coupling after first removing the three blanking screws. Withdrawal of this coupling by any other method or by imposing a load on the flange is not recommended and may result in distortion of the flange face.

    When assembling the coupling on a Direct Drive Reverse Gear ensure that the three blanking screws are replaced and firmly tightened in the coupling boss in order to prevent oil leakage from the reverse gear aft bearing.

    3. Ahead and astern clutch operating gear (cross-shafts, etc.).
    4. All nuts and upper three bolts from main ball bearing housing at aft end.
    5. Upper half reverse gear case.
    6. Astern brake shoes.
    7. Nuts and bushes from main drive spider lugs.
    8. Lubricating oil pump. See para. 7.
    (MAINSHAFT ASSEMBLY MUST NOW BE PUSHED AFT ABOUT 1 in.)
    9. The six nuts which hold spigot sleeve to flywheel.

        These nuts can be seen between the aft face of the flywheel and the main spider. The spigot sleeve should now be levered aft out of engagement with the flywheel. For this purpose the outer diameter of the spigot sleeve is provided with relief to receive a large screwdriver or equivalent tool.

        Before the mainshaft has been pushed aft sufficiently to withdraw the aft bearing bush from its housing and the forward end spigot sleeve from engagement with the flywheel, the shaft and running gear assembly must be chocked or slung to take its weight, otherwise damage would occur when it loses its register at either end.

        When drawing the running gear away from the engine it will be found necessary to slightly lift the aft end of the shaft so that the clutch case passes the forward wall of the oil sump.

    It is to be noted that the large diameter internally screwed collar fitted to the mainshaft immediately forward of and in contact with the aft ball bearing should, if removed for any purpose, be refitted in its precise original position. For the older type collar, this can be determined by the pointed setscrew countersinks. On later type collars of the split type, the collar must be set to its original position by measuring its distance from the oil pump eccentric before dismantling. Alternatively, if this measurement has not been taken, it must be positioned so that its aft face is $23\frac{5}{8}$ in. from the forward face of the driving spider lugs.

21. **Alignment with Tail Shaft.**—It is of the utmost importance that the reverse gear or reduction gear is maintained in perfect alignment with the tail shaft. Malalignment may cause failure of shafts, couplings, bearings, gears, etc. Inspect frequently after a new installation has been carried out, until the craft has "settled," and when fully seasoned, inspect at regular intervals. The alignment of gear unit and tail shaft is effected by shimming between the engine/gear unit feet and the engine bearers. The quantity and sizes of shims supplied for each engine and gear unit is as follows:—

DESCRIPTION AND MAINTENANCE—*continued*

Location of shims	Dimensions of shims		Drawing No.	Total number of shims supplied per engine and reverse gear unit	
	Size	Thickness		6L3B	8L3B
ENGINE Fore and Aft Supporting Feet 6L3B and 8L3B	$9\frac{1}{2}'' \times 2\frac{5}{8}''$	·003″ ·007″ ·032″	J 7247 J 7248 J 7249	16 12 8	16 12 8
ENGINE Centre Supporting Feet 8L3B only	$8'' \times 2\frac{5}{8}''$	·003″ ·007″ ·032″	J 7244 J 7245 J 7246	– – –	8 6 4
REVERSE GEAR Supporting Feet	$3\frac{15}{16}'' \times 2\frac{3}{4}''$	·003″ ·007″ ·032″	J 7250 J 7251 J 7252	8 6 4	8 6 4

22. **Table of Alignment Shims.**—To obtain alignment within ·003 in. and to obtain a total thickness of shims between ·003 in. and $\frac{1}{16}$ in. with steps not greater than ·003 in., it is necessary to have available, shims of the thickness and quantity quoted below for each individual foot on the Engine/Reverse Gear Unit.

4 off shims	·003″	thick
3 ,, ,,	·007″	,,
2 ,, ,,	·032″	,,

With the above shims it is possible by selection to make up the aggregate thicknesses given in the table overleaf.

DESCRIPTION AND MAINTENANCE—*continued.*

TABLE OF ALIGNMENT SHIMS

Total thickness of shims	Quantity of shims to be used			Total thickness of shims	Quantity of shims to be used		
	·003″	·007″	·032″		·003″	·007″	·032″
·003″	1	–	–	·035″	1	–	1
·006″	2	–	–	·038″	2	–	1
·007″	–	1	–	·039″	–	1	1
·009″	3	–	–	·041″	3	–	1
·010″	1	1	–	·042″	1	1	1
·012″	4	–	–	·044″	4	–	1
·013″	2	1	–	·045″	2	1	1
·014″	–	2	–	·046″	–	2	1
·016″	3	1	–	·048″	3	1	1
·017″	1	2	–	·049″	1	2	1
·019″	4	1	–	·051″	4	1	1
·020″	2	2	–	·052″	2	2	1
·021″	–	3	–	·053″	–	3	1
·023″	3	2	–	·055″	3	2	1
·024″	1	3	–	·056″	1	3	1
·026″	4	2	–	·058″	4	2	1
·027″	2	3	–	·059″	2	3	1
·030″	3	3	–	·062″	3	3	1
·032″	–	–	1	·064″	–	–	2
·033″	4	3	–				

SECTION 2

ASSEMBLING AND INSTALLATION

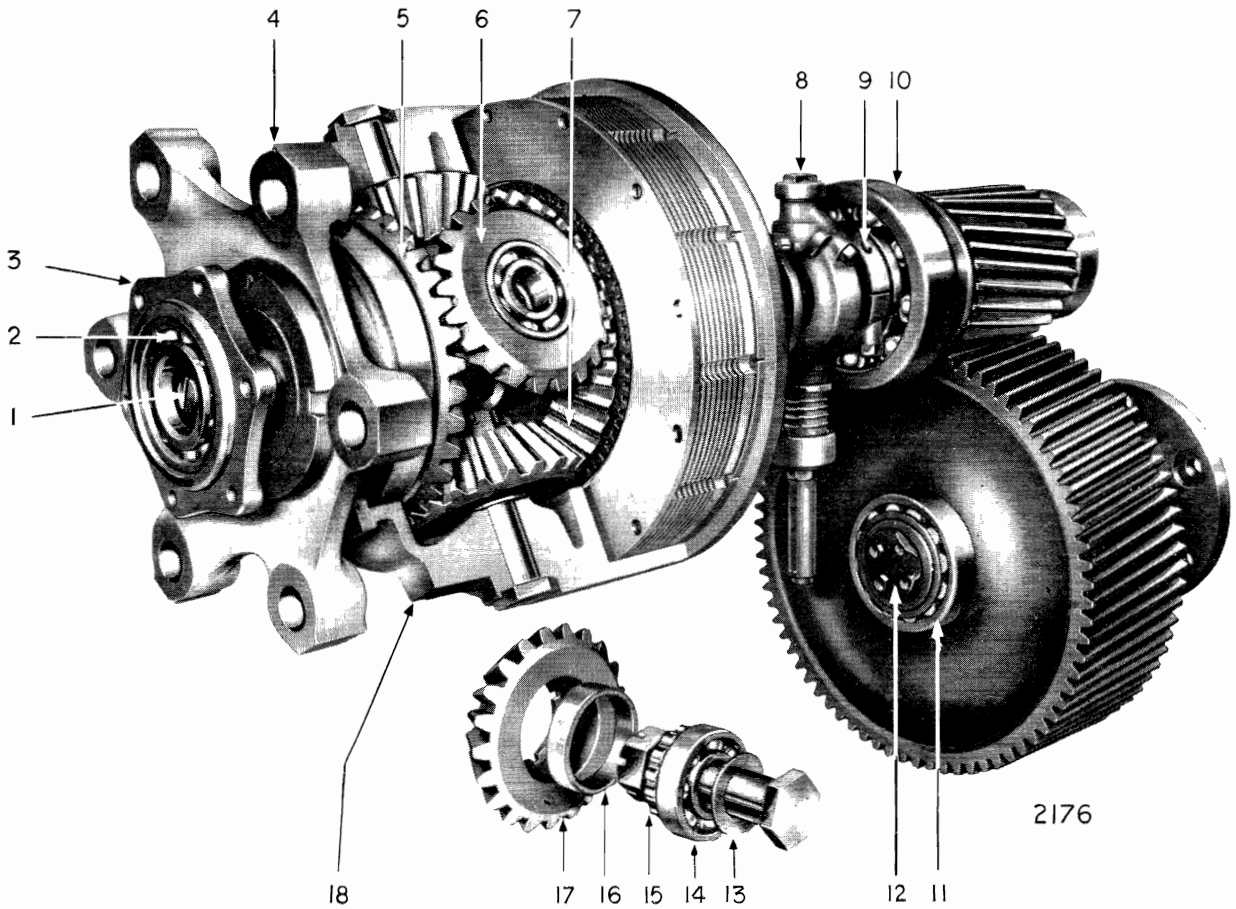


Fig. 6

1. Mainshaft end plug
2. Mainshaft front bearing
3. Spigot sleeve
4. Driving spider
5. Driving bevel
6. Planet bevel
7. Driven bevel
8. Lubricating oil pump
9. Locating collar
10. Mainshaft aft bearing
11. Secondary shaft front bearing
12. Locking plate
13. Thrust washer
14. Ball bearing
15. Roller bearing
16. Roller bearing outer race
17. Planet bevel
18. Gear casing

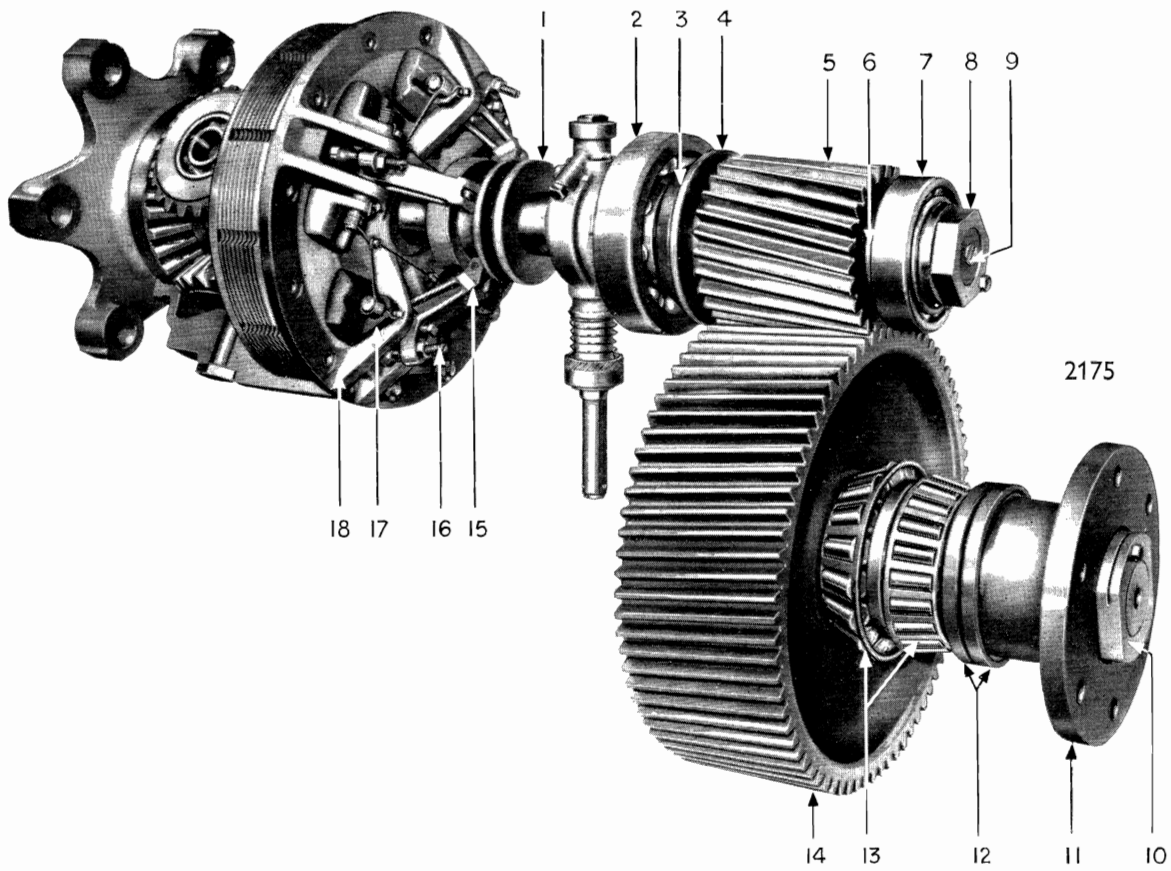


Fig. 7

1. Clutch sleeve
2. Mainshaft aft bearing
3. Synthetic rubber oil seal
4. Flanged distance collar
5. Driving gear
6. Distance collar
7. Driving gear end bearing
8. Retaining nut
9. End plug
10. Retaining nut
11. Half coupling
12. Duplex oil seals
13. Thrust bearings
14. Driven gear
15. Ahead clutch lever
16. Ahead clutch lever adjusting screw
17. Clutch lever balance weight
18. Gear case cover

SECTION 2.

ASSEMBLY AND INSTALLATION

The following assembly instructions are based on normal Works procedure and the clearance figures quoted are those specified for new gears. After the gear has been in service these clearances may be found to be slightly greater due to initial "bedding-in" and providing the gear teeth do not reveal signs of excessive wear or fretting, such slight increases are acceptable.

If, however, the above defects are apparent, or if noise is generated through maladjustment or malalignment, both driving and driven gears must be replaced and the source of trouble rectified.

When re-assembling existing parts ensure that they are replaced in precisely the positions they occupied before dismantling so that continuity of contact between matching parts is maintained.

It is important that correct torque loadings are applied when tightening certain nuts, whether slotted or current plain type, and these are specified in the table below.

Split pins formerly used with the slotted nuts may be omitted in these applications as any additional locking device is unnecessary on a correctly tightened nut.

NUT TIGHTENING TORQUES

No. 3UC Reversing Gear Nut Tightening Torques

Description	Size	Torque lb. in.
Planet Bevel Bearing Bolts	$1\frac{1}{8}$" BSF	3,000
Bevel Gear Case Cover Bolts	$\frac{1}{2}$" BSF	600
Mainshaft Locating Collar Bolt	$\frac{1}{2}$" BSF	1,200
Spigot Sleeve Flywheel Studs	$\frac{7}{16}$" BSF	550
Driving Spider Coupling Bolts	$\frac{5}{8}$" BSF	1,400

23. **Assembling the Bevel Gears.**—Before assembling the running gear it should be noted that both the driving bevel and the four planet bevels have a number stamped on the end of one of their teeth. This figure will be between ·002 in. and ·008 in. and represents the backlash obtained when that particular gear is meshed with a master gear. Works practice is to select a set of gears which will give a total backlash of ·006 in. when assembled in the gear case; this total being the sum of the two figures on the driving bevel and planet bevel.

Having noted this figure, fit the ball bearing into its housing in the bevel gear case. This bearing is a light driving fit, both into its housing and onto the driving spider. Fit the feather key into the driving bevel and by entering the driving spider from the outside of the case and the driving bevel from the inside, the two can be drawn together. Screw on the retaining nut and tighten firmly with a hammer. With a suitable size drill transfer the setscrew hole in the retaining nut into the driving spider and insert the 1 B.A. setscrew, finally locking the setscrew by lightly punching metal from the nut into the screwdriver slot.

To facilitate assembly of the planet bevels and check backlash, the gear case should now be placed with its open end uppermost on a suitable stand, to permit free rotation of spider and bevel gear.

Fit the two bearings into the planet bevels ensuring that the roller race is inserted first and the ball race last; **this is important.**

Insert the planet bevel bolts into the case from outside and place the distance washers over the bolts, followed by the planet bevels. Tighten the nuts and check that the backlash agrees with the sum of the figures stamped on the driving and planet gears. This clearance should be checked at various positions around the driving bevel. Having ascertained that the backlash is within the limits specified, i.e. ·006 in. $\pm$ ·002 in. tighten the nuts of the planet bevel bolts to the correct torque of 3,000 lb. in. then proceed to set the backlash between the planet bevels and the driven bevel. This backlash must agree with the sum of the two figures on the driven bevel and planet bevels, but it need not necessarily correspond to the backlash between the driving bevel and planet bevels. The amount of backlash is determined by the length of the thrust collar interposed between the driving and driven bevels.

When fitting a new set of gears the length of thrust collar required to maintain correct backlash must first be ascertained. To do this, place an undersize collar on a distance piece of known length centrally on top of the driving bevel, add paper washers of known thickness to the top of the collar or distance piece and pack up the driven bevel until the appropriate backlash is obtained.

ASSEMBLY AND INSTALLATION—*continued.*

When assembling an existing set of gears it is a simple matter to check the backlash by using the existing collar. If the backlash is below the figure required a replacement collar, machined to correct length, must be fitted.

24. **Checking End-Float of Reversing Gear Main Shaft.**—Having obtained the desired backlash in the bevel gears it is necessary to check the end-float of the main shaft in the bevel gear case. This is governed by the length of the boss on the driven bevel which is machined to give an end-float of ·004 in. to ·006 in. To check this end-float proceed as follows:—

With the driven bevel resting on the paper shims and undersize thrust collar, as described in para. 23, place a distance piece on the boss of the driven bevel of identical thickness to the ball race which fits in the gear case cover, but slightly undersize in diameter to allow free entry into the bearing housing. Place the gear case cover in position over the distance piece and measure the gap clearance between the cover flange and gear case rim. Increase this gap by raising the cover say a further ·012 in. and insert four sets of feeler gauges of suitable thickness diametrically opposite one another between cover and case. Tighten down the cover on to the feeler gauges by inserting four bolts through the holes adjacent to the gauges and measure the clearance that remains between the distance piece and cover at the mainshaft aperture. It should be noted, when all 12 bolts are tightened to the correct torque of 600 lb. in. the centre of the cover will be depressed a further ·003 in. *This fact must be allowed for when calculating the adjustment necessary to obtain correct end-float.*

Having ascertained the clearance between distance piece and cover, subtract this figure from the gap clearance between cover and case. To the resulting figure add ·004 in. for end-float, plus ·003 in for final tightening of cover, and the sum of this will be the total amount that is required to be removed from the boss of the driven bevel in order to obtain the correct end-float on final assembly.

When re-assembling an existing set of gears, together with the existing collar, it will be found unnecessary to insert feeler gauges between the cover and the gear case rim since a clearance will already exist between the distance piece and the cover with the latter bolted in position. A direct reading, therefore, may be taken at this point to determine the amount of end-float present. **Account must be taken of the ·003 in. allowance for final tightening when measuring this clearance.**

25. **Assembling the Running Gear and Ahead Clutch.**—Having checked the backlash of the bevel gears and the end-float of the main shaft in the bevel gear case, the running gear can be assembled as follows:—

Bolt the clutch plate hub to the driven bevel, press the ball race onto the mainshaft against the shoulder and fit the feather key for the driven bevel. The driven bevel and hub assembly can now be pressed onto the shaft. This should require a load of approximately 8-12 tons. Place the thrust collar on the face of the driving bevel and lower the end of the mainshaft, complete with driven bevel, through the thrust collar and driving bevel until the gears are in mesh.

It is advisable at this stage to re-check the backlash, finally lubricating all the gears and bearings liberally with engine oil.

The clutch plates may now be assembled. The lower or first plate is of steel and has six radial grooves machined on one face and a bevel on its inner circumference. These grooves must face upwards or away from the bevel gears and lie against the friction plates when assembled.

The thinner sintered bronze and steel plates are then assembled alternately over the hub; each plate surface being lightly oiled as it is assembled. Clutches fitted with bronze plates containing $\frac{3}{8}$ in. offset holes must be assembled so that the offset holes in each consecutive plate are positioned 180° to each other throughout the assembly, i.e. the hole positioned nearest to the perimeter of the plate must be placed diametrically opposite its previously assembled counterpart.

NOTE.—On clutches fitted to L3-type engines and early L3B engines the thick steel plate was not machined with radial grooves. When assembling this type of plate in the casing **the bevel edge must face upwards or away from the bevel gears.**

Fit the bevel gear case cover and ensure that the numbers stamped on cover and case coincide. Fit the 12 bolts and tighten down evenly to correct torque of 600 lb. in. Slide the clutch sleeve over the shaft.

With the clutch sleeve pulled back to the "Ahead" position, there must be a minimum clearance of ·025 in. between the operating diameter of the sleeve and the clutch lever rollers, see Fig. 8. Fit the spring plunger assemblies before making this check. If the clearance is below ·025 in., a small amount of metal may be removed from the abutment face of the levers until the desired clearance is obtained.

Similarly, with the clutch sleeve in the "Neutral" position there must be a minimum of ·025 in. clearance

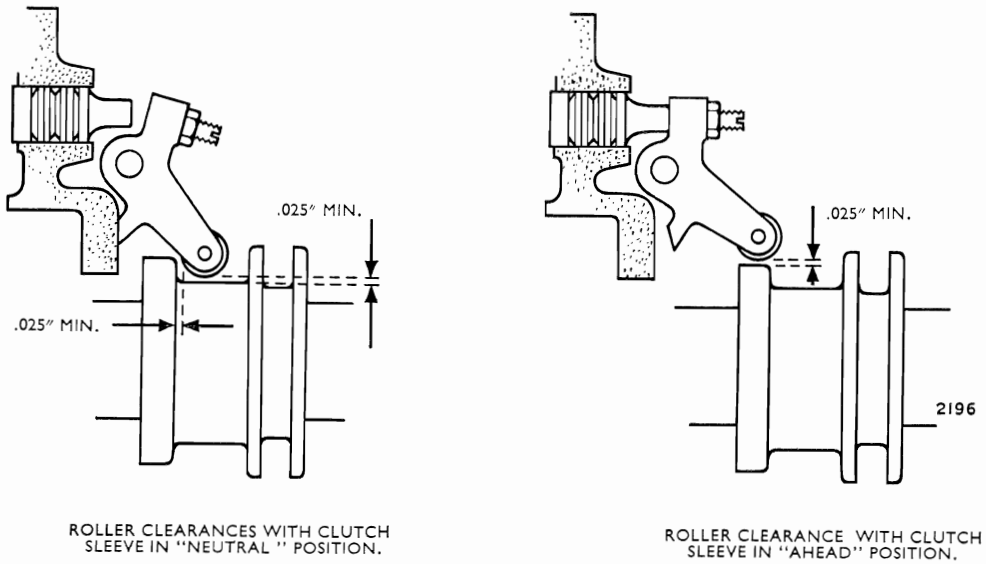


Fig. 8. Basic nominal settings for "Ahead" clutch lever rollers

between the rollers and the smaller diameter of the sleeve; if this is not obtained it is recommended that a replacement lever be fitted.
Final assembly of the clutch levers, balance weights, retaining springs and locking screws can now be carried out, completing the assembly by locking the spring retaining screws with locking wire.

26. **Completing the Mainshaft Assembly.**—When fitting a replacement mainshaft or a new flywheel-end ball bearing (Item 2, Fig. 6) check before assembly that the inner race of the bearing is a correct fit on the mainshaft.
It is imperative that interference between these two components is no greater than a tight sliding or push fit. Any excessive tightness must be relieved by careful lapping of the shaft end with a fine abrasive until the desired fit is obtained.
Fit the lubricating pump eccentric on the mainshaft and lock in position with setscrew. Check that the lubricating oil hole in the eccentric coincides with the oil hole in the shaft; **this is vitally important.** Screw the locating collar (Item 9 Fig. 6) on to the mainshaft and position so that its aft face is $23\frac{5}{8}$ in. from the forward face of the driving spider lugs. This will ensure a clearance of $\frac{1}{8}$ in. between the driving spider and the aft face of the flywheel on final installation in the reverse gear case. This clearance is necessary to allow for linear expansion of the running gear.
With the locating collar correctly positioned, tighten the clamping screw to a torque load of 1,200 lb. in. It should be noted that this entails considerably more pressure than would normally be applied to a spanner of this hexagon size ($\frac{1}{2}$ in.).
On earlier L3 type reverse gears the position of the locating collar is determined by a pointed setscrew and countersunk hole in the shaft.
If, for any reason, the blanking plugs at either end of the mainshaft have been removed, care must be taken to ensure an oil tight seal when the plugs are replaced. Examine the shoulders for signs of damage and remove any particles of dirt which might impair their seating: a leaking plug, item 9 Fig. 7, can cause dilution of the gear oil with engine oil by transfer of oil from the main shaft pump system.
Fit the ball race into the spigot sleeve and slide the sleeve over the forward end of the mainshaft at the spider end until it just enters the driving gear assembly, but do not push fully home. It is advisable to leave the sleeve in this position to facilitate fitting the nuts to the retaining studs on the flywheel when the unit is finally installed in the reversing gear case.

27. **Assembling the Mainshaft Aft Bearing.**—The type of aft bearing to be fitted to the mainshaft depends upon whether the final drive is direct through the propeller shaft or through a reducing gear.
With direct drive installations, the aft bearing assembly on the mainshaft takes the thrust of the propeller

ASSEMBLY AND INSTALLATION—*continued.*

and comprises adjustable double taper roller bearings and a single synthetic rubber seal. The end-float of ·002 in. to ·004 in. in this bearing must be checked before the running gear and mainshaft is installed in the gear casing. For detailed instructions, reference should be made to para. 36.

When a reducing gear is employed, however, the aft bearing on the mainshaft comprises a single large diameter ball race which is housed in the bearing bush. There must be a nip of ·0015 in. to ·002 in. on the outer race of this bearing when the end plate is bolted to the bearing bush. The correct nip being obtained by machining the appropriate amount off either the spigot or the flange of the end plate, depending upon the gap being greater or smaller than the specified amount.

It is important to ensure that the oil drain groove in the end plate and the oil hole in the bearing bush are in alignment when assembled. To facilitate this, zero marks are stamped on the flanges of both end plate and bush and these must coincide at the top when the complete unit is finally bolted to the reverse gear case.

Having checked that the correct amount of nip is present, fit the sealing ring into its housing in the end plate with its open side towards the ball race. Slide the end plate onto the flanged distance collar and fit the distance collar into the ball race. Ensure that the fit is not too tight, since excessive tightness will cause shrinkage of the collar bore and thus prevent its assembly on the mainshaft.

Finally slide the complete bearing and bush assembly onto the mainshaft until the inner race of the ball bearing is hard against the mainshaft locating collar. This completes the assembling of the running gear and it will now be ready for installation in the reverse gear case.

28. **Assembling the Lower Half Gear Case.**—The lower half gear case is located by the spigot on the end plate and by two special bolts which are a light driving fit in their holes. Each bolt is located in the second hole from the top on either side of the gear case and, when fitted, ensure that the supporting feet on the gear case are in alignment with the feet on the crankcase.

To fit the lower half gear case, apply jointing compound to the flange faces, lift the gear case into position on the end plate and insert the top bolts, one each side.

These should be just nipped to hold the case against the end plate. Lever upwards on the underside of the case until it is fully home against the spigot. The locating bolt holes should now be aligned. Insert the locating bolts and tighten firmly. Fit the remaining bolts and tighten in pairs, one each side of the case from top to bottom, to ensure alignment is maintained. Finally place a jack or other firm packing under the aft end of the gear case to prevent sag and relieve it from stress until the top half of the case is fitted.

After completing this operation, it may be noted that although the gear case feet are in alignment with the crankcase feet, they are not on the same horizontal plane. To remedy this difference in height, steel packings of correct thickness must be pegged to the undersurface of the gear case feet to bring all feet on to the same level.

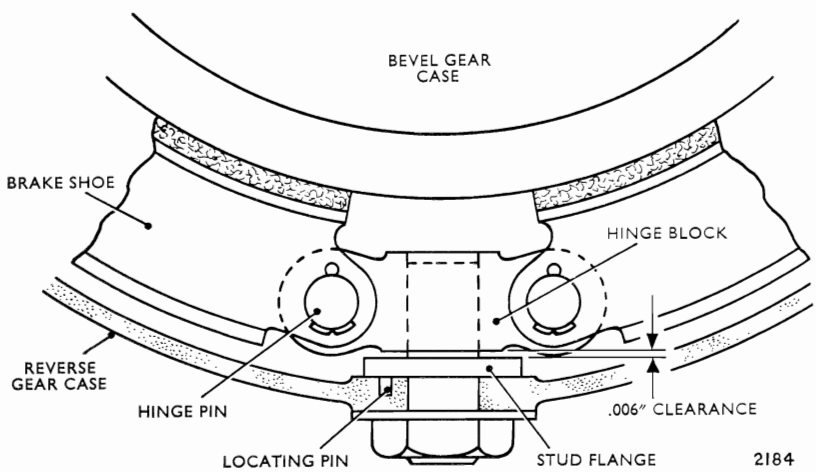


Fig. 9. Brake Shoe Hinge Block and Stud Assembly

ASSEMBLY AND INSTALLATION—*continued.*

29. **Fitting the Hinge Block Stud.**—When the Astern clutch brake shoes around the bevel gear case are released, a drop of ·006 in. is required to ensure that the heels of the friction linings are clear of the revolving gear case, see Fig. 9.
To check this clearance, fit the hinge block stud in the base of the gear case, ensuring that there are no burrs or particles of dirt under the stud flange, and tighten the nut. Fit the hinge block over the stud and note that this is stamped "TOP" to prevent incorrect assembly. Lift the running gear and mainshaft into position in the gear case. Place the brake shoes in position and couple to the hinge block, using the hinge pins. Clamp the shoes round the bevel gear case by inserting the long bolt (supplied with the tool kit) in the slots at the upper end of each shoe.
With the shoes firmly clamped in this manner, measure the clearance with feeler gauges between the hinge block and the flange of the hinge block stud. If the clearance is less than ·006 in. an appropriate amount of metal must be machined from the top surface of the stud flange to obtain the correct clearance. Conversely, if the clearance is excessive, shims must be inserted between the flange and the casing to pack up the stud and thus reduce the clearance.
NOTE.—New studs are supplied with an oversize flange thickness and if a new stud is required, proceed by first checking the clearance with the old damaged or worn stud in position. Then by measuring the thickness of its flange and checking the clearance, the amount of metal to be removed from the new stud can be quickly established.
Having checked the clearance and adjusted the hinge block stud accordingly, fit the steady peg, re-tighten the nut and lock with a new tab washer.

30. **Installation of Running Gear.**—Before lifting the running gear into position check that the flywheel-end ball bearing is a correct fit on the shaft-end (see para. 26). Place the ball race retaining ring in its recess in the flywheel, and as mentioned previously, see that the spigot sleeve is not pushed fully home in the driving bevel.
Lift the running gear into position and guide the spigot sleeve over the studs, push the complete assembly forward just enough to allow the driving spider to engage with the studs on the flywheel and the aft bearing bush to rest on the extreme edge of its housing. Fit the nuts on the spigot sleeve studs and tighten to the correct torque of 550 lb. in. The running gear assembly can now be pushed fully forward. Fit the steel bushes over the driving spider studs and tighten the nuts to correct torque of 1,400 lb. in. Check that the $\frac{1}{8}$ in. clearance has been maintained between the flywheel and spider lugs, and test to see that the running gear rotates freely.
NOTE.—On earlier type gears the spider and spigot sleeve were matched to the flywheel studs and were not interchangeable with other units. When assembling these units, it is important to check that all the numbers stamped on the flywheel, spigot sleeve and driving spider coincide with one another and that the numbers on the steel bushes correspond with the numbers on the lugs of the driving spider.
Fit the lubricating oil pump as described in para. 7. Assemble the brake shoes on the hinge block and fit the astern clutch screw shaft, complete with astern clutch lever and springs, onto the brake shoes. Place the two spherical thrust washers on the screwed shaft, one each side, followed by the left and right hand adjusting nuts and locking collars. Place the long bolt across the slots provided at the ends of the brake shoes, **using the slots furthest from the flywheel,** and clamp the shoes lightly to the bevel gear case.
At the aft end of the mainshaft, check that the zero stamps on the end plate and aft bearing bush are at the top. The assembly is now ready to receive the upper half gear case.

31. **Assembling the Upper Half Gear Case.**—Before lowering the upper half gear case into position, ensure that the pivot screws for the astern clutch cross-shaft are fully withdrawn. Apply jointing compound to the faces of the forward and lower flanges and lower into position. Fit the two bottom bolts one each side at the end plate end, and nip these sufficiently to pull the gear case against the end plate, but do not tighten. Next, fit two bolts, one each side through the flange of the upper and lower half cases at the forward end and tighten up firmly. Fit the remaining bolts around the end-plate and flanged joints and tighten in pairs, alternating from one side of the case to the other, to ensure a good joint all round.
Bolt up the aft bearing bush and end plate and again ensure that the "zero" stamp is at the top. Centralise the Astern Clutch screw shaft between the bosses on each side of the gear case and adjust the pivot screws as described in para. 14.

ASSEMBLY AND INSTALLATION—*continued.*

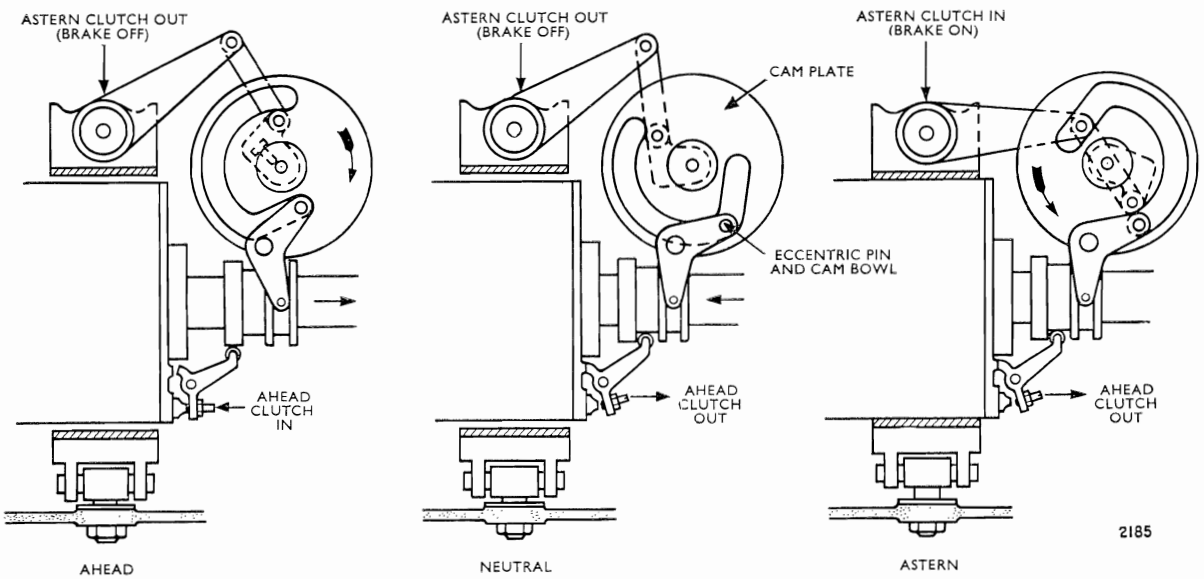


Fig. 10. Rotation of Cam Plate engaging "Ahead" and "Astern" clutches

32. **Setting the Ahead Clutch Crank.**—Refer to Fig. 9.
With the clutch sleeve in the neutral position a clearance of ·025 in. must be obtained between the clutch lever rollers and the shoulder of the operating sleeve. This safeguards against the possibility of the ahead clutch being partially engaged when the gear is set in Neutral, see Fig. 8. At the same time it is essential that the rollers on the clutch levers have a sufficient run on the operating diameter of the sleeve.
Both these conditions are governed by the setting of the eccentric pin which is a tight driving fit in the ahead clutch crank, see Fig. 10.

To check the clearance and ascertain the amount of travel of the roller on the operating diameter of the sleeve, fit the trunnion blocks in the crank of the lower shaft and place the bowl on the eccentric pin. Assemble the crank in position, adjusting the pivot screws as described in para. 14. Next, fit the Astern clutch crank, or upper shaft. To do this, slacken the setscrew in the cam plate and push the cam plate along the shaft against the crank. Centralise the crank between the two bosses in the casing and adjust the pivot screws. Slide the cam plate along the shaft to engage the bowl in the cam recess, and finally, tighten the cam plate setscrew.

On the joint face of the upper casing, which receives the gear case cover, will be found a scribed line. Also, on the periphery of the cam plate will be found a line scribed across the conical recess which receives the spring loaded plunger. With these two marks in alignment the clutch sleeve will be in the Neutral position Check the ·025 in. clearance between the clutch lever rollers and the shoulder of the clutch sleeve. Rotate the crank and cam plate until the bowl is at the "AHEAD" end of the cam and check the position of the clutch lever roller on the operating diameter of the clutch sleeve.

By removing and rotating the eccentric pin in the Astern clutch crank it is possible to obtain the best position for these two conditions.

With the eccentric pin adjusted to the correct position, reassemble the two cranked shafts and adjust the pivot screws of the upper shaft, so that the Astern clutch link swings freely between the fork ends. Finally connect the clutch link by fitting the link pin and split pins.

ASSEMBLY AND INSTALLATION—*continued.*

The adjustment of the "Ahead" and "Astern" clutches can now be carried out. This procedure is fully described in paras. 10, 12 and 13.

Fit the gear case cover and control lever and ensure that the quadrant teeth are correctly meshed as described in para. 16. If, during overhaul, the eccentric pin carrying the cam bowl has been disturbed, check the lever control travel and adjust the stop screws as described in para. 15.

Finally, if the gear installed is for direct drive, the coupling can be pressed on the end of the main shaft. This will require a load of 1 - 2 tons and a drive of about ·0005 in. on the feather key to obtain the correct fit. Screw home the locknut and tighten firmly; lock by clamping the split halves together with the setscrew.

Check, with a dial indicator, that the aft face of the half coupling is running true (see Fig. 16).

33. **Preparation for Reducing Gear Assembly.**—When a reducing gear is to be installed, the mainshaft of the reversing gear must first be checked to ensure that it runs in true alignment and is square to the aft face of the reverse gear casing. To do this proceed as follows:—

Fit the feather key to the shaft and remove the end plug, if fitted. Next, fit the jacking tool in position and press the driving pinion onto the shaft with the engraved number in the blue circle facing aft. A load of 5 - 8 tons will be required to press the pinion onto the shaft.

Fit the distance collar on the shaft with its radial grooves facing aft, making sure that the internal oil seal ring is in good condition and correctly bedded in its annular groove, before doing so. Fit the end roller bearing (or ball race in the case of earlier L3 type gears), and tighten up the retaining nut firmly with a long spanner. Do not tighten the locking setscrew at this stage, since this screw will be required later to retain the locking plate for the fan spindle.

Place the outer race of the roller bearing over the rollers and mount the Dial Indicator support on the aft face of the reverse gear case, positioning the indicator so that the button rests on the periphery of the outer race as shown in Fig. 11. Rotate the shaft and check that it runs perfectly true.

Next mount the D.I. on a suitable rigid bracket attached to the end of the mainshaft as shown in Fig. 12 and take readings on the machined surface of the reverse gear casing by rotating the shaft and bracket. A tolerance of not more than ·002 in. is permissible on this aft face. This completes the initial checks prior to fitting the reducing gear.

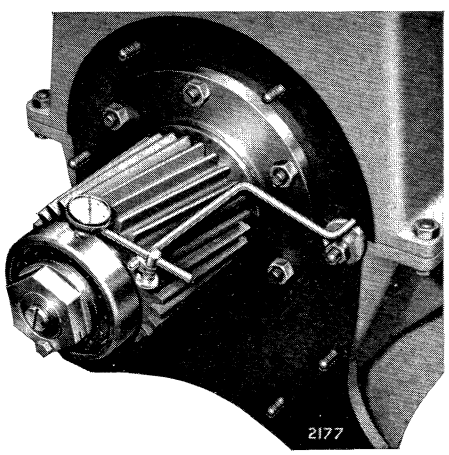


Fig. 11. Checking Mainshaft Alignment

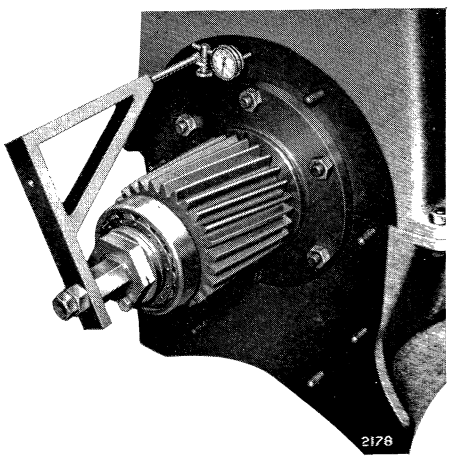


Fig. 12. Checking Rear Face of Reverse Gear Case

ASSEMBLY AND INSTALLATION—*continued.*

34. **Assembling the Reducing Gear Case.**—Before fitting the reducing gear case to the reverse gear case, the outer race of the secondary shaft front bearing must be lightly tapped into its housing in the reducing gear case, with the makers' markings facing aft, followed by the spring circlip. Apply jointing compound to the forward face of the casing and position the casing on the end of the reverse gear case so that the locating peg holes are in alignment. Fit the locating pegs and tighten the stud nuts. With 3:1 ratio reducing gears it is important that the two bolts attaching the casing to the strengthening webs of the reverse gear case, form an oil-tight seal. Ensure therefore, before fitting, that the abutment surface of these bolt heads are in good condition, apply jointing compound to the shank and head and insert each bolt from the inside of the reducing gear case. Tighten by turning the nut only, whilst holding the head firmly with a spanner.

Having fitted the casing and tightened up all nuts, check the rear cover joint face for squareness to the mainshaft with a D.I. as shown in Fig. 13. This may have a tolerance of not more than ·002 in.

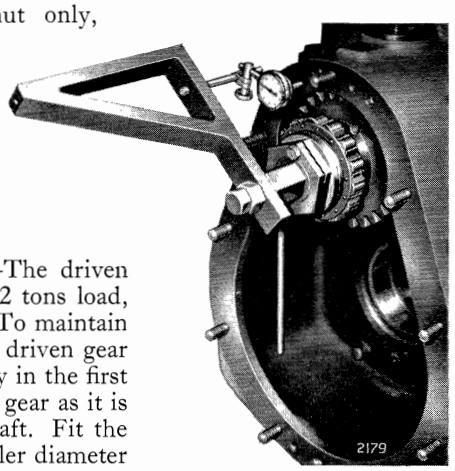


Fig. 13. Checking Rear Face of Reducing Gear Case

35. **Assembling the Reducing Gear Case Cover.**—The driven gear is pressed onto its shaft at approximately 8 - 12 tons load, with engraved number in the blue circle facing aft. To maintain alignment of the feather key with the keyway in the driven gear during this process, it is advisable to fit a dummy key in the first keyway which will then act as a guide for the driven gear as it is pressed into position against the shoulder on the shaft. Fit the inner section of the forward roller race onto the smaller diameter of the secondary shaft, with the makers' markings towards the driven gear, and secure in position with the locating plate, locking plate and four setscrews.

Press the outer race of the mainshaft rear bearing into the upper housing in the gear case cover, with makers' markings facing aft in assembled position, and fit the oil thrower and retaining plate to the inside of the cover, locking the heads of the two setscrews by bending over the ends of the retaining plate.

Press the outer race of the front taper roller bearing into its housing in the gear case cover, with its smaller diameter facing the engine in the assembled position, then press the outer race of the rear taper roller bearing into the bearing end plate with its smaller diameter facing aft.

36. **Checking End-Float in Thrust Bearing.**—It is imperative that the correct amount of end-float is maintained in the taper roller thrust bearings and it is therefore essential that the following instructions be carefully followed when assembling these components.

With direct drive installations the method of adjusting the end-float of the thrust bearings is similar in all respects except that the bearing bush in the reverse gear case takes the place of the end cover in the reducing gear case.

The permissible end-float in these bearings is ·002 in. to ·004 in. and is governed by the quantity and thickness of shims interposed between the end cover and the flange of the end plate.

These shims are available in ·002 in., ·005 in. and ·008 in. thickness and, when the unit is assembled, the amount of shimming required is normally between ·030 in. and ·040 in.

In order to check and adjust the end-float it is necessary to first obtain a dummy coupling or suitable distance sleeve which can be placed on the shaft under the retaining nut when tightening the assembly together, thus avoiding the necessity of pressing the half-coupling on and off the shaft whilst adjusting the end-float.

ASSEMBLY AND INSTALLATION—*continued.*

To assemble the gear and shaft in the end cover, proceed by first fitting the forward taper roller bearing into its outer race in the cover and placing the aft roller race centrally on top. Next place the shims in position over the studs to a total thickness of approximately ·037 in.

It is desirable, during this initial assembly, to fit a sufficient number of shims so that an end-float in excess of the specified amount is obtained. It will then be a simple matter to determine the shim thickness which is to be removed in order to provide the correct end-float.

With the estimated amount of shims in position, fit the end plate (complete with outer race but without the oil seals) in position and tighten all six nuts evenly and firmly. Check with the fingers that the roller races are free to rotate. If not, further shims must be added until freedom of rotation is attained then add one further ·005 in. shim to ensure there is a margin of end-float.

Next press the end cover and end plate assembly onto the driven gear shaft, using a tubular distance piece against the inner race of the aft bearing. The distance piece must be long enough to receive the shaft end as the cover assembly is pressed fully home. A load of approximately $2\frac{1}{2}$ tons will be required.

Complete the assembly by fitting the dummy coupling or distance sleeve, previously mentioned, and tighten up the retaining nut firmly to ensure that the assembled components on the shaft are tightly locked together.

To check the end-float a suitable rigid stand must be improvised to which the end cover can be bolted with the shaft in a vertical position and the coupling end uppermost. With the assembly in this position, a simple form of leverage can be devised which will raise and lower the shaft in relation to the end cover.

Normal practice at the Works is to use a special rig for this purpose, see Fig. 14, to which the lever arm is hinged in such a manner that weights may be added to one end of the lever in order to counteract the weight of the driven gear and shaft, etc., at the other end. The fulcrum of the lever is designed to provide a 3:1 ratio at the lifting end. Thus, by adding weights of 88 lb. for 3:1 ratio gears and 57 lb. for 2:1 ratio gears to the operating end of the lever, the reducing gear shaft can be lifted to the limit of end-float in the thrust bearing.

By mounting a dial indicator so that it is positioned over the end of the shaft, the end-float can be ascertained as the shaft is raised and lowered, as shown in Fig. 14.

NOTE.—The reading must be taken with the button of the D.I. on the centre line of the shaft and not on the face of the coupling. This can be done by inserting a setscrew into the end of the shaft.

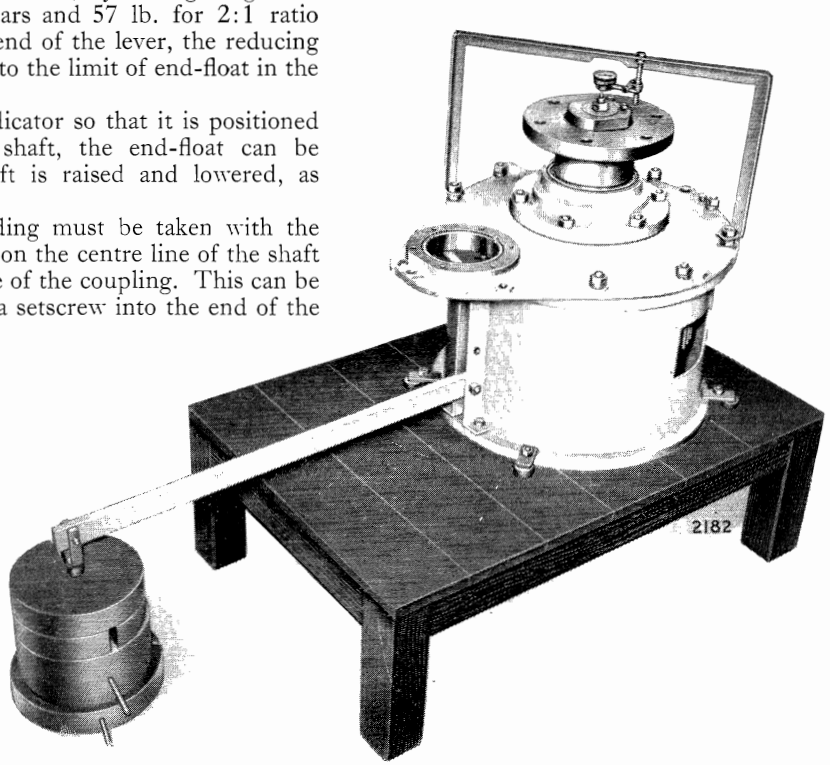


Fig. 14. Checking End-Float in Thrust Bearings

ASSEMBLY AND INSTALLATION—*continued.*

Having established the end-float, support the shaft, withdraw the dummy coupling and the end-plate, and adjust the thickness of shims as necessary; applying a thin coating of liquid jointing compound on each face of the shims upon reassembly.

Final assembly may now be carried out. Fit the oil seals in the end plate back to back and fill the space between with heavy grease, scraping away the surplus grease to a depth of $\frac{1}{32}$ in. below the internal diameter of the seals to allow for increase in this diameter when the coupling is entered. Fit the end plate to the gear case cover and the feather key to the shaft. Press the coupling into position and tighten up the retaining nut, locking with the setscrew and tab washer.

NOTE.—It is important to ensure that the surface finish of the metal parts which operate in any of the synthetic rubber seals is of the highest quality and free from any bruises, scratches or imperfections.

37. **Checking Backlash of Reducing Gears.**—The gear case end cover, complete with secondary shaft, driven gear and half coupling, is fitted to the gear case as a complete unit.

To do this, apply jointing compound to the joint face and lift the cover assembly by attaching a sling under the boss of the half coupling. Guide carefully into position to avoid damaging the gear teeth and ensure that the secondary shaft front roller race enters a squarely into its outer race in the gear casing. This operation can be facilitated if an extension arm is screwed onto the end of the secondary shaft in place of the retaining nut. With the weight still taken by the sling, fit the locating pegs, screw on the nuts and tighten evenly to ensure a good joint.

The design backlash between the driving and driven gears of the reducing gear is ·010 in. to ·022 in. and should be checked at this stage.

To do this, obtain a suitable steel bar and bolt this to the end of the shaft. See Fig. 15. Scribe a mark on the edge of the bar at a distance from the centre of the shaft equal to the radius of pitch-line of the driven pinion, as follows:—

7·47 inches for 3:1 ratio gears
5·35 inches for 2:1 ratio gears

Mount a D.I. on the gear case so that the button contacts the scribed mark on the bar. By rocking the coupling back and forth, the amount of backlash can be determined. After checking the backlash, finally check the rear face of the half coupling with a D.I. for perfectly true running, see Fig. 16.

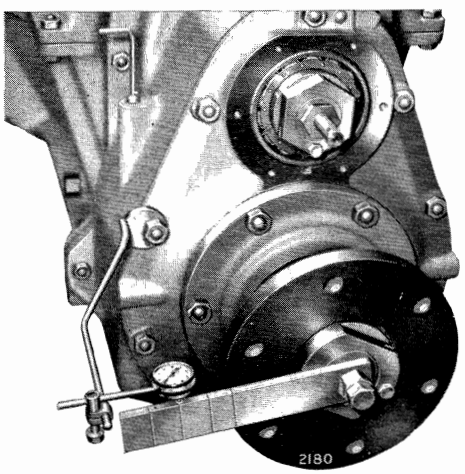


Fig. 15. Checking Backlash in Reducing Gears

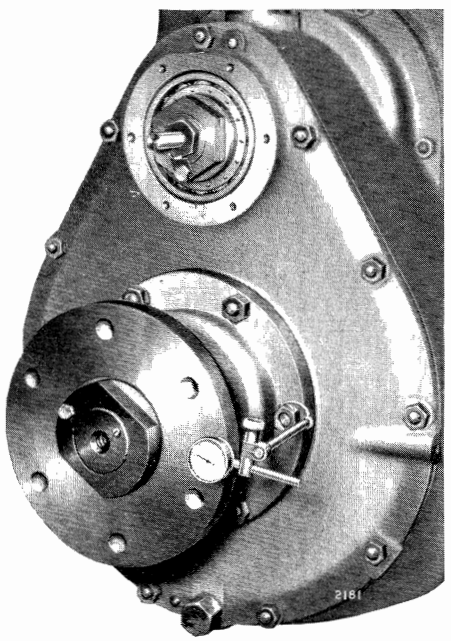


Fig. 16. Checking Shaft Coupling for True Running

ASSEMBLY AND INSTALLATION—*continued.*

38. **Installation of Cooling Fan and Cowling.**—Screw the fan spindle into the blanking plug hole in the aft end of the mainshaft, making sure that a good oil-tight seal is maintained between the shaft and spindle. Tighten firmly and secure with the locking plate which is fitted under the head of the setscrew that also locks the driving pinion retaining nut. Check that the spindle is running in true alignment by mounting the dial indicator support on the cover of the reducing gear case. Maximum permissible error is ·002 in. with the reading taken at the end of the spindle.

Fit the dust cover over the fan spindle, locating the dowels in their holes in the gear case cover. Screw in two bolts, one each side, and tighten. Using feeler gauges, check the clearance of the fan spindle in the bore of the dust cover. This must not be less than ·004 in. all round, i.e. total diametral clearance ·008 in. If the clearance is insufficient the bore of the dust cover must be enlarged by scraping until the required clearance is obtained. Having checked and obtained the correct clearance, the dust cover can be finally bolted in position after applying jointing compound to the joint face.

Thoroughly soak the dust excluding felt washer in engine oil and fit this into the recess in the dust cover. Fit the fan to the spindle with the embossed arrow facing aft and lock in position with the setscrew making sure that the point of screw registers in the countersink on the spindle. Fit the spring around the periphery of the blades and see that it is correctly positioned in the grooves.

The fan cowling is insulated from the gear casing by anti-vibration rubber mountings and to assemble proceed as follows:—

Taking the top attachment bolt first, place the washer against the head of the bolt followed by the rubber rings and insert the bolt through the top hole in the cowling. Thread the second rubber ring onto the bolt followed by the distance piece and the third rubber ring, then screw the bolt into the reducing gear case, two or three threads only. Repeat the same sequence of assembly with the two side attaching bolts. Tighten all three bolts until there is a gap of $\frac{1}{64}$ in. to $\frac{1}{32}$ in. between the washer and the cowling, then secure by locking the heads of the bolts to the lugs on the cowling with locking wire. Care must be taken not to tighten sufficiently to make the assembly metal to metal.

Finally fit the fan guard and secure in position with the setscrews.