GM BEDFORD

220-330 SERIES

BEDFORD POWER & INDUSTRIAL ENGINES
SERVICE MANUAL BD/SE/2

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Detroit Diesel Allison
Division of General Motors Limited

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SERVICE MANUAL

220 and 330 cu. in.

BEDFORD
INDUSTRIAL DIESEL ENGINES

Detroit Diesel Allison
Division of General Motors Limited

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BD/SE/2 **MARCH 1980**

SECTION 8

CLUTCH SYSTEM

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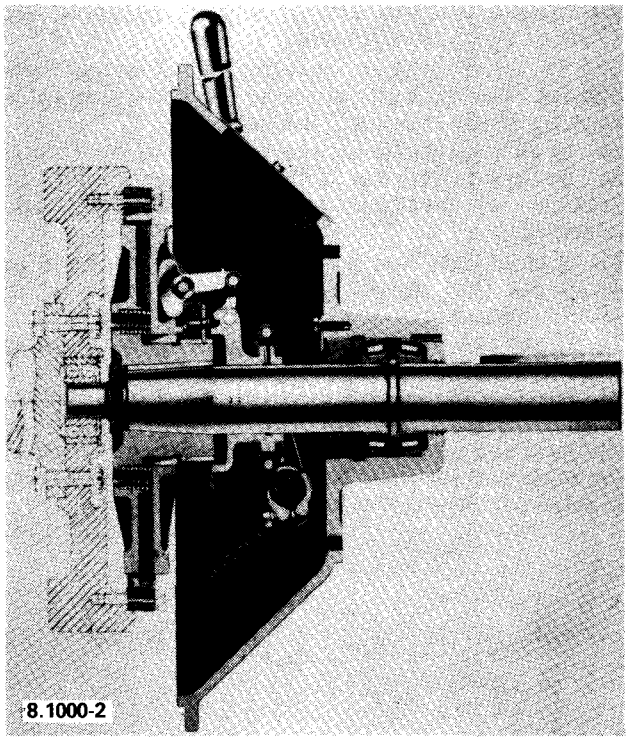
8.1000

POWER TAKE-OFF OVERCENTRE CLUTCH

POWER TAKE-OFF OVERCENTRE CLUTCH (DESCRIPTION)

1. Power Take-Offs consist of a housing assembly and a clutch unit assembly, the former being attached to the engine crankcase whilst the latter is mounted on the power take-off shaft; additionally, the clutch unit incorporates a drive ring which is bolted to the flywheel.
2. The clutch operating lever is carried on a cross-shaft running through the housing and to which a clutch withdrawal yoke is keyed; the yoke is secured by two bolts and is formed with two jaws which engage the release-bearing trunnions.



HOUSING ASSEMBLY

3. The power take-off shaft is supported in the housing assembly and runs in two tapered roller bearings which are kept in position by a bearing retainer; the latter part is formed with slots in order that it may be screwed in or out to adjust the bearings and give correct end-float to the shaft, it is secured against vibration by a lockplate which engages on to the slots. (In some cases it will be found that the bearings are contained within a bearing-housing which is bolted to the clutch housing). Annular grooves formed in the bore of the housing and of the bearing retained, prevent the egress of lubricant from the bearing housing when the shaft is revolving.
4. Two grease nipples are located on the outside of the clutch housing, one being screwed in and serving the main bearings with lubricant, whilst the other is secured by a circlip and serves the clutch release bearing through a flexible tube. A further grease nipple is screwed into the end of the shaft for the purpose of lubricating the pilot bearing in the flywheel; for convenience this nipple may be fitted in place of a screwed plug part-way along the shaft, and the plug fitted in the nipple's original position.
5. Access to the interior of the clutch, and to the adjusting ring in particular, is permitted by the removal of an inspection cover which is secured by two screws.

CLUTCH-UNIT ASSEMBLY

6. The inner end of the power take-off shaft is tapered to carry the body of the clutch-unit which is keyed into position and secured by a nut and a lock-washer. Splines are formed on the body to receive a pressure plate carrying three pins upon which release levers are mounted, the levers being counter-balanced to offset the effects of centrifugal force, which might otherwise tend to disengage the clutch: each release lever carries an anti-rattle spring which reacts against the pressure plate to eliminate any "shake" which may be present. (In the instance of Twin Plate Clutches, four release levers are fitted and also an intermediate pressure plate is used). The heels of the release levers are arranged to contact the inner face of an adjusting ring which is secured on to the clutch body.
7. Torque transmission is effected through a facing member which is supplied for replacement in three sections and, when the clutch is engaged, is clamped between the pressure plate and the flange of the clutch body; the facing sections are formed with gear teeth which engage with corresponding teeth on the inside diameter of the clutch drive ring. (With Twin Plate Clutches, two sets of facings are used, one being interposed between the pressure plate and the intermediate pressure plate whilst the other is between the latter part and the clutch body).
8. As the facing member wears, the clamping action will become less positive; in order to avoid clutch slip, therefore, it will be necessary periodically to compensate for this wear by screwing the adjusting ring further on to the body. Positive adjustment is ensured by an automatic locking device comprising a pinion which is loaded by a Belleville washer and mounted on a rivet in the adjusting ring. The pinion engages the splines on the clutch body and is able to rotate as the adjusting ring is turned; at the conclusion of adjustment the pinion is locked by the loading of the Belleville washer and prevents the adjusting ring from slackening itself off.

RELEASE BEARING

9. A release sleeve is mounted on the shaft, beyond the clutch body, and is formed with a flange encircled by the two halves of a release bearing which are held by two bolts fitted with self-locking nuts; a trunnion is formed upon each half of the release bearing to engage the jaws of the release yoke; the

sleeve is connected to the release levers by means of links fitted in pairs.

OPERATION

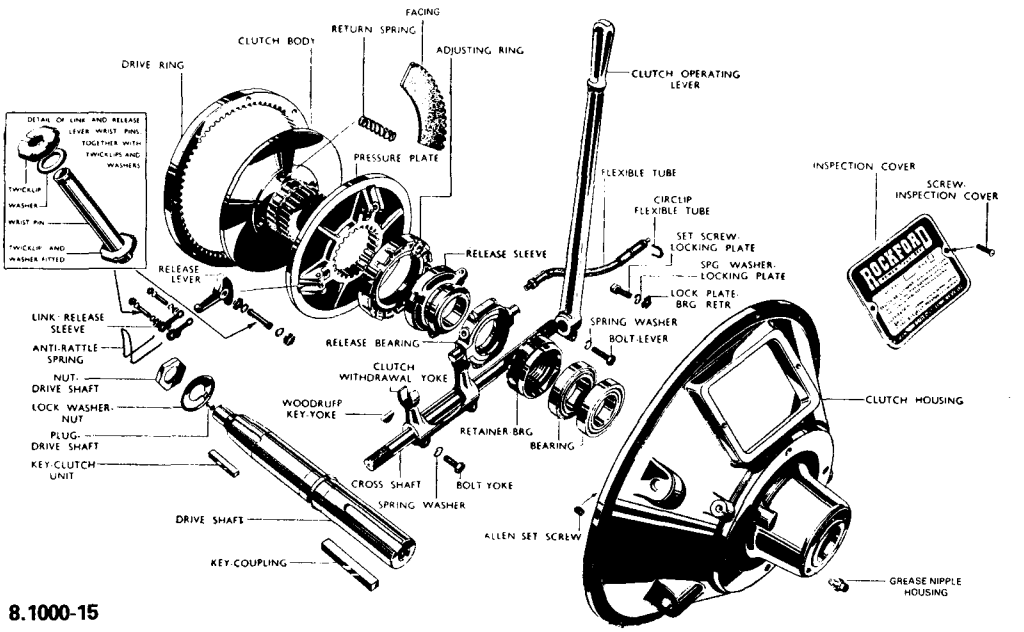
10. When the operating handle is moved to engage the clutch, the release sleeve moves inwards and the links cause the release levers to pivot about the pins on which they are mounted, thus displacing the pressure plate inwards. Continued movement of the release sleeve causes the inner ends of the links to move "over-centre" (ie further inwards than the outer ends), which positively clamps the facing member between the pressure plate and clutch body. The engine torque is now transmitted to the power take-off shaft via the drive ring, the facing member and the clutch body. Upon moving the handle to disengage the clutch, the pressure plate is displaced away from the facing member by the action of the release levers and by four springs assembled between the plate and the clutch body; the torque transmission is thus discontinued. It is important that the clutch is engaged at low engine RPM, 800-1000 RPM, if maximum life is to be obtained from the facings.

POWER TAKE-OFF OVERCENTRE CLUTCH (REMOVAL)

11. Withdraw the driving pulley or gear from the end of the shaft.
12. Engage clutch to ensure simultaneous withdrawal of the facing sections.
13. Remove the bolts securing the clutch housing to the crankcase from the engine.
14. Remove the drive ring from the flywheel.

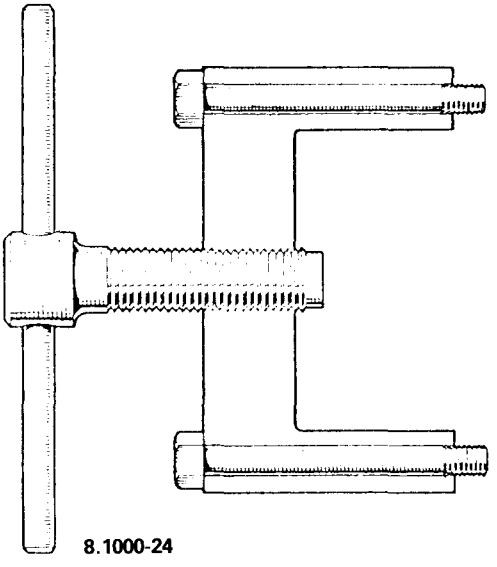
POWER TAKE-OFF OVERCENTRE CLUTCH (INSPECTION AND OVERHAUL)

15. The exploded view of the single plate clutch shown below, 8.1000-15, can be used as a guide when dismantling the power take-off, the double plate clutch is similar.
16. Move the operating lever to disengage the clutch, withdraw the facing sections and remove the lever from the cross-shaft.
17. After the clutch has been in use for some time, the facings should present a polished appearance through which the grain of the material is clearly visible. If small quantities of lubricant have contacted the facings, they will present a darker appearance due to burning of the lubricant, consequent upon the heat generated during engagement. Provided that the grain of the facing material remains clearly distinguishable, the clutch will continue to yield a satisfactory performance.
18. If an excessive amount of lubricant has fouled the facings they may be glazed with a thin carbon deposit which obliterates the grain of the material. The lubricant may be only partially burned, and in this case a resinous deposit will be apparent, the effect of which is undesirable.
19. An even greater quantity of lubricant will blacken the facings, and the torque-transmitting capacity of the clutch will diminish.
20. In all cases where excessive fouling of the facings has occurred, renewal will be necessary and the presence of lubricant must be determined and remedied.
21. It is unlikely that the teeth of the facings will be worn, but they should nevertheless be subjected to careful inspection.
22. If any one section of a facing is faulty, all three sections must be renewed.
23. Remove the inspection cover and disconnect the flexible hose (where applicable) by removing the circlip at the outer end and unscrewing the union at the inner end (in some cases it will also be necessary to release a locking clip inside the housing).



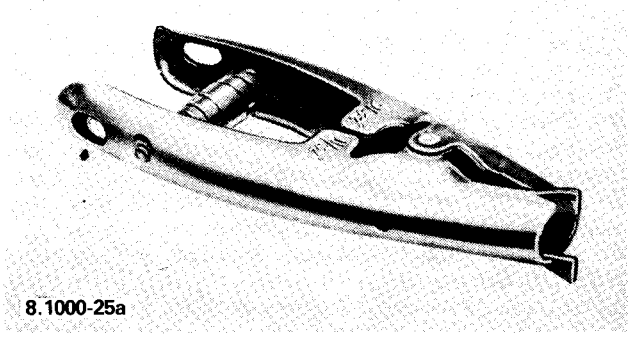
8.1000-15

24. Remove the nut and lockwasher, and extract the clutch unit from the power take-off shaft. This can be achieved by attaching the clutch withdrawal tool to the two threaded holes (0.50 ins BSF) in the forward face of the clutch assembly and then turning the puller screw to loosen the clutch assembly.

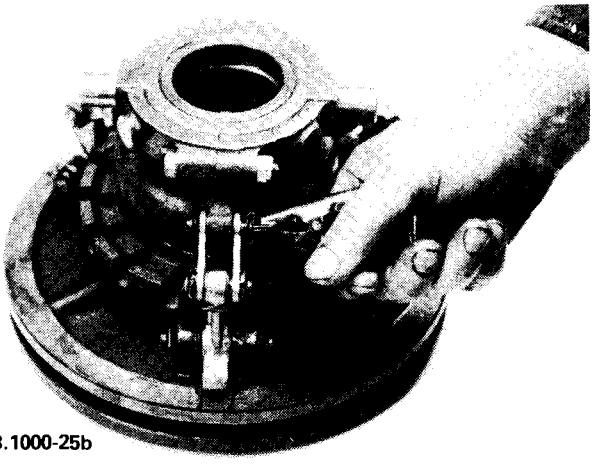


8.1000-24

25. Remove one Twicklip, using the special Twicklip pliers shown below (or snap ring, if fitted) from each of the wrist pins, expel the pins and separate the release levers, the links and the release sleeve. Unscrew the self-locking nuts from the release bearing bolts and separate the halves of the bearing.



8.1000-25a



8.1000-25b

26. Unscrew the adjusting ring from the clutch body, slide off the pressure plate and, where applicable, the intermediate pressure plate, and remove the four return springs.
27. Slacken the release-yoke clamping bolts, slide the yoke clear of the Woodruff keys, remove the keys from the cross-shaft and push the shaft out of the housing.
28. Remove the key from the outer end of the power take-off shaft, unscrew the bearing retainer and expel the shaft and its bearings, using a hide-faced mallet. Drive the bearing off the shaft, remembering that they are prevented from moving in one direction by a shoulder on the shaft. The cup of one bearing may, in all probability, remain in the housing, and its removal may be effected by tapping metal rods inserted through holes in the outer end of the housing.
29. Immediately prior to assembly, lightly smear with grease the jaws of the withdrawal yoke, the bores of the cross-shaft bosses in the clutch housing, the wrist pins, the heels of the release levers and the inner contact surfaces of the links. The recommended lubricant is a high melting-point grease.

RECOMMENDED LUBRICANTS
UNITED KINGDOM

The following high melting point greases are suggested as being suitable. The order in which they are listed does not imply any preference. This list does not imply approval by General Motors Limited or constitute a complete list of available products which are suitable.

BP	CASTROL	DUCKHAMS	ESSO	GULF	MOBIL	REGENT	SHELL
Ener-Grease L.2	Castrol-ease LM	LB 10 Grease	Esso Multi-Purpose Grease H	Gulfsil Grease G.64 A-2	Mobil-Grease MP	Marfac Multi-Purpose 2	Retinax A

Or GM 4733-M specification

HOUSING ASSEMBLY

30. Ensure that the socket headed grubscrew is fitted inside the clutch-housing to blank-off the longitudinal channel through which the main bearings are lubricated (this grubscrew is not used if the bearing-housing is a separate part). The bearing-housing, if applicable, is to be securely attached to the clutch-housing by setscrews, each of which is fitted with a spring washer.
31. Fit the rear tapered-roller bearing cup in the clutch housing or bearing-housing ensuring that it is square and firmly home.
32. Press the roller and cone assemblies into position against the spacing shoulder, ensuring that they are perfectly square against the shoulder. At this stage, apply the suggested grease in the space between the bearings. When lubricating, the object is to use a quantity of grease sufficient to ensure that the clutch will not run dry and overheat (causing possible seizure of the bearings); on the other hand, the use of too great a quantity would lead to a greasy clutch with resultant slip. The aim should be to have the whole of the space inside the bearing housing filled to no more than two-thirds of its capacity; whilst this cannot be measured, overpacking should be avoided as it would cause overheating; the rule should be to apply a little grease and often to the bearings, with only the slightest trace of leakage when the clutch is running.
33. Assemble the shaft and bearings in the housing, followed by the forward roller bearing cup which must be inserted into the bore squarely and true; lightly tap the cup until the bearing retainer can be engaged in the threads. Screw up the retainer, by means of the slots provided, until the end-float of the shaft has been reduced to approximately 1.3 mm (0.05 ins).
34. Attach a clock indicator to the flange of the clutch housing so that the plunger of the indicator is in contact with the face of the pilot-end of the shaft.

8.1000-37

35. Whilst slowly revolving the shaft, screw up the bearing retainer until the 1.3 mm (0.05 ins) end-float has been reduced to 0.13 mm/0.18 mm (0.005/0.007 ins).
36. Remove the clock indicator and strike the outer end of the shaft with a hide-faced mallet to ensure that the forward cup is in register with the bearing retainer; re-check the end-float and make any slight adjustment that may be necessary. Fit the locking plate inside the housing to secure the bearing retainer, using a spring washer, on the setscrew (if the locking plate is of the type which incorporates a clip for securing the flexible tube, it should not be fitted until a later stage).
37. Hold the withdrawal yoke inside the housing (as shown in 8.1000-37) with the clamp bolts facing outwards, and push the cross-shaft through the housing and the yoke, fitting two Woodruff keys. Ensure that the yoke is centrally disposed and tighten the clamp bolts.

CLUTCH UNIT

38. Lay the clutch body on the bench, with the splines uppermost, and, if applicable, locate the intermediate pressure plate upon it (the flat side facing downwards); fit the four return springs in the pockets and slide the pressure plate on to the body, flat face first. Screw the adjusting ring on to the body, exercising the utmost caution when the pinion engages the splines; the setting of the adjusting ring will be perfomed after the clutch has been attached to the engine.
39. Fit the anti-rattle springs on the release levers, position the levers within the lugs on the pressure plate so that the web on each faces outwards, and fit the wrist pins; fit the Twicklip or, if applicable, the circlips (note that if the former are used they must be fitted with the round-section washers before being attached to the wrist pins). Attach a pair of links to each release lever, again using wrist pins together with the Twicklips and washer or, if applicable, the circlips (note that the enlarged ends of the links are to point inwards).
40. Place the halves of the release bearing around the release sleeve and secure with the bolts and self-locking nuts. Offer up the release sleeve to the links, fit the wrist pins, and secure with the Twicklips and washers or, if applicable, the circlips.
41. Fit the facing segments between the pressure plate and the clutch body; in the case of a Twin plate clutch, the first set of facings is fitted between the body and the intermediate pressure plate, whilst the second set is fitted between the intermediate pressure plate and the main pressure plate. Locate the drive ring over the facings, so that the teeth are correctly engaged, and place blocks beneath the ring to support it in that position.
42. Press down upon the release bearing to engage the clutch; the drive ring may now be removed and the facing segments will remain firmly gripped between the pressure plate and the clutch body.
43. Screw the flexible tube or the grease nipple (whichever is applicable) into the release bearing.

NOTE. On the later clutches, a shakeproof washer is fitted at the threaded end of the tube.

ASSEMBLING THE CLUTCH UNIT TO THE SHAFT

44. Offer up the clutch unit to the power take-off shaft, with the keyways aligned and with the release bearing trunnions engaging the jaws of the withdrawal yoke; the bearing is to be located so that the boss into which the flexible tube is screwed is on the same side as the inspection hole in the clutch housing; if a grease nipple is fitted on the bearing trunnion it is to be on the same side as the smaller hole at the side of the housing. Fit the key, the lock-washer and the nut, securely tighten the nut to 238-245 Nm (175-180 lbs/ft) torque and set the lockwasher.

45. Pass the outer end of the flexible tube through the appropriate hole in the housing, and secure with the circlip; if applicable, fit the tube locking clip inside the housing.

POWER TAKE-OFF OVERCENTRE CLUTCH (REFITTING)

46. Assemble the drive ring to the flywheel.

47. Offer up the clutch and Power Take-off assembly to the crankcase and tighten the securing bolts.

48. Fit the grease nipple which serves the main bearing and if the bearings have not been removed during overhaul lubricate them as described previously.

49. Fit the operating lever at the most suitable angle on the cross-shaft and secure by tightening the clamp bolt.

50. Adjust the clutch as follows:-
Turn the adjusting ring in the required direction, using a tommy-bar, until torque transmitting capacity is obtained without incurring excessive hand loads at the operating lever (in most applications, 25 kgm (55 lbs) hand load will be found adequate). The adjusting ring should be stiff to operate, on no account is lubricant to be applied to the pinion.

51. In some applications a socket screw is fitted in the adjusting ring to provide an additional lock. It must be unscrewed before adjustment is made, and re-tightened after adjustment, ensuring that it engages in a tooth space and not on the crest of the threads.

52. Regular attention to clutch adjustment is necessary to obviate the onset of clutch slip. The time interval between checks will depend upon the application and usage of the clutch. Failure to maintain the clutch in correct adjustment may lead to serious damage.

53. Fit the inspection cover.

54. Disengage the clutch and check that the power take-off shaft will rotate easily by hand without showing any binding tendencies.

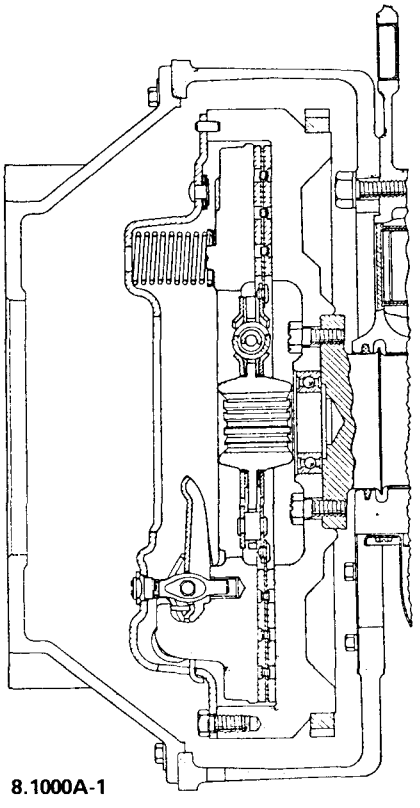
55. Install the driving pulley or gear.

8.1000A

AUTOMOTIVE CLUTCH

AUTOMOTIVE CLUTCH (DESCRIPTION)

1. The clutch is a Borg and Beck multiple coil spring dry plate type, bolted to the flywheel and enclosed in a detachable housing bolted to the flywheel housing. The clutch is operated by a pedal through a push rod, clutch fork and release bearing.



8.1000A-1

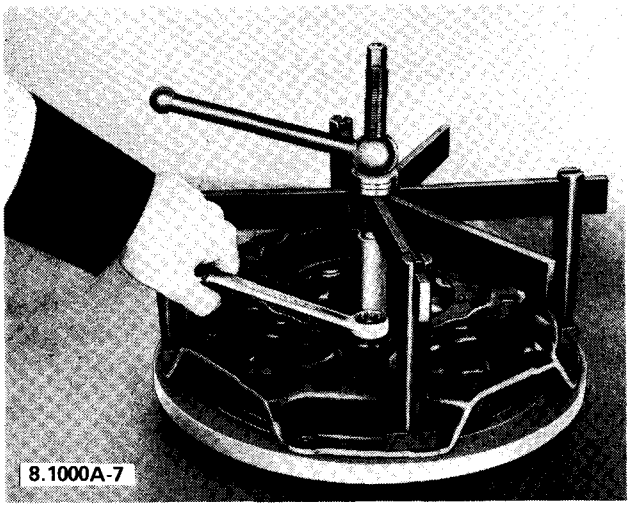
2. The clutch used on 220 cu in engines is 10 inches, while the clutch used on 330 cu in engines is 12 or 13 inches.
3. The clutch assembly comprises two main units, a pressure plate and cover assembly and a disc assembly. The driving pressure is provided by coil springs located between the pressure plate and cover which are connected by four drive straps. Four levers are incorporated for clutch release, and pivot on pins passing through adjustable eye bolts. The levers are fitted with anti-rattle springs. The disc plate has riveted friction facings cushioned by spring steel segments and the splined hub is spring-loaded by coil type and damper springs.

AUTOMOTIVE CLUTCH (REMOVAL)

4. Remove the clutch housing, fork and release bearing as described under section 8.1100.
5. Remove the eight bolts and washers securing the clutch assembly to the flywheel and withdraw the clutch assembly together with the disc assembly from the locating dowels.

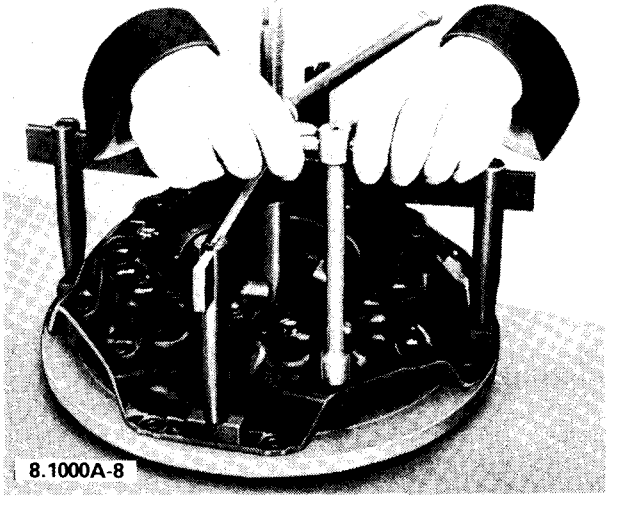
AUTOMOTIVE CLUTCH (INSPECTION AND OVERHAUL)

6. Mark the clutch cover and pressure plate so that they can be reassembled in the original relative position, if neither has to be renewed.
7. Using a clutch jig, compress the thrust springs and unscrew the eye bolt nuts.



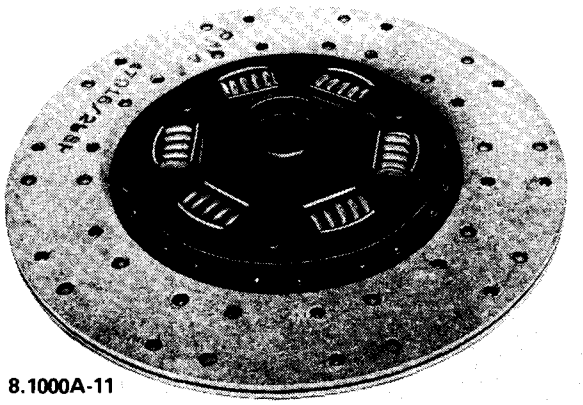
8.1000A-7

8. Remove the four bolts securing the drive straps.

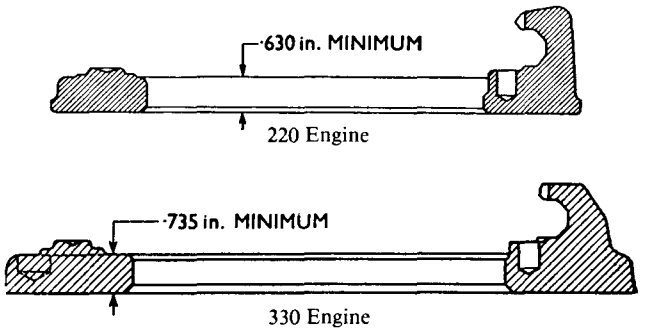


8.1000A-8

9. Release the pressure on the clutch cover. Lift off the cover, and remove the springs, struts, release levers and eye bolts.
10. Check the disc hub springs for slackness, and the friction facings for wear.
11. When renewing friction facings do not shear the rivets with a chisel as this may distort the clutch disc segments. The rivets should be drilled, using a 7/64 ins diameter drill, sufficiently to allow them to be punched out without distorting the segments. Carefully rivet a facing to each side of the segments, inserting the rivets so that the heads of each radial pair run alternately on each side of the disc.


8.1000A-11

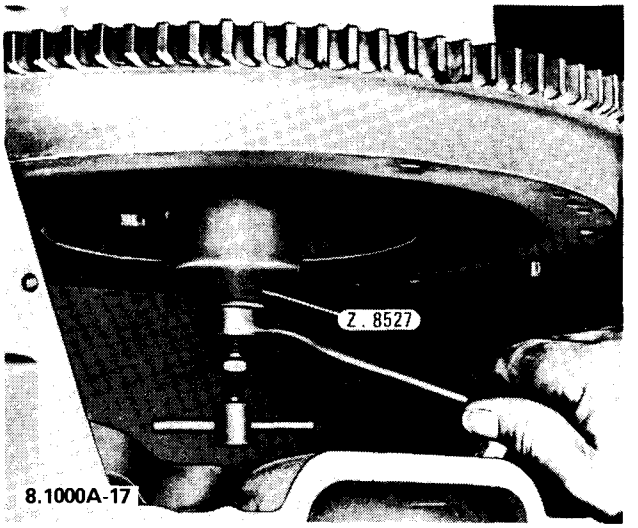
12. Check the friction surface of the pressure plate for wear or scores, scores on the friction surface of the pressure plate can be removed by grinding, provided the plate thickness after machining is not less than the specified thickness. Thickness must be checked at the position indicated at various points around the plate.



8.1000A-12

13. Check the rate of the thrust springs from the following table:

14. Renew all springs if any show signs of collapse, or if there is evidence of the pressure plate having overheated.
15. Place the cover on the base of the jig to check the distortion of the attaching flange.
16. Check the spigot bearing in the crankshaft flange for roughness.
17. To renew, first withdraw the bearing, using Drag-Z8527. Ensure that the new bearing is packed with GM 4616-M or GM 4617-M grease, and install it so that the shielded side is facing away from the engine.



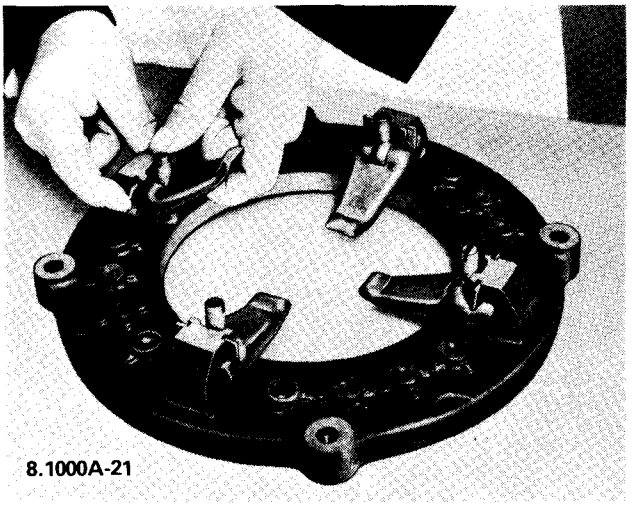
8.1000A-17

18. Check the friction surface of the flywheel for wear or scores. If necessary, remove and reface.
19. Lubricate the bearing surfaces of the release levers, eye bolts, pins and struts with the GM 4530-M grease. Use the lubricant sparingly to avoid contact with the friction facings.
20. Assemble the pin to the eye bolt and place the threaded end of the bolt through the slot in the release lever so that it rests in the lever recess.

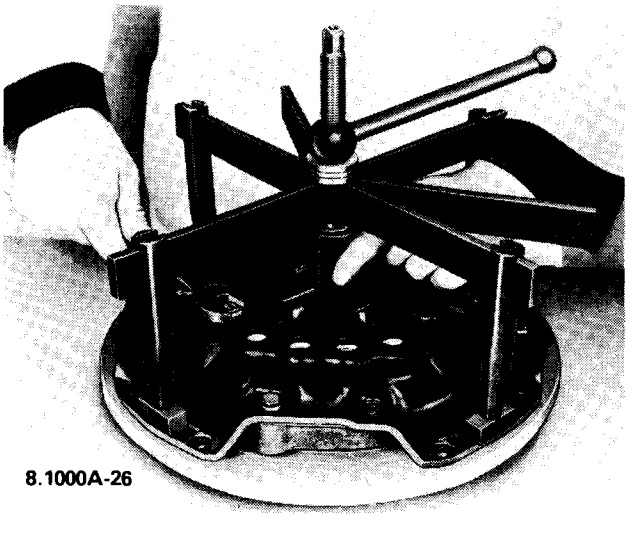
THRUST SPRINGS

TYPE 10 AS	— Colour Code — Black — Assembled Height — 42.86 mm (1 11/16") — Load at Assembled Height — 68.1-72.64 Kg (150-160 lb)
TYPE 12 AS	— Colour Code — Cream — Assembled Height — 42.86 mm (1 11/16") — Load at Assembled Height — 54.48-59.02 Kg (120-130 lb)
TYPE 13 AS	— Colour Code — Yellow/Light Green — Assembled Height — 42.86 mm (1 11/16") — Load at Assembled Height — 61.29-65.83 Kg (135-145 lb)

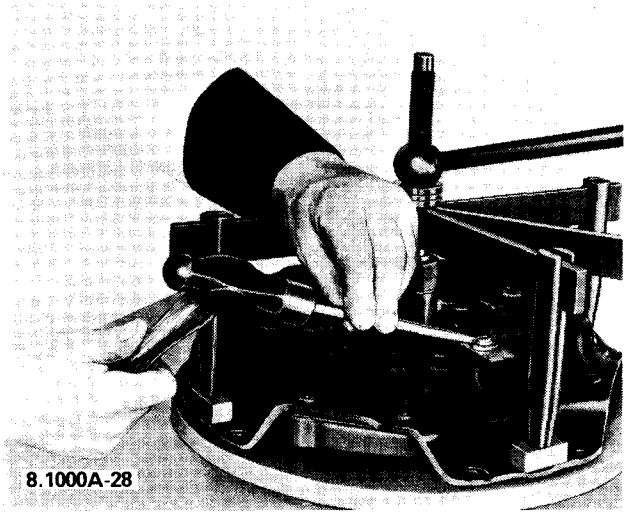
21. Assemble each release lever and eye bolt to the pressure plate, locating the plain end of the eye bolt in the hole provided in the pressure plate.


8.1000A-21

22. Raise the inner end of the lever, and insert the strut so that its lugs engage the groove in the pressure plate boss. Release the lever, making sure the eye bolt is located in the plate hole and the bottom edge of the strut located in the recess in the outer end of the lever.
23. Fit the anti-rattle spring in the holes in the clutch cover so that the spring ends are towards the centre of the cover.
24. Using the jig, complete the reassembly of the clutch, noting the points in paragraphs 25, 26, 27 and 28.
25. When reassembling the original parts, make sure that the marks made on the cover and pressure plate when disassembling, are in alignment.
26. Check and adjust the height of the release levers. Do not lock the eye bolt nuts at this stage.

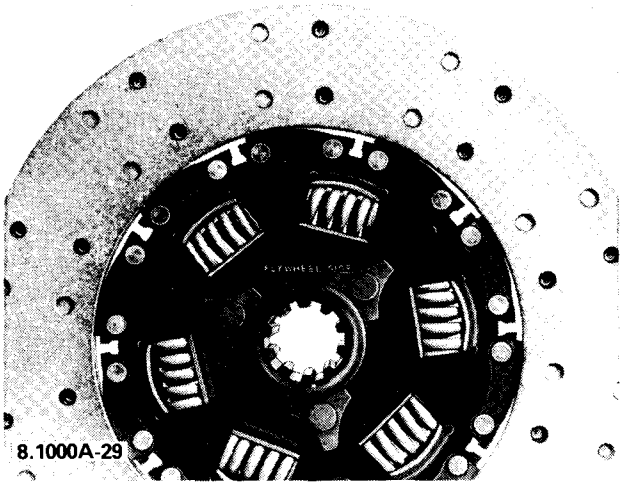

8.1000A-26

27. Operate the release levers several times so that the moving parts can settle into their working positions.
28. Make a final check of the release lever height. Adjust if necessary, then lock each eye bolt nut by staking the inner edge of the nut into each end of the eye bolt slot.


8.1000A-28

AUTOMOTIVE CLUTCH (REFITTING)

29. Install the clutch disc so that the face marked 'Flywheel Side' is towards the flywheel.


8.1000A-29

30. Before tightening the clutch cover attaching bolts, insert a clutch disc aligner through the disc hub until it engages the spigot bearing in the crankshaft. Tighten the bolts evenly to a torque of 30-37 Nm (22-27 lbs ft), then remove the shaft.
31. Refit the clutch housing, fork and release bearing as described under section 8.1100.

8.1100

CLUTCH FORK AND RELEASE BEARING

CLUTCH FORK AND RELEASE BEARING (DESCRIPTION)

1. The clutch fork pivots on a ball support mounted in the clutch housing. Housings are manufactured for both RH and LH applications. Two pins incorporated in the fork jaws engage a grooved sleeve of the release bearing which slides on the tubular extension of the transmission front cover. The bearing is of the single row ball type and is packed with lubricant and sealed during manufacture. Periodic lubrication is not required.

CLUTCH FORK AND RELEASE BEARING (REMOVAL)

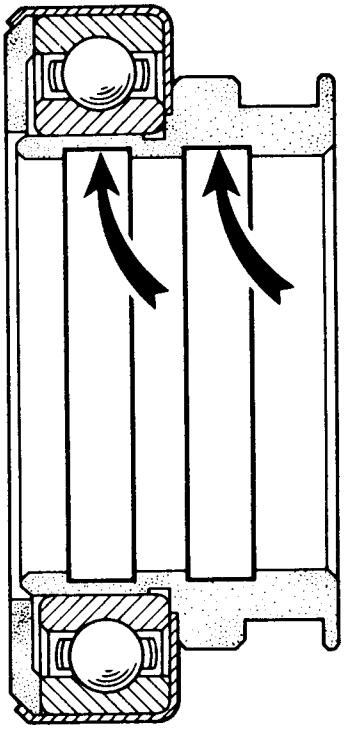
2. The following procedure must be followed to remove the clutch assembly from the engine:
3. Remove the transmission.
4. Disconnect the clutch fork return spring.
5. Disconnect the clutch push rod from the pedal lever or relay lever and withdraw the rod from the fork.
6. The thrust bearing which is resting between the fork can now be removed.
7. Remove the twelve bolts and washers and withdraw the clutch housing complete with the clutch fork and ball assembly.
8. Unscrew the clutch fork and ball assembly from the housing.

CLUTCH FORK AND RELEASE BEARING (INSPECTION AND OVERHAUL)

9. Inspect the ball, seating and fork jaw pins for excessive wear and replace where necessary.
10. Check the release bearing for roughness or noisy operation. The bearing is packed with lubricant during manufacture and sealed. It must not be washed in cleaning fluid or immersed in a degreasing plant, as such treatment will destroy the lubricant and render the bearing unfit for further use.

CLUTCH FORK AND RELEASE BEARING (REFITTING)

11. Screw the clutch fork and ball assembly onto the clutch housing after smearing the ball with grease, specification GM 4530-M.
12. Clean off any burrs from the faces of the clutch housing and flywheel housing before refitting the clutch housing.
13. Fill the two grooves in the release bearing, arrowed in 8.1100-13, with GM 4530-M grease and place onto the fork jaw pins.



8.1100-13

14. Reconnect the push rod to the pedal lever or relay lever.
15. Reconnect the clutch fork return spring.
16. Before installing the transmission, ensure that there are no burrs on the front cover sleeve and also smear the sleeve and the splines of the main drive pinion sparingly with grease of GM 4616-M or GM 4617-M specifications.

8.0000

SPECIFICATIONS

Dimensions quoted are the manufacturing limits for new parts except where maximum and minimum permissible figures are given.

P.T.O. OVERCENTRE CLUTCH

Make and Type	Borg & Beck 11½" Single Plate
	Borg & Beck 11½" Twin Plate

CLUTCH CROSS-SHAFT

Diameter	24.73 mm (0.974 in)
Clearance in Bushes	0.13 mm (0.005 in)

RELEASE BEARING

Minimum Travel	22.35 mm (0.88 in)

TORQUE WRENCH DATA

Clutch Pedal Journal Support Pin Nut	74 Nm (55 lb ft)
Drive Shaft Nut	238-245 Nm (175-180 lb ft)

AUTOMOTIVE CLUTCH

Clutch Assembly (Make and Type)

Four Cylinder Engine	Borg & Beck 10 AS Single Dry Plate
Six Cylinder Engine	Borg & Beck 12 AS or 13 AS Single Dry Plate
Clutch Disc (Type)	Borglite

CLUTCH DISC

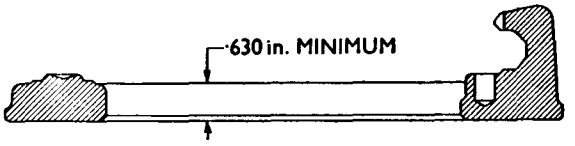
Hub Springs	FOUR CYLINDER ENGINE	SIX CYLINDER ENGINE
Number	8	6
Identification Colour:		
Type 10 AS	4 Yellow 4 Blue	—
Type 12 AS	—	—
Type 13 AS	—	Light Blue Black

PRESSURE PLATE AND SPRINGS

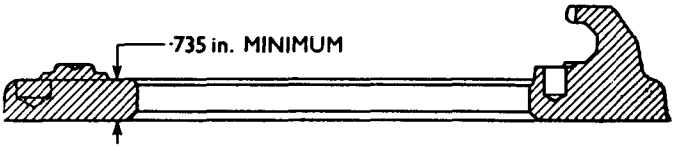
Thrust Springs	FOUR CYLINDER ENGINE	SIX CYLINDER ENGINE
Number	12	16
Assembled Height	42.86 mm (1 11/16")	42.86mm (1 11/16")
Load at Assembled Height:		
Type 10 AS	68.1-72.64 Kg (150-160 lb)	—
Type 12 AS (330 cu in engine)	—	54.48-59.02 Kg (120-130 lb)
Type 13 AS	—	61.29-65.83 Kg (135-145 lb)
Identification Colour:		
Type 10 AS	Black	—
Type 12 AS (330 cu in engine)	—	Cream
Type 13 AS	—	Yellow/ Light Green

CLUTCH SYSTEM SPECIFICATIONS 2

Pressure Plate Thickness		
(Minimum Permissible After Refacing)	16.00 mm (.630 in)	18.68 mm (.735 in)
	Checked at several points around plate	
Release Lever Height	49.403-49.911 mm (1.945-1.965")	56.515-57.785 mm (2.225-2.275")
	Using a gauge plate 8.36-8.41 mm (.329"-.331") thick; Lever heights must be same within 0.381 mm (.015")	



Pressure Plate Machining Limit, Four Cylinder Engines.



Pressure Plate Machining Limit, Six Cylinder Engines.

TORQUE WRENCH DATA

Flywheel Bolts	88-95 Nm (65-70 lb ft)
Clutch Cover to Flywheel Bolts	30-37 Nm (22-27 lb ft)

SECTION 9

TRANSMISSIONS

Contents

9.1000

HYDRAULIC MARINE GEAR

A list of the marine gearboxes used on Bedford 220 and 330 cu in engines is listed below:

Borg Warner Forward & Reverse Gearboxes

71CR Direct Drive
71CR 1.523:1 Reduction
71CR 1.91:1 Reduction
71CR 2.1:1 Reduction
71CR 2.57:1 Reduction
71CR 2.909:1 Reduction

72CR Direct Drive
72CR 1.523:1 Reduction
72CR 1.91:1 Reduction
72CR 2:1 Reduction
72CR 2.1:1 Reduction
72CR 2.57:1 Reduction
72CR 2.909:1 Reduction

73CR 2.909:1 Reduction

Parsons Gearboxes

DA Series	Direct Drive
HG4 Series 4/100	Direct Drive
HG4 Series 4/100	2:1 Reduction
HG4 Series 4/100	3:1 Reduction

For service and overhaul procedures covering these marine gearboxes, refer to the appropriate service manual published by the manufacturers. These can be obtained from:

Warner Gear
Division of Borg-Warner Corporation
1106 East Seymour Street
Muncie
Indiana
USA
Telephone: 317/284-8411

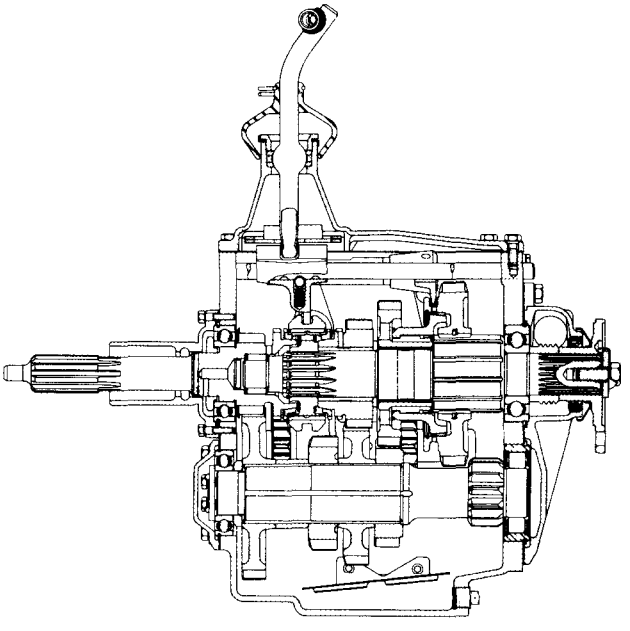
The Parsons Engineering Co. Ltd.
An Associated British Engineering Co.
Town Quay Works
Southampton
England
Telephone: Southampton 27362

9.4000

TRANSMISSION-HIGHWAY

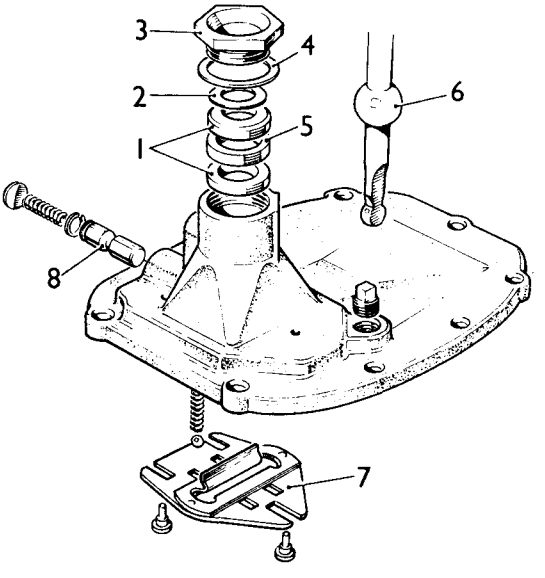
TRANSMISSION-HIGHWAY (DESCRIPTION)

1. The transmission most used on highway applications is the Bedford four speed type.



9.4000-1

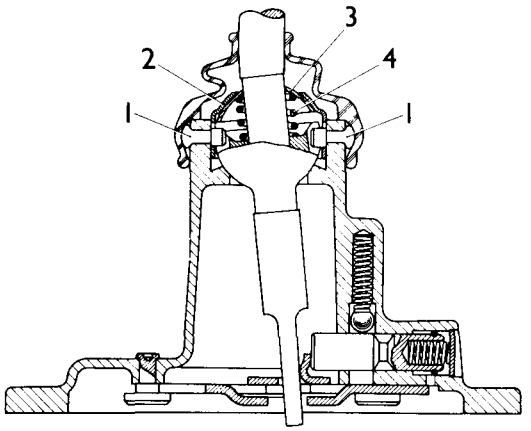
2. The Bedford four-speed transmission incorporates synchromesh engagement on second, third and fourth speeds. The rear of the main drive pinion is supported by a ball bearing in the transmission casing, and a spigot at the front end of the pinion engages a bearing in the crankshaft. The mainshaft is supported at the front by needle rollers in the main drive pinion counterbore and by a ball bearing in the rear of the transmission casing.
3. The third and fourth speed synchromesh mechanism incorporates a clutch and a hub which is splined to the mainshaft. The second speed synchromesh mechanism is incorporated in the front of the first and reverse gear. The gear houses an insert and a cone with two driving lugs for synchronizing second speed engagement. The bore of the gear is grooved to accommodate a spring damper ring and rubber compression strip.
4. The second speed gear is bushed but the third speed gear operates on a sleeve pressed on the mainshaft. The layshaft assembly is supported in the front of the transmission casing by a ball bearing and at the rear by a roller bearing. Endwise location of the layshaft is controlled by the front bearing inner race which is clamped between a spacer on the shaft spigot and a thick washer secured by bolts. The first speed gear is integral with the layshaft, the others being keyed and pressed on the shaft.
5. The reverse idler pinion is bushed and operates on a fixed shaft pressed into the casing and secured by a spring pin.
6. Striking forks and the reverse lever head operate on fixed rods in the top of the casing. Spring loaded balls, housed in the fork and reverse lever head bosses, engage slots in the rods for gear retention in the neutral and engaged positions.
7. Jaws in the reverse lever head engage the top of a reverse striking lever which pivots on an eccentric bolt in the side of the casing. The lower end of the lever engages the reverse idler pinion.
8. Individual gear selection is provided by a slotted interlock plate engaged with the forks and reverse lever head and attached to the top cover.
9. The transmission incorporates a standard SAE power take-off facing.
10. There are two types of transmission top covers, the first incorporates two ball seatings (1), a spacer (5) and washer (2). The change speed lever (6) is retained by a nut (3) which is locked by a tab washer (4).



9.4000-10

11. Individual gear selection is provided by a slotted interlock plate (7) which engages the striking forks. A spring loaded plunger (8) prevents accidental engagement of reverse when forward speeds are being selected.
12. The second type of transmission top cover is similar to the first except that the turret has an integral ball seat for the gear shift lever.

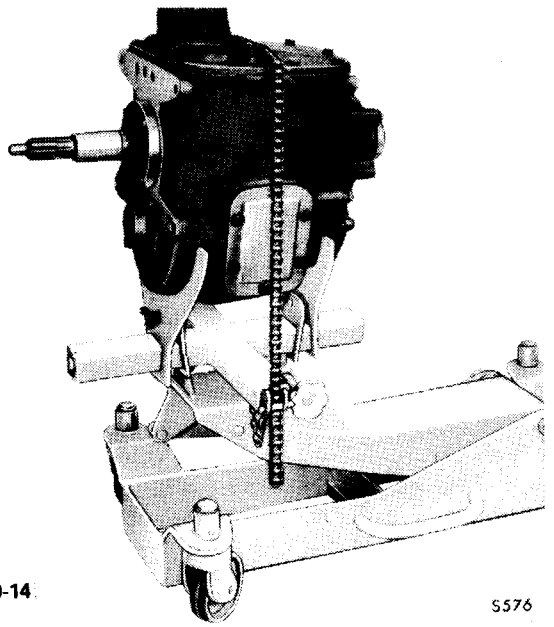
13. The half round ball on the gear shift lever is loaded against the seat by a spring (4) which is held captive by a cup (3) and bayonet retaining cap (2). The lever ball is slotted to engage two pins (1) in the cover turret which prevents rotation of the lever.



9.4000-13

TRANSMISSION-HIGHWAY (REMOVAL)

14. Due to the weight of the transmission which is approximately 66 Kg (145 lb), it is recommended that a cradle is used during removal.



9.4000-14

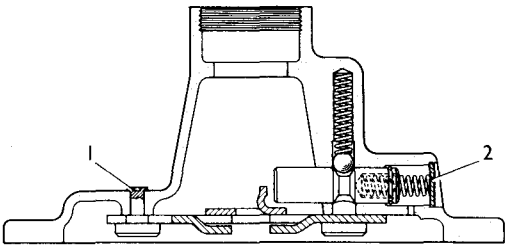
S576

15. The transmission assembly is secured to the clutch housing by three bolts, and one nut in the lower right-hand side of the clutch housing. These should be removed and the transmission lifted away on its cradle.

TRANSMISSION-HIGHWAY (INSPECTION & OVERHAUL)

16. Remove the gear shift lever, either by removing the tab washer and nut and lifting the lever clear, or by depressing and turning the retaining cap anti-clockwise and lifting the lever clear.

17. To remove the interlock plate, chisel off the ends of the pins (1). Reverse stop plunger and spring can be withdrawn after removing the expansion plug (2).

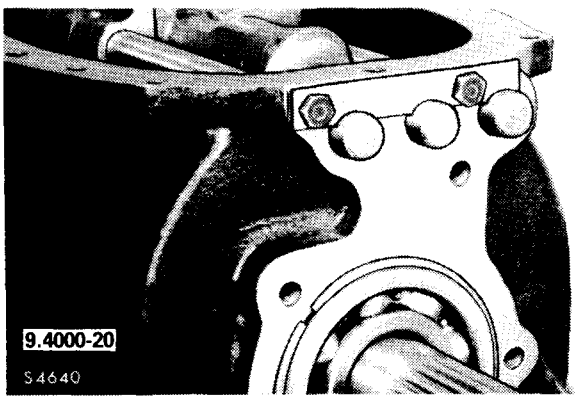


9.4000-17

18. To facilitate disassembly and reassembly of the transmission, bolt two supports to the casing lower attaching lugs.

19. Engage top and reverse gears and remove the coupling flange bolt.

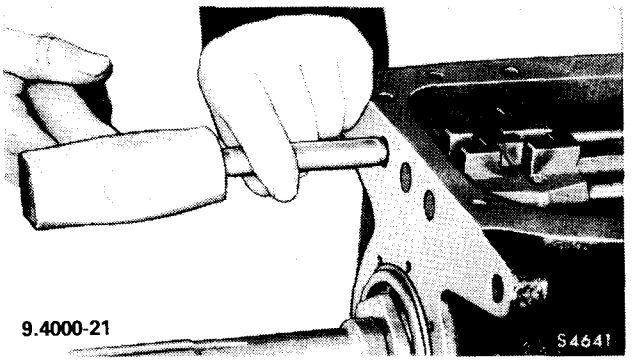
20. The striking fork rods are located in the transmission casing by a retainer bolted to the rear of the casing. Remove this retainer.



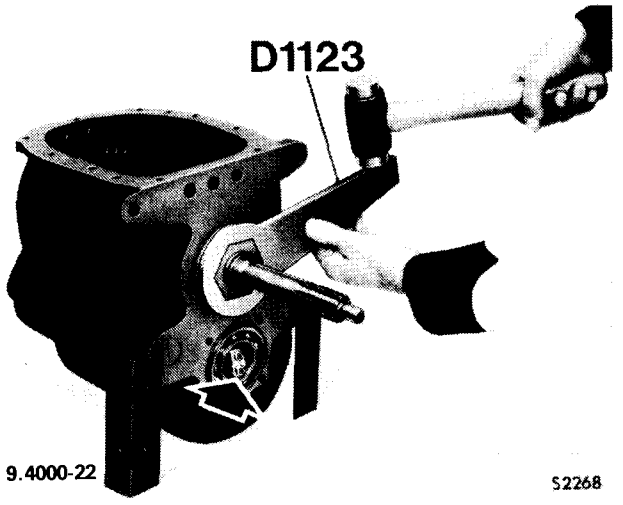
9.4000-20

S4640

21. The fork rods must be driven out from the front of the casing. Care must be taken that the locking balls are not lost as the forks become detached.

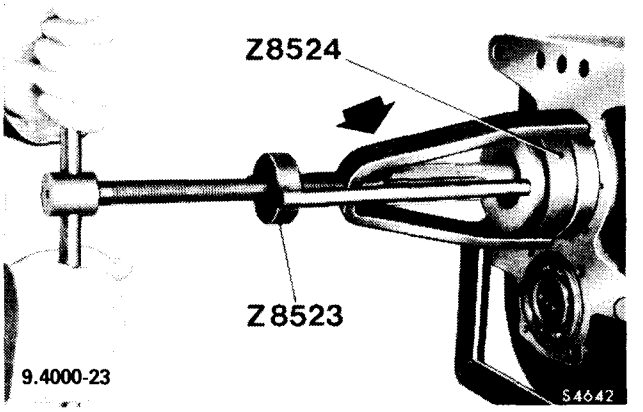


22. To facilitate removal of the pinion left hand threaded nut, and layshaft bearing retainer bolts, engage second and third gears. Use wrench D1123 to unscrew the pinion nut.

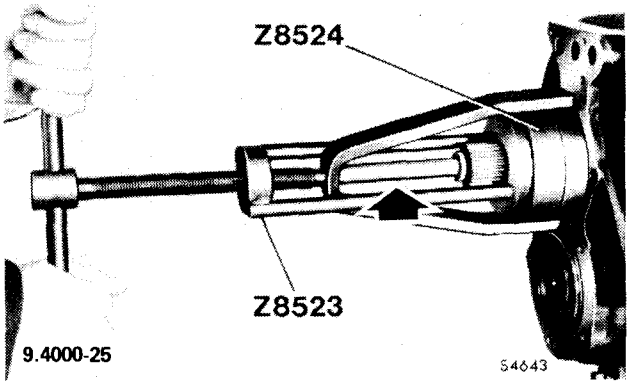


23. Next remove the main drive pinion bearing, to achieve this remove the locating ring from the outer race and assemble adaptor Z8524 to the bearing. Use remover Z8523 to withdraw the bearing off of the shaft and out of the casing. Ensure that the bridge piece (arrowed) is interposed between the remover screw and the casing to relieve the main drive pinion of end thrust.

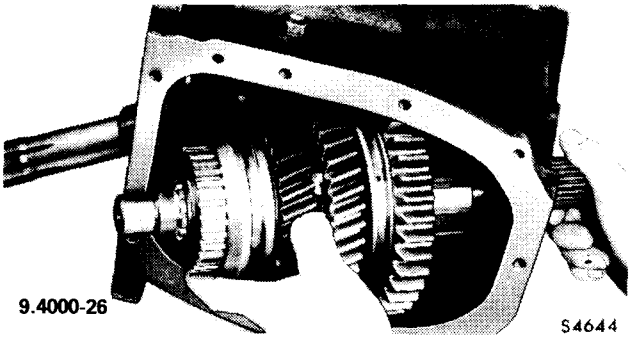
24. After removing the bearing, withdraw the oil thrower to prevent damaging it during the removal of the mainshaft.



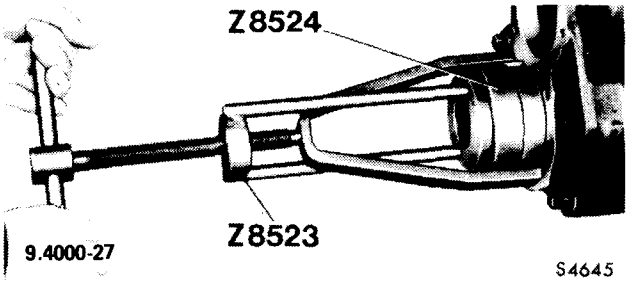
25. The mainshaft bearing is removed in a similar manner to the main drive pinion bearing, using adaptor Z8524 and remover Z8523 together with a distance piece (arrowed) and a plug supplied with the remover.



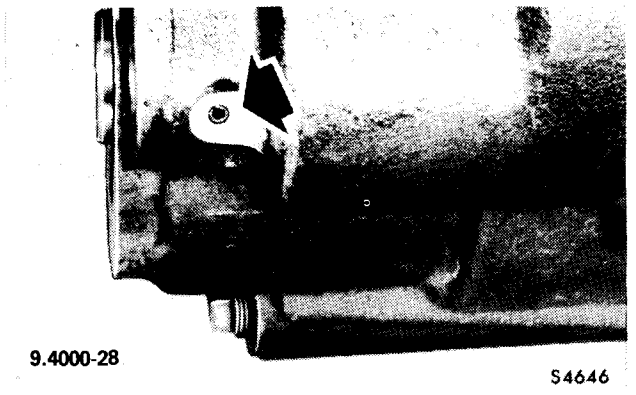
26. To facilitate the removal of the mainshaft, slide first and reverse gear forward on the mainshaft to engage the second gear. Slide the third and fourth clutch rearwards on the clutch hub to engage third gear. Lay the transmission on its side, and with the main drive pinion located as far forward as possible through the casing bore, withdraw the mainshaft assembly through the top of the casing.



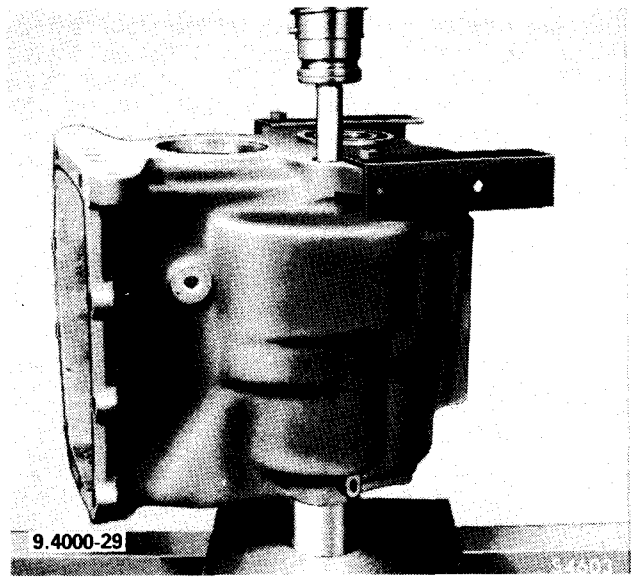
27. Use adaptor Z8524 and remover Z8523 to remove the layshaft rear bearing.



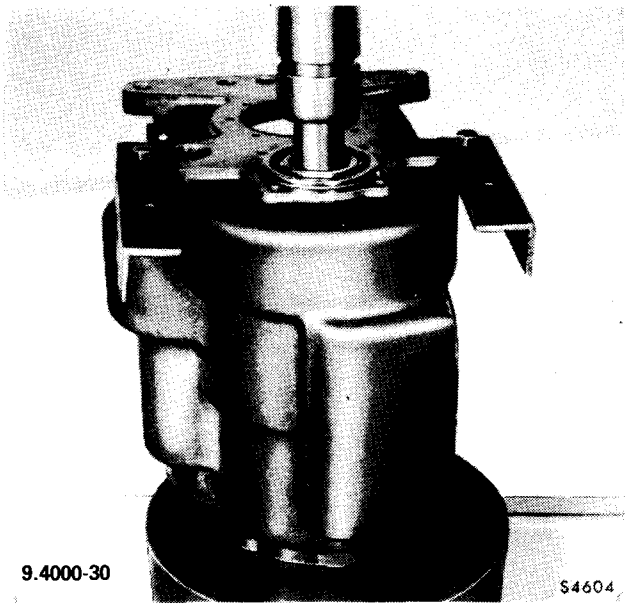
28. The reverse pinion shaft is retained in the casing by a spring pin. This pin must be driven in as far as possible so that it is contained within the pinion shaft.



29. When pressing the reverse pinion shaft out of the casing, support the rear of the casing on a sleeve.

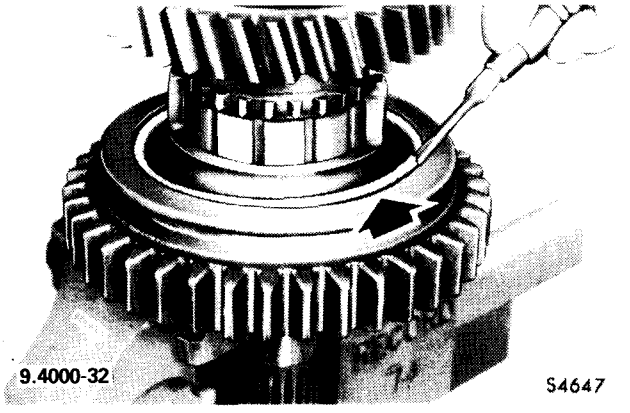


30. The layshaft gear can now be pressed out of front bearing and the assembly lifted out of the casing. The front bearings can then be tapped out from inside of the casing.

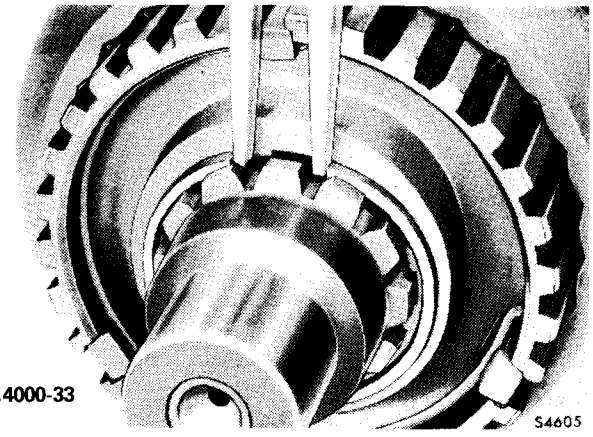


31. Before disassembling the mainshaft, mark the radial position of the third and fourth speed clutch relative to its hub, with a spot of paint. Also mark the position of the first and reverse gear splines in relation to their mating splines on the mainshaft. This will ensure that the components will be reassembled in the same relationship as before.

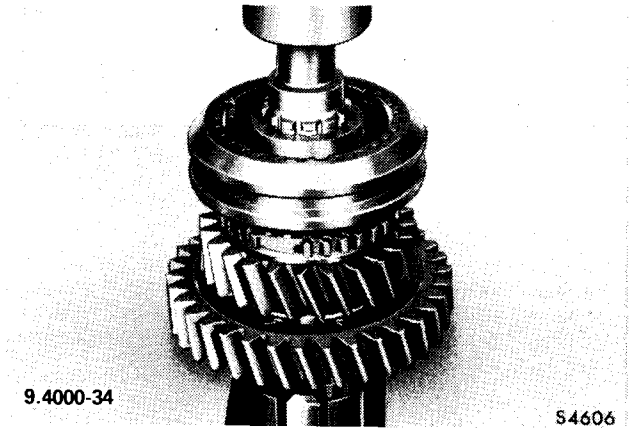
32. The first and reverse gear can be withdrawn off the mainshaft after removing the synchronizing cone retainer.



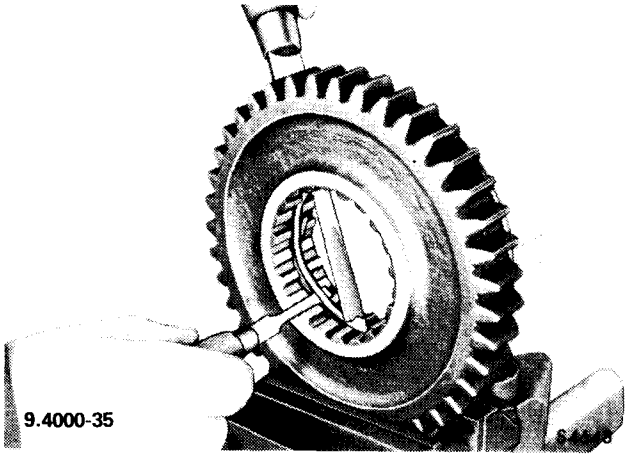
33. The third and fourth speed clutch hub is retained on the front end of the mainshaft by a retaining ring. This can be removed.



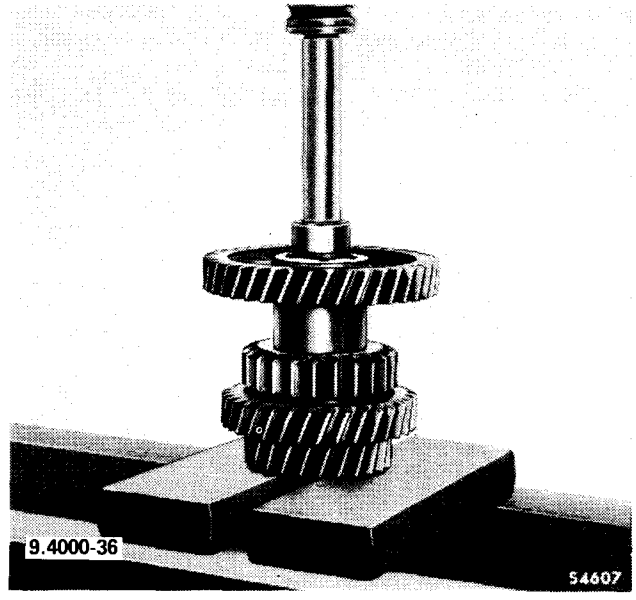
34. To press the clutch hub and third gear sleeve off the mainshaft, support the second gear on a press making sure that the synchronising springs are clear of the press.



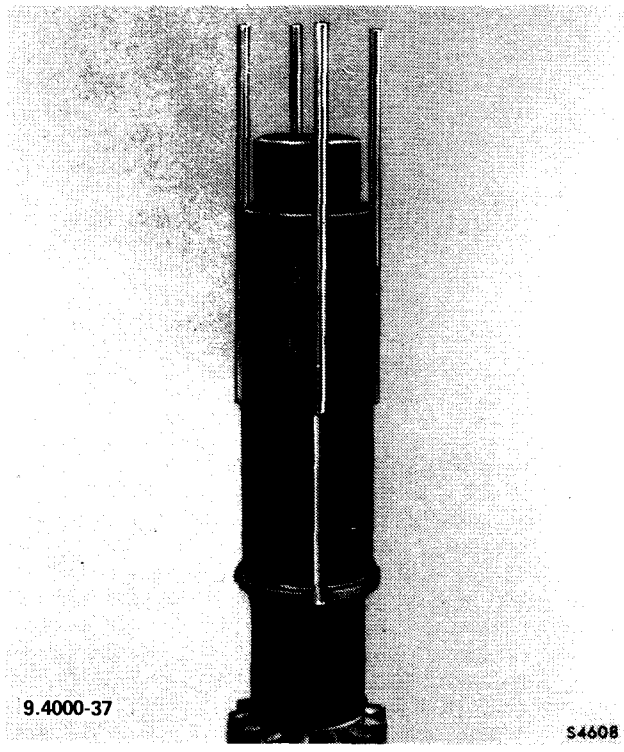
35. Discard the damper ring and compression strip of the first and reverse gear.



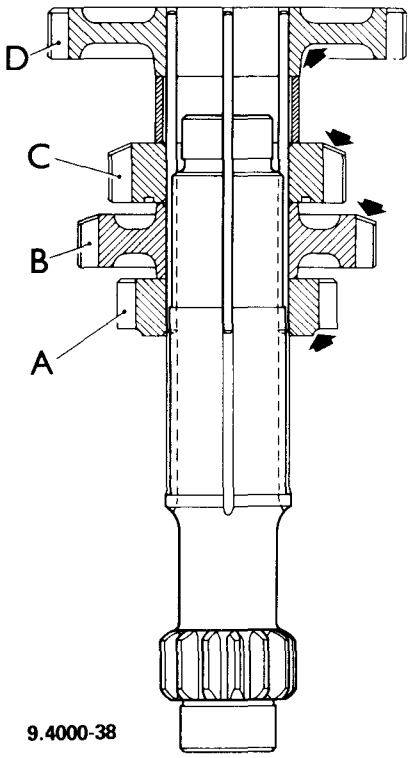
36. The layshaft first speed gear is integral with the layshaft. The remaining gears are pressed and keyed to the layshaft. Support the rear face of the second gear on the press and press the layshaft out of the gears. Discard the keys.



37. Before assembling the gears to the layshaft, locate new keys onto the shaft so that each key projects halfway above the ends of the keyways. Retain the keys in this position with stiff grease.

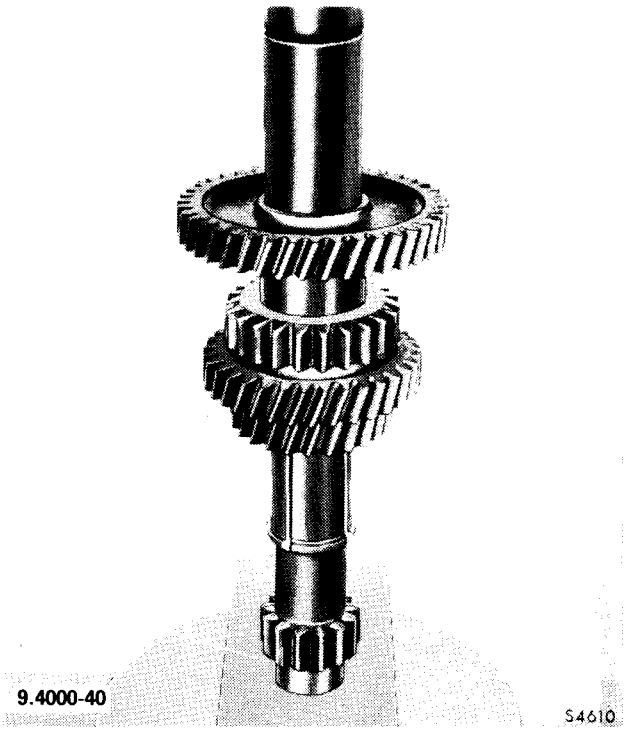


38. The layshaft gears must be assembled to the layshaft as follows:
'A' — Second gear, with boss to rear of the shaft;
'B' — Third gear and 'C' — reverse gear, with the chamfers on the end of teeth to the front of the layshaft;
'D' — Driven gear, with the boss to the rear of the shaft.
Ensure that the spacer, between the driven gear and the reverse gear is concentric with the boss of the driven gear.

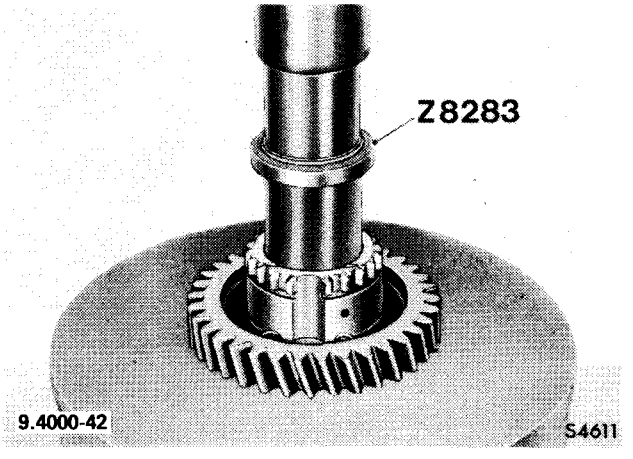


9.4000-38

39. Before pressing the gears onto the shaft, the keys must be flush with the driven gear end face.
40. When pressing the gears onto the shaft, use a sleeve to contact the driven gear end face and the ends of the keys. The gears must be pressed onto the shaft until the second gear contacts the layshaft shoulder. During this operation care must be taken to ensure the keys do not jam in the bottom ends of the shaft keyways. The gears and spacer must be in firm contact with each other and the keys must be tapped below the end face of the driven gear, after the gears are finally assembled.

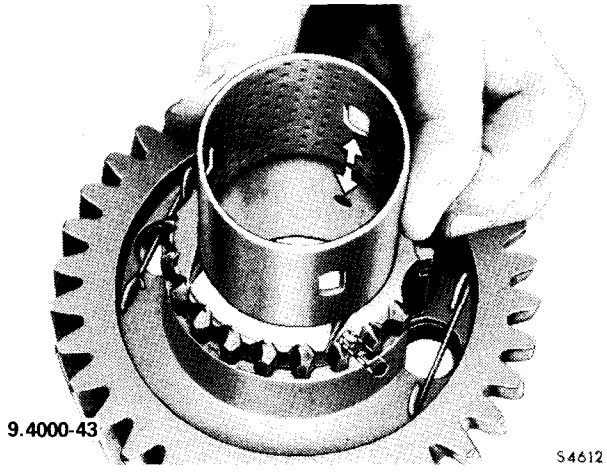

9.4000-40 S4610

41. The third and fourth speed clutch and hub, and also the first and reverse gear and mainshaft are matched assemblies, therefore components of each assembly must not be renewed individually.
42. Press the bush out of the mainshaft second speed gear, using the long end of remover Z8283.

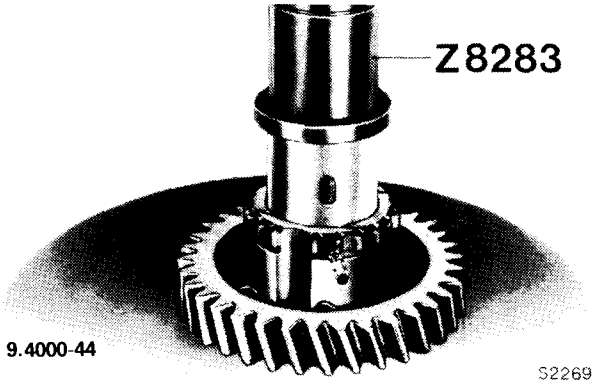


9.4000-42 S4611

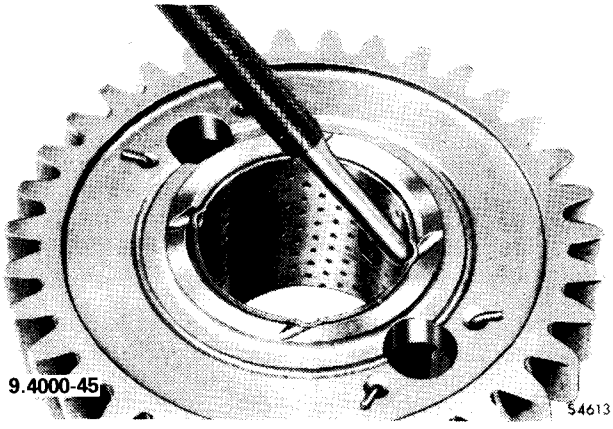
43. The new bush must be located so that the oil holes are aligned with the holes in the gear bore.



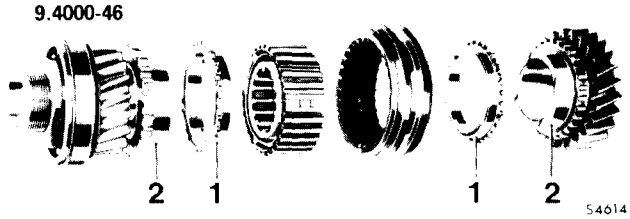
44. Use the short end of installer Z8283 and press the bush into the gear until the collar on the drift contacts the gear. Replacement bushes are pre-finished to size.



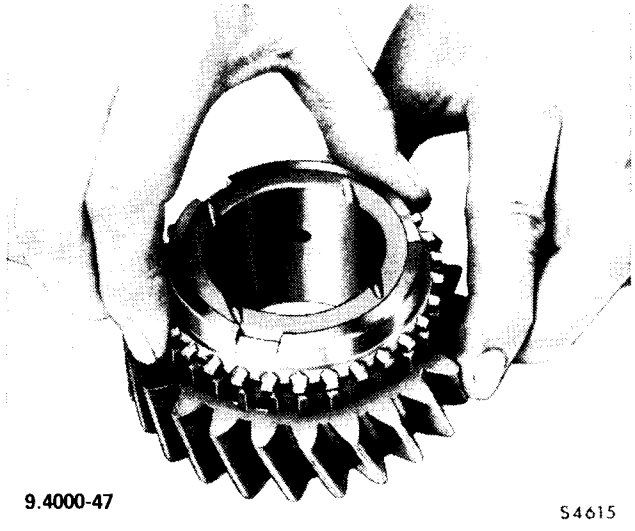
45. After installing, the bush must be staked into the oil grooves in the front end face of the gear.



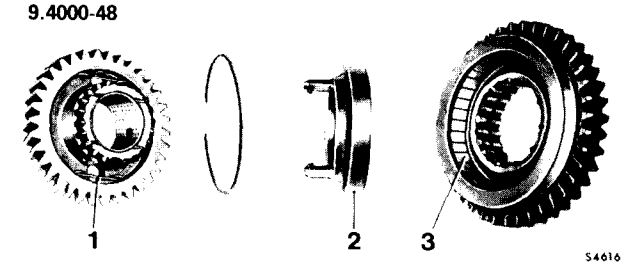
46. For effective synchromesh action, it is essential that friction surfaces of the synchronizing rings (1) and gear cones (2) are in good condition. Mis-shapen synchronizing ring teeth will create baulking trouble.



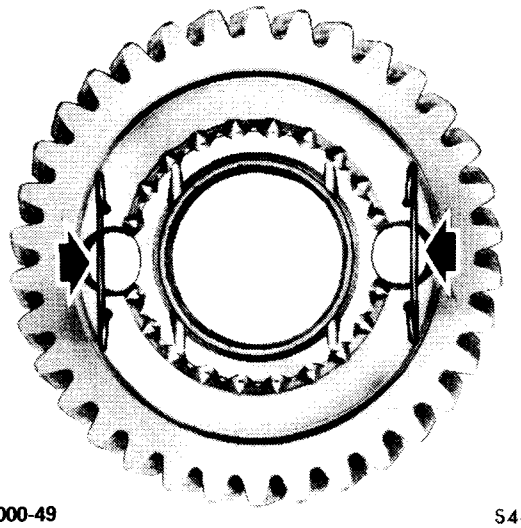
47. Rocking of the ring on the gear cone indicates ovality in either the ring or the cone, or both, resulting in insufficient grip. The wear on the rings or gear cones can be assessed by comparing frictional grip and the relative location of the ring or cone with that of new components.



48. Synchromesh operation on the second speed gear depends on the condition of the synchronizing springs (1) in the second speed gear synchronizing cone (2) and the synchronizing insert (3) incorporated in the first and reverse gear.

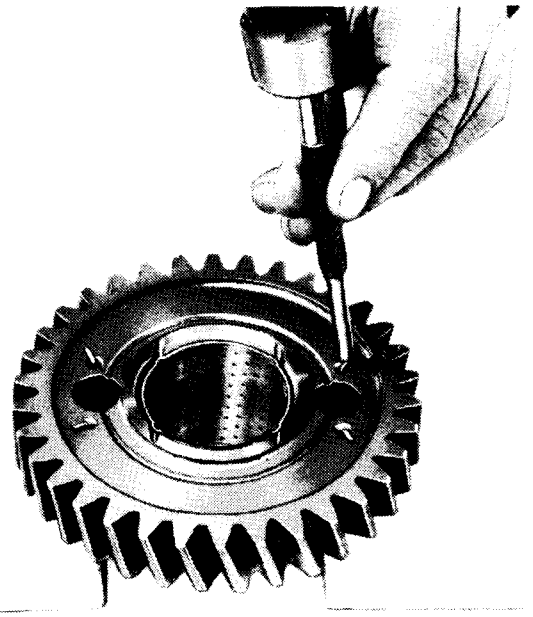


49. The synchronizing springs can be removed by straightening the ends of the springs. In order that the lugs of the first and reverse gear cone can engage the holes in the second gear, new synchronizing springs must be installed so that the straight section of the spring (arrowed) is offset outwards from the centres of the holes in the gear.



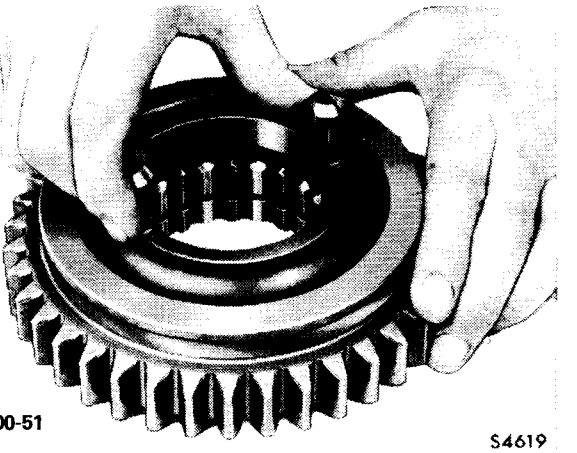
9.4000-49 S4617

50. To secure the springs in the gear, support the spring eyes on the wood blocks and bend over the ends of the springs. Ensure each spring is secure in the gear and with no end float.



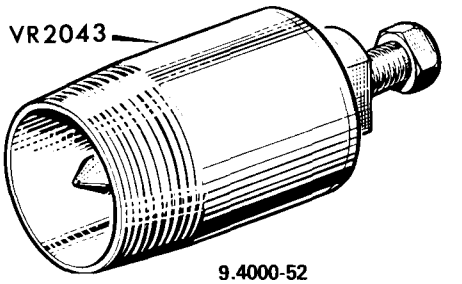
9.4000-50 S4618

51. Wear on the second gear synchronizing cone and insert can be assessed by comparing the frictional grip and relative location of the cone in the gear insert with that of new components. It is essential that friction surfaces of the insert and cone are in good condition.



9.4000-51 S4619

52. Oil leakage from the transmission rear cover is prevented by a spring loaded seal. To withdraw this seal, use remover VR2043 with the coupling flange bolt installed as a distance piece. Before tightening the thrust screw, screw the threaded body of the remover firmly into the seal.



9.4000-52

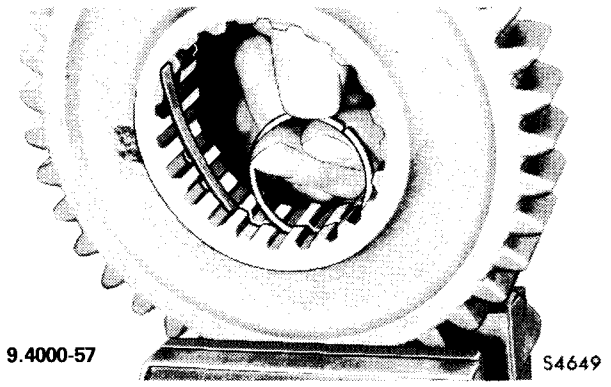
53. When installing the rear seal, install open side inwards, and drive in flush with the rear cover end face. After installing smear the lip of the seal with Rocol anti-scuffing paste.

54. The rear cover seal can be renewed with the transmission in the vehicle. To gain access to the bolt, securing the universal joint flange to the transmission mainshaft on vehicles with multi propeller shafts, it is necessary to remove one of the propeller shaft bearing support bracket bolts. Slacken the remaining bolt and ease the shaft to one side. The front end of the shaft must not hang unsupported, as this will dislodge the bearing rubber cushion.

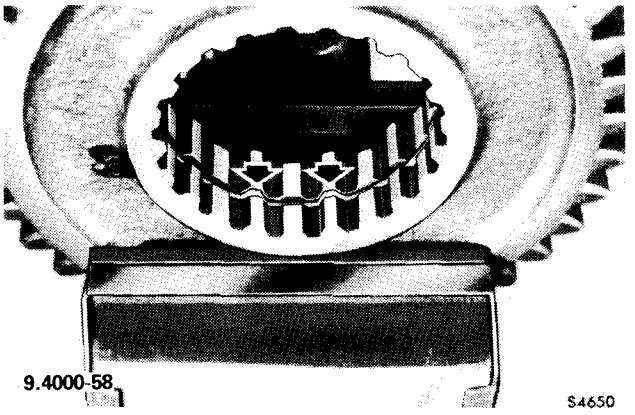
55. The coupling flange retaining bolt must be tightened to a torque of 105 Nm (77 lb ft) and secured with a tab washer.

56. When reassembling the transmission the following points should be adhered to.

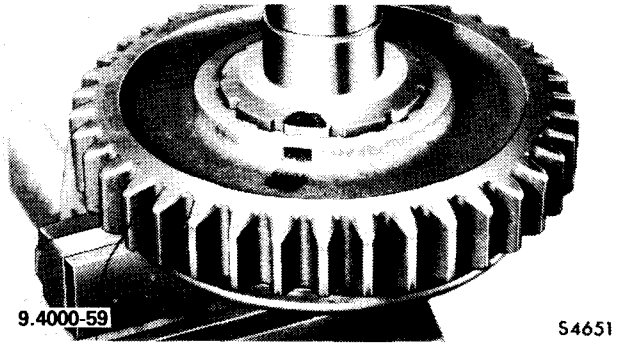
57. When installing compression strip in the bore of the first and reverse gear, ensure that the strip is not twisted. The top speed hub retainer can be used to roll the strip into the groove.



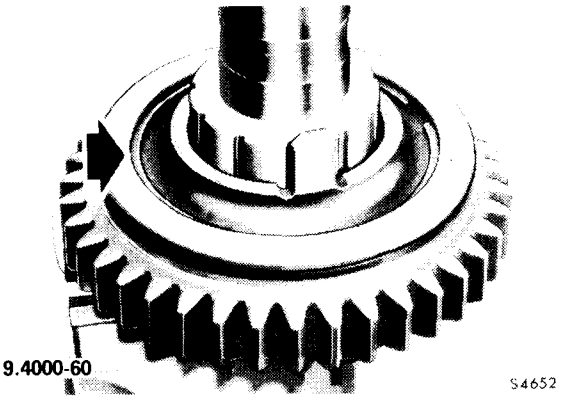
58. After installing the compression strip, the damper rings must be located in the groove so that the centre lugs (arrowed) on the ring are aligned with the high splines in the gear.



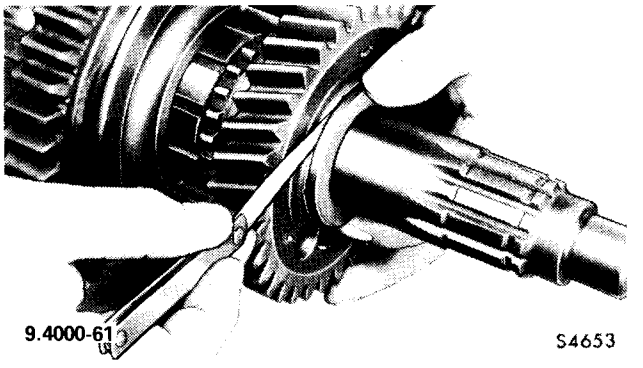
59. When installing first and reverse gear on the mainshaft, the marked spline of the gear and shaft must be realigned. Ensure the lugs of the damper ring engage the splines of the shaft, and tap the gear onto the shaft.



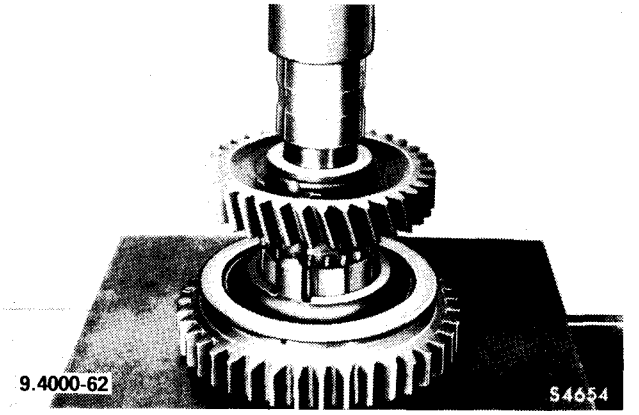
60. After installing the gear onto the shaft, the synchronizing cone must be assembled to the gear and secured with the retainer (arrowed).



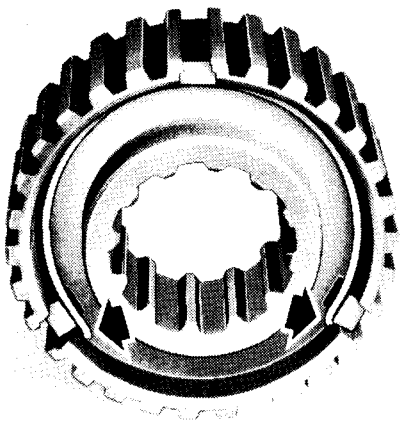
61. After assembling the second gear on the mainshaft, locate a new thrust washer, with the chamfered end of the bore first, against the shoulder on the mainshaft and check that the gear end float is within 0.2286/0.3556 mm (0.009/0.014 ins).



62. When pressing the third gear mainshaft sleeve onto the shaft, avoid excessive pressure when the sleeve contacts the thrust washer as this may distort the sleeve. After installing, ensure the gear rotates freely on the sleeve.

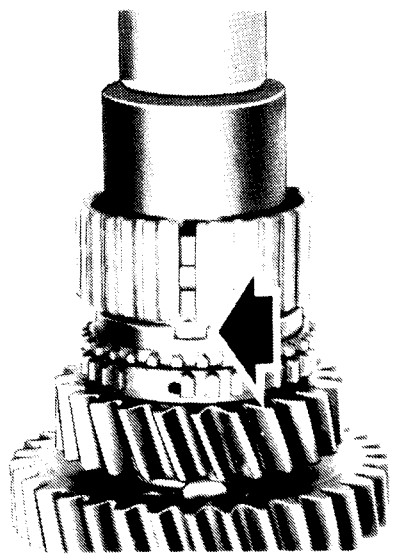


63. When assembling the clutch key springs to the third and fourth speed clutch hub, the springs must be located on the keys so that the ends of both springs are on the same keys. The spring ends must also be clear of the curved surface of the clutch hub.



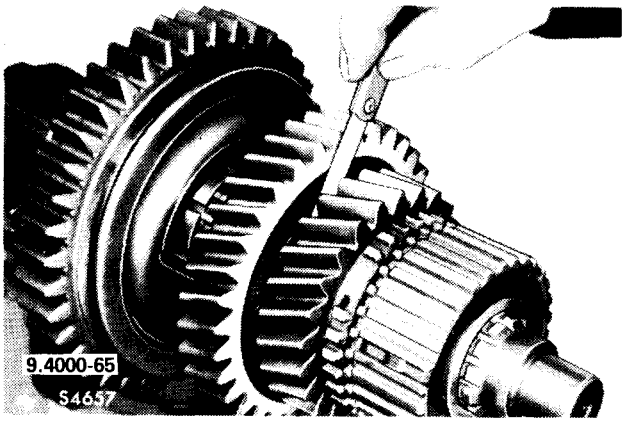
9.4000-63 S4655

64. The third and fourth clutch hub must be located on the mainshaft so that the longer boss of the hub is towards the spigoted end of the shaft. Align the slots (arrowed) in the synchronizing ring with keys while pressing the hub onto the shaft. Avoid excessive pressure when the hub contacts the third gear sleeve as this may distort the sleeve and result in insufficient clearance for the gear.

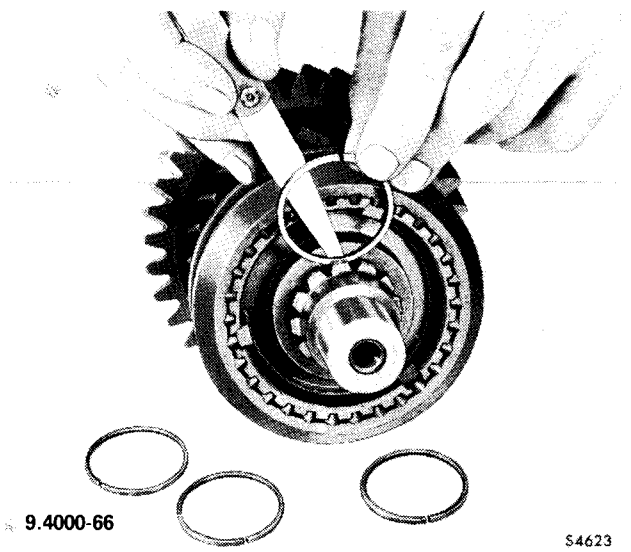


9.4000-64 S4656

65. After installing the third and fourth speed clutch hub, check that the third gear end float is within 0.2286/0.3556 mm (0.009/0.014 ins) and that the gear rotates freely. The clutch must be assembled to the hub with the location marks aligned.



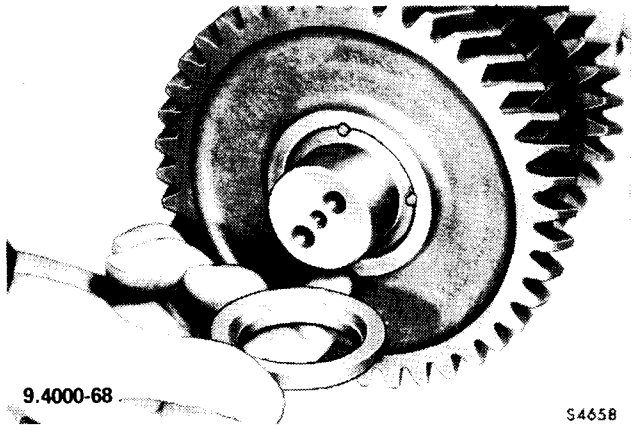
66. The third and fourth speed clutch hub retaining ring is serviced in four thicknesses. Select a new ring which will give the minimum clearance between the ring and clutch hub; clearance must not exceed 0.1778 mm (0.007 ins).



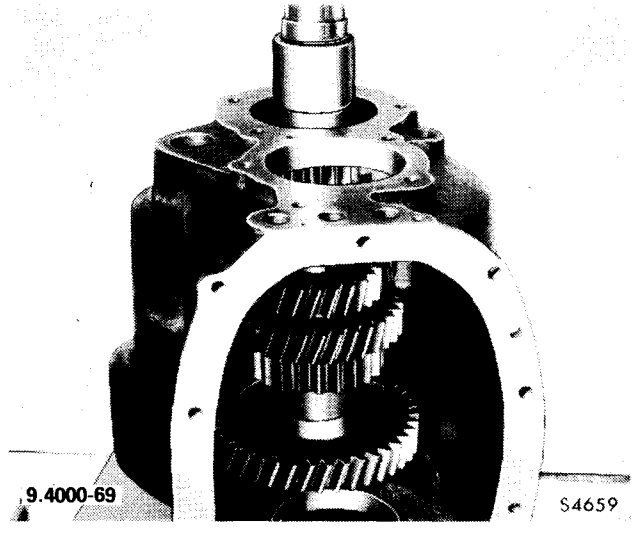
9.4000-66 S4623

67. The layshaft front bearing must be pressed into the casing until the bearing locating ring contacts the front face of the casing.

68. The layshaft front bearing spacer must be assembled, bore chamfer first, to the layshaft front spigot. Smear spacer with petroleum jelly to retain it on the spigot while installing the layshaft gear assembly.

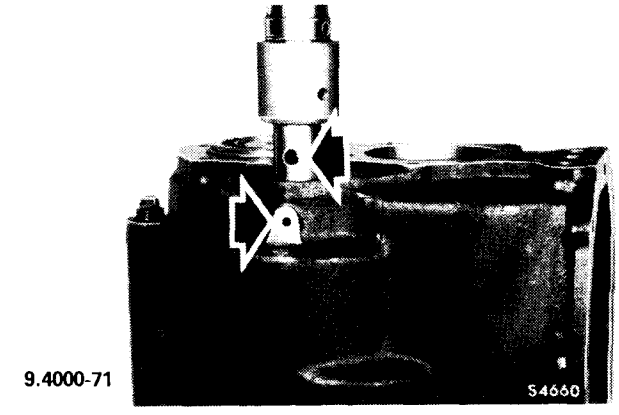


69. To install the layshaft gear assembly, up-end the casing so that the layshaft front bearing rests on the press. After aligning the spigot on the front end of the layshaft with the bearing, press in the layshaft to fully engage the spigot in the bearing.



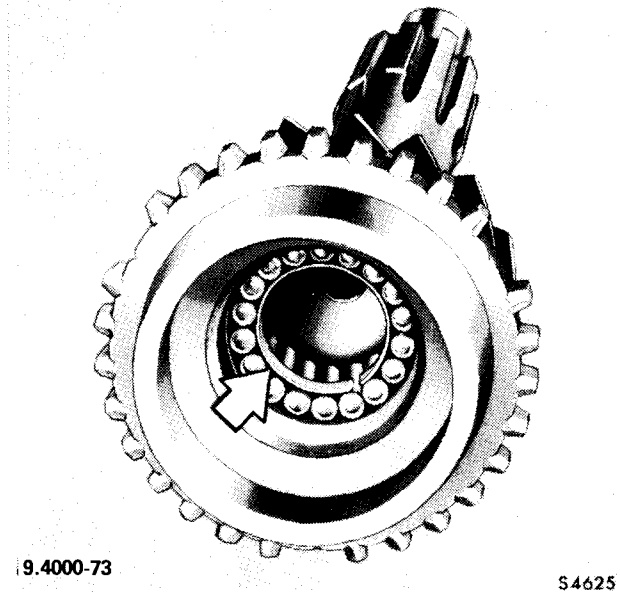
70. The layshaft rear bearing must be installed so that the bearing locating ring contacts the rear face of the casing.

71. Before pressing in the reverse pinion shaft ensure that the retaining pin hole in the rear end of the shaft is aligned with the hole in the casing. The shaft must be secured by a pin driven in flush with the casing.



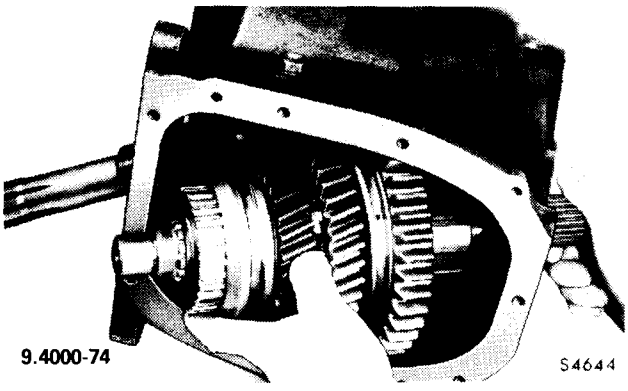
72. The front end of the mainshaft is supported in the main drive pinion counterbore by 18 bearing rollers.

73. Smear the rollers with grease when assembling them to the pinion bore and locate the keep ring (arrowed) midway along the rollers to retain them in position prior to engaging the mainshaft spigot.

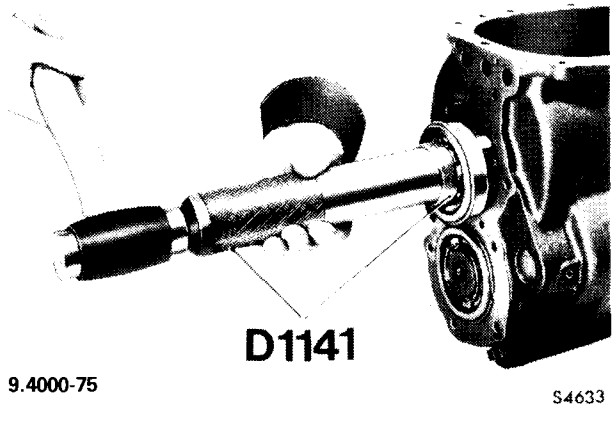


74. To facilitate installation of the mainshaft, lay the transmission casing onto its side. Assemble a synchronizing ring to the main drive pinion cone and insert the pinion shaft as far as possible through the casing bore. Slide the first and reverse gear forward on the mainshaft to engage second gear. Slide the third and fourth clutch rearwards on the clutch hub

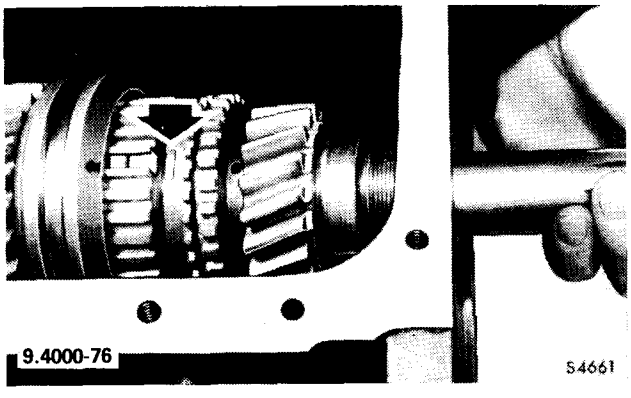
to engage third gear, and place the mainshaft assembly in the casing so that the rear of the shaft is as far as possible through the casing bore.



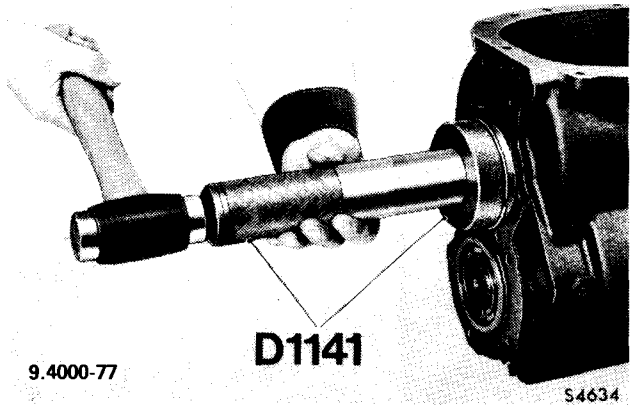
75. The mainshaft rear bearing must be located on the shaft so that the bearing retaining ring is to the rear of the shaft. Use installer D1141 to drive the bearing into contact with the shaft splined hub.



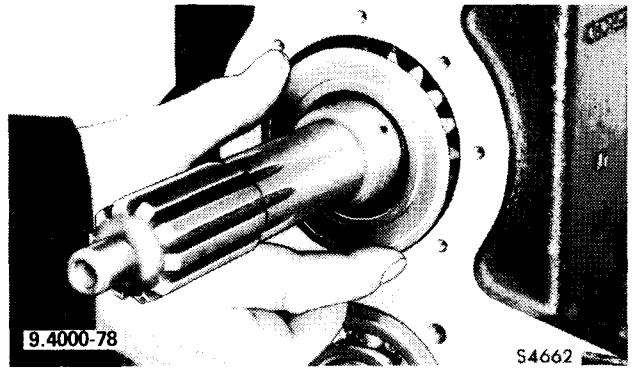
76. When assembling the main drive pinion to the mainshaft spigot ensure that the synchronizing ring slots are aligned with the clutch keys.



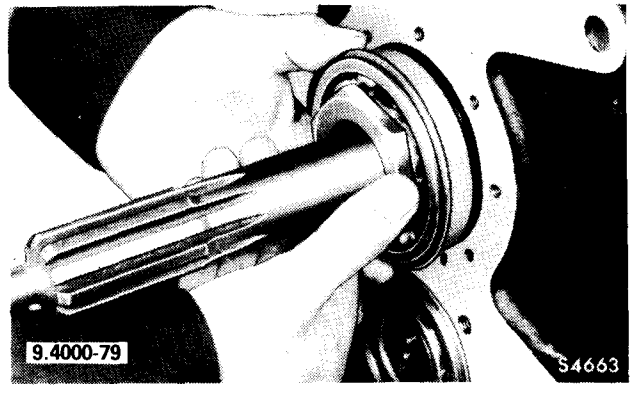
77. To prevent the third and fourth speed clutch contacting the layshaft third gear when installing the mainshaft rear bearing in the casing, the clutch must be located in the neutral position. Use installer D1141 to drive the bearing in until the bearing retaining ring contacts the rear face of the casing.



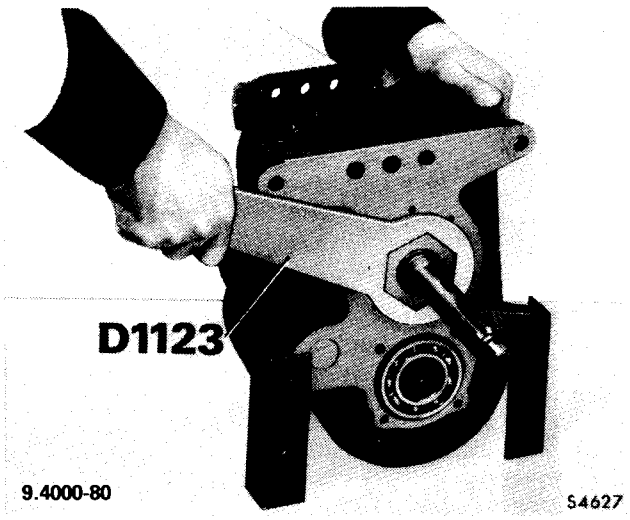
78. The oil thrower is located on the main drive pinion with the concave side to the pinion teeth, and concentric with the pinion shoulder. Use stiff grease to retain the oil thrower in position during the subsequent installation of the bearing.



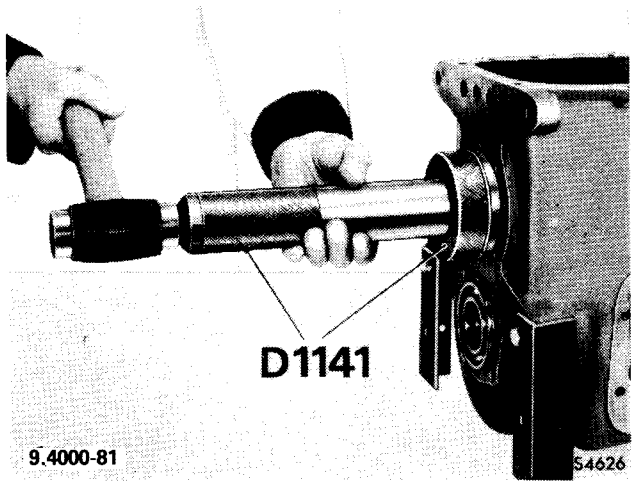
79. To ensure the pinion bearing is located squarely on the shaft and in the casing bore, hold the bearing on the nut spigot and screw the nut on to the shaft until finger tight.



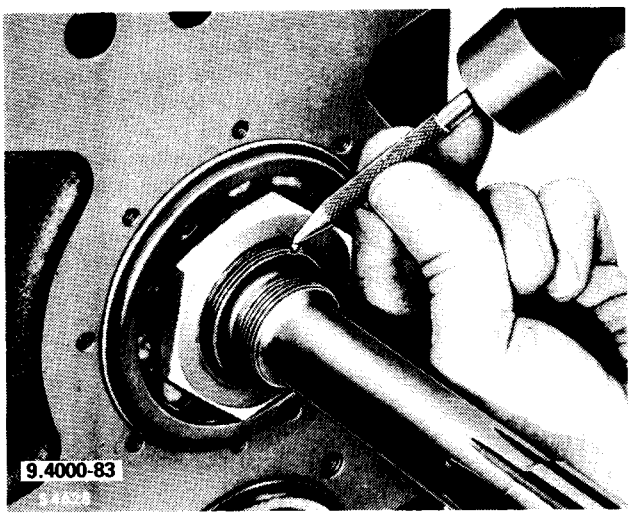
80. After engaging both second and reverse gears, use wrench D1123 to tighten the nut approximately three turns.



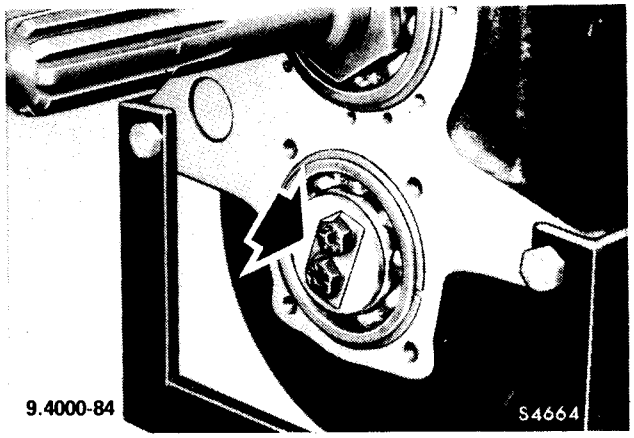
81. Then carefully tap the bearing into the casing with installer D1141.



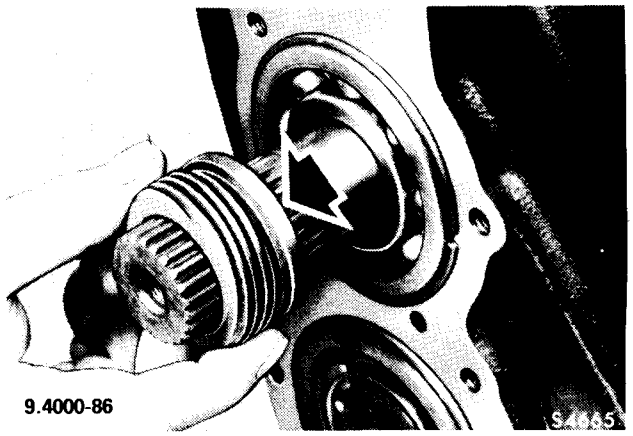
82. Repeat procedure in paragraphs (80 and 81) until the bearing retaining ring contacts the casing. During this operation ENSURE THE FOURTH SPEED SYNCHRONIZING RING IS NOT FORCED INTO CONTACT WITH THE GEAR CONE, otherwise the synchronizing ring will be damaged. Ensure the main drive pinion oil thrower remains in position.
83. After tightening the pinion nut, secure it by staking it into the hole provided in the main drive pinion.



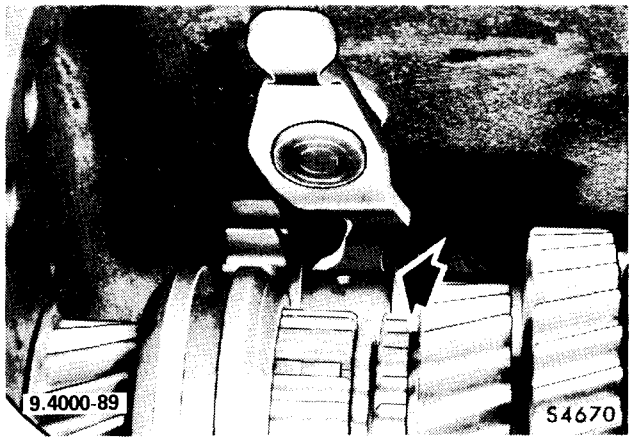
84. When assembling the retainer to the front spigot of the layshaft, ensure the bolts are secured by the locking plate.



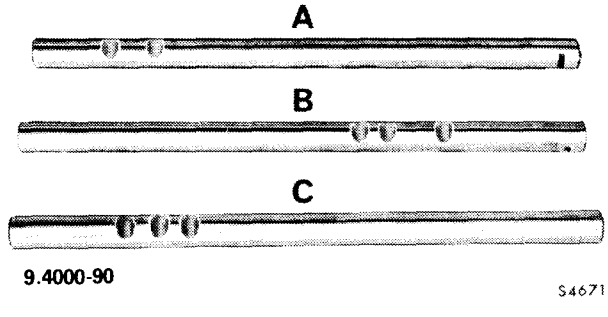
85. When assembling the layshaft front cover and gasket, smear the bolts with jointing compound.
86. The speedometer driving gear must be installed on the mainshaft so that the shoulder (arrowed) is towards the bearing.



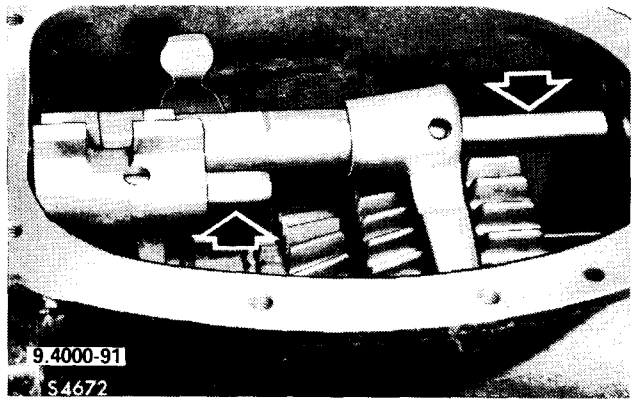
87. When installing the rear cover use jointing compound on the cover bolts.
88. With both the top and reverse gears engaged, tighten the coupling flange bolt to a torque of 105 Nm (77 lb ft).
89. When installing the reverse striking lever, the lower end of the lever must be fully engaged in the reverse idler gear groove in all positions when operated. The lever shape can be reset. Do not secure the nut of the lever eccentric bolt at this stage.



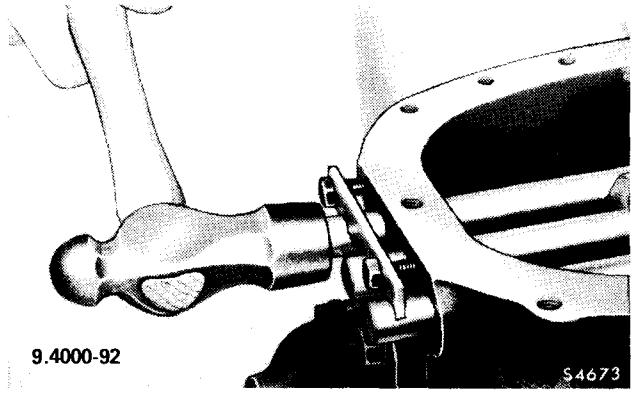
90. The striking fork rods are identified by location and the number of locking slots:
'A' — Reverse, has two locking slots at the front of the rod.
'B' — First and second, has three locking slots at the rear of the rod.
'C' — Third and fourth, has three locking slots at the front of the rod.



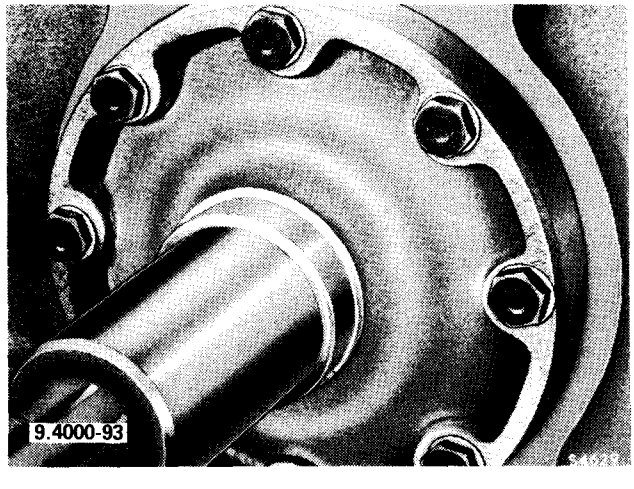
91. To facilitate assembly of the striking forks to the rods, use pilot rods (arrowed) to retain the locking ball and spring in the forks and the reverse lever head when installing rods.



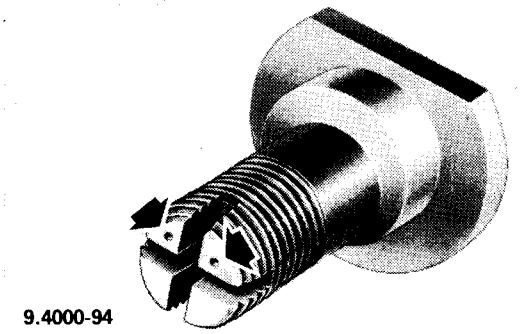
92. Before driving the striking fork rods into the casing, engage top and second gear. Position the retainer in the rod locating grooves so that the chamfered edge of the retainer is to the bottom of the casing and to the rear of the rods. Temporarily instal the guide bolts to align the retainer holes with the tapped holes in the casing and drive the rods into the casing.



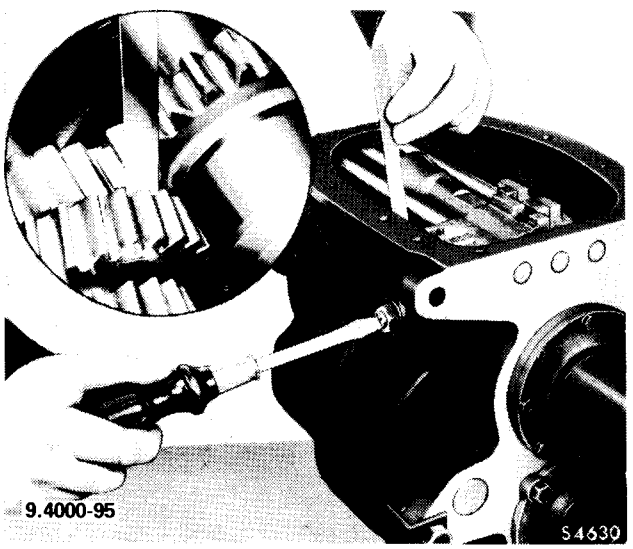
93. Use new sealing washers on the main drive pinion cover bolts and ensure that the washers do not project beyond the cover flange.



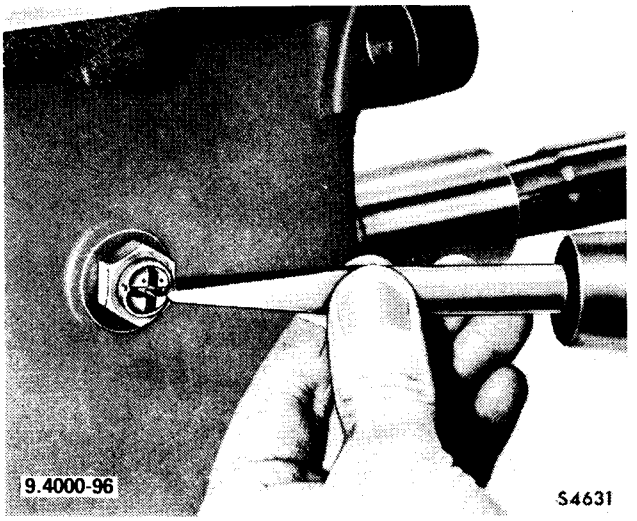
94. To ensure the reverse idler gear fully engages the mainshaft first and reverse gear when in reverse, the striking lever can be adjusted by means of an eccentric pivot bolt. The high side of the eccentric is indicated by punch marks (arrowed).



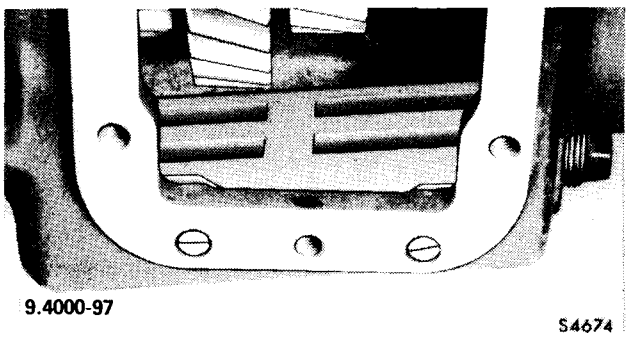
95. To adjust the reverse striking lever, select the reverse gear and rotate the eccentric pivot bolt until the clearance between the reverse gear and the layshaft third speed gear is 1.3-1.5 mm (0.05-0.06 ins).



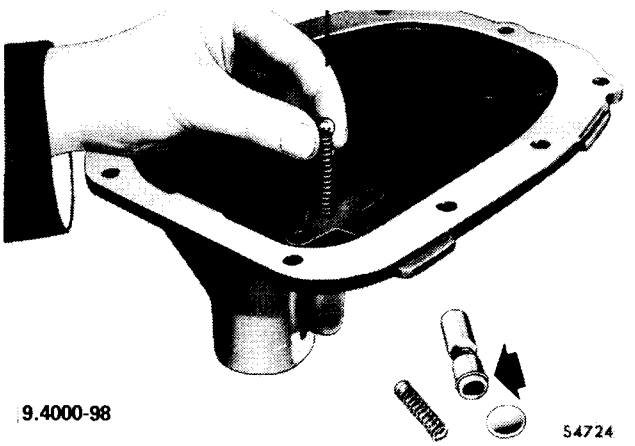
96. After setting the reverse striking lever, do not disturb the pivot bolt when tightening the nut. Secure the nut by staking it into each end of the pivot bolt slots.



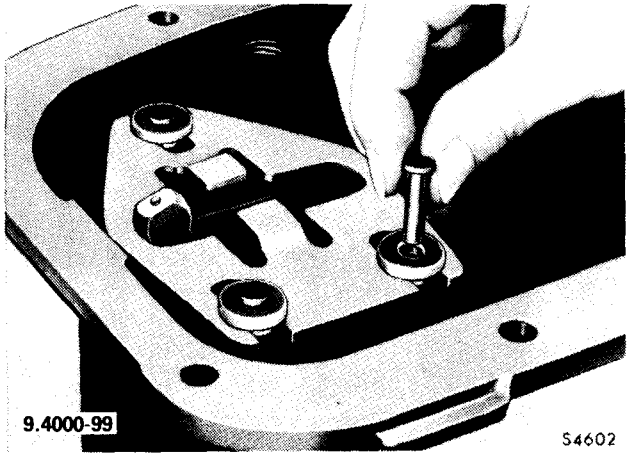
97. Ensure the clip collector is installed in the bottom of the casing before assembling the cover to power take-off aperture.



98. Insert the locking ball and spring in the top cover before installing the reverse stop plunger. Use a short tapered rod to depress the locking ball and spring while inserting the plunger. Ensure the circlip (arrowed) is located on the plunger before installing a new expansion plug.



99. Special service replacement pins and guides are used to secure the interlock plate to the top cover.



After riveting the plate to the cover, ensure that the plate slides freely on the guides.

100. Before installing the change speed lever, ensure the lower seating is located in the cover turret.

101. After locating the lever, spacer, upper seating and washer in the turret, tighten the retaining nut just sufficiently to eliminate lever slackness and secure the nut with a tab washer.

102. Before installing the transmission, lubricate the front cover sleeve and main drive pinion splines sparingly with grease (specification GM 4530-M).

TRANSMISSION-HIGHWAY (REFITTING)

103. Connect the transmission to the clutch housing ensuring alignment of the main drive. Tighten the clutch housing nuts to a torque of 190 Nm (140 lb ft).

104. Insert the universal joint flange bolts and tighten to a torque of 75 Nm (55 lb ft).

105. Refill the transmission with the recommended oil up to the oil level plug.

106. Reconnect the linkage.

9.0000

SPECIFICATIONS

Dimensions quoted are the manufacturing limits for new parts except where maximum and minimum permissible figures are given.

HIGHWAY TRANSMISSION

Make & Type ..... Bedford Four-Speed
Oil Capacity ..... 3.2 Litres (6.5 Imp Pints)
Weight ..... 66 Kg (145 lb) Approx

GEAR SHIFT LEVER AND CHANGE SPEED LEVER

Inner Tube Outside Diameter ..... 13.26/13.31 mm (0.522/0.524 ins)
Tube Clearance in Bushes ..... 0.025/0.127 mm (0.001/0.005 ins)

MAINSHAFT

Permissible clearance between Clutch Hub & Retaining Ring ..... 0.178 mm (0.007 ins) Maximum
Thrust Washer Thickness ..... 4.45/4.52 mm (0.175/0.177 ins)

MAINSHAFT SECOND SPEED GEAR

Mainshaft Diameter ..... 47.562/47.590 mm (1.8725/1.8735 ins)
Gear Clearance on Shaft ..... 0.025/0.089 mm (0.0010/0.0035 ins)
Gear End Float on Shaft ..... 0.229/0.357 mm (0.009/0.014 ins)

MAINSHAFT THIRD SPEED GEAR AND SLEEVE

Sleeve Diameter ..... 50.711/50.737 mm (1.9965/1.9975 ins)
Gear Clearance on Sleeve ..... 0.051/0.102 mm (0.002/0.004 ins)
Gear End Float on Shaft ..... 0.229/0.356 mm (0.009/0.014 ins)

LAYSHAFT

Rear Journal Diameter ..... 44.996/45.011 mm (1.7715/1.7721 ins)
Journal Clearance in Bearing ..... 0.015/0.061 mm (0.0006/0.0024 ins)

REVERSE IDLER GEAR

Shaft Diameter ..... 30.130/30.155 mm (1.1862/1.1872 ins)
Gear Clearance on Shaft ..... 0.203/0.254 mm (0.008/0.010 ins)

TORQUE WRENCH DATA

Coupling Flange Bolt ..... 105 Nm (77 lb ft)

RECOMMENDED LUBRICANTS — United Kingdom

Usage	BP	Castrol	Duckhams	Esso	Gulf	Mobil	Petrofina	Shell	Texaco
Transmission	BP Gear Oil SAE 90	Castrol ST	SG 90 Gear Oil	Esso Gear Oil GP85W/140	Trans-mission Oil 90	Mobilube C90	Pontonic WA SAE 90	Dentax 90	Thuban 90
Oil Seals Mainshaft Splines Thrust Washers	Rocol Anti-Scuffing Paste								
Clutch Yoke Cross-Shaft Bushes Transmission Front Cover Sleeve	BP Energrease L21M	Castrol MS 3 Grease	CG Grease or LBM 10 Grease	Esso Graphite Grease or Esso MP Grease (Moly)	Gulf Graphite Grease No 1 or Gulflex (Moly)	Mobil-grease Super	Fina Marson LM2	Shell Retinax AM	Regent Grease 904 or Molytex Grease 2
Main Drive Pinion Splines Clutch Release Bearing Bush Gear Shift Control Top Linkage	BP Energrease L2	Castrol LM Grease	LB 10 Grease	Esso Multi-Purpose Grease H	Gulflex A	Mobil-grease MP	Fina Marson HTL2	Shell Retinax A	Marfak All Purpose
Gear Shift Linkage Bushes	Rocol M.204 G Grease								
Range Shift Air Cylinder Piston & Control Valve O-Rings	Dow-Corning 200/60 000								
Range Shift Air Cylinder & Control Valve Bores	Tectyl Valvoline 502-C								
Range Shift Control Switch	Rocol E1A Grease								
Gear Shift Lever Locking Ball and Spring	Duckhams Keenol								

RECOMMENDED LUBRICANTS — Overseas

Usage	SAE Viscosity Number	Specification
Transmission Above 0°C Below 0°C	 90 80	GM 4753-M Without EP Additives
Oil Seals Mainshaft Splines Thrust Washers	—	Paste of Heavy Mineral Oil With 25% by Weight of Molybdenum Disulphide
Clutch Yoke Cross-Shaft Bushes Transmission Front Cover Sleeve	—	GM 4530-M
Main Drive Pinion Splines Clutch Release Bearing Bush Gear Shift Control Top Linkage	—	GM 4733-M
Gear Shift Linkage Bushes	—	Special Compound of Molybdenum Disulphide and Extreme Viscosity Fluids
Range Shift Air Cylinder, Piston and Control Valve O-Rings	—	Dow-Corning 200/60 000
Range Shift Air Cylinder and Control Valve Bores	—	Tectyl Valvoline 502-C
Range Shift Control Switch	—	Rocol E1A Grease
Gear Shift Lever Locking Ball and Spring	—	GM 4550-M

SECTION 10

SHEET METAL

There are no Service Instructions for this Section

SECTION 11

ENGINE MOUNTINGS

There are no Service Instructions for this Section

SECTION 12

SPECIAL EQUIPMENT

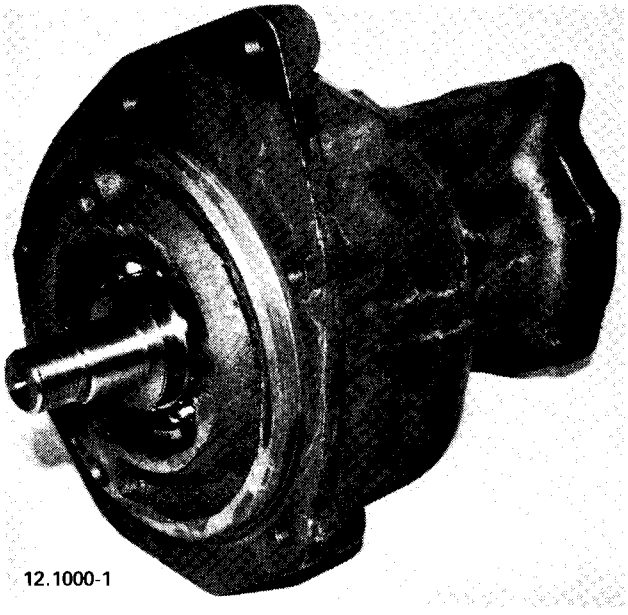
Contents

12.1000

TIMING GEAR SHAFT

TIMING GEAR SHAFT (DESCRIPTION)

1. The timing gear shaft and housing is used to connect the fuel injection pump and coupling to the accessory drive gear when neither a compressor or exhauster are required.



12.1000-1

2. The shaft rotates in two bearings and is encased in a housing which is attached between the crankcase front plate and the fuel injection pump carrier bracket.

TIMING GEAR SHAFT (REMOVAL)

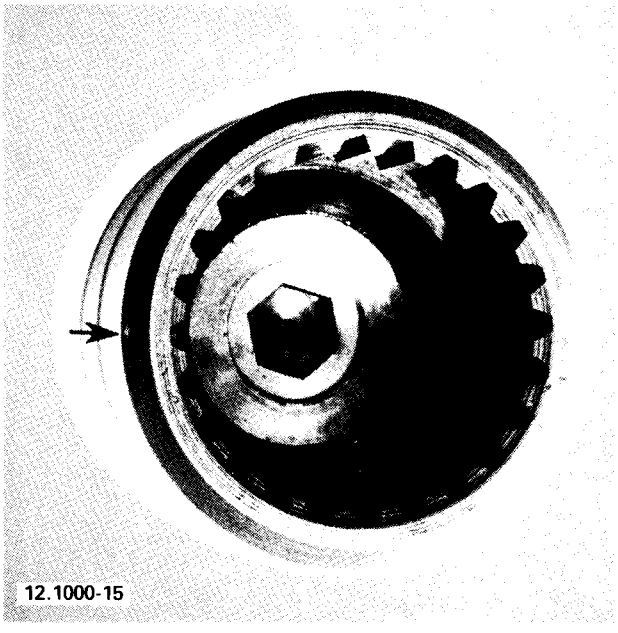
3. Remove the fuel injection pump (2.2000) front cover plate (1.3100) and accessory drive gear (1.7200).
4. Disconnect the oil pipe from the carrier bracket ensuring the dirt does not enter into the pipes.
5. Remove the five bolts and washers securing the carrier bracket to the timing shaft housing and also the bolt connecting the carrier bracket to the support bracket. The carrier bracket can now be withdrawn from the timing shaft housing.
6. The bolts and washers securing the housing to the crankcase front plate can next be removed which will allow the shaft and housing assembly to be withdrawn.

TIMING GEAR SHAFT (INSPECTION AND OVERHAUL)

7. Remove the nut and bolt from the coupling and withdraw the coupling from the shaft. The circlip can now be removed from the front of the housing which will allow the shaft and bearings to be withdrawn from the housing.
8. Check the fit of the bearings in the housing and on the shaft. To renew the bearings, remove the circlips and press the bearings off the shaft. Press the new front bearing on first and install its circlip before installing the rear bearing and circlip.
9. Examine the housing for damage to machined faces.
10. Replace the shaft and bearing assembly into the housing. Renew the oil seal after half filling the space between the rear bearing and the oil seal with a lithium soap grease containing 3% molybdenum disulphide.
11. Install the coupling onto the rear end of the shaft and tighten the retaining nut to a torque of 37 Nm (27 lb ft).

TIMING GEAR SHAFT (REFITTING)

12. Ensure that the faces of the housing and crankcase are free from burrs, install the housing assembly to the crankcase front plate. It is recommended that a new gasket is used when installing the housing. The five bolts should be tightened to a torque of 19 Nm (14 lb ft).
13. **NOTE.** When installing the housing it is advisable to use the front cover retaining bolt as well as the five bolts mentioned above to ensure correct alignment. When the five bolts have been tightened the front cover retaining bolt can be removed.
14. Insert a new oil seal into the carrier bracket and replace the carrier bracket onto its support mounting. Replace the five bolts securing the carrier bracket to the timing gear housing.
15. Replace the fuel injection pump (2.2000) ensuring on DPA pumps that the blind spline on the shaft is aligned with the master spline on the pump.



12.1000-15

16. To check the accuracy of the timing marks on

the pump and carrier flanges, or after installing a new pump carrier, which would be unmarked, proceed as follows:-

17. Remove the cover plate from the side of the pump. Rotate the engine until the flywheel timing mark (21 deg BTDC) is aligned with the timing aperture pointer and No 1 cylinder is on compression stroke. Check that the timing mark 'D' on the pump rotor is aligned with the squared end of the circlip.

18. If necessary, adjust the position of the pump on the carrier and scribe a line on the carrier relative to the line on the pump flange.

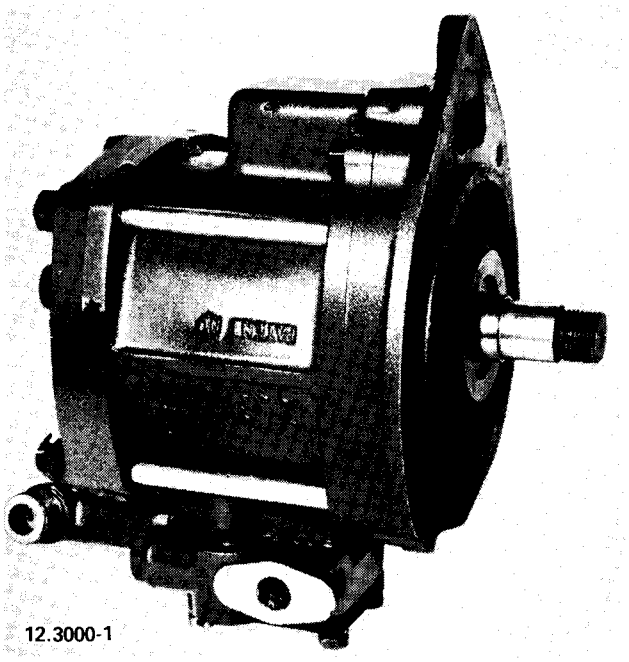
19. The accessory drive gear (1.7200) and front cover plate (1.3100) can now be replaced.

12.3000

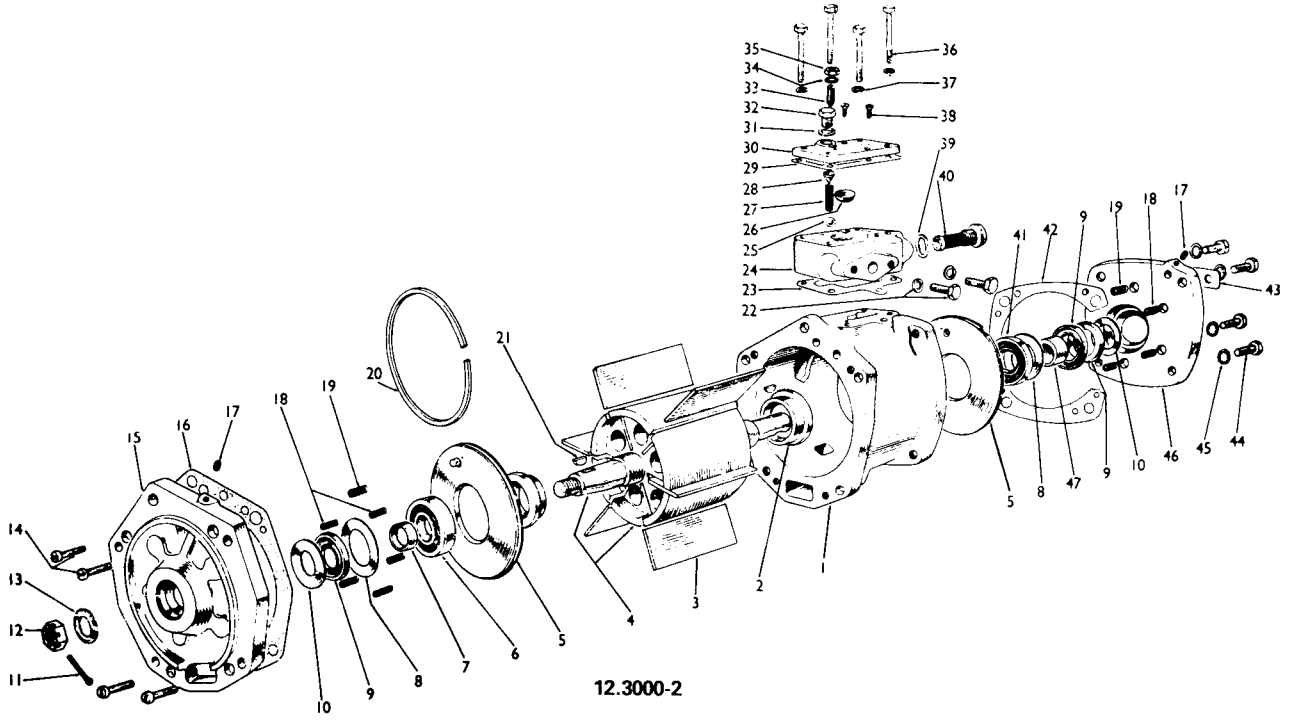
EXHAUSTER

EXHAUSTER (DESCRIPTION)

1. The exhauster is a rotary sliding vane type pump having a six bladed rotor.
2. Notations in the following paragraphs refer to the exploded drawing below (12.3000-2).
3. The rotor and shaft assembly (4) is supported eccentrically in the body by ball or roller bearings (6) and (41) housed in the body end covers (15) and (46). Arrangement is made by keyways at both ends of the shaft for the accommodation of the fuel pump drive gear and coupling, the gear being retained in position by a tab washer and nut. Seals (9) pressed in the end covers contact hardened steel collars on the shaft to prevent air entering the exhauster body; double seals at open end covers also prevent oil leakage due to initial pressure in the exhauster body under starting conditions.
4. Six similar sized fibre blades (3) are fitted in slots in the rotor. The spaces between the blades are sealed by circular plates (5) held in contact with the ends of the rotor by springs (18) and (19) housed in pockets



12.3000-1



12.3000-2

1. Exhauster Body
2. Cam Ring
3. Rotor Blade
4. Rotor and Shaft
5. Sealing Plate with peg
6. Front Bearing
7. Shaft Collar
8. Seal Back Plate (inner)
9. Oil Seal
10. Seal Back Plate (outer)
11. Split Pin
12. Slotted Nut
13. Plain Washer
14. Cheese Head Screw
15. Drive End Cover
16. End Cover Joint
17. Grub Screw
18. Sealing Plate Spring (small)
19. Sealing Plate Spring (large)
20. Piston Ring
21. Woodruff Key
22. Bolt with Spring Washer
23. Valve Body Joint
24. Valve Body
25. Snifter Valve Ball
26. Non Return Valve
27. Snifter Valve Spring
28. Spring Keeper
29. Valve Cover Joint
30. Valve Cover
31. Copper Washer
32. Hex. Plug
33. Adjusting Screw
34. Copper Washer
35. Lock Nut
36. Hex. Bolt
37. Spring Washer
38. C/Sk. Head Screw
39. Copper Washer
40. Oil Filter Assy.
41. Rear Bearing
42. End Cover Joint
43. Nameplate
44. Special Bolt
45. Shakeproof Washer
46. Rear End Cover
47. Shaft Collar

in the end covers. A peg riveted to each sealing plate, engages with one of the spring pockets to prevent rotation of the plate.

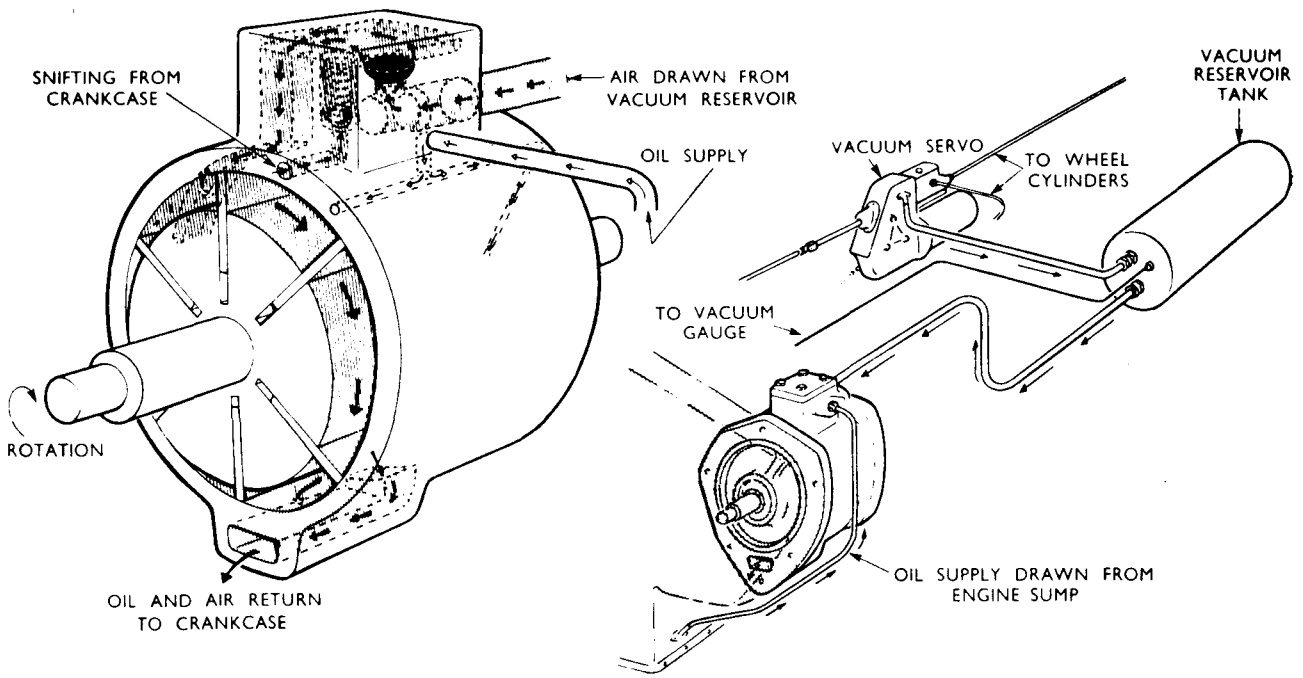
5. On certain exhausters the sealing plates are drilled with an oil transfer hole which, to ensure its correct situation at assembly, is positioned by one of the six springs and spring pockets being of larger diameter than the remainder.

6. Cam rings (2) fitted in the sealing plates and held concentrically with the exhauster body, contact the inner edges of the rotor blades and maintain the blades in close relationship with the body bore. An intake port in the exhauster body aligns with a passage formed in the valve body which is pipe connected to the vacuum reservoir mounted on the chassis frame. The non-return valve is either of the rubber-faced metal type or a hemispherical rubber type. The non-return valve and the snifter valve are located within the valve body attached to the top of the exhauster by set bolts or studs. The snifter valve is connected by passages to the intake port on the one side and on the other side to atmosphere. The outlet port formed in the base of the exhauster body aligns with the aperture in the drive housing or mounting base and connects with the engine casing. At operating speeds the rotor blades are kept in contact with the bore of the body by centrifugal force, but at engine idling speed, particularly when the oil is cold, the blades have insufficient centrifugal force to keep them in their true position. This is overcome by the action of the cam rings (2) which contact the inside edges of the blades, forcing them to move out radially in their grooves and thus maintain contact with the bore of the body.

7. When the rotor turns, the spaces between the rotor blades decrease because of the eccentric mounting of the rotor in the exhauster body, and the air between them is compressed (see 12.3000-7 below). As the point of maximum compression is reached, the air is expelled through the outlet port, together with the lubricating oil, into the engine crankcase. After passing the outlet port the spaces between the rotor blades increase and a depression is thereby created which is filled by air drawn from the vacuum reservoir. This air is then compressed and expelled.

8. Where a snifter valve is fitted the withdrawal of air from the reservoir continues until 635 mm (25 ins) of mercury is obtained, at which point the snifter valve is lifted off its seat to admit air. This action limits the maximum vacuum and prevents unnecessary heating of the exhauster. When the vacuum in the reservoir is greater than the vacuum generated by the exhauster, due to the slowing down or stopping of the engine, the non-return valve drops on its seat and prevents loss of vacuum from the reservoir.

9. The exhauster is dependent upon an adequate supply of oil for lubrication of the bearings and moving parts and to provide a seal between the rotor blades and the bore of the body. The exhauster draws its own lubricant from the engine sump, or if mounted independently of the engine, from a combined oil separator and reservoir.



12.3000-7 Diagram showing operation of Exhauster and associated components.

LUBRICATION FROM THE ENGINE SUMP

10. The oil inlet port is connected by a cross-drilling to the end covers. The vacuum created in the end covers is utilised to draw oil into the exhauster. The oil lubricates all parts and is ejected through the outlet port to the engine sump together with the air evacuated from the reservoir. Adequate crankcase ventilation must be available to prevent a build-up of pressure. If a filter is not fitted to the exhauster a sump filter should be incorporated well below the oil level and at a distance of up to a maximum of twelve inches below the centre line of the exhauster drive shaft.
11. Premature failure of an exhauster can often be traced to a fault in the lubrication system, the main causes usually being a partially blocked filter or an indented pipe line, either of which can result in a restricted and reduced oil flow. A defective oil pipe joint will also affect operational efficiency by admitting air to the system and consequently diminishing or interrupting the oil supply.

EXHAUSTER (REMOVAL)

12. Remove the front cover plate (1.3100), accessory drive gear ((1.7200), fuel injection pump (2.2000) and carrier bracket (12.1000).
13. Disconnect the pipes from the exhauster and plug the open pipe ends to prevent entry of foreign matter.
14. Remove the bolts and lockwashers securing the exhauster and lift away the assembly.

EXHAUSTER (INSPECTION AND OVERHAUL)

15. To get the best service from the exhauster the following periodic inspection and preventive maintenance should be carried out.

WEEKLY

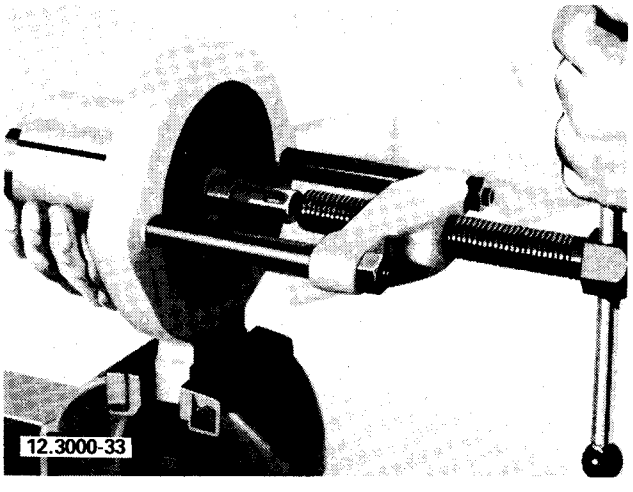
16. Check the vacuum lines and fittings. Vacuum leakage may occur through the non-return valve if the valve seat is dirty or pitted.
17. A check should be made for oil leaks at the exhauster particularly at the joint between the end covers and body and around the protruding end(s) of the rotor shaft. If seepage around the rotor shaft is severe, oil will be thrown from the shaft while the exhauster is running. Check the oil supply and discharge lines for leaks at fittings and connections. Rubber connecting hoses, if used, may become hardened due to the hot oil, with cracking and leaking a consequence.

MONTHLY

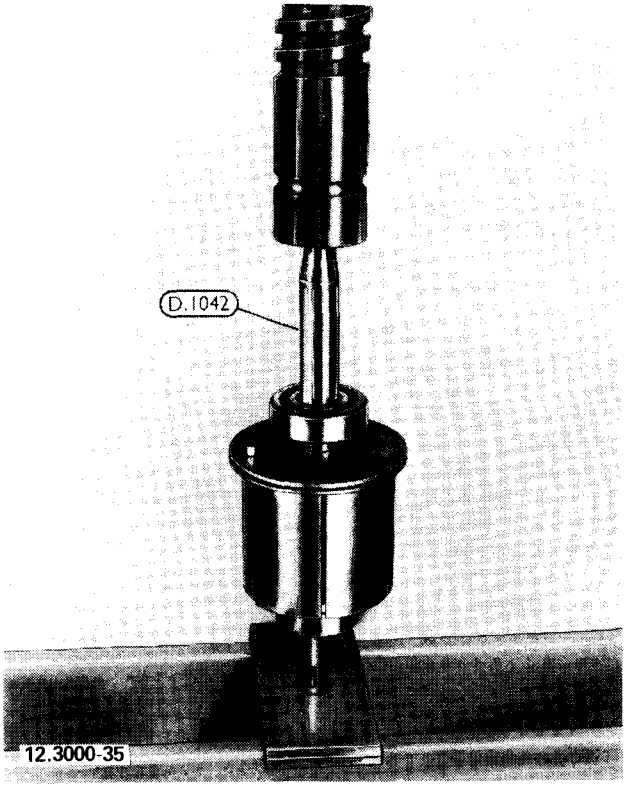
18. Clean the oil filter of the exhauster.
19. Check all mounting studs and end cover retaining bolts for tightness.

YEARLY

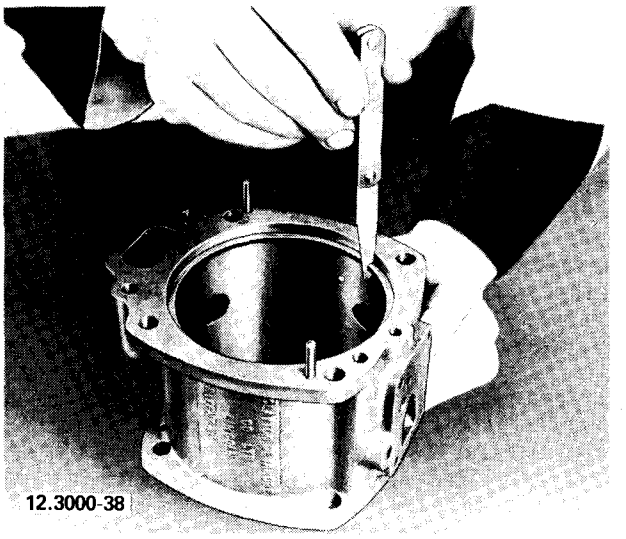
20. The exhauster should be removed for dismantling and detailed examination of component parts as described below.
21. Unscrew the oil filter (40). Mark the valve body (24) and cover (30) in relation to the exhauster body to ensure correct location at reassembly. Remove the bolts (36) or nuts, and lockwashers and lift off the body and cover. The valve body cover on certain exhausters may be held separately by two countersunk-head screws which, after removal, permit the non-return valve and snifter valve to be withdrawn.
22. Detach the front and rear end covers (15) and (46) by releasing the bolts or nuts (according to the type of exhauster) and tap covers evenly from the body; remove the six sealing plate springs from each end cover. Retain the seal back plates (8) with the end covers.
23. Remove both sealing plates (5) from the body by working them outwards over the bearings, then withdraw the rotor assembly (4).
24. Mark the rotor blades in relation to the rotor to facilitate reassembly in the same relative positions if blades are suitable for further service.
25. **NOTE.** Further dismantling of the rotor assembly need be undertaken only if, after inspection, it is found necessary to renew the bearings, shaft collars or cam rings.
26. The following cleaning operations should be observed:-
27. Wash the bearings in thin flushing oil or white spirit and blow dry with compressed air directed through the bearings. Spinning the bearings with the compressed air should be avoided otherwise damage to balls and races will occur. Lubricate the bearings with light machine oil and protect against dirt ready for inspection.
28. Wash the remaining components in clean paraffin and blow dry with compressed air.
29. Clean the oilways in the end covers and exhauster body with compressed air.
30. Rotate each bearing slowly to check for roughness and examine for wear, pitting discolouration and cracked races. Premature failure may have been caused by end thrust on the rotor shaft or shortage of oil.
31. Inspect the cam ring contact faces for wear. Check the fit of the cam rings in the sealing plates.
32. Inspect the rotor shaft oil seal collars for wear. To renew:-
33. Withdraw the bearings from the shaft as shown below using bearing drag D1039 and Adaptor Set



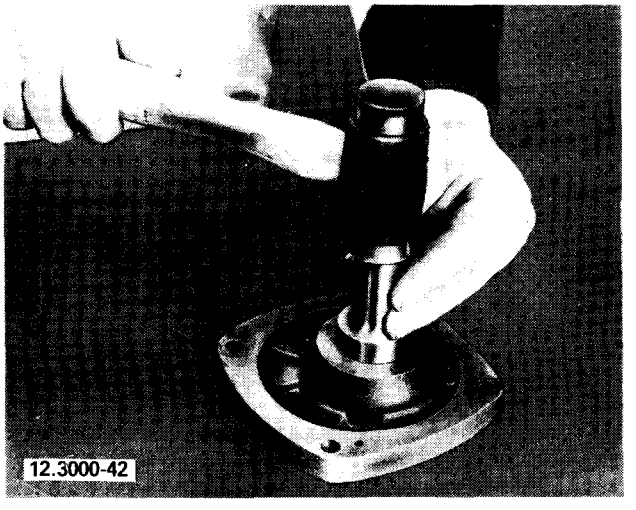
D1040. Place the drag in a vice and supporting the rotor assembly, insert it through the drag; position the split adaptor between the bearing and the cam ring and extract the bearing and shaft collar by screwing in the bolt against the end of the rotor shaft.
34. Assemble the cam rings over the rotor shaft with the flange facing outwards.
35. Using the Installer D1042, press on the new bearings until they contact their locating shoulders, as shown in 12.3000-35. When the internal diameter of the bearing is larger than that of the shaft collar it is recommended that the Installer is replaced by a tube of suitable length and bore, or that a washer, sufficiently large to just slip over the exhauster shaft, is placed between the bearing and the Installer.



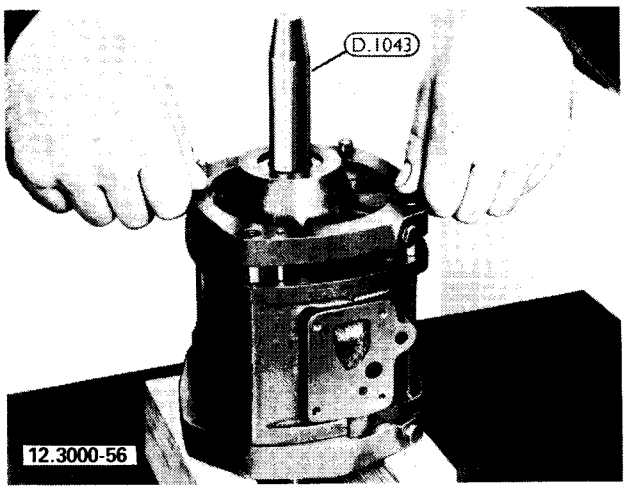
36. **NOTE.** The rotor assembly should be supported on the bed of the press by a tubular spacer placed over the shaft end and not by the rotor or the shaft itself.
37. Using the same Installer, press the seal collars on the shaft until they contact the bearings.
38. Inspect the sealing plates for wear or scoring. Spring rings should only be removed from the sealing plates if the rings or plates need replacing and should normally last the life of the exhauster. If a new spring ring is fitted, first locate the ring in the exhauster body and check that the gap does not exceed 0.4826 mm (0.019 ins). If sealing plate is drilled with an oil transfer hole, ascertain that this is unobstructed.



39. Inspect the rotor and shaft for cracks or damage. With cast-iron rotors a degree of looseness on the shaft may eventually develop. This is permissible if slight and will not affect the efficiency of the machine.
40. Check the fit of the blades in the rotor slots. Examine the inner edges of the blades for wear. If stepped at the point of contact with the cam rings, the blades should be renewed. The rotor blades are either of steel or fibre. A replacement blade must be of the same material as the original, otherwise the whole set must be replaced.
41. Examine the oil seals carefully. Wear or deterioration is caused primarily by dirty oil and grit, and ineffective seals should be replaced.
42. Lift out the seal inner back plate, using a punch to avoid damaging the seal outer back plate, drive out the seal(s).



43. If undamaged, replace the seal outer back plate in the end cover seal housing.
44. Press into position the new oil seal with the lip facing the outer back plate. Where a second seal is fitted the lip must face inwards.
45. Lightly smear one side of the seal inner back plate with grease and locate in the end cover against the seal.
46. Examine the body for longitudinal ripples or lines. If these are only slight the body is still serviceable, if excessive the body should be renewed.
47. Check the snifter valve spring. Examine the ball for wear or pitting.
48. The rubber non-return valve (either disc type or hemispherical) should be renewed if the condition of the rubber is impaired.
49. The oil filter gauze should be examined for damage.
50. All parts not specifically mentioned should be inspected and renewed as necessary.



REASSEMBLY

51. Lubricate all moving parts with clean engine oil and renew all gaskets.
52. Replace the rotor blades in the rotor slots making sure, if possible, that they are located in their original positions, check for freedom of movement.
53. Slide the rotor assembly into the exhauster body. Pass the sealing plates over the races and locate them on the cam rings inside the bore of the body.
54. Correctly position the end cover gaskets with grease. Replace sealing plate springs in pockets of end covers and retain in position with grease. All springs and spring pockets are of uniform size except on models where the sealing plates are drilled with an oil transfer hole, when it will be found that one spring and the spring pocket accommodating the sealing plate peg, are of increased diameter.
55. Place installer D1042 on the front end of the rotor shaft. Assemble the drive end cover to the body, taking care to align the sealing plate locating peg with the appropriate spring pocket in the end cover. Secure the end cover.
56. Invert the exhauster. Place Installer D1043 on the rear end of the rotor shaft and assemble the rear end cover to the body, taking care to align the sealing plate locating peg with the appropriate spring pocket in the end cover. On exhausters having a blank end cover this can be easily assembled without the aid of any special tool.
57. Tighten the end covers in position by the method applicable to the exhauster under assembly. Check rotor for ease of rotation.
58. Replace keys and couplings.
59. On exhausters not fitted with a valve body, replace the snifter valve in the body, ensuring that the ball contacts the small end of the spring. The ball can be reseated by tapping it on its seat using a brass drift.
60. If exhauster is of the type having the non-return valve, snifter valve and oil filter combined in the valve body, replace the non-return valve and ascertain its correct seating. Replace the snifter valve ball and spring, with the ball contacting the small end of the spring.
61. With a smear of grease on the faces locate new gaskets on the valve body and cover, and observing the alignment marks previously made, assemble the valve cover to the body and secure with the two counter-sunk headed screws. Position the complete valve assembly on the exhauster, assemble the retaining bolts and nuts and tighten. Screw in the oil filter, taking care to replace the copper washer.
62. If the snifter valve is of the adjustable type assemble the components in their correct sequence, ensuring that the ball contacts the small diameter end of the spring.
63. Screw in the adjuster a few turns.
64. Connect the exhauster to the vacuum reservoir which should be equipped with a reliable gauge.
65. Run the exhauster at 200 rpm and allow the vacuum gauge to attain a steady reading. Screw in the adjuster gradually, allowing the gauge reading to settle after each adjustment, until the snifter valve is operating at the correct pressure of 635 mm (25 inches) of mercury. Lock the adjuster in position and secure the lock nut with the tab washer.

EXHAUSTER (REFITTING)

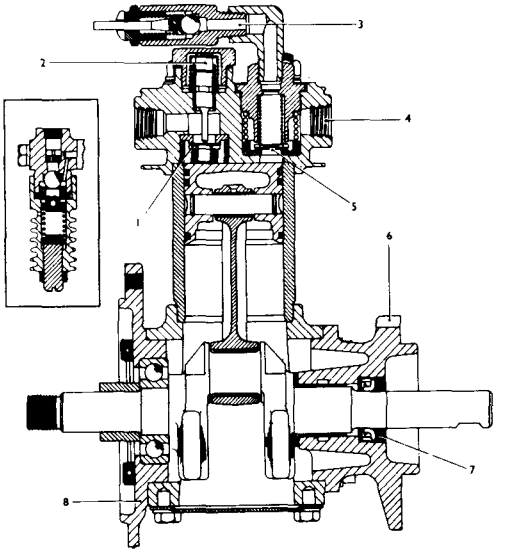
66. Ensure that the exhauster flange and timing gear faces are free from burrs, and that all traces of the old gasket have been removed.
67. Place the exhauster in position using a new gasket.
68. Temporarily install the exhauster bottom attaching bolt to ensure correct alignment before tightening the retaining bolts. Tighten to 20-24 Nm (15-18 lb ft).
69. Install the exhauster gear with the timing marks in alignment as detailed in section 1.7200.
70. Install the carrier bracket (12.1000), fuel injection pump (2.2000) and front cover plate (1.3100).

12.4000

AIR COMPRESSOR

AIR COMPRESSOR (DESCRIPTION)

1. Two types of air compressor are used, SC6 and SC9, the SC9 having a larger capacity.
2. Both types are similar in design and comprise a single cylinder air cooled unit mounted behind the engine timing case on the left hand side and driven by the crankshaft through the idler gear.

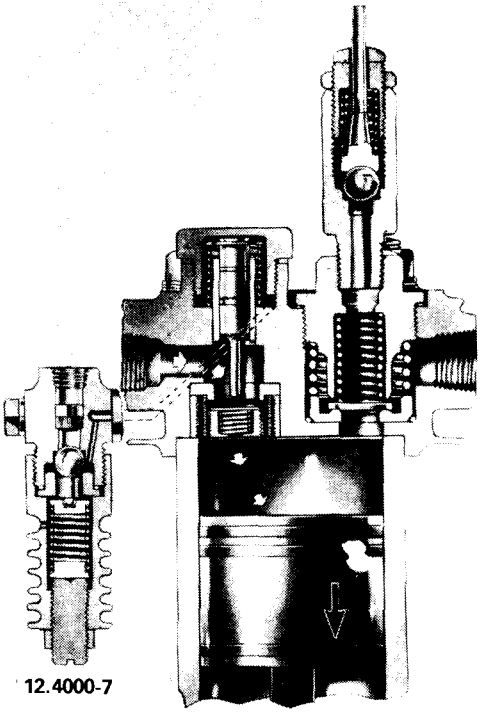


12.4000-2

1. Air Intake Valve
2. Unloader Valve
3. Safety Valve
4. Air Delivery Port
5. Air Delivery Valve
6. Rear End Cover
7. Oil Seal
8. Drive End Cover

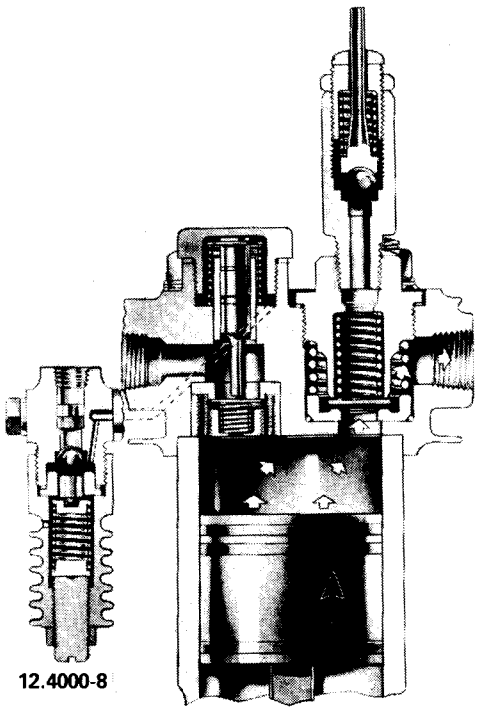
Inset. Governor Valve Assembly

3. The compressor cylinder head is an aluminium die casting secured by four nuts to studs which are screwed into the crankcase. The head is spigot mounted on a cast iron cylinder which is similarly located in the crankcase. The cylinder head embodies an intake valve and a delivery valve each consisting of a spring-loaded steel disc locating on a detachable valve seat. The intake valve seat is retained by a push fit valve spring guide, and the delivery valve seat by a spring locating in the valve cap. A gauze type air cleaner is attached to the air intake port. An unloader valve, in the form of a spring-loaded plunger, is located above the intake valve and incorporates an extension which projects into the intake port directly over the centre of the intake valve disc. The unloader valve chamber is connected by a drilling to a governor valve bolted to the side of the cylinder head.
4. The aluminium alloy piston is attached to the connecting rod by a fully floating pin retained by circlips. The piston carries three rings, two stepped compression rings at the top of the skirt and one scraper ring at the bottom. The aluminium die-cast connecting rod is fitted with a steel backed lead bronze lined bush at the small end and a split shell-type white metal lined steel bearing at the big end. The one piece forged steel crankshaft is supported in the crankcase by a single row ball bearing and a plain bush. The ball bearing is located in the drive end cover whilst the bush is pressed into the rear cover. A white metal faced steel thrust washer is located against the rear face of the crankshaft to control end float, and a rubber seal assembled to the outer end of the rear cover prevents oil leakage.
5. The compressor lubrication is by pressure feed from the engine lubrication system via a pipe connected between the compressor rear end cover and the engine main oil gallery. The oil is fed to the end cover bearing, through a drilling in the crankshaft to the connecting rod big end bearing and on SC9 compressors the plain bearing in the crankcase. The piston pin and cylinder wall are splash lubricated and also the ballrace crankshaft bearing on the SC6 unit. Surplus oil returns to the engine crankcase through drain holes in the drive end cover.
6. A safety valve and governor valve are supplied as loose items. The suggested location for the safety valve is on the air reservoir and the governor valve in the line between the air reservoir and compressor. A tapping taken off the governor valve goes to the pressure gauge.
7. During the down stroke of the piston, vacuum is created above the piston which unseats the inlet valve allowing air drawn from the air cleaner to enter the upper space in the cylinder.



12.4000-7

8. As the piston starts the upward stroke, the enclosed air is compressed and the pressure created, combined with the action of the inlet valve spring, closes the inlet valve. The air above the piston is further compressed until the pressure lifts the delivery valve and the compressed air is discharged through the line to the reservoir. On the piston down-stroke, the delivery valve reseats, preventing the compressed air from returning to the cylinder, and the same cycle is repeated.

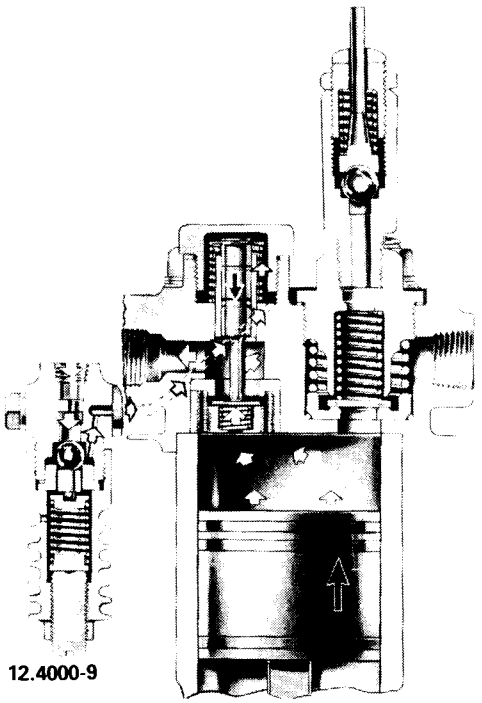

12.4000-8

9. When the air pressure in the reservoir reaches the setting of the governor valve, compressed air from the reservoir passes through the governor into the cavity above the unloader plunger in the cylinder head. The air pressure depresses the unloader plunger which, in turn, lifts the inlet valve off its seat. During each upstroke of the piston, air is merely passed back to the air cleaner.
10. When the air pressure in the reservoir falls below the governor setting, the governor releases the air pressure above the unloader plunger. The unloader spring lifts the unloader plunger and the inlet valve spring returns the inlet valve to its seat and compression of air is resumed.

AIR COMPRESSOR (PREVENTIVE MAINTENANCE)

EVERY MONTH

11. Remove, dismantle and clean the air cleaner or filter. Replace if necessary.


12.4000-9

12. Make a visual check of all joints, unions etc., for leakage or looseness and rectify where necessary.
13. Visually check that all pipe lines are secure and free from corrosion and damage; note that loose pipe line connections should be tightened only sufficiently to prevent leakage. If the cylinder head has recently been removed, check that the cylinder head nuts are fully tightened to a torque of 20-22 Nm (15-16 lb ft).
14. Check that the compressor is securely mounted.

EVERY SIX MONTHS

15. Clean the compressor oil supply line.
16. SC6 units only. Remove the delivery valve cap and the delivery valve seat retaining spring and check for presence of excessive carbon. Withdraw and check the condition of the delivery valve. If excessive carbon is found, disconnect the air lines from the cylinder head taking precautions to prevent ingress of dirt. Remove and clean the cylinder head; also check the compressor discharge line for carbon and clean or replace the line where necessary.
17. SC9 units only. Disconnect the compressor delivery line and check the line and the delivery port in the cylinder head for presence of excessive carbon. Clean or replace the delivery line if necessary. If excessive carbon is found in the cylinder head, disconnect the air lines from the cylinder head taking precautions to prevent dirt from entering the air lines. Remove and dismantle the cylinder head, thoroughly clean all parts and blow out the head passages with compressed air. Check the condition of the valves and seats. Reassemble the cylinder head and reconnect the air lines.

EVERY TWO YEARS OR 161,000 KILOMETRES (100,000 MILES)

18. This is the overhaul period. When a complete overhaul of the compressor is necessary, it must be performed in a fully equipped workshop. If these facilities do not exist a factory replacement unit service is available in the United Kingdom and certain other countries. This provides new or reconditioned units fully tested and guaranteed.
19. For organisations with complete workshop facilities, and overseas organisations that do not have a factory replacement service, a major repair kit should be purchased in advance. This contains all items required during overhaul and ensures safe operation for a further period.
20. Periodically between major overhauls, service checks should be carried out to ensure that the compressor is securely mounted and that the air cleaner is in good condition. The following tests should also be carried out to ensure the compressor is working efficiently.

OPERATING TESTS

21. With the compressor running, check for oil leaks.
22. Reduce the pressure in the reservoir by operating the brakes and check that the governor valve and unloader mechanism are functioning at the correct pressure. (If possible the engine gauge should be replaced by a master gauge during this test).
23. If air leakage in the remainder of the system is not excessive, failure of the compressor to maintain the normal air pressure in the system usually denotes loss of efficiency due to wear. Another sign of wear is excessive oil passing through to the reservoir or condenser and drain valve unit. If either condition develops, and inspection shows the remainder of the system to be in good condition, the compressor must be overhauled or replaced.

AIR LEAKAGE TESTS

24. Excessive leakage past the delivery valve can be detected with the engine stopped by applying 689 KPa (100 PSI) air pressure to the delivery port and carefully listening for the sound of escaping air.
25. If this test is satisfactory, charge the air pressure system to normal maximum operating pressure and stop the engine. Check once more for audible leaks, which if present indicate leakage at the unloader plunger.
26. Leakage at the delivery valve can be remedied by cleaning, lapping or replacing the valve and/or the baseplate if the valve seat is defective. Unloader plunger leakage can be remedied by replacing the plunger sealing ring or plunger.

AIR COMPRESSOR (REMOVAL)

27. Prior to removing the compressor from the engine release all air pressure from the system and clean all grease and dirt from around the unit, ensuring first that the vehicle cannot move.
28. Disconnect the battery cables. Remove the radiator assembly (5.3000) if it is engine mounted and the timing gear case cover (1.3100). Withdraw the compressor drive gear (1.7200). Remove the fuel injection pump (2.2000) and disconnect the air and oil pipes from the compressor taking precautions to prevent dirt from entering the compressor and pipes.
29. Remove the five bolts and washers securing the carrier bracket to the air compressor end cover and also the bolt securing the carrier bracket to the bracket support. The carrier bracket can now be withdrawn from the compressor. Remove the six bolts securing the air compressor to the crankcase front plate and withdraw the unit from the engine.

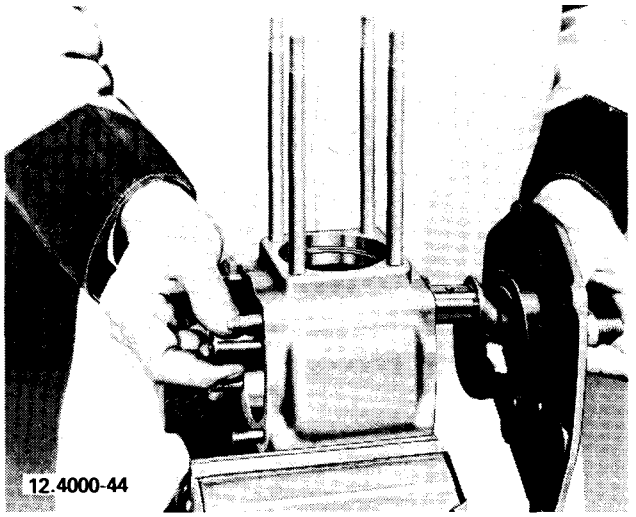
AIR COMPRESSOR (INSPECTION AND OVERHAUL)

30. Before dismantling remove grease and dirt from the exterior of the compressor and mark the following items to show the correct relationship ready for reassembly: cylinder head and crankcase; end covers and crankcase; crankshaft and crankcase.
31. Remove the nuts and washers securing the cylinder head and lift off the assembly, if only the head is being overhauled take care not to disturb the cylinder. Remove the cylinder head gasket. The head assembly can now be dismantled as follows:
32. Remove the air filter.
33. Remove the governor valve and safety valve. These can be dismantled separately at a later stage if necessary.
34. Unscrew the safety valve and intake port adaptors.
35. Remove the delivery valve cap and washer, and withdraw the valve spring and valve seat retaining spring. Invert the head and tip out the delivery valve, valve seat and sealing ring. If necessary the valve seat can be shaken from its position by bumping the head on a flat piece of wood.
36. Remove the unloader valve cap and washer and withdraw the valve assembly.
37. Withdraw the intake valve spring guide, using an extractor made from two ¼" UNF bolts and a metal plate.

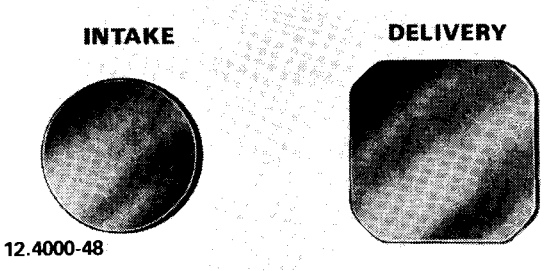

12.4000-37

38. Remove the intake valve and valve spring, and shake out the valve seat.
39. Mark the cylinder in relation to the crankcase and withdraw the cylinder and sealing ring.

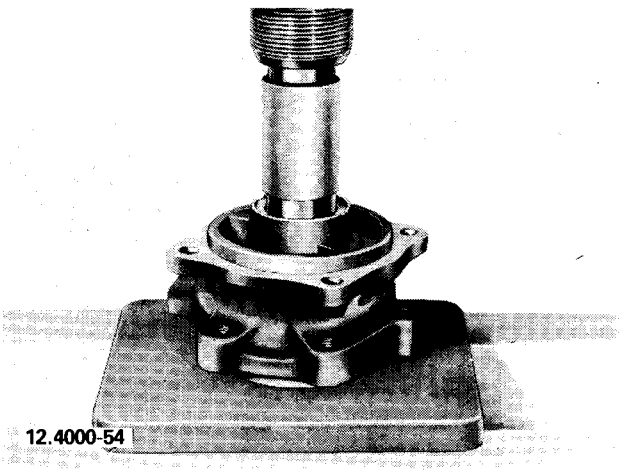
40. Remove the crankcase bottom or side cover and gasket. Mark the connecting rod in relation to the crankcase, knock back the tabs of the lock plate and unscrew the cap bolts. Withdraw the connecting rod and piston assembly.
41. Remove the rings from the piston and the circlips securing the piston pin. Push out the pin and remove the piston from the rod.
42. Remove the nuts and lockwashers securing the rear end cover and withdraw the cover and gasket. Remove the thrust washer from the inner face of the cover.
43. Remove the drive keys from the crankshaft.
44. Remove the locking wire from the drive end cover bolts, unscrew the bolts and withdraw the cover and crankshaft assembly.



45. Tap the crankshaft and bearing from the cover.
46. Discard those items which will be renewed from the repair kit.
47. Clean all components in a cleaning solvent and blow dry with compressed air. Remove traces of carbon and any remaining particles of old joints from all surfaces.
48. Clean the intake and delivery valves by lapping them on a sheet of crocus cloth held on a flat surface. Renew the valves if scored. The difference between the intake and delivery valves are shown below.



49. Examine the valve seats for scratches and pitting. If necessary, lap with fine carborundum paste. If the pitting is severe, use a seat reamer and finish off by lapping.
50. Renew the delivery valve spring and check the remaining springs for weakness.
51. Examine the head for cracks and damage and the unloader valve guide for wear. Check that the unloader valve is a good sliding fit in the guide.
52. Examine the crankcase, side covers, bottom covers and end covers for cracks and damage. Replace if necessary.
53. Check the condition of the rear end cover oil seal and renew if necessary. To renew the seal drive, drive out the old seal from the cover using a suitable drift, and press in the new seal so that the seal lip is towards the inside of the cover.
54. The crankshaft should be a neat sliding fit in the plain bearings. If worn excessively the bush must be renewed, by pressing out the old bush using a suitable drift and then pressing in the new bush until its outer edge is flush with the bottom of the cover bore chamfer. Fine bore the bush to the specified diameter and concentric with the end cover spigot to within 0.05 mm (0.002 ins).



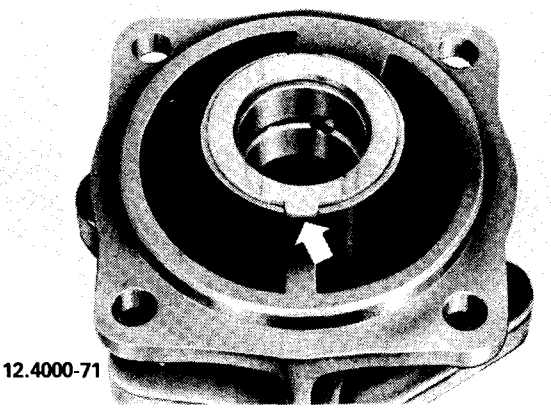
55. Check the condition of the drive end bearing. Check also for a light press fit in the end cover. To renew the bearing press off or withdraw the old bearing from the crankshaft with a suitable drag and then press on the new bearing using a sleeve to contact the bearing inner race.
56. Check that the oilways in the crankshaft are clear, using a piece of wire, if necessary, and flush with cleaning solvent. Check that the oilways in the end-cover are clear and clean.
57. Check the cylinder bore for excessive wear, out-of-round or scoring. If scored or out-of-round more than 0.05 mm (0.002 ins) or tapered more than 0.076 mm (0.003 ins), the cylinder should be replaced. The original bores should be 66.69-66.70 mm (2.6255-2.6260 ins) for SC6 units and 85.00-85.03 mm (3.3465-3.3475 ins) for SC9 units, while the clearance for the pistons is 0.08-0.13 mm (0.0032-0.0052 ins) for SC6 units and 0.19-0.23 mm (0.0075-0.009 ins)

for SC9 units. Check for wear in the cylinder bore and rectify in accordance with the following table:-

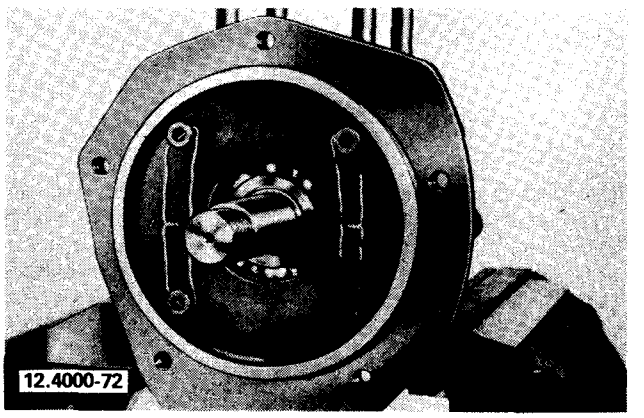
Wear in Bore	Remedy
Up to, but not exceeding 0.127 mm (0.005 ins)	Fit New Standard Rings
Wear exceeding 0.127 mm (0.005 ins)	Fit New Cylinder, New Piston and Standard Rings

58. Examine the piston for scores, cracks and damage of any kind. Replace if necessary.
59. Check the fit of the compression rings in the ring grooves. The clearance should be 0.015-0.066 mm (0.0006-0.0026 ins) for SC6 units and 0.033-0.084 mm (0.0013-0.0033 ins) for SC9 units.
60. Install the ring in the cylinder and check that the gap is 0.003-0.007 mm (0.0762-0.1778 ins) for SC6 units and 0.254-0.381 mm (0.01-0.015 ins) for SC9 units.

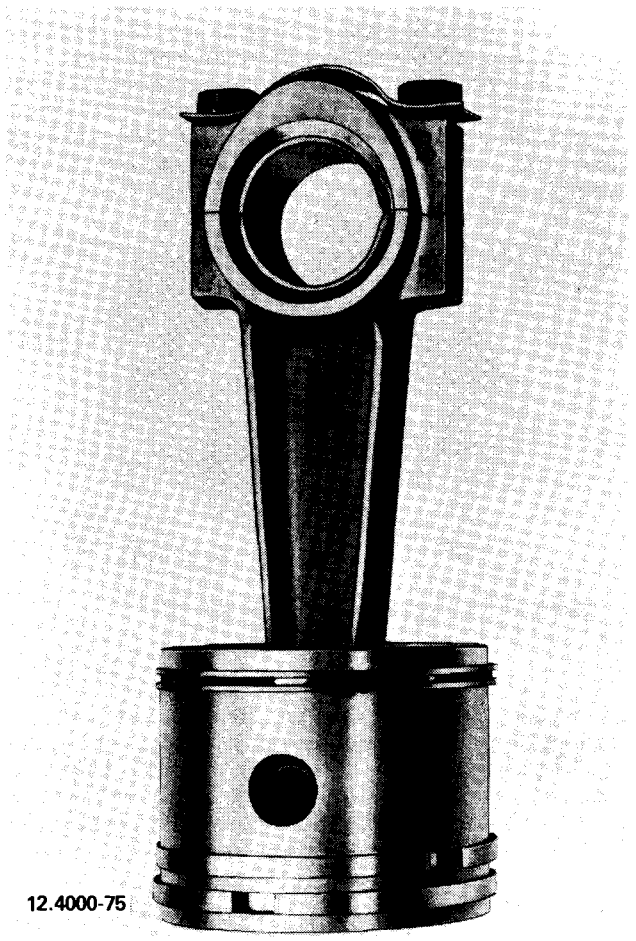
61. Check the fit of the gudgeon pin in the piston and connecting rod. The gudgeon pin should be a finger push fit in the piston and the clearance in the connecting rod bush should not exceed 0.038 mm (0.0015 ins).
62. Inspect the connecting rod for cracks and damage, and the bearing for correct fit on the crankshaft journal. The clearance between the rod journal and bearing must not be more than 0.0762 mm (0.003 ins).
63. Inspect the crankshaft for wear and check the threads, shaft ends, keyways and drive keys for damage. The crankpin diameter should be within the limits 22.187-22.200 mm (0.8735-0.8740 ins) for SC6 units and 31.725-31.737 mm (1.2490-1.2495 ins) for SC9 units.
64. Examine the thrust washers for wear.
65. Before reassembling the compressor lubricate all working parts with clean engine oil to prevent possible damage until the oil supply is functioning.
66. The crankshaft and end covers must be reassembled and as there are differences between the SC6 and SC9 units, paragraphs 67 to 69 refer to the SC6 units and paragraphs 70 to 73 refer to SC9 units.
67. Place the joint on the drive-end cover and install the crankshaft, complete with ball bearing into the cover. Insert the crankshaft into the crankcase and align the positioning marks made on the cover and crankcase during dismantling. Ensure that the joint is correctly positioned and does not cover the oil drain holes. Fit the locking strips in line with the cylinder head studs and with the tabs facing inwards. Securely tighten the setscrews. Bend up the locking strip tabs. Fit the distance piece so that the chamfered end abuts the ball race.
68. Aligning the positioning marks made during dismantling, fit the rear end-cover complete with joint, and fit the spring washers and nuts.
69. Check the crankshaft to ensure free rotation and then tighten the nuts.
70. Position one of the thrust washers in the crankcase with the steel side facing towards the plain bearing and the tab located in the slot provided.
71. Insert the threaded end of the crankshaft into the plain bearing in the crankcase. Place the thrust washer on the cover with the steel side facing towards the plain bearing and the tab located in the slot (arrowed).



72. Aligning the positioning marks made during dismantling, fit the end-cover complete with joint, and fit the spring washers and set screws. Check the crankshaft to ensure free rotation and then tighten the set screws. Finally, secure the drive end cover bolts with locking wire as shown below.

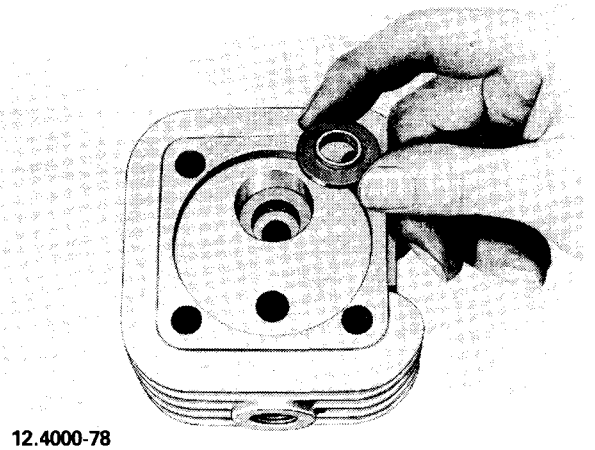


73. Fit the drive keys on the crankshaft.
74. Refit the piston rings ensuring that all compression rings are fitted with the internal recesses facing towards the piston crown, and assemble the piston to the connecting rod.
75. Ensure that the big end bearing inserts are correctly located in the connecting rod and bearing cap, and assemble the connecting rod on the crankshaft as originally fitted. Fit the locking strap and replace and tighten the connecting rod bolts to a torque of 5.1-5.4 Nm (3.75-4 lb ft) on SC6 units and 12-15 Nm (9-11 lb ft) on SC9 units.



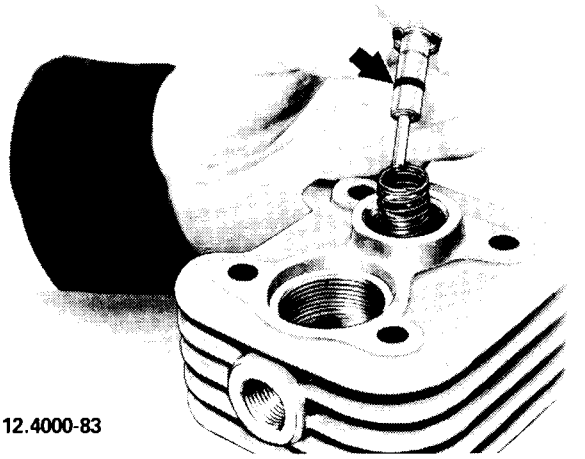
12.4000-75

76. Space the piston ring gaps. Place the cylinder, complete with sealing ring over the piston and insert the end into the crankcase.
77. As the cylinder head and valves have various differences, reassembly of the SC6 unit is described in paragraphs 78 to 84 and the SC9 unit in paragraphs 85 to 89 inclusive.
78. Heat the cylinder head and, when the head is sufficiently hot, insert the inlet valve seat so that the flat side abuts the shoulder in the bore.



12.4000-78

79. Place the inlet valve on the seat and the spring on the valve. Position the shim on the spring and centralise the spring and shim.
80. Insert the valve spring guide and, holding the guide firmly down against the resistance of the spring, stake the face of the cylinder head in three places around the guide.
81. Fit the sealing ring on to the delivery valve seat. Screw in the seat, using a wrench inserted in the hexagonal hole through the centre of the fitting, and tighten securely.
82. Place the delivery valve on the seat and position the springs. Screw in the valve cap together with the sealing washer and tighten securely.
83. Fit the sealing ring and circlip on to the unloader plunger and lightly smear the sliding surfaces of the unloader plunger and the bore of the plunger guide bush in the cylinder head with 'Dow-Corning MS 200' fluid. Insert the spring and plunger. Screw in the unloader cap together with the sealing washer and tighten securely.

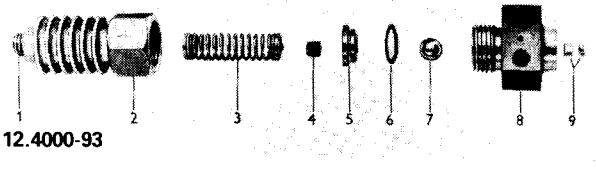


12.4000-83

84. Place the joint on the cylinder and correctly position the cylinder head on the studs. Fit the nameplate, plain washers, spring washers, and nuts onto the studs and tighten the nuts progressively to a torque of 20-22 Nm (15-16 lb ft).
85. Insert the shim washer into the recess in the baseplate. Place the smaller spring on the shim washer. Place and centralise the inlet valve disc on the spring and the delivery valve disc on its seat in the baseplate.
86. Press the delivery valve spring into its recess in the manifold and position the manifold on the joint and baseplate. (If necessary, insert a dowel or pencil through the unloader plunger guide bush in the manifold to hold the inlet valve below the surface of the baseplate before positioning the manifold). Check that the valve discs are correctly positioned and then fit the spring washers and setscrews.
87. Securely tighten the setscrews. Lift the valves off their seats several times to ensure that they are fitted correctly.
88. Fit the sealing ring on to the unloader plunger and lightly smear the sliding surfaces of the unloader plunger and bore of the plunger guide bush in the manifold with 'Dow-Corning MS 200' fluid. Insert the spring and plunger complete with the spring circlip. Screw in the unloader cap together with the washer and tighten securely.
89. Place the joint on the cylinder and correctly position the cylinder head on the studs. Fit the spring washers and nuts on the studs and tighten the nuts progressively to a torque of 20-22 Nm (15-16 lb ft).
90. Apply clean engine oil over the crankshaft and on the cylinder wall.
91. Fit the crankcase bottom or side cover together with gasket, spring washers and setscrews. Securely tighten the setscrews.
92. Before refitting the governor valve and safety valve they should be dismantled and inspected for wear.

AIR COMPRESSOR GOVERNOR

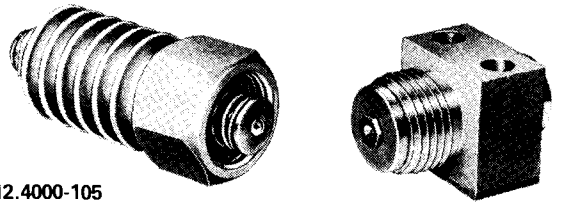
93. Unscrew the valve cap (2) from the governor body (8) and remove the valve spring and seats (3), valve guide (4), valve seat (5), shim (6) and ball valve (7).



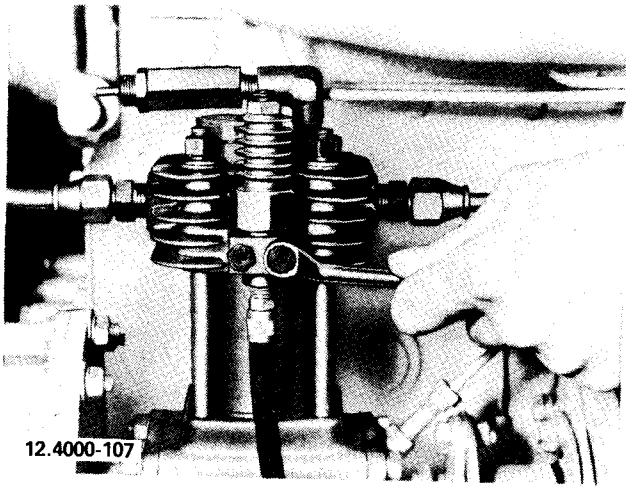
12.4000-93

1. Adjusting Screw
2. Valve Cap
3. Valve Spring and Seats
4. Ball Valve Guide
5. Ball Valve Seat
6. Shim
7. Ball Valve
8. Governor Body
9. Air Filter and Retainer

94. Using a suitable piece of rod push out the air filter and retainer (9).
95. Do not disturb the adjuster and locknut unless new parts are required.
96. Wash all parts in cleaning solvent and blow out the air passages with compressed air.
97. Examine the body and cap for cracks and damage and the ball valve seats for wear.
98. Check the ball for scratches and discolouration.
99. Check the spring for corrosion and weakness.
100. Renew the filter.
101. If a new governor body is required the ball valve must be bedded in as follows:-
    a. Insert the ball and seat into the body without the shim.
    b. Compress the ball and seat in the body, using a ½ inch BSP steel union nut, until the flange of the seat contacts the end of the body.
    c. Unscrew the nut and extract the seat and ball. Remove any burrs from the seat bore.
102. Reassemble the components noting the following points in paragraphs 103, 104 and 105.
103. Install the filter retainer so that it locates against the filter at the bottom of the body bore.
104. Install the shim under the flange of the valve seat.
105. Ensure that the dimple in one end of the ball valve guide is related to the pip of the spring seat as shown below.


12.4000-105

106. Using a new gasket between the governor body and the cylinder head, and ensuring that the centre drilling registers with that in the head refit the governor valve.
107. Tighten the governor valve securing bolts.

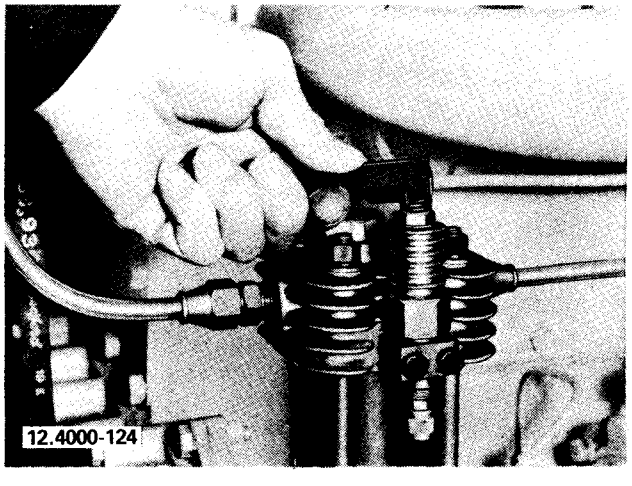

12.4000-107

AIR COMPRESSOR SAFETY VALVE

108. Slacken the locknut and unscrew the adjusting screw.
109. Withdraw the release pin and valve spring, and tip out the ball valve.
110. Wash all parts in cleaning solvent and blow out the valve body with compressed air.
111. Check the ball for scratches and discolouration and the valve seat for wear.
112. Examine the body for cracks or damage.
113. Check the spring for corrosion and weakness.
114. Reassemble, do not tighten the valve adjusting screw at this stage.
115. Refit the safety valve to the compressor heads. If the valve attaching elbow (where fitted) has been disturbed, tighten it so that when the valve is installed, the end of the air release pin is towards the intake port.

AIR COMPRESSOR (REFITTING)

116. Ensure that the oil drain holes are clear for oil to return to the engine crankcase.
117. Replace the air compressor to the crankcase front plate and tighten the six bolts. It is recommended that a new gasket is fitted when remounting.
118. Refit the carrier bracket (12.1000), fuel injection pump (2.2000), compressor drive gear (1.7200) and engine front cover (1.3100). If the radiator is engine mounted refit as described in 5.3000. Reconnect the battery cable.
119. Before connecting the oil supply line to the compressor, clean the supply line and, if possible, run the engine for a few seconds to be sure that the oil is flowing freely and ensure that the air cleaner or filter is clean and properly installed.
120. With the compressor running check for oil and air leaks.
121. The governor valve and safety valve should now be adjusted.

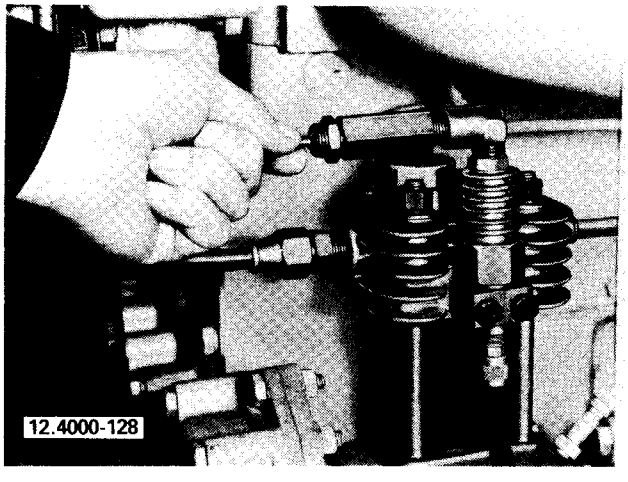


GOVERNOR VALVE ADJUSTMENT

122. Remove the drain plug from the bottom of the air reservoir and install an air pressure gauge.
123. Start the engine and charge the system until the air pressure reaches the specified limit of 710-737 KPa (103-107 PSI).
124. Slacken the locknut on the governor valve adjusting screw, and with the engine running, adjust the screw until the valve operates within the limits specified. Tighten the locknut.
125. Stop the engine and exhaust the air pressure system by pulling on the safety valve air release pin.
126. Recharge the system and check the accuracy of the valve adjustment.
127. Slowly unscrew the air pressure gauge and install the reservoir drain plug and washer.

SAFETY VALVE TEST

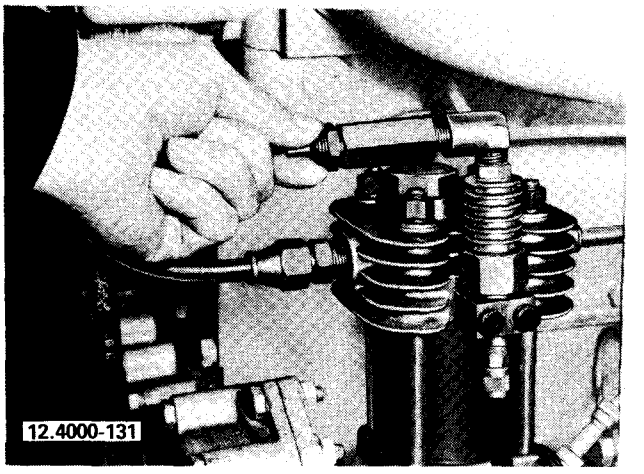
128. The safety valve may be tested for operation by pulling the exposed end of the valve release pin when the system is fully charged. The outward movement of the pin releases the spring load from the ball valve and allows air to escape. If the valve does not blow-off, the ball is stuck on its seat and the valve assembly must be disassembled for cleaning.



SAFETY VALVE ADJUSTMENT

129. Remove the drain plug from the bottom of the air reservoir and install an air pressure gauge.
130. Disconnect the governor air feed pipe from the reservoir and install a suitable plug in place of the pipe connector.

131. Slacken the locknut on the safety valve adjusting screw and with the engine running adjust the screw until the valve blows-off at the specified pressure of 1000-1068 KPa (145-155 PSI). Tighten the screw locknut.
132. Stop the engine and exhaust the air pressure system by pulling on the safety valve air release pin (See 12.4000-128).
133. Recharge the system and check the accuracy of the valve adjustment.
134. Slowly unscrew the air pressure gauge and install the reservoir drain plug and washer. Refit the governor air feed pipe.

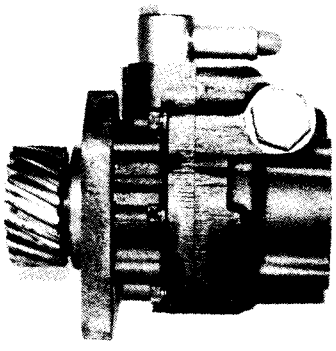


12.5000

HYDRAULIC PUMP

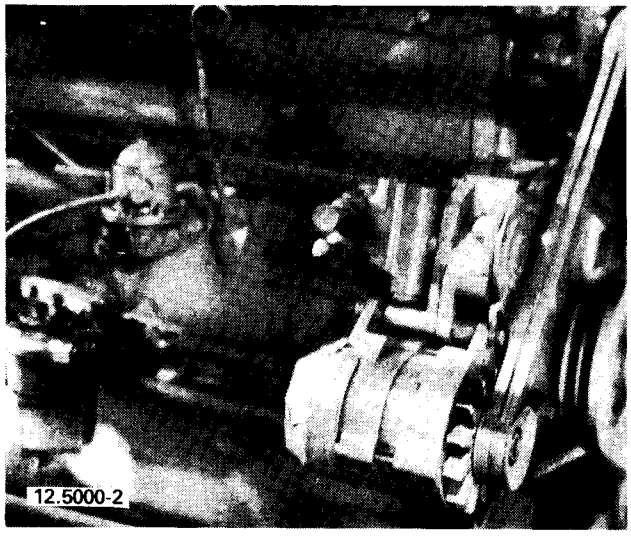
HYDRAULIC PUMP (DESCRIPTION)

1. The hydraulic pumps used on 220 and 330 cu in engines are of the roller pump type manufactured by Hobourn Eaton Manufacturing Company Ltd.



12.5000-1

2. The pump is attached to the rear face of the crankcase front plate on the right hand side of the engine and driven by a gear which engages the camshaft gear.



12.5000-2

3. The pump consists of a cast iron body and end cover, each fitted with a steel backed bronze bush in which the pump drive shaft rotates. A ball bearing retained by a circlip is mounted at the front end of the pump cover and supports the shaft at the drive end.

4. Located between the ball bearing and plain bush is a spring loaded lip type neoprene oil seal.

5. The pump contains six (6) roller vanes inserted between the arms of the carrier which is keyed to the pump shaft. The carrier and rollers rotate in a white metal bush pressed into the pump cover.

6. A combined flow control and relief valve is fitted in the top of the pump cover secured by a valve retaining cap and 'O' ring seal. The oil relief valve limits the oil pressure in the system to 6890 KPa (1000 PSI) and the oil control valve regulates the volume of oil circulated through the hydraulic system. An oil supply chamber at the front of the vane carrier bush connects with a port in the pump cover which in turn is attached to a hose adaptor bolted to the pump body.

7. Two neoprene 'O' type sealing rings fitted in a recess in the pump cover form a seal between the mating faces of the body and the cover.

8. The pump body is dowelled and bolted to the pump cover.

OPERATION

9. The pressure delivered by the pump is controlled by the relief valve which is set to open at a predetermined pressure. This allows oil to circulate within the pump until the pressure drops below the valve operating pressure. The oil flow control valve regulates the output volume. As the pressure is built up within the pump, oil is directed through small delivery holes to the delivery pipeline. As the pressure within the pump increases the valve maintains the correct output volume and excess oil is allowed to leak past the valve recirculating within the pump.

HYDRAULIC PUMP (REMOVAL)

10. Disconnect the cables from the battery.

11. Thoroughly clean the exterior and surrounding area of the pump assembly.

12. Place a tray underneath the engine to catch the oil which will drain out when disconnecting the hydraulic hoses.

13. Slacken the clip and disconnect the hose from the adaptor on the side of the pump. Plug the end of the hose to prevent further drainage of oil.

14. Disconnect the hose at the banjo connector on top of the pump, taking care not to lose the copper washers.

15. Remove the three (3) screws securing the pump to the timing gear case. The pump and gear assembly can now be withdrawn from the engine.

HYDRAULIC PUMP (INSPECTION AND OVERHAUL)

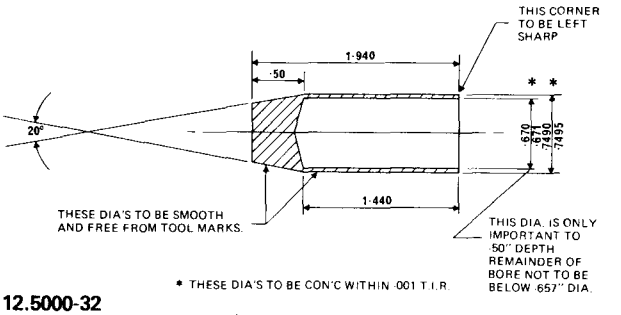
16. Overhaul of the pump consists of cleaning of components and replacing worn parts, for example, pump shaft bushes, bearing vane carrier and rollers.

17. To dismantle the pump, clamp the body in a vice, remove the bolt and tab washer from the end of the shaft and using a suitable drag withdraw the gear from the shaft. The key can be removed from the shaft using a pair of pliers.

18. Remove the adaptor screw, adaptor, fibre washer and gasket from the top of the pump cover.

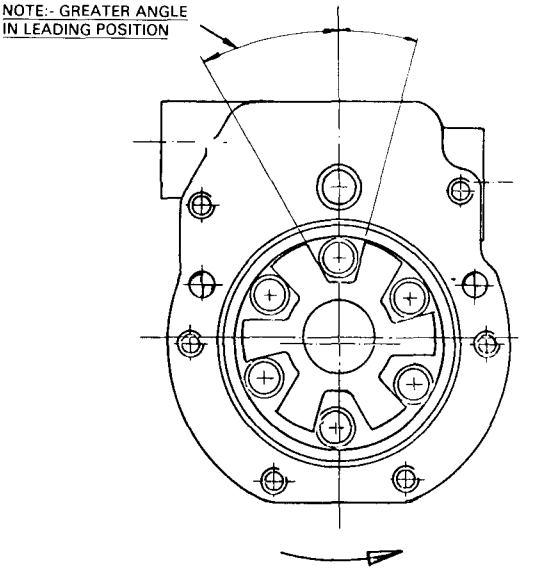
19. **NOTE.** The venturi flow director which is pressed into the pump cover must not be removed.
20. The four (4) allen screws holding the mounting plate to the pump must next be unscrewed and using a hide faced mallet, knock the mounting plate from the pump shaft.
21. Separate the pump body from the pump cover by removing the six allen screws.

22. Remove the pump from the vice and separate the cover from the body; keep vertical to prevent components from falling out.
23. The drive pin must be removed next from the shaft, then by gently tapping the shaft at the body end, the shaft and bearing can be withdrawn.
24. Remove and discard the 'O' ring seals from the grooves in the pump body.
25. Extract the roller vanes and carrier and lift out the cam insert and cam locking peg from the pump body.
26. Remove the valve cap, valve and valve spring from the top of the pump body taking care that the components do not spring out when unscrewing the valve cap.
27. Place all parts of the valve assembly where they will not be damaged or subjected to contamination.
28. Withdraw the shaft seal from the pump cover ensuring that no damage is caused to the shaft bearing bush.
29. Wash all the pump components in a suitable solvent and dry with an air line or wipe clean with a lint free cloth.
30. During assembly operations, extreme caution should be used to prevent any dirt from entering the pump. All parts should be lightly oiled before assembly.
31. Check the pump body and cover for wear and renew either part if the faces or bushes are worn.
32. Grease the lip of a new shaft seal and using a suitable tool, install the seal into the pump cover taking care that no damage is done to the lip of the seal.



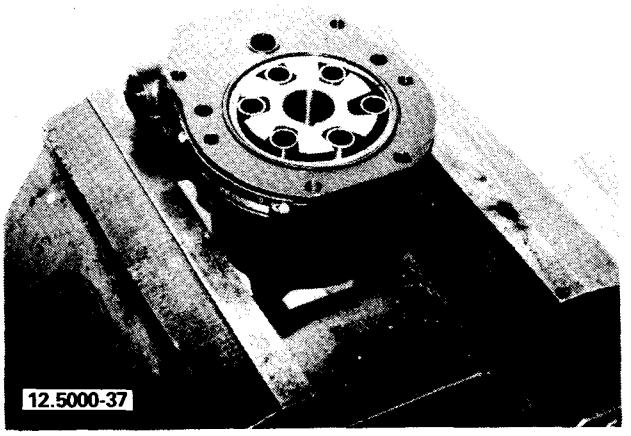
Tool for installing seal.

33. Inspect the cam and cam locking peg, and replace if they are worn or damaged. Install the cam locking peg in the slot of the pocket, then place the cam in the pocket with the slot over the locking peg. Ensure that the cam is seated on the pocket face.
34. Check the vane carrier for wear and place it into the cam, ensuring that the greater angle is in the leading position.



35. Inspect the rollers, paying particular attention to the finish on the ends, and replace if they are scored, damaged or out of round. Place a straight edge across the cam surface and using feeler gauges, check the end clearance which should not exceed 0.05 mm (0.002 ins). If the end clearance is in excess of this figure the vane carrier or rollers must be replaced.
36. Inspect the shaft and bearing assembly. If the bearing balls are loose or if excessive grease has seeped out of the bearing, the bearing must be replaced. Insert the shaft and bearing assembly from the seal side of the pump cover, using an oil seal inserting tool, ensuring that there are no sharp edges on the shaft to cut the seal lip.

37. Install two new 'O' rings (arrowed) into the grooves in the pump cover joint face of the pump body.



38. Align the vane carrier bore with the shaft bushing bore in the pump body, place the vane carrier drive pin in the shaft and insert the shaft into the carrier bore and the pump body bushing bore, bringing the body and cover together. Secure the body to the cover with the five screws and tighten evenly to a torque of 19-22 Nm (14-16 lb ft). Check that the shaft rotates freely after tightening the screws.
39. Replace the flow control valve spring into its bore after testing the spring tension which should be 3.6-4.1 kg (8-9 lb) at 20.83 mm (0.82 ins) long. If not it must be replaced.
40. Insert the valve into the bore so that the exposed ball end enters last, ensuring that the valve is not sticking.
41. Replace the 'O' ring on the valve cap and install the valve cap and 'O' ring into the pump, tightening to a torque of 41-48 Nm (30-35 lb ft).
42. Install a new gasket in the groove on top of the pump cover housing and replace the adaptor, fibre washer and adaptor screw.
43. Install the mounting plate onto the shaft bringing the mounting plate and pump together. Secure with the four screws.
44. Place the driving gear key into the shaft, assemble the driving gear, tab washer and bolt onto the end of the shaft and tighten the bolt to a torque of 20-27 Nm (15-20 lb ft).

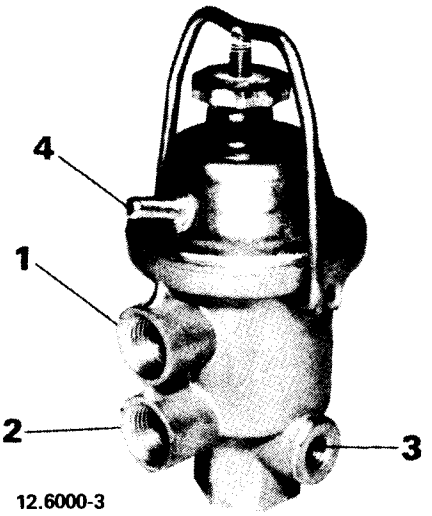
HYDRAULIC PUMP (REFITTING)
45. Place the pump assembly into position on the rear face of the crankcase front plate and insert the three retaining screws.
46. Remove the oil plugs and reconnect the hoses onto their appropriate adaptors.
47. Reconnect the battery cables.

12.6000

COLD STARTING AID

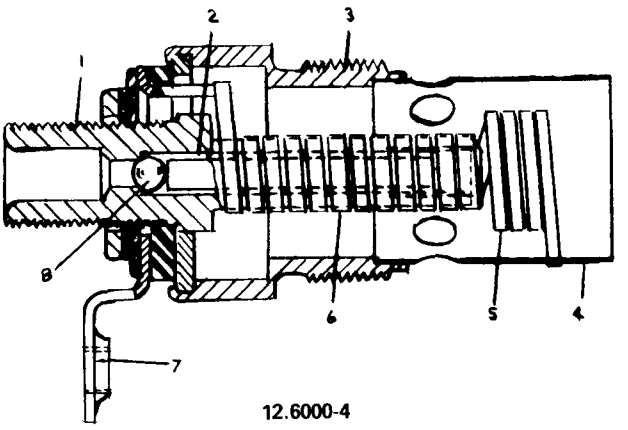
COLD STARTING AID (DESCRIPTION)

1. The cold starting aid comprises a fuel tank connected by a pipeline to an igniter unit screwed into the intake manifold.
2. The supply tank is mounted on a bracket attached to the inlet manifold.
3. The tank incorporates a supply port (2) from the main fuel filter and a delivery orifice (3) to the igniter. Excess fuel is returned to the fuel tank from the upper port (1). The tank is vented through a pipe (4).



12.6000-3

4. The igniter is the CAV thermostart type 357. This unit comprises a tubular valve body secured to a holder screwed into the inlet manifold, and surrounded by a heater coil, an extension of which forms an igniter coil. The valve body houses a needle, the stem of which holds a ball valve in position against a preformed seat. The valve body and heater coil are enclosed by a perforated shield which projects into the manifold.
5. While the unit is cold, the ball valve is held closed. When the unit is switched on, the heat from the coil expands, opening the ball valve and permitting the entry of fuel. The fuel is vapourised by the heat of the valve body and when the engine is cranked the air is drawn into the manifold, the vapour is ignited by the coil extension and continues to burn, thus heating the inlet air. When the unit is switched off, the flow of air in the manifold cools the valve body rapidly and the valve closes.
6. To check the igniter for leakage, remove the unit from the manifold and clear the flame shield. Reconnect the fuel pipe to the igniter and run engine at a fast idle. Any sign of moistening inside or outside the flame shield indicates a faulty ball valve and therefore the igniter, being a sealed unit, must be renewed.



12.6000-4

1. Valve Body
2. Valve Stem
3. Valve Body Holder
4. Shield
5. Igniter Coil
6. Heater Coil
7. Feed Wire Terminal
8. Ball Valve

7. If the igniter is suspected of leaking only when the inlet manifold is under heavy depression, the fuel pipe should be disconnected from the igniter and blanked off, and the engine run at load. If the exhaust smoke is reduced the igniter is faulty.
8. The igniter must be removed from the engine before carrying out any electrical tests as a fire hazard exists when fuel contacts the glowing igniter element.

COLD STARTING AID (REMOVAL)

9. To remove the fuel supply tank from its mounting bracket, disconnect the fuel pipes and the mounting bracket bolts from the fuel supply tank, and lift it from the mounting bracket.
10. The thermostart can be removed by disconnecting the terminal and the fuel supply pipe. Then unscrew the thermostart from the inlet manifold.

COLD STARTING AID (INSPECTION AND OVERHAUL)

11. The thermostart is a sealed unit and servicing is confined to periodic cleaning of the flame shield by brushing of carbon deposit and ensuring all perforations are clear.

COLD STARTING AID (REFITTING)

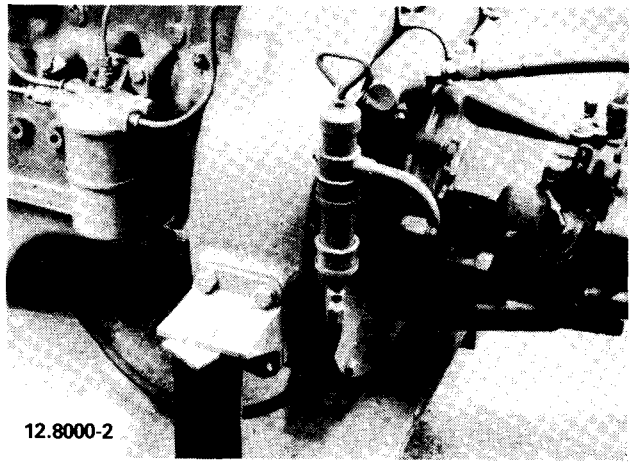
12. To refit the thermostart and fuel supply tank to the inlet manifold, reverse the procedure of the removal operations.
13. To start the engine, the thermostart control switch is switched on for 15 to 20 seconds and then the electric starter engaged. Both starter and thermostart switches should be released when the engine starts. If after 10 seconds cranking time the engine has not started, it is advantageous to stop cranking for 7 to 10 seconds leaving the thermostart energised, and then to resume.
14. When installing the unit, or if it has been standing for a long period, air should be vented from the fuel system by loosening the pipe union at the thermostart until fuel flows freely. Failure to do this may result in damage to the thermostart.

12.8000

SUMP PUMP

SUMP PUMP (DESCRIPTION)

1. The sump pump is used mainly on marine applications where the engine is situated in a confined space and where draining the sump in the conventional way would prove extremely difficult.
2. The pump is attached by two clips to a bracket which in turn is attached to the flywheel housing.



12.8000-2

3. The pump is connected to the sump by a hose assembly.

SUMP PUMP (REMOVAL)

4. Place a tray beneath the pump to catch any surplus oil in the pump or hose assembly.
5. Disconnect the hose from the pump.
6. Remove the clip retaining screws and withdraw the pump from the engine.

SUMP PUMP (INSPECTION AND OVERHAUL)

7. Servicing of the pump consists of a visual check for signs of damage or cracks and checking the plunger for wear.
8. The hose assembly should be checked for leaks and renewed if necessary.
9. Unscrew the pump cover and withdraw the complete plunger assembly.
10. Inspect the plunger for wear and renew the rubber washer if necessary. Care should be taken when removing the retaining bolt that the steel ball used as a non return valve is not lost.
11. Reassemble the plunger and return the complete plunger assembly into the pump body.

SUMP PUMP (REFITTING)

12. Replace the pump with the two retaining clips and tighten the nuts to a torque of 30-37 Nm (22-27 lb ft).
13. Reconnect the oil hose.

12.0000

SPECIFICATIONS

Dimensions quoted are the manufacturing limits for new parts except where maximum and minimum permissible figures are given.

EXHAUSTER

Make & Type ..... Clayton Dewandre REGA 1369A-2
..... Clayton Dewandre REGA 1427A
..... Clayton Dewandre REGA 1427A/1

BEARINGS

Fit in End Covers ..... 0.02 mm (0.0008 ins) Clearance to 0.005 mm (0.0002 ins) Interference
- Bearing Diameter 57.125-57.137 mm (2.2490-2.2495 ins)
- Cover Bore Diameter 57.132-57.145 mm (2.2493-2.2498 ins)

Fit on Shaft ..... 0.0025 mm (0.0001 ins) Clearance to 0.015 mm (0.0006 ins) Interference
- Bearing Bore Diameter 22.22-22.23 mm (0.8748-0.8752 ins)
- Shaft Diameter 22.228-22.235 mm (0.8751-0.8754 ins)

DRIVING GEAR

Fit on Shaft ..... Zero to 0.038 mm (0.0015 ins) Interference
- Gear Bore Diameter 21.94-21.96 mm (0.8637-0.8647 ins)
- Shaft Diameter 21.96-21.976 mm (0.8647-0.8652 ins)

EXHAUSTER BODY

Bore Diameter ..... 115.8367-115.9383 mm (4.5605-4.5645 ins)

ROTOR SEALING PLATE

Outside Diameter ..... 115.7732-115.8113 mm (4.5580-4.5595 ins)
Bore Diameter ..... 57.937-58.064 mm (2.281-2.286 ins)
Thickness ..... 6.35-6.60 mm (0.250-0.260 ins)
Spring Ring Gap in Body ..... 0.28-0.48 mm (0.011-0.019 ins)

SC6 COMPRESSOR

Make & Type ..... Clayton Dewandre, Single Cylinder, Air Cooled

PISTON RINGS

Ring Gap in Cylinder Bore ..... 0.051-0.152 mm (0.002-0.006 ins)
Clearance in Piston Groove ..... 0.013-0.064 mm (0.0005-0.0025 ins)

PISTON

Clearance in Cylinder Bore ..... 0.051-0.076 mm (0.002-0.003 ins)

PISTON PIN

Clearance in Connecting Rod Bush ..... 0.0381 mm (0.0015 ins)
Fit in Piston Bosses ..... Finger Push Fit

CRANKSHAFT REAR MAIN BEARING

Clearance on Crankshaft ..... 0.014-0.046 mm (0.00055-0.0018 ins)
Bush Bore Diameter ..... 25.394-25.413 mm (0.99975-1.0005 ins)

SPECIAL EQUIPMENT SPECIFICATIONS 2

CONNECTING ROD
Bearing Clearance on Crankshaft ..... 0.0254-0.0762 mm (0.001-0.003 ins)

CRANKSHAFT
Crankpin Diameter ..... 22.1869-22.1996 mm (0.8735-0.8740 ins)
Main Journal Diameter ..... 25.367-25.380 mm (0.9987-0.9992 ins)

SC9 COMPRESSOR
Make and Type ..... Clayton Dewandre, Single Cylinder, Air Cooled

PISTON RINGS
Compression Ring Gap in Cylinder Bore ..... 0.2286-0.3556 mm (0.009-0.014 ins)
Scraper Ring Gap in Cylinder Bore ..... 0.254-0.381 mm (0.010-0.015 ins)
Compression Ring Clearance in Piston Groove ..... 0.0152-0.066 mm (0.0006-0.0026 ins)
Scraper Ring Clearance in Piston Groove ..... 0.0127-0.0635 mm (0.0005-0.0025 ins)

PISTON
Clearance in Cylinder Bore ..... 0.1905-0.2286 mm (0.0075-0.0090 ins)

PISTON PIN
Clearance in Connecting Rod Bush ..... 0.0051-0.0152 mm (0.0002-0.0006 ins)
Fit in Piston Bosses ..... Finger Push Fit

CRANKSHAFT MAIN BEARINGS
Clearance on Crankshaft ..... 0.0191-0.0572 mm (0.00075-0.00225 ins)
Bush Bore Diameter ..... 38.0937-38.1191 mm (1.49975-1.50075 ins)

CONNECTING ROD
Bearing Clearance on Crankshaft ..... 0.0127-0.0508 mm (0.0005-0.0020 ins)

CRANKSHAFT
Crankpin Diameter ..... 31.7246-31.7373 mm (1.2490-1.2495 ins)
Main Journal Diameter ..... 38.0619-38.0746 mm (1.4985-1.4990 ins)

SAFETY VALVE
Pressure Setting ..... 999-1068 KPa (145-155 psi)

GOVERNOR VALVE
Cut-Out Pressure ..... 813-841 KPa (118-122 psi)
Cut-In Pressure ..... 703-730 KPa (102-106 psi)

HYDRAULIC PUMP
Make & Type ..... Hobourn Eaton - Roller Type
Fluid Pressure ..... 5170 KPa (750 psi) minimum
Flow Control Valve Spring — Load at 20.83 mm (0.82 ins) ..... 3.6-4.1 Kg (8-9 lb)
Vanes & Carrier End Clearance ..... 0.05 mm (0.002 ins) maximum
Cam Insert Clearance in Body ..... 0.023-0.064 mm (0.0009-0.0025 ins)

COLD START AID
Make & Type ..... CAV Thermostart Type 357
Maximum Current Consumption 12v ..... 18 Amperes
Maximum Current Consumption 24v ..... 7.5 Amperes
Fuel Flow Rate Through Thermostart ..... 9 c.c. per minute (nominal)

TORQUE WRENCH DATA
Compressor Cylinder Head Nuts ..... 20-22 Nm (15-16 lb ft)
SC6 Compressor Connecting Rod Bolts ..... 5.1-5.4 Nm (3.75-4 lb ft)
SC9 Compressor Connecting Rod Bolts ..... 12-15 Nm (9-11 lb ft)
Hydraulic Pump Cover Screws ..... 19-22 Nm (14-16 lb ft)
Hydraulic Pump Flow Control Valve Cap ..... 41-48 Nm (30-35 lb ft)
Hydraulic Pump Gear Retaining Bolt ..... 20-27 Nm (15-20 lb ft)

Fuel Pump Coupling Retaining Nut	37 Nm (27 lb ft)
Timing Gear Shaft Housing	19 Nm (14 lb ft)
Exhauster Retaining Bolts	20-24 Nm (15-18 lb ft)
Sump Pump Retaining Nuts	30-37 Nm (22-27 lb ft)

SECTION 13

OPERATING INSTRUCTIONS

Contents

13.1000

ENGINE OPERATING INSTRUCTIONS

BEFORE STARTING A NEW ENGINE

1. Before the engine left the factory the cooling and lubricating systems were drained, and several other operations were carried out to prevent possible corrosion and other troubles occurring during storage or delivery to the customer.
2. Before using the engine for the first time the sequence of operations given below must be carefully followed. Any attempt to run the engine before carrying out this procedure, may result in serious damage.

AIR CLEANER

3. Fill the air intake oil bath air cleaner to the indicated level, with viscosity S.A.E. 50 engine oil.

LUBRICATION SYSTEM

4. Fill the engine oil pan to the "Full" mark on the dipstick. See Maintenance page 3 for oil specifications.
5. On six cylinder engines with CAV inline fuel injection pumps a third of a pint (200 cc) of engine oil must be added to the fuel injection pump cambox.
6. On both 220 and 330 cu in engines where a mechanical governor is fitted in conjunction with an inline fuel injection pump, the governor casing must be filled to the level plug opening with engine oil. D.P.A. fuel injection pumps are self lubricating.

FUEL SYSTEM

7. See that there is fuel in the tank and then air vent the fuel system. This must be done whenever the fuel pipe lines are disconnected. The air venting procedure is as follows.

ENGINES FITTED WITH A.C. FUEL FILTER & SIMMS "IN-LINE" FUEL INJECTION PUMP

8. Slacken the off centre plug in the filter head and operate the priming lever on the fuel lift pump. Continue operating the lever until fuel, free from air bubbles, is discharged. Tighten the plugs as fuel is being discharged.
9. Slacken the plugs directly above the pump side cover, operate lift pump until fuel free from air is being discharged. Tighten screw as air free fuel is being discharged.

ENGINES FITTED WITH C.A.V. IN-LINE TYPE FUEL PUMP

10. Slacken the air vent plug at the top of the fuel filter.
11. Operate the priming lever of the fuel feed pump until fuel, free from air bubbles, is discharged from the air vent. Tighten the air vent plug as fuel is being discharged.
12. Similarly, slacken the two air vent plugs immediately above the fuel injection pump inspection cover and operate the priming lever until fuel, free from air bubbles, is being discharged from the air vents. Tighten the air vent plugs as fuel is being discharged.

ENGINES FITTED WITH C.A.V. DISTRIBUTOR TYPE FUEL INJECTION PUMPS AND HYDRAULIC GOVERNORS

13. Slacken the spare outlet plug on the filter head and operate the fuel lift pump until air free fuel is discharged, tighten plug whilst fuel is still being discharged.
14. Slacken the banjo on the fuel pump which is attached to fuel pipe from filter, operate fuel lift pump until air free fuel is discharged, tighten banjo whilst fuel is still being discharged.
15. Slacken the vent valve fitted on one of the two hydraulic head locking screws, and the vent screw on the top of the governor housing. Operate the fuel lift pump until air free fuel is discharged. Tighten the housing vent screw and then the governor vent screw whilst air free fuel is still being discharged.
16. Slacken any two injector high pressure pipe unions at the injector end. Set the throttle to the fully open position and ensure the stop control is in the "run" position. Turn the engine with the starter motor until fuel free from air flows. Tighten the unions whilst fuel is flowing. There is a possibility that the engine may start and run on 4 cylinders, if it should the throttle should be returned to idle position and injectors tightened as above.

ENGINES FITTED WITH D.P.A. FUEL INJECTION EQUIPMENT MECHANICAL GOVERNOR

17. Make provision for some spillage of fuel beneath engine and when an instruction calls for air free fuel allow sufficient to bleed to achieve this.
18. Ensure adequate fuel is within fuel tank and stop cock is open.
19. Slacken hexagonal headed bleed (9/16 in AF) on fuel filter head, operate priming lever on fuel lift pump, at the same time ensure any emergency stop fuel shut off is de-activated, and continue to operate priming lever until air free fuel flows from bleed, at which time bleed should be re-tightened.
20. Slacken hexagonal headed bleed screw (5/16 in AF) and operate priming lever until air free fuel is expelled from bleed screw. Re-tighten.

NOTE. Care should be exercised that the 5/16 in bleed screw is slackened and not the cam ring locking stud into which the bleed screw is threaded.

21. Slacken banjo pipe attachment, actuate priming lever until air free fuel is expelled and leave slightly slack at this point.
22. Slacken one or more injector pipes at the injector end, and the fuel pump end at No. 4 pressurising valve.
23. With the pipes slackened, set stop lever to run position, deactivate any automatic shut-down system and crank engine until air free fuel is expelled from the slackened pipes. Tighten all pipes except one high pressure pipe to No. 4 injector and its associated pressurising valve and attempt to start engine by cranking, and when engine commences to run re-tighten pressurising valve connection at the fuel pump end and injector end of the No. 4 injector

line. Operate speeder lever to required engine speed and check that no leaks exist in fuel system. Stop engine. Wipe clean any spilt fuel on engine or equipment.

COOLING SYSTEM

24. Ensure that the coolant drain tap at the rear left hand side of the cylinder block is closed. Fill the cooling system with coolant taking care to vent external connections.
25. Check that the fan belts are tensioned correctly. A deflection of ½ inch (12 mm) should be obtained with a load of 8-10 lbs (3.6-5.4 kg), midway between the fan and alternator pulleys.

VENTILATING SYSTEM

26. Ensure that the breather pipe hose clips are all secure.

TRANSMISSIONS

27. If the engine is fitted with a Bedford standard automotive gearbox, it should be filled to the level of the filler plug opening, situated at the rear left hand side of the gearbox.
28. The grade of oil used depends on the ambient temperature, these are listed in table 1.
29. If an Allison transmission is fitted add 9.1 litres (2 imperial pints) of Dexron (R) transmission fluid.
30. Engines fitted with Parsons marine gearboxes should follow the procedure in paragraphs 31 to 34.
31. Parsons gearboxes should be filled with the same grade of oil as used in the engine.
32. The forward and reverse units can be filled through the filler situated on top of the gearbox close to the engine. The level can be checked using the dipstick located on the left hand side of the gearbox.
33. The reduction gearbox has a hexagon plug on top of the gearbox which is used as a filler. The level is checked by removing another hexagon plug on the left side of the rear face, the level being correct when the oil flows from this hole. Replace the plugs before starting engine.
34. Various models of Parsons marine gearboxes are used with varying quantities of oil shown in table 2.
35. On Paragon marine gearboxes the oil should be the same heavy duty oil that is used in the engine. The quantity of oil will vary dependent on the inclination of the marine gear, therefore when filling oil should be brought up to the FULL mark on the bayonet oil gauge.
36. Borg Warner Velvet Drive marine gearboxes should be filled with "Automatic transmission fluid Type "A" Suffix 'A' SAE 10W". The filler is located below the gear change lever on the rear left hand side of the gear case. The oil capacity varies depending on model and inclination angle, therefore the oil should be sufficient to reach the FULL mark on the dipstick.

TABLE 1.

AMBIENT TEMPERATURE	GM SPECIFICATION	OIL GRADE
ABOVE 0°C (32°F)	4519-M	SAE 90
0° to −31°C (32° to −25°F)	4592-M	SAE 80
BELOW −31°C (−25°F)	—	SAE 80 & 10% KEROSENE

TABLE 2

TYPE	QUANTITY
'DA'	
Reverse Gear	.568 Litres (1 Pint)
2:1 Reduction Gear	.142 Litres (.25 Pint)
3:1 Reduction Gear	.284 Litres (.5 Pint)
Marinomatic 'DA' Mark III	
Reverse Gear	.710 Litres (1.25 Pints)
2:1 Reduction Gear (2 Wheel or R.H. Rotation)	.142 Litres (.25 Pint)
3:1 Reduction Gear (2 Wheel or R.H. Rotation)	.227 Litres (.4 Pint)
H.G.4 — Mark II	
Hydraulic Reverse Gear	2.272 Litres (4 Pints)
30/100 and 35/100 2:1 Reduction Gear (Two Wheel)	.355 Litres (.625 Pint)
30/100 and 35/100 2:1 Reduction Gear (Three Wheel)	.497 Litres (.875 Pint)
30/100 and 35/100 3:1 Reduction Gear (Two Wheel)	.426 Litres (.75 Pint)
30/100 and 35/100 3:1 Reduction Gear (Three Wheel)	.568 Litres (1 Pint)
4/100 2:1 Reduction Gear (Two Wheel)	.426 Litres (.75 Pint)
4/100 2:1 Reduction Gear (Three Wheel)	.568 Litres (1 Pint)
4/100 3:1 Reduction Gear (Two Wheel)	.710 Litres (1.25 Pints)
4/100 3:1 Reduction Gear (Three Wheel)	.825 Litres (1.5 Pints)

STARTING THE ENGINE

37. The method for starting the engine is dependent on the ambient temperature, and the type of fuel injection pump fitted.

TEMPERATURES ABOVE 0°C (32°F) — INLINE FUEL INJECTION PUMP

38. Switch on.
39. Firmly operate the starter control and engine should start. It may sometimes be necessary, especially during cold weather, to keep the engine speed control almost fully open for a few moments after the engine starts, do not exceed 30 seconds. If engine does not start allow 60 seconds rest and attempt to start again. If after 4 attempts the engine will not run find out why.

TEMPERATURES BETWEEN —8.4° To 0°C (15° To 32°F) — INLINE FUEL INJECTION PUMP

40. Place the throttle lever in the maximum position.
41. Set the excess fuel device on the injection pump. This device allows more fuel to be made available to the engine. To operate it on the 6 cylinder engine, pull the stop control bodily outwards. With the 4 cylinder engine push the shaft which protrudes through the stop control lever right up to the face of the lever. In each case this will set and hold the pump in the excess fuel position until the engine starts.
42. Switch on.
43. Operate the starter control and the engine should start. Keep the engine speed control almost fully open for a few moments after the engine starts.

TEMPERATURES BELOW —8.4°C (15°F) — INLINE FUEL INJECTION PUMP

44. When the engine is used in a territory where the night temperature frequently falls below minus 8.4°C (15°F) a "Thermostart" heater should be fitted to the intake manifold.
45. Place the throttle lever in the maximum position.
46. Set the injection pump excess fuel device (see paragraph 41 above).
47. Switch on.
48. Firmly press in and hold depressed the "Thermostart" heater button.
49. After 10 seconds, with the throttle almost fully open, operate the starter control, still keeping the "Thermostart" heater button depressed. After a few seconds motoring the engine should start. Release both starter control and "Thermostart" button and maintain a reasonably high engine speed for a few moments.

TEMPERATURES ABOVE 0°C (32°F) — D.P.A. FUEL INJECTION PUMP

50. On engines fitted with distributor type fuel pumps no excess fuel device is fitted as the fuel pump has a form of advance and retard mechanism built into it.
51. The starting procedure for temperatures above freezing is the same as for inline fuel pumps.

TEMPERATURES BELOW 0°C (32°F) — D.P.A. FUEL INJECTION PUMP

52. The "Thermostart" control switch, which is spring loaded to the off position, is switched on for 15 to 20 seconds, and then the starter operated. Both starter and thermostart switches should be released when the engine starts. If after 10 seconds cranking time the engine has not started it is advantageous to stop cranking for 10 seconds leaving the Thermostart energised, and then resume cranking.

RESTARTING A WARM ENGINE

53. When the engine is warm it can be restarted by switching on and then operating the starter control. This applies to all types of injection pumps, fitted on G.M. Bedford engines.
54. As soon as the engine is running, check that the oil pressure is present either by observing the indicator light or the oil pressure gauge.
55. **WARNING.** If the engine is equipped with a "Thermostart" cold starting aid do not use ether start aid. Ether applied while thermostart is in operation could cause a severe explosion.
56. Allow the engine to warm up thoroughly and then reset accurately the valve clearances to .013 in, with the engine running (see paragraph 3 of page 1 of engine tune-up section (14.0000).
57. Check engine for fuel, oil and coolant leaks, rectifying as necessary.

RUNNING IN

58. The engine will run in under 75% load conditions more effectively than by light operation, however it is important to ensure that operating temperatures of 71°-77°C (160°-170°F) are reached before applying full load. During the first 30 hours of engine life, full load should only be applied for short periods up to 15 minutes if operating circumstances permit.
59. When a period of full load has been run the engine should run at light or no load at 1000-1500 RPM for 5 minutes before shutting down, this will allow high temperature parts of the engine to return to normal without distortion.
60. Do not idle for long periods, if engine is not required shut it down and heat will be retained longer than at idle.
61. After the first 20 hours of operation, the engine oil should be drained and refilled with an approved lubricant (see page 3 of routine maintenance).

STOPPING THE ENGINE

62. To stop the engine move the engine stop control to the "stop" position, and hold it in this position until the engine stops. See that the control is returned to the running position after the engine has stopped.

13.1100

OPERATING INSTRUCTIONS — A.C. POWER GENERATOR SET

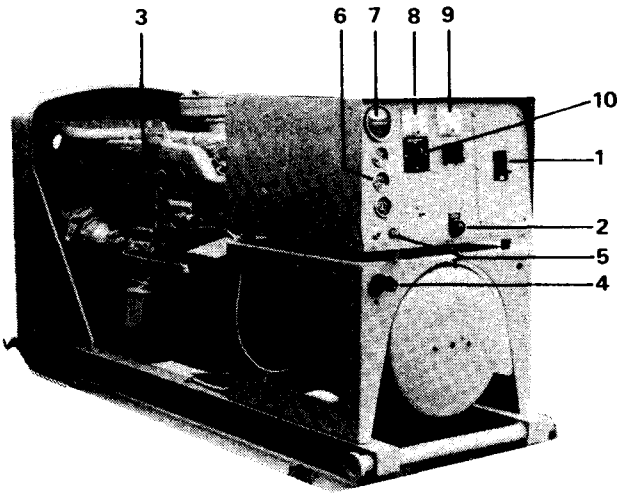
1. These instructions cover the fundamental procedures for operating an alternating current power generator set. The operator should read these instructions before attempting to operate the unit.

PREPARATION FOR STARTING

2. Before attempting to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed under "before starting a new engine" in section 13.1000. Before a routine start, see Daily operations in the lubrication and preventive maintenance chart in section 15.1000.
3. In addition to the Engine operating instructions, the following instructions also apply when operating an alternating current power generator set.
4. Before applying the set to a job it is essential to ensure that the correct frequency will be provided by the engine governor so that the engine can operate satisfactorily at synchronous speed, i.e.,
1500 RPM = 50 Hz, 1800 RPM = 60 Hz.
5. It is also essential that the terminal linkage within the cabinet be connected to provide the correct voltage, since the machine stator has star windings with centre taps, which permit the windings to be individually run in series or parallel.
6. Before connecting driven equipment or buss bars it is essential to ensure that phase rotation is correct, normally these are numbered 1, 2 & 3, or in colour coding, red, yellow, or white and blue. The correct phase rotation is essential if motors connected are to be driven in the correct direction, also it is the first essential if the set is to be paralleled with any other set.
7. For instructions on changing frequency or voltage see page 2 of control panel section (7.6000).
8. If is is suspected that the unit has been subjected to damp, the insulation resistance of the main stator winding should be checked and if this is less than 1M OHMS, the equipment should be slowly dried out until this insulation resistance is achieved.
9. The other windings within the equipment operate at low voltage, therefore, it should not normally be necessary to check the insulation resistance of these.
10. Check the earthing arrangements and ensure that the neutral lead is properly attached.
11. All annotations refer to 13.1100-11.
12. Place main breaker switch, item (1) in off position.
13. Turn the voltage regulator control, item (2) to its minimum position, fully anticlockwise.

STARTING

14. Set engine governor stop control, item (3) to 'run' position.
15. Set throttle control, item (4) to midway position. Depress knob in centre of control, pull outer knob to desired position and release centre. Fine adjustment can be made by turning knob anticlockwise to increase speed and clockwise to decrease speed.



13.1100-11

1. Main Breaker
2. Regulator Control
3. Engine/Stop/Run
4. Engine Speed Control
5. Engine Start Switch
6. Oil Pressure Gauge
7. Frequency Meter
8. Voltmeter
9. Ammeter
10. Ammeter Selector Switch

16. Operate key switch, item (5) to crank engine and when it fires and runs, check oil pressure, item (6) is present.
17. If this is the initial start for the unit, leave engine operating at approximately 1500 RPM for a few moments and check for coolant, lube oil or fuel oil leaks. AT NO TIME MUST THE ENGINE BE RUN AT IDLE SPEED.
18. Run engine to synchronous speed as indicated on frequency tachometer, item (7) and if time permits allow speed to settle to remove the chill from the cooling system.

PREPARING UNIT FOR LOAD

19. Set voltage 2% over required load voltage and frequency at 2 cycles per second above that required, if it is intended to take over more than ¾ load on switching in, proportionally lower settings for ½ and ¼ load and exactly on frequency and voltage for loads of less than ¼.
20. Ensure that no personnel are engaged on lines and switch main breaker, item (1) to 'on' position, check voltage on voltmeter (item 8) and frequency on frequency meter (item 7) and adjust as necessary. The load in amperes should be checked by reference to the ammeter (item 9) and each phase should be checked in turn by use of the selector (item 10).
21. Further slight adjustment may be required when engine alternator and regulator have achieved normal working temperature.

PARALLELING

22. Successful parallel operation can only be achieved if all of the engine governors are of the same characteristic, and it is advantageous to utilize sets of similar alternators and voltage regulators.
23. Check phase rotation of buss to which set is to be connected.
24. Follow starting instructions in paragraphs 12 to 18 inclusive.
25. Switch all units to parallel run.
26. Close synchronising lamp switches.
27. Check frequency of units running on load at 50 or 60 Hz, whichever is applicable.
28. Adjust voltage on coming set to correct level.
29. Observe synchronising lamps alternating bright and dim in rotating pattern, adjust engine governor control to slow the rate of change to minimum and when a steady period of darkness exceeding ten seconds has been repeated three times place hand on breaker, item (1) and at commencement of next dark period on upper lamp count five seconds and close breaker.
30. Switch off synchronising lamps.
31. Adjust engine governor control, item (4) to indicate each set providing proportional share of load by ammeter, item (9).

WARNING. On no account should the voltage regulator control be varied whilst parallel operating sets.

STOPPING

32. The procedure for stopping a power generator unit or taking a unit out of parallel is as follows:
33. Open main breaker, item (1).
34. Stop engines with stop control, item (3).

13.2000

ENGINE OPERATING CONDITIONS

1. The engine operating charts are included as an aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represented are true values, and that instruments are accurate, before attempting to make corrections to the engine.

2. **NOTE 1.** Exhaust back pressures represent the restriction of flow in the EXTERNAL EXHAUST SYSTEM and should be measured at the outlet of the engine exhaust manifold. Pressures are read in inches of mercury.

3. **NOTE 2.** Restriction to air flow reduces the power output and life expectancy of any engine and therefore limits are set on the amount of restriction the air intake system may create.

4. **NOTE 3.** Fuel consumption figures are for fuel at specific gravity of 0.838.

220 cu in ENGINES

	IDLE SPEED 550 RPM	1000 RPM	1500 RPM	2000 RPM	2600 RPM
Lubrication System					
Oil Pressure (P.S.I.)					
Normal	15 (104 kpa)			50 (375 kpa)	
Minimum (Safe Operation)				25 (172 kpa)	
Oil Temperature (°C)					
Normal	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)
Air System					
Air Inlet Restriction (Inches of Water)					
Clean Air Cleaner (Maximum)		2.3 (58 mm)	6.0 (152 mm)	9.6 (244 mm)	12.0 (305 mm)
Dirty Air Cleaner (Maximum)		4.5 (114 mm)	9.5 (241 mm)	14.5 (368 mm)	20.5 (521 mm)
Crankcase Pressure (Inches of Water)					
Up to Serial No. P&I 10932		0.5 (13 mm)	0.8 (20 mm)	1.1 (28 mm)	1.3 (33 mm)
From Serial No. P&I 10933		2.5 (63.5 mm)	5.0 (127 mm)	6.0 (152 mm)	6.0 (152 mm)
Exhaust Back Pressure (Inches of Mercury)		0.9 (23 mm) max	2.0 (51 mm) max	3.3 (84 mm) max	6.0 (152 mm) max
Fuel System					
Fuel Consumption (Imp Gallons Per Hour)					2.8 at 65 B.H.P.
Injector Delivery Pressure	175 Atmospheres	175 Atmospheres	175 Atmospheres	175 Atmospheres	175 Atmospheres
Cooling System					
Coolant Temperature (°C)					
Normal	93° (205°F)	93° (205°F)	93° (205°F)	93° (205°F)	93° (205°F)
Compression					
Compression Pressure (P.S.I.)					
Minimum at 68°F (20°C)	450				

ENGINE OPERATING CONDITIONS 2

330 cu in ENGINES

	IDLE SPEED 550 RPM	1000 RPM	1500 RPM	2000 RPM	2600 RPM
Lubrication System					
Oil Pressure (P.S.I.)					
Normal	15 (104 kpa)			50 (375 kpa)	
Minimum (Safe Operation)				25 (172 kpa)	
Oil Temperature (°C)					
Normal	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)
Air System					
Air Inlet Restriction (Inches of Water)					
Clean Air Cleaner (Maximum)		2.8 (71 mm)	5.6 (142 mm)	9.6 (244 mm)	16.5 (419 mm)
Dirty Air Cleaner (Maximum)		5.5 (140 mm)	10.5 (267 mm)	15.2 (386 mm)	22.5 (571 mm)
Crankcase Pressure (Inches of Water)					
Up to Serial No. P&I 7598		0.3 (9 mm)	0.9 (23 mm)	1.6 (41 mm)	3.0 (76 mm)
From Serial No. P&I 7599		2.5 (63.5 mm)	5.0 (127 mm)	6.0 (152 mm)	6.0 (152 mm)
Exhaust Back Pressure (Inches of Mercury)		0.5 (13 mm)	1.3 (33 mm)	2.2 (56 mm)	3.75 (95 mm)
Fuel System					
Fuel Consumption (Imp Gallons Per Hour)					2.8 at 65 B.H.P.
Injector Delivery Pressure	175 Atmospheres	175 Atmospheres	175 Atmospheres	175 Atmospheres	175 Atmospheres
Cooling System					
Coolant Temperature (°C)					
Normal	93° (205°F)	93° (205°F)	93° (205°F)	93° (205°F)	93° (205°F)
Compression					
Compression Pressure (P.S.I.)					
Minimum at 68°F (20°C)	450				

330T cu in ENGINES

	IDLE SPEED 550 RPM	1000 RPM	1500 RPM	2000 RPM	2600 RPM
Lubrication System					
Oil Pressure (P.S.I.)					
Normal	15 (104 kpa)			50 (375 kpa)	
Minimum (Safe Operation)				25 (172 kpa)	
Oil Temperature (°C)					
Normal	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)	93°-107° (200°-225°F)
Air System					
Air Inlet Restriction (Inches of Water)					
Clean Air Cleaner (Maximum)		3.5 (89 mm)	5.8 (147 mm)	8.5 (216 mm)	12.7 (323 mm)
Dirty Air Cleaner (Maximum)		5.5 (140 mm)	10.5 (267 mm)	15.2 (386 mm)	22.5 (571 mm)
Crankcase Pressure (Inches of Water)		0.3 (9 mm)	0.9 (23 mm)	1.6 (41 mm)	3.0 (76 mm)
Exhaust Back Pressure (Inches of Mercury)		0.5 (13 mm)	0.75 (19 mm)	1.1 (28 mm)	1.6 (41 mm)
Fuel System					
Fuel Consumption (Imp Gallons Per Hour)					2.8 at 65 B.H.P.
Injector Delivery Pressure	175 Atmospheres	175 Atmospheres	175 Atmospheres	175 Atmospheres	175 Atmospheres
Cooling System					
Coolant Temperature (°C)					
Normal	93° (205°F)	93° (205°F)	93° (205°F)	93° (205°F)	93° (205°F)
Compression					
Compression Pressure (P.S.I.)					
Minimum at 68°F (20°C)	450				

13.2100

ENGINE RUN-IN INSTRUCTIONS

1. Following a complete overhaul or any major repair job involving the installation of piston rings, pistons or bearings, the engine should be "run-in" on a dynamometer prior to release to service.
2. The dynamometer is a device for applying specific loads to an engine. It permits the serviceman to physically and visually inspect and check the engine while it is operating. It is also an excellent method of detecting improper tune up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.
3. The operating temperatures within the engine affect the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature, 77°-96°C (170°-205°F) should be maintained throughout the run-in.
4. The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10° higher than the water inlet temperature.
5. A thermostat is used in the engine to control the coolant flow. Therefore, be sure it is in place and fully operative or the engine will overheat during the run-in.
6. The run-in schedules are shown on pages 2, 3 and 4.

DYNAMOMETER TEST AND RUN-IN PROCEDURES

7. The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger and a torque loading and measuring device.
8. The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit.
9. The power absorbed is generally measured in torque (Nm or lb-ft) on a suitable scale. The value for a given engine speed will show the brake horsepower developed in the engine by the following formula.

$$BHP = (T \times RPM)/5250$$

where BHP = brake horsepower, T = torque and RPM = revolutions per minute.
10. Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.
11. During the actual operation, all data taken should be recorded immediately onto an ENGINE TEST SCHEDULE (see sample on page 6).
12. Certain instrumentation is necessary so that data required to complete the engine test schedule may be obtained. The following list contains both the minimum amount of instruments and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

(a) Oil pressure gauge installed into the top of oil filter.
(b) Oil temperature gauge installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.
(c) Water temperature gauge installed in the thermostat housing or water outlet.
(d) Adaptor for connecting a pressure gauge or water manometer to the crankcase.
(e) Adaptor for connecting a pressure gauge or mercury manometer to the exhaust manifold at the flange.
(f) Adaptor for connecting a fuel pressure gauge to the fuel inlet passage.
(g) Adaptor for connecting a pressure gauge or mercury manometer to the turbocharger, if fitted.

13. In some cases, gauges reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is important that the scale of these gauges are of a low range and finely divided if accuracy is desired. This is especially true of a gauge reading in PSI, the reading of which is to be converted into inches of water.
The following conversion factors may be helpful:

$$\text{Inches of Water} = \text{PSI} \times 27.7 \text{ in}$$
$$\text{Inches of Mercury} = \text{PSI} \times 2.04 \text{ in}$$

14. Before starting the run-in or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on starting in paragraphs 15 to 19 listed below.
15. Fill the lubrication system as outlined in section 13.1000.
16. Prime the fuel system as outlined in section 13.1000.
17. A preliminary valve clearance adjustment must be made, this is outlined in section 14.1000.
18. Check the injectors and governor timing as outlined in section 14.1000.
19. On turbocharged engines, remove the oil supply line and add clean engine oil to the oil inlet to ensure pre-lubrication of the turbocharger. Reconnect the oil lines and idle engine for at least one minute after starting and before increasing speed.
20. After performing these preliminary steps, ensure all water valves, fuel valves, etc. are open. Also inspect the exhaust system to ensure it is properly connected to the engine.
21. Start the engine with minimum dynamometer resistance.
22. The operator should be observant at all times so that any malfunction which may develop will be detected. Minor difficulties should be detected and corrected so that a major problem will not develop.
23. After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb ft on the torque gauge (or 10-15 HP on a horsepower gauge). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.
24. Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.
25. Refer to the standard run-in schedule and the engine test schedule and follow the tests and run-in quoted.

INTERLACE RUN-IN SCHEDULE 220/330 cu in 1500/1600/1700 RPM FULL LOAD SPEED

RPM	TIME (Mins)	TOTAL TIME (Hrs/Mins)	220		330	
			LBS	BHP	LBS	BHP
1000	15	15	2.65	13.25	4.4	22.0
1200	6	21	2.71	16.25	4.33	26.0
1400	3	24	2.83	19.8	4.43	31.0
Idle	1	25	0	0	0	0
1000	6	31	F.L.	F.L.	F.L.	F.L.
1400	3	34	2.83	19.8	4.43	31.0
Idle	1	35	0	0	0	0
1500	3	38	4.3	32.25	6.5	48.8
Idle	1	39	0	0	0	0
1200	3	42	F.L.	F.L.	F.L.	F.L.
Idle	1	43	0	0	0	0
1500	3	46	F.L.	F.L.	F.L.	F.L.
Idle	1	47	0	0	0	0
1200	6	53	F.L.	F.L.	F.L.	F.L.
Idle	1	54	0	0	0	0
1500	6	1.00	F.L.	F.L.	F.L.	F.L.

INTERLACE RUN-IN SCHEDULE 220/330 cu in 1800/1900 RPM FULL LOAD SPEED

RPM	TIME (Mins)	TOTAL TIME (Hrs/Mins)	220		330	
			LBS	BHP	LBS	BHP
1000	15	15	2.65	13.25	4.4	22.0
1400	6	21	2.86	20.0	4.36	30.5
1800	3	24	2.89	26	4.17	37.5
Idle	1	25	0	0	0	0
1000	6	31	F.L.	F.L.	F.L.	F.L.
1800	3	34	2.89	26	4.17	37.5
Idle	1	35	0	0	0	0
1500	3	38	F.L.	F.L.	F.L.	F.L.
Idle	1	39	0	0	0	0
1500	3	42	F.L.	F.L.	F.L.	F.L.
Idle	1	43	0	0	0	0
1600	6	49	F.L.	F.L.	F.L.	F.L.
Idle	1	50	0	0	0	0
1800	3	53	F.L.	F.L.	F.L.	F.L.
Idle	1	54	0	0	0	0
1600	6	1.00	F.L.	F.L.	F.L.	F.L.

INTERLACE RUN-IN SCHEDULE 220/330 cu in
2000/2100 RPM FULL LOAD SPEED

RPM	TIME (Mins)	TOTAL TIME (Hrs/Mins)	220		330	
			LBS	BHP	LBS	BHP
1000	15	15	2.65	13.25	4.4	22.0
1600	6	21	2.91	23.25	4.25	34.0
2000	3	24	2.85	28.5	4.1	41.0
Idle	1	25	0	0	0	0
1000	6	31	F.L.	F.L.	F.L.	F.L.
2000	3	34	2.85	28.5	4.1	41.0
Idle	1	35	0	0	0	0
1500	3	38	F.L.	F.L.	F.L.	F.L.
Idle	1	39	0	0	0	0
2000	3	42	2.85	28.5	4.1	41.0
Idle	1	43	0	0	0	0
1500	6	49	F.L.	F.L.	F.L.	F.L.
Idle	1	50	0	0	0	0
2000	3	53	4.28	42.75	6.15	61.5
Idle	1	54	0	0	0	0
1800	6	1.00	F.L.	F.L.	F.L.	F.L.
Idle	1	1.01	0	0	0	0
2000	3	1.04	4.28	42.75	6.15	61.5
1800	6	1.10	F.L.	F.L.	F.L.	F.L.

INTERLACE RUN-IN SCHEDULE 220/330 cu in
2200/2300 RPM FULL LOAD SPEED

RPM	TIME (Mins)	TOTAL TIME (Hrs/Mins)	220		330	
			LBS	BHP	LBS	BHP
1000	15	15	2.65	13.25	4.4	22.0
1600	6	21	2.91	23.25	4.25	34.0
2000	3	24	2.85	28.5	4.1	41.0
Idle	1	25	0	0	0	0
1000	6	31	F.L.	F.L.	F.L.	F.L.
2000	3	34	2.85	28.5	4.1	41.0
Idle	1	35	0	0	0	0
1500	3	38	F.L.	F.L.	F.L.	F.L.
Idle	1	39	0	0	0	0
2000	3	42	2.85	28.5	4.1	41.0
Idle	1	43	0	0	0	0
1500	6	49	F.L.	F.L.	F.L.	F.L.
Idle	1	50	0	0	0	0
2000	3	53	2.85	28.5	4.1	41.0
Idle	1	54	0	0	0	0
1800	6	1.00	F.L.	F.L.	F.L.	F.L.
Idle	1	1.01	0	0	0	0
2200	3	1.04	2.8	30.75	4.05	44.5
2000	6	1.10	F.L.	F.L.	F.L.	F.L.

INTERLACE RUN-IN SCHEDULE 220/330 cu in 2400/2500 RPM FULL LOAD SPEED

RPM	TIME (Mins)	TOTAL TIME (Hrs/Mins)	220		330	
			LBS	BHP	LBS	BHP
1000	15	15	2.65	13.25	4.4	22.0
1600	6	21	2.91	23.25	4.25	34.0
2000	3	24	2.85	28.5	4.1	41.0
Idle	1	25	0	0	0	0
1000	6	31	F.L.	F.L.	F.L.	F.L.
2000	3	34	2.85	28.5	4.1	41.0
Idle	1	35	0	0	0	0
1500	3	38	F.L.	F.L.	F.L.	F.L.
Idle	1	39	0	0	0	0
2200	3	42	2.8	30.75	4.05	44.5
Idle	1	43	0	0	0	0
1500	6	49	F.L.	F.L.	F.L.	F.L.
Idle	1	50	0	0	0	0
2400	3	53	2.71	32.5	4.0	48.0
Idle	1	54	0	0	0	0
1800	6	1.00	F.L.	F.L.	F.L.	F.L.
Idle	1	1.01	0	0	0	0
2400	3	1.04	2.71	32.5	4.0	48.0
2200	6	1.10	F.L.	F.L.	F.L.	F.L.

INTERLACE RUN-IN SCHEDULE 220/330 cu in 2600 RPM FULL LOAD SPEED

RPM	TIME (Mins)	TOTAL TIME (Hrs/Mins)	220		330	
			LBS	BHP	LBS	BHP
1000	15	15	2.65	13.25	4.4	22.0
1600	6	21	2.91	23.25	4.25	34.0
2000	3	24	2.85	28.5	4.1	41.0
Idle	1	25	0	0	0	0
1000	6	31	F.L.	F.L.	F.L.	F.L.
2000	3	34	2.85	28.5	4.1	41.0
Idle	1	35	0	0	0	0
1500	3	38	F.L.	F.L.	F.L.	F.L.
Idle	1	39	0	0	0	0
2400	3	42	2.71	32.5	4.0	48.0
Idle	1	43	0	0	0	0
1500	6	49	F.L.	F.L.	F.L.	F.L.
Idle	1	50	0	0	0	0
2600	3	53	2.62	34.0	3.96	51.5
Idle	1	54	0	0	0	0
2000	6	1.00	F.L.	F.L.	F.L.	F.L.
Idle	1	1.01	0	0	0	0
2600	3	1.04	2.62	34.0	3.96	51.5
2400	6	1.10	F.L.	F.L.	F.L.	F.L.

INTERLACE RUN-IN SCHEDULE
330 cu in TURBOCHARGED ENGINES
2600 RPM

RPM	TIME (Mins)	TOTAL TIME (Hours/Mins)	LBS	BHP
1000	15	15	4.4	22.0
1600	6	21	4.25	34.0
2000	3	24	4.1	41.0
Idle	1	25	0	0
1000	6	31	8.4	42.0
2000	3	34	4.1	41.0
Idle	1	35	0	0
1500	3	38	8.9	67.0
Idle	1	39	0	0
2400	3	42	4.0	48.0
Idle	1	43	0	0
1500	6	49	8.9	67.0
Idle	1	50	0	0
2600	3	53	3.96	51.5
Idle	1	54	0	0
2000	6	1.00	8.7	87.0
Idle	1	1.01	0	0
2600	3	1.04	3.96	51.5
Idle	1	1.05	0	0
1500	6	1.11	F.L.	F.L.
Idle	1	1.12	0	0
2600	3	1.15	7.0	91.0
Idle	1	1.16	0	0
2000	6	1.22	F.L.	F.L.
Idle	1	1.23	0	0
2600	3	1.26	7.0	91.0
2400	4	1.30	F.L.	F.L.

DETROIT DIESEL ALLISON DIVISION OF GENERAL MOTORS LIMITED

DIESEL ENGINE TEST SCHEDULE

ENGINE MODEL: T.S. NO:

FUEL PUMP: D.P.A. ☐ INLINE ☐ GOVERNOR TYPE: MECH. ☐ HYDRAULIC ☐ PNEUMATIC ☐

EQUIPMENT AND FITTINGS AS TESTED:

FAN ON ☐ OFF ☐ SILENCER TEST BED ☐ SPECIAL ☐ AIR CLEANER ON ☐ OFF ☐

RADIATOR ON ☐ OFF ☐ GEARBOX ON ☐ OFF ☐

OTHER AUXILIARIES TO BE FITTED FOR TEST:

RUN IN SCHEDULE: SEE SHEET 2 [SEE NOTE A(ITEM 1)]

1. RECORD: TEST CELL TEMP. AND BAROMETER
2. ENGINE WATER TEMP. IN ☐ OUT ☐ (TO BE BETWEEN 170° AND 205°F) (SEE NOTE B)
3. SET IDLE SPEED.....RPM
4. SET NO LOAD SPEED:.....RPM ± .....RPM
5. RECORD F.L. BHP AT ..... RPM TO BE BETWEEN [SEE NOTE A(ITEM 2)]
   MAX. .....LBS .....BHP AND MIN. .....LBS .....BHP
6. RECORD BOSCH SMOKE READING AT FULL LOAD AT .....RPM MUST NOT EXCEED.....
7. RECORD BHP AT:
8. RECORD FUEL CONSUMPTION AT:
9. RECORD LUB OIL PRESSURE AT: (MIN.....PSI AT MAX. RATED SPEED)
10. RECORD LUB OIL TEMP. (NOT TO EXCEED.....)
11. SEE NOTE C

SPECIAL REQUIREMENTS:

INHIBIT FOR:

NOTE A — PROTOTYPES APPROVED:

DATE:

For units marked PROTOTYPE on Sales/Work Order this Test Schedule must be deviated from as follows:-

1. Units should be run-in to prototype run-in schedule for .....RPM F.L. Speed.
2. Brake load to be between MAX. .....LBS .....BHP MIN. .....LBS .....BHP.

NOTE B MARINE ENGINES ONLY WATER TEMP "OUT" ONLY TO BE RECORDED.

NOTE C TURBOCHARGED ENGINES ONLY RECORD BOOST PRESSURE AT .....RPM
TO BE WITHIN .....INS HG AT .....RPM.

13.3000

FUEL, OIL AND COOLANT SPECIFICATIONS

FUEL OIL

1. The quality of fuel oil used for high speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life and acceptable exhaust.

2. Fuel oil should be clean and free of contamination. Storage tanks should be inspected regularly for dirt, water or water emulsion sludge, and cleaned if contaminated. Storage instability of the fuel can lead to the formation of varnish or sludge in the tank. The presence of these contaminants from storage instability must be resolved with the fuel supplier.

3. Fuel oil used in all Bedford diesel engines should be to specification BS 2869 Class "A".

TABLE 1. REQUIREMENTS FOR ENGINE FUELS

	CLASS A1	CLASS A2	Test Method	
			BS References §	Technically identical with
Viscosity kinematic at 37.8°C (100°F) centistokes ‡				
min	1.6	1.6	BS	ASTM D445-1P71
max	6.0	6.0	BS	1P41
Cetane number, min	50	45		
Carbon residue, Conradson % by weight, max	—	—	BS	ASTM D189-1P13
Carbon residue, Conradson on 10% residue % by weight, max	0.2	0.2		
†Distillation recovery at 375°C or 675°F, % by volume, min	90	90	BS	ASTM D86-1P123 (Paragraph 4)
Flash point closed, Pensky Martens, min	†55°C or 130°F	†55°C or 130°F	BS	ASTM D93-1P34
Water content % by volume, max	0.05	0.5	BS	1P74
Sediment % by weight, max	0.01	0.01	BS	ASTM D473-1P53
Ash % by weight, max	0.01	0.01	BS	ASTM D482-1P4
Sulphur content % by weight, max	0.05	1.0	BS	1P63
Copper corrosion test, max	1	1		ASTM D130-1P154
Cloud point, max				—
Summer	0°C (32°F) Mar/Nov inclusive	0°C (32°F) Mar/Sep inclusive		
Winter	†—7°C or 20°F Dec/Feb inclusive	†—7°C or 20°F Oct/Feb inclusive	BS	ASTM D2500-1P219 (See Paragraph 7)

† The alternative Celsius and Fahrenheit temperatures shown in this table are in some cases not exactly equivalent but are the closest whole number equivalents compatible with the test procedures. Such cases are indicated by the use of the term 'or' between the two values.

‡ An indication of the approximate viscosity equivalents in Redwood 1 seconds at the same temperature as given below:

Kinematic viscosity, centistokes	1.6	6.0	14.0
Redwood 1, seconds	30Φ	41	65

The figure marked Φ represents the minimum flow time permissible for the Redwood 1 viscometer. The above values must not be regarded as accurate conversions from Redwood 1 seconds to kinematic viscosities.

§ Pending publication of the appropriate BS methods, the technically identical methods listed in the table are to be used for testing against the requirements of the British Standard.

4. Fuel selected must show at least 98 per cent by volume recovery when subjected to ASTM D-86-1P 123 distillation.
5. All diesel fuel oils contain a certain amount of sulphur. Too high a sulphur content results in excessive cylinder wear due to acid build-up in the lubricating oil. For most satisfactory engine life, fuels containing less than 0.5% sulphur should be used.
6. "Table 1. Requirements for engine fuels" will serve as a guide to the selection of the proper fuel for various applications. The fuels must be clean, completely distilled, stable and non-corrosive. DISTILLATION RANGE, CETANE NUMBER and SULPHUR CONTENT are three of the most important properties of diesel fuels that must be controlled to ensure optimum combustion and minimum wear. Engine speed, load and ambient temperature influence the selection of fuels with respect to distillation range and cetane number. The sulphur content of the fuel must be as low as possible to avoid excessive deposit formation, premature wear, and to minimize the sulphur dioxide exhausted into the atmosphere.
7. During cold weather engine operation, the cloud point (the temperature at which wax crystals begin to form in diesel fuel) should be 6°C (10°F) below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.
8. At temperatures below —29°C (—20°F), consult an authorized Detroit Diesel Allison service outlet, since particular attention must be given to the cooling system, lubricating system, fuel system, electrical system and cold weather starting aids for efficient engine starting and operation.

LUBRICATING OIL

9. Three considerations must be given when selecting lubricating oils for Bedford diesel engines, these are quality, high heat resistance and control of contaminants.

Lubricating Quality

10. The reduction of friction and wear by maintaining an oil film between moving parts is the primary requisite of a lubricant. Film thickness and its ability to prevent metal-to-metal contact of moving parts is related to oil viscosity. The optimums for Bedford Diesel engines are SAE 20 or 30 weight.

High Heat Resistance

11. Temperature is the most important factor in determining the rate at which deterioration or oxidation of the lubricating oil will occur. The oil should have adequate thermal stability at elevated temperatures, thereby precluding formation of harmful carbonaceous and/or ash deposits.

Control of Contaminants

12. The piston and compression rings must ride on a film of oil to minimize wear and prevent cylinder seizure. At normal rates of consumption, oil reaches a temperature zone at the upper part of the piston where rapid oxidation and carbonization can occur. In addition, as oil circulates through the engine, it is continuously contaminated by soot, acids and water originating from combustion. Until they are exhausted, detergent and dispersant additives aid in keeping sludge and varnish from depositing on engine parts. These additives in excessive quantities can result in detrimental ash deposits. If abnormal amounts of insoluble deposits form, particularly on the piston in the compression ring area, early engine failure may result.
13. Oil that is carried up the cylinder wall is normally consumed during engine operation. The oil and additives leave carbonaceous and/or ash deposits when subjected to the elevated temperatures of the combustion chamber. The amount of deposits is influenced by the oil composition, additive content, engine temperature, and oil consumption rate.
14. Detroit Diesel Allison lubricant recommendations are based on general experience with current lubricants of various types and give consideration to the commercial lubricants available.
15. Bedford diesel engines have given the best performance and experienced the longer service life with the oil performance levels given in the table below and having the ash and zinc limits shown in paragraphs 16 and 17.

Ash Limit

16. The sulphated ash limit of all the lubricants recommended for use in Bedford diesel engines should not exceed 1.000 per cent by weight, except lubricants that contain only barium detergent-dispersant salts where 1.500 per cent by weight is allowed. Lubricants having a sulphated ash content between 0.55 and 0.85 per cent by weight have been found excellent while lubricants having a sulphated ash content above 0.85 per cent by weight are prone to produce greater deposit levels in the ring belt and exhaust valve area of the engine.

Specification	A.P.I. Letter Code	Oil Grade	Temperature Range	GM Spec
MIL-L-2104B	CC	SAE 30	Above 31°C (90°F)	4712-M
MIL-L-2104B	CC	SAE 20 or 20W	31°C to —8°C (90°F to 10°F)	4706-M
MIL-L-2104B	CC	SAE 10	—8°C to —24°C (10°F to —10°F)	4705-M

Zinc Content

17. The zinc content, as zinc diorganodithiophosphate, of all the lubricants recommended shall be a minimum of 0.07 per cent by weight.

18. Multigrade oils are not recommended, investigations with some multigrade oils indicate they do not, generally, exhibit the anti-scuffing and anti-wear properties obtained from straight SAE grade oils operating in the same conditions. Neither fuel nor oil consumption rates were improved using multigrade oils.

Oil Changes

19. The oil should be changed approximately at 100 hour intervals under normal operating conditions, but note paragraphs 20 to 23.

20. Oil change intervals are dependent upon the various operating conditions of the engines and the sulphur content of the diesel fuel used. Oil drain intervals in all service applications may be increased or decreased with experience using a specific lubricant, while also considering the recommendations of the oil supplier.

USED LUBE OIL ANALYSIS WARNING VALUES

21. The presence of ethylene glycol in the oil is damaging to the engine. Its presence and need for an oil change and for corrective maintenance action may be confirmed by glycol detector kits which are commercially available.

22. Fuel dilution of the oil may result from loose fuel connections or from prolonged engine idling. A fuel dilution exceeding 2.5 per cent by volume indicates an immediate need for an oil change and corrective maintenance action. Fuel dilution may be confirmed by ASTM D-322 test procedure performed by oil suppliers or independent laboratories.

23. In addition to the above considerations, if any of the following occur, the oil should be changed:

(a) The viscosity at 37.8°C (100°F) of a used oil sample is 40 per cent greater than the viscosity of the unused oil measured at the same temperature (ASTM D-445 and D-2161).

(b) The iron content is greater than 150 p.p.m.

(c) The pentane insolubles (total contamination) exceed 1.00 per cent by weight (ASTM D-893).

(d) The total base number (TBN) is less than 1.0 (ASTM D-664).

NOTE. The sulphur content of the diesel fuel used will influence the alkalinity of the lube oil. With high sulphur fuels, the oil drain interval will have to be shortened to avoid excessive acidity in the lube oil.

24. The lube oil filter element should be changed every 200 hours.

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

25. In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpt has been taken from a policy statement of General Motors Corporation:

26. Therefore Detroit Diesel Allison does not recommend the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, reodorants, tune-up compounds, top oils, break-in oils, graphitizers and friction-reducing compounds.

27. **NOTE.** The manufacturer's warranty applicable to Bedford Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's fuel or lubricating recommendations may not be within the coverage of the warranty.

SERVICE AND INSPECTION INTERVALS

28. Generally, operating conditions will vary for each engine application, even with comparable hours and, therefore, maintenance schedules can vary. A good rule of thumb for piston, ring, and liner inspections, however, would be 1500 hours for the first such inspection and at 1000 hour intervals thereafter.

ENGINE COOLANT

29. Engine coolant is any solution which is circulated through the engine to provide the means for heat transfer from the different engine components. In general, water containing various materials in solution is used for this purpose.

30. The function of the coolant is basic to the design and to the successful operation of the engine. Therefore, coolant must be carefully selected and properly maintained.

31. A suitable coolant solution must meet the following basic requirements:

(a) Provide for adequate heat transfer.

(b) Provide a corrosion resistant environment within the cooling system.

(c) Prevent formation of scale or sludge deposits in the cooling system.

(d) Be compatible with the cooling system hose and seal materials.

(e) Provide adequate freeze protection during cold weather operation.

32. The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When operating conditions dictate the need for freeze protection, a solution of suitable water and a permanent type antifreeze containing adequate inhibitors will provide a satisfactory coolant.

Water

33. Any water will produce a corrosive environment in the cooling system. Also, scale deposits may form on the internal surfaces of the cooling system due to the mineral content of the water. Therefore, water selected as a coolant should be properly treated with inhibitors to control corrosion and scale deposition.

34. To determine whether water is suitable as a coolant when inhibited, the following characteristics must be considered: concentration of chlorides, sulphates, total hardness and dissolved solids.

35. Chlorides and/or sulphates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium present) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these.

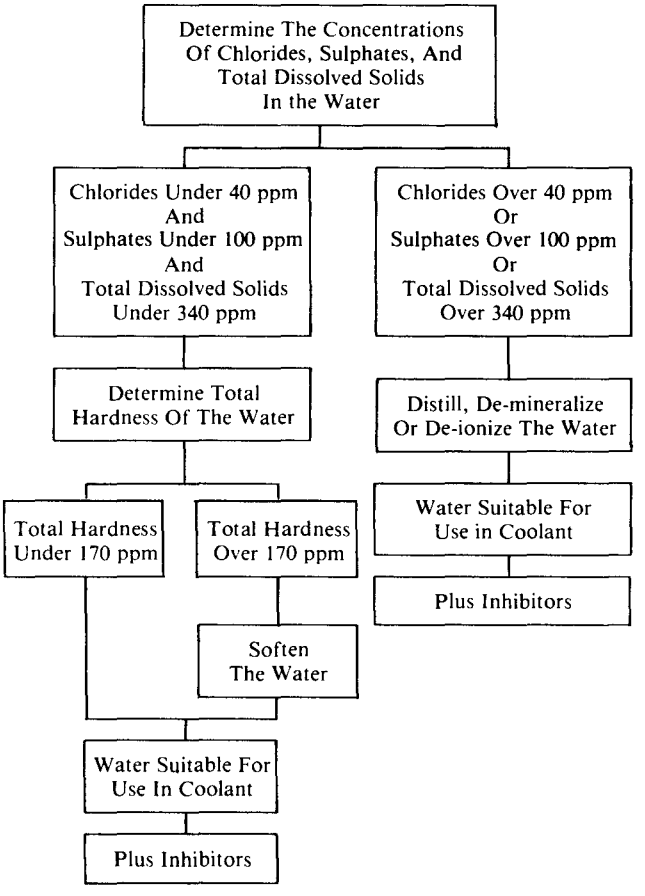
Chlorides, sulphates, magnesium and calcium are among but not necessarily all the materials which make up dissolved solids. Water, within the limits specified in tables 2 and 3 is satisfactory as an engine coolant when proper inhibitors are added.

TABLE 2

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulphates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

Refer to Table 3 for evaluation of water intended for use in a coolant solution.

TABLE 3



INHIBITOR SYSTEMS

36. An inhibitor system is a combination of chemical compounds which provide corrosion protection, PH control, and which provide water softening abilities. Corrosion protection is discussed in paragraphs 37 to 42 inclusive. The PH control is used to maintain an acid free solution. The water softening ability deters formation of mineral deposits.

37. Corrosion Inhibitors are water soluble chemical compounds which protect the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates and soluble oil. Depletion of all types of inhibitors occurs through normal operation and, therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals. Always follow the suppliers recommendations on inhibitor usage and handling.

Chromates

38. Sodium chromate and potassium dichromate are two of the best and most commonly used water system corrosion inhibitors. However, due to the toxic nature of these materials no chromate materials are now being used for ecological considerations.

39. Chromate inhibitors should not be used with permanent type antifreeze solutions. Chromium hydroxide (green slime), can result from chromate inhibitors and permanent type antifreeze. This material deposits on the cooling system passages and reduces the heat transfer rate, resulting in overheating. Engines which have operated with a chromate inhibited water system must be chemically cleaned before the addition of permanent antifreeze. A commercial heavy duty de-scaler should be used in accordance with the manufacturers recommendations for this purpose.

Soluble Oil

40. These require close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume.

41. Soluble oil is NOT recommended as a corrosion inhibitor.

Non-Chromates

42. Non chromate inhibitors (borates, nitrates, nitrides, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water and permanent antifreeze solution.

43. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives, and as an integral part of the permanent antifreeze. The system recommended for Bedford diesel engines is Nalcool 2000 which is a non-chromate liquid which is compatible both with water and Ethylene Glycol base antifreeze.

ANTIFREEZE

44. To prevent damage to the engine due to freezing of water, a reliable antifreeze solution should be added to the cooling system during cold weather conditions. Only Ethylene Glycol type of antifreeze is recommended in Bedford Diesel engines. The use of an alcohol antifreeze is not recommended as it lowers the boiling point of the coolant and causes high losses due to evaporation.

45. A 20% solution of anti-freeze will safeguard a parked engine against cracking down to approximately 35° of frost (—3°F) or —22°C).

46. Complete protection against the formation of ice crystals in the solution is afforded down to approximately 17°F (—8°C) and the engine may be put to work immediately after starting up from cold without the fear of boiling.

47. From 17°F (—8°C) down to 7°F (—14°C) ice crystals will form and the solution becomes mushy. Within this temperature range the engine can be started, but not put to work immediately after starting up from cold. To prevent any danger from boiling, the radiator should be covered and the engine run at a fast speed for at least five minutes before commencing work.
48. At temperatures lower than 7°F (—14°C) the solution will be sufficiently hard to prevent the water pump from rotating and no attempt should be made to start the engine. To avoid damage it will be necessary to thaw out the engine before starting it.
49. Where temperature conditions warrant it, a 30% antifreeze solution should be used. This will give complete protection against the formation of ice down to 5°F (—15°C) and the engine may be put to work immediately after starting up.
50. A 50% solution of antifreeze will give complete protection down to a temperature of —30°F (—36°C).
51. When topping up the cooling system, it is essential that only anti-freeze solution of the correct strength should be used. The use of plain water will dilute the solution in the system and reduce the degree of protection. Do not overfill the system.
52. Do not forget to account for cabin heater circuits when determining the quantity of antifreeze required.
53. Antifreeze tends to loosen any rust from the water passages and the cooling system should be cleaned out to prevent this occurring.
54. After completing the cleaning process, but before filling with antifreeze solution, it is advisable to check the following:

(a) Water hoses for deterioration — renew if necessary
(b) Water hose connections for tightness
(c) Cylinder head nuts for tightness.

Any leakage of antifreeze solution past the cylinder head gasket will result in a "gummed up" engine and necessitate repairs.
55. When warm weather returns, the system should be drained and the process of cleaning and flushing repeated.
56. If a water filter is in the circuit ensure the correct element is used for antifreeze solutions.

SECTION 14

ENGINE TUNE-UP

Contents

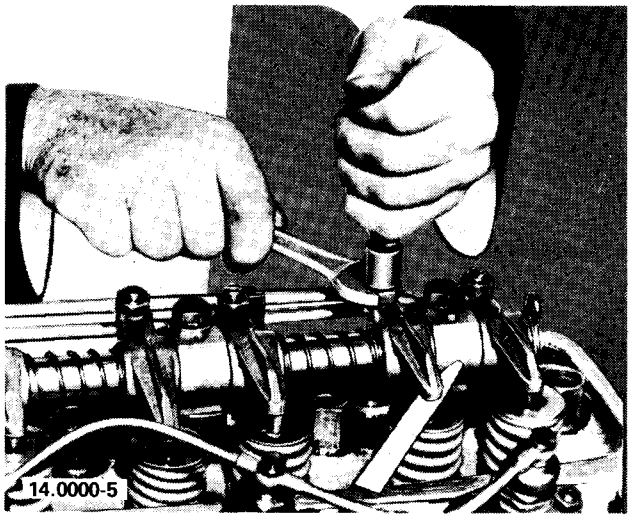
14.0000

TUNE-UP PROCEDURES

1. There is no scheduled interval for performing an engine tune-up. As long as the engine is performing satisfactorily, no tune-up should be required. Minor adjustments to valves, injectors, etc. should only be required periodically to compensate for normal wear on parts.
2. The tune-up operations listed should be carried out with the engine at normal operating temperature. Since adjustments are usually made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperatures.

VALVE CLEARANCES

3. Check the tightness of the rocker gear and check the valve clearance. To carry out these operations the engines must be thoroughly hot, and if it is not, it should be run at a fast idling speed for twenty minutes.
4. Remove the rocker cover and check the tightness of the rocker gear attachments to the cylinder head. Check the clearance between the valve stems and rocker arms with the engine running slowly. Adjustment for valve clearance is provided by a screw and nut at the push rod end of each valve rocker. The correct clearance when the engine is hot is .013 inches for all valves.
5. Insert a .013 inch feeler gauge between the end of the valve stem and the rocker arm. Slacken off the adjustment locknut and turn the adjuster by means of a screwdriver until it is nipping the gauge; then slacken it off slightly until the gauge can just be withdrawn. Finally tighten the locknut.



INJECTOR TIMING

6. The injectors must be removed periodically from the engine to check their operation and, if necessary to clean and recondition them.
7. The period at which the injectors require attention depends on so many factors that it is impossible to quote one figure that will satisfy all conditions, however in no case should the interval between checks exceed 500 hours.
8. Depending on the operating conditions, cleanliness and quality of fuel, etc., the injectors may require servicing at more frequent intervals; in general, frequent periods of idling is more detrimental to injector condition than continuous operation, but experience is the only guide.
9. The need for servicing make itself apparent in various ways and the following symptoms can be taken as evidence of the need for attention to the injectors.
   (a) Black smoke from the exhaust.
   (b) Loss of performance.
   (c) Increased fuel consumption.
   (d) Heavy "Diesel Knock" on one or more cylinders.
   (e) Complete or intermittent misfiring.

10. When any of these symptoms are observed, the injectors should be removed and checked however short the time since the last check, as running with faulty injectors may be harmful to the engine. A quick method for locating a completely inoperative injector is by slackening off the high pressure pipe union nut of an injector while the engine is idling, thus cutting out the injector. If, after slackening the union nut, the engine revolutions do not vary, it may be assumed that the injector is faulty. Do this with each injector in turn. This method will enable a quick diagnosis to be made but it should not be regarded as final proof. The only completely satisfactory means of testing is by removal of the injectors and testing on the special equipment developed for this purpose. See section 2.1000 for injector overhaul and testing.

GOVERNORS

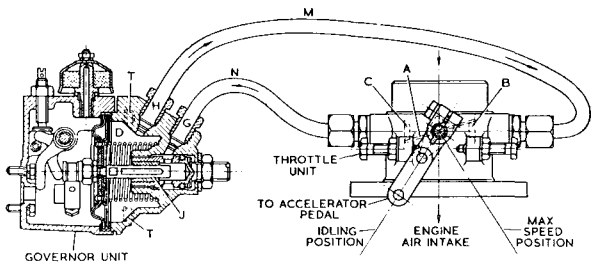
11. Several types of governors are used, dependent on the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly.
12. A list of these governors is shown in Table 1. below.

TABLE 1.

Engine	Inline Governor	D.P.A. Hydraulic Governor	D.P.A. Mechanical Governor
220	22° B.T.D.C.	—	26° B.T.D.C.
330	26° B.T.D.C.	24° B.T.D.C.	16° B.T.D.C.
330T	22° B.T.D.C.	20° B.T.D.C.	12° B.T.D.C.

TUNE-UP OF PNEUMATIC GOVERNORS

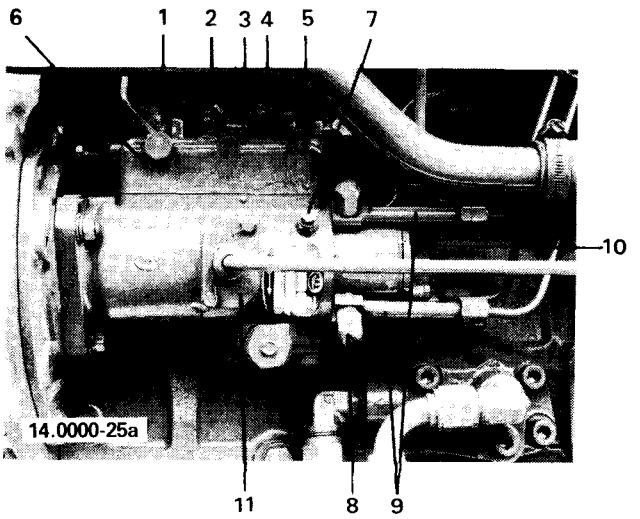
13. Adjust the exhaust valve clearances. (Paragraphs 3-5 inclusive).
14. Time the fuel injectors. (Paragraphs 6-10 inclusive).
15. Set the maximum speed stop on the throttle unit so that the engine develops the maximum specified speed, running light.



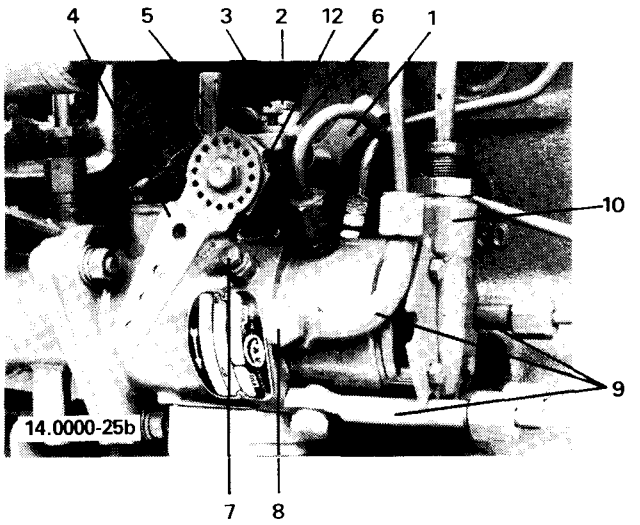
14.0000-15

A. Butterfly Throttle Valve
B. Intake Port. Engine Side of Throttle Unit
C. Outlet Port. Atmospheric Side of Throttle Unit
D. Chamber
G. Intake. Port-Governor Unit
H. Outlet. Port-Governor Unit
J. Damping Valve Guide
M. Suction Pipe-Governor Unit to Throttle Unit
N. Suction Pipe-Throttle Unit to Governor Unit
T. Governor Unit Retaining Screws (4 off)

16. Set the idling stop screw on the throttle unit to obtain slow running speed.
17. Slacken the locknut and adjust the damping valve guide 'J' until steady idling is obtained.
18. Care should be taken when adjusting the valve guide to keep the locknut finger tight against the governor housing, thus ensuring that no air leaks pass the screw threads.
19. Retighten the locknut.
20. Under no circumstances should the engine be run without the throttle unit (Venturi) inlet manifold or with either of the two suction pipes disconnected.
21. In dusty conditions of operation, the gauze pad in the air cleaners should be removed and washed in paraffin.
22. Use a new rocker cover gasket after tune-up is complete.



1. Shut Off Lever
2. Gov. Housing Vent. Screw
3. Idling Speed Screw
4. Throttle Lever
5. Maximum Speed Screw
6. Governor Housing
7. Hyd. Head Vent. Screw
8. Pressurising Valve
9. Injector Pipe Connections
10. Regulating Valve
11. Timing Cover



1. Shut Off Lever
2. Gov. Housing Vent. Screw
3. Idling Speed Screw
4. Throttle Lever
5. Maximum Speed Screw
6. Governor Housing
7. Hyd. Head Vent. Screw
8. Pressurising Valve
9. Injector Pipe Connections
10. Regulating Valve
12. Vernier Plate

TUNE-UP OF MECHANICAL & HYDRAULIC D.P.A. GOVERNORS

23. Adjust exhaust valve clearances. (Paragraphs 3-5 inclusive).
24. Time the fuel injectors. (Paragraphs 6-10 inclusive).
25. To adjust the maximum engine speed, open throttle fully and then set the engine speed to the correct specification by adjusting the stop screw. Tighten the locknut and recheck the maximum speed.
26. To adjust the idling speed, slacken the stop screw lock nut and adjust the idling stop screw until the specified idling speed is obtained. The engine is then run to three quarters maximum speed and allowed to return to idle to check that the speed remains as specified.
27. Use a new rocker cover gasket after the tune-up is complete.