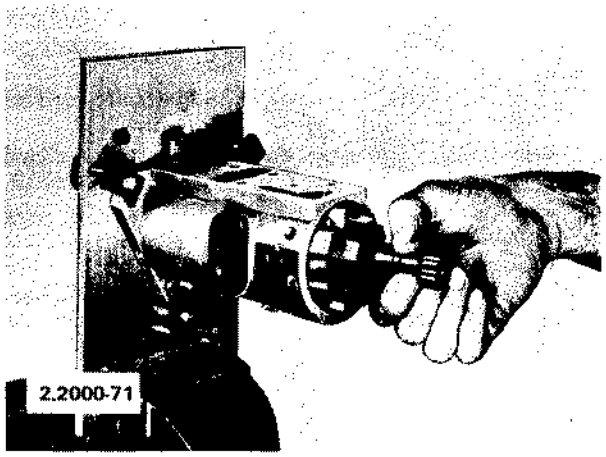
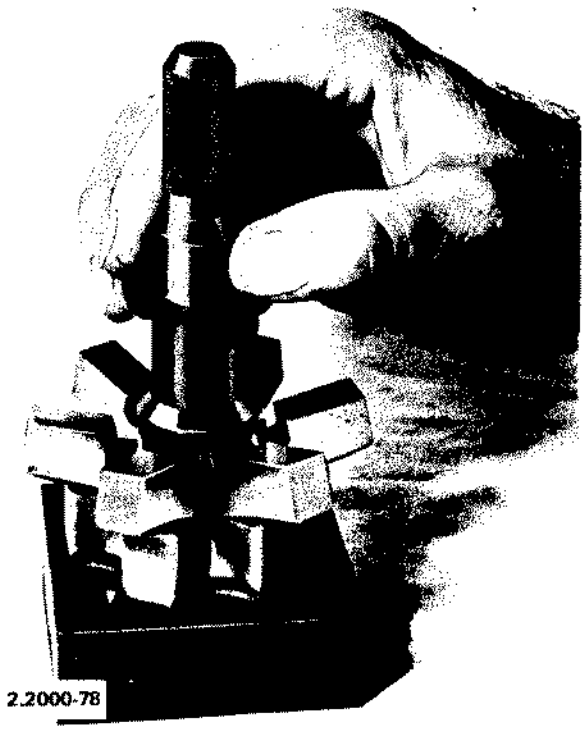
71. Withdraw the splined shaft together with the governor weight assembly.



72. Remove the 'O' seal from drive shaft and separate the weight assembly from the shaft.
73. Remove the thrust sleeve, thrust washer, and the weights from the weight carrier.
74. Withdraw the drive hub from the pump housing and extract the oil seal using Tool, Part No. 7044/893A.

75. Any parts which are showing any signs of scoring or wear should be replaced, also all seals and gaskets should be replaced with new parts.
76. Fit a new drive hub oil seal, driving it onto its seat with the special drift, Part No. 7144/260A. Insert the Perspex plug, Part No. 7144/13 in the seal. If the seal is correctly seated a continouous black line will be seen where the seal is viewed through the flanged end of the plug.
77. Pass the mandrel of Tool, Part No. 7144/894 through the weight carrier and fit the mandrel into the base plate trapping the carrier between the shoulder on the mandrel and the upper face of the base plate.
78. Place the weights in position on the upper surface of the weight carrier with the slot in each weight uppermost and nearest the mandrel. Each weight should be aligned with a carrier pocket and with its inner end resting against the mandrel.



79. Place the thrust washer and then the thrust sleeve on the mandrel, and in position against the governor weights.
80. Exert downward pressure on the thrust sleeve and the assembly will enter the weight carrier. Withdraw the mandrel and remove the assembly from the base plate of the tool.
81. Pass the drive hub through the oil seal in the pump housing, seating the hub flange against the housing.
82. With the governor weights uppermost, insert the drive shaft into the weight carrier (large threaded hole first) and fit a new 'O' seal in the groove in the surface of the shaft. Protection cap, Part No. 7044/900 should be fitted over the drive shaft splines when fitting the 'O' seal.
83. Slide the drive shaft and weight assembly into the pump housing and engage the drive shaft splines with the splines in the inner end of the drive hub. In this position the weight carrier is trapped between the end face of the drive hub and a shoulder on the drive shaft.

84. Fit the support washer in the recess between the two sets of splines in the drive hub, and secure the drive shaft to the drive hub by fitting the spring washer and socket head drive shaft screw.
85. Hold the drive hub with a special tool, Part No. 7144/773 and tighten the hub securing screw to a torque value of 285 lbs/in. using the adaptor Part No. 7144/261 and a standard torque wrench.
86. Compress the timing ring with the circlip pliers and seat it against the shoulder in the bore of the pump housing. The scribed timing mark should be positioned in the centre of the inspection aperture in the housing. Rings without a timing mark should be positioned so that the open ends of the circlip are at 180 degrees to the inspection aperture.
87. Place the cam ring in position against the timing ring. The direction indicated by an arrow on the visible face of the cam ring, should correspond with the direction of pump rotation marked on the nameplate.
88. Screw the cam advance screw into the cam ring and tighten to a torque value of 300 lbs/in. using the special adaptor Part No. 7244/125B or a socket and a standard torque wrench.
89. Place the bottom adjusting plate in position on the pumping and distributing rotor.

NOTE: In the correct position of assembly the 'cut-out' in the periphery of the adjusting plate is aligned with the 'cut-out' in the periphery of the rotor, and the eccentric slots in the adjusting plate are in line with the roller shoe guides.

90. Remove the corks retaining the twin plungers in the transverse bore in the rotor and insert the roller and shoe assemblies in the roller shoe guides. The contours of the projecting ears on the shoes should conform with the contour of the eccentric slots in the adjusting plate.
91. Fit the top adjusting plate, engaging two lugs with the bottom adjusting plate, locating the two plates one to the other with the adjusting slot co-incident with the scribed line.
92. Secure the drive plate to the end of the rotor by fitting and lightly tightening the two drive plate screws. The underside of the drive plate is recessed.
93. Fit the pumping and distributing rotor in the bore of the hydraulic head and secure by fitting and lightly tightening the transfer pump rotor.
94. Fit Tool Part No. 7144/262, to two of the high pressure outlets on the hydraulic head and connect to a nozzle testing outfit until a pressure of 30 atm. is obtained and turn the pump rotor until the plungers and the roller shoes are forced to the maximum fuel position. Set the roller-to-roller dimension in accordance with the test specification by moving the adjusting plates.
95. Hold the drive plate with Tool Part No. 7144/744 and tighten the drive plate screws to a torque value of 160 lbs./in. on plungers with a diameter up to and including 7.5 mm. using a standard torque wrench.

NOTE: For plunger diameters larger than 7.5 mm. refer to local C.A.V. dealer for torque value.

96. Disconnect the nozzle testing outfit and remove the stirrup pipe from the high pressure outlets on the hydraulic head.
97. Fit the external 'O' seal on the hydraulic head and lubricate the portion of the head which fits into the pump housing.
98. Slide the hydraulic head into the pump housing, engaging the splines on the inner end of the drive shaft with those of the drive plate. Rotate the head and rotor assembly to prevent damage to the 'O' seal as it enters the pump housing.
99. Secure the hydraulic head to the housing with the two locking screws. These screws should be left finger-tight until the advance device has been fitted.
100. Hold the drive hub with Tool, Part No. 7144/773 and tighten the transfer pump rotor to a torque value of 65 lbs./in. using Tool, Part No. 7044/889, and a standard torque wrench.
101. Fit the transfer pump liner in the counter bore in the end of the hydraulic head and the pump vanes in the slots of the transfer pump rotor. Rotate the liner to ensure that the vanes do not bind on the liner.
102. Assemble the end plate as follows:-
103. Place the priming spring in the base of the end plate chamber.
104. Fit new washer to regulating sleeve.
105. Insert the regulating piston into the bore of the regulating sleeve.
106. Holding the regulating sleeve so that the larger diameter is uppermost, insert the regulating spring above the piston and then insert the spigoted end of the sleeve plug to transfer pressure regulator if fitted.
107. Pass the nylon filter over the regulating valve assembly and insert the assembly, small end first, into the end plate ensuring that the regulating piston is retained within the regulating sleeve.
108. Fit the retaining spring.
109. Fit a new 'O' seal in the recess in the end face of the hydraulic head.
110. Engage the dowel on the inner face of the end plate with the slot in the transfer pump liner and then secure the end plate to the hydraulic head by fitting the four end plate screws. Tighten screws to a torque value of 45 lbs./in.
111. On a pump fitted with a steel end plate proceed as follows.-
Fit the sealing washer on the fuel inlet adaptor and screw it into the end plate. Tighten to a torque value of 720 lb./in. (8.2 kg.m.). Place the gauze filter in the fuel inlet adaptor and secure in place by fitting and tightening the fuel inlet connection to a torque value of 420 lb./in. (4.85 kg.m.).
112. If an aluminium end plate is fitted to the pump, then use the following assembly sequence.-
Fit a new washer to the fuel inlet connection, assemble to the end plate, and secure by tightening the fuel inlet connection to a torque value of 360 lb./in. (4.15 kg.m.)
113. Fitting the automatic advance device unit, proceeding as follows:-
114. Fit new 'O' seal to the piston spring cap, and the piston plug using protection cap, Part No. 7044/898.
115. Screw the piston plug into the device at the end where the fuel passage joins the cylinder.
116. Insert the piston in the bore of the housing with counterbored end outwards, and check for freedom of movement.
117. Fit the upper 'O' seal on the head locating fitting.

protecting the seal from damage by using the protection cap, Part No. 7044/897.

118. Place the end steel ball on its seating in the head locating fitting and then pass the fitting through the advance device housing.

119. Fit the lower 'O' seal and the washer on the head locating fitting, protecting the seal by using protection cap, Part No. 7044/18.

120. Place the sealing gasket in position against the pump housing.

121. Engage the cam advance screw with the piston, and screw the head locating fitting into the hydraulic head. The advance device housing should be drawn onto the jointing face progressively as the fitting is tightened. When a rubber jointing gasket is fitted tighten the head locating fitting to a torque value of 300 lb./in. and when a cork gasket is fitted, to a torque value of 350 lb./in.

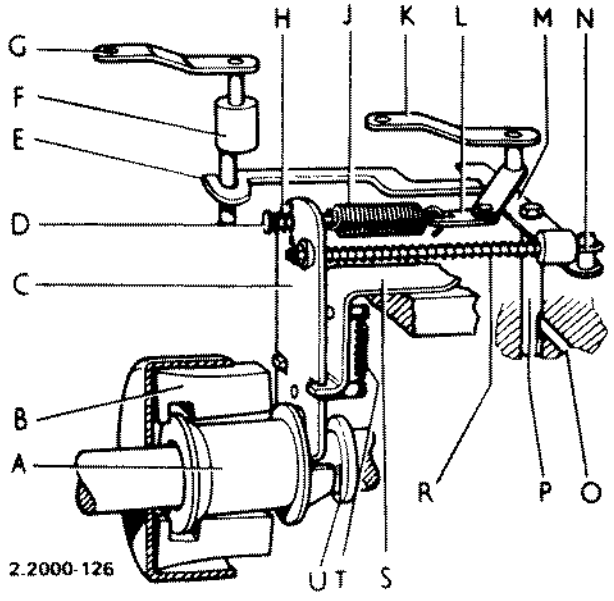
122. Tighten the two head locking screws to a torque value of 170 lb./in.

123. Check for freedom of movement, by moving the piston.

124. Insert the springs in the counterbored end of the piston and then fit the spring cap.

125. Fit the spring cap screw with the sealing washer and screw it into the spring cap.

126. Assemble the governor linkage as follows:- (annotations refer to illustration 2.2000-126).



Details for control mechanism of mechanical governor

A Thrust sleeve.	L Swivel link.
B Governor weights.	M Control lever.
C Governor control arm.	N Hook lever.
D Idling spring guide.	O Metering port.
E 'Shut-off' bar.	P Metering valve.
F 'Shut-off' shaft.	R Light spring.
G 'Shut-off' lever.	S Control bracket.
H Idling spring.	T Retaining spring.
I Governor spring.	U Drive shaft.
K Throttle lever.	

127. Engage the governor arm with the governor bracket and connect the two components with the small retaining spring.

128. Using protection cap, Part No. 7144/458A, fit the lower 'O' seals to the throttle and 'shut-off' shafts, and using protection cap Part No. 7144/459A, fit the upper 'O' seals. Pack the groove between the 'O' seals with Shell Alvania, No. 2 grease.

129. Fit the idling spring on the shank of the idling spring guide. Pass the guide through the specified hole in the governor arm and couple the governor spring to the guide. There are three holes in the governor arm; the correct hole to be used is indicated in the relevant test specification.

130. Slide the spring retaining block, the linkage spring and the spring retaining washer onto the hook lever. Pass the threaded end of the linkage hook through the governor arm, fit the pivot ballwasher and secure the assembly by fitting and tightening the securing nut.

131. Attach the hook end of the lever to the metering valve.

132. Connect the free end of the governor spring to the swivel link on the throttle shaft. Three holes are provided on the link; the one to be used is indicated in the relevant test specification or in pump code.

133. Reverse the fixture in the vice.

134. Fit the assembled governor control linkage on the pump housing, engaging the lower end of the governor arm with the thrust sleeve and inserting the metering valve into position in the hydraulic head.

135. Place the keep plate into position on the governor control bracket, and fit new tab washers on the governor cover studs. Pass the studs through the keep plate and the bracket and screw them into the pump housing to secure the governor control assembly. Lock tab washers. Fit and tighten the screw at the end of the bracket, near the metering valve.

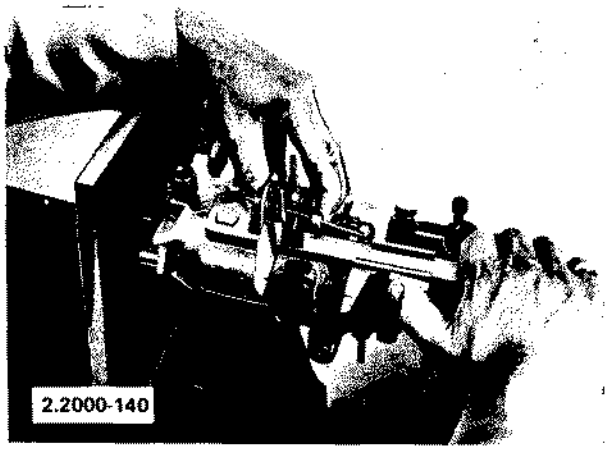
136. Fit the 'shut-off' lever. Two different types of 'shut-off' lever and 'shut-off' shaft are in general use. Levers of early manufacture were of steel strip, which was bent to engage the cranked 'shut-off' shaft. Levers of later manufacture are stamped from flat steel strip.

137. 'Shut-off' shafts of earlier manufacture have a bearing at each end in the governor control cover and in the upper face of the pump housing. Shafts of a later manufacture have a single lengthened bearing in the governor control cover.

138. 'Shut-off' levers of the 'bent-strip' type are assembled to the crank on the 'shut-off' shaft and then passed through the slot in the governor bracket.

139. When a two bearing shaft is fitted in conjunction with the more recent stamped 'shut-off' lever, it is passed under a tab on the control cover stud locking washer and must be engaged with the shaft and passed through the slot in the bracket before the stud is fitted. Later type 'shut-off' bars can be placed in position after the control bracket has been secured, and are engaged by the control shaft when the governor cover is fitted.

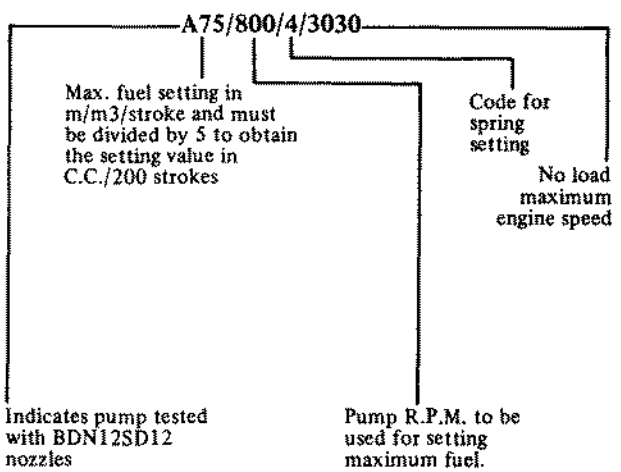
140. Set the internal dimension between one governor control stud and the metering valve lever pin to the dimension quoted in the test specification. Adjustment is made by screwing or unscrewing the nut on the end of the hook lever. Light pressure should be applied to the governor arm to hold the metering valve in the fully open position, and the vernier gauge must be held parallel to the axis of the pump.



141. Fit the spring into the correct hole on the governor arm and also the throttle link. The correct location can be determined from the following table:

Governing Arm	Throttle Arm	Code
1	1	1
1	2	2
1	3	3
2	1	4
2	2	5
2	3	6
3	1	7
3	2	8
3	3	9

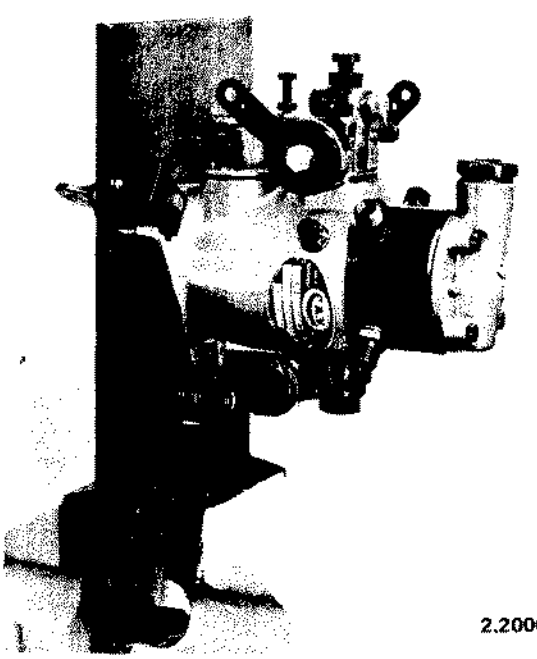
142. The correct code to which a particular pump is set can be identified by reference to the plate on the pump. EXAMPLE: The number is quoted as A75/800/4/3030. This enables the pump to be set and the engine RPM set.



143. Fit a new control cover gasket on the upper face of the pump housing.
144. If a 'shut-off' shaft with a single bearing is to be fitted, press the shaft into the control cover, using protection cap, Part No. 7144/459A to protect the 'O' seal. The peg which engages the 'shut-off' bar must be close to the inside edge of the cover.
145. Press the throttle shaft into the cover, using the protection cap, Part No. 7144/459A to protect the seals, and then slide the cover over the securing studs. Before tightening the nuts on the securing studs ensure that the crank pin of the 'shut-off' shaft is engaged with the slot in the 'shut-off' lever. Tighten the nuts to a torque value of 40 lb./in. (0.46 kg.m.).
146. Fit the control levers on the throttle and 'shut-off' shafts.
147. Replace the inspection cover complete with gasket and secure in place with the cover retaining screws.
148. The identification label on the pump indicates the correct direction of rotation of the pump. To check that the label has not been replaced upside down, hold the pump with the drive end pointing downwards. The letters and numerals on the label should then read the right way up.
149. Before fitting the fuel pump to the engine it should be tested using a suitable test machine, see page 14.

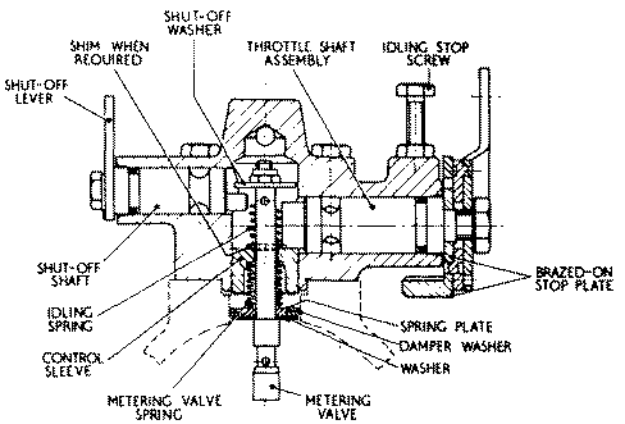
D.P.A. PUMP WITH HYDRAULIC GOVERNOR

150. Remove the adjusting cover from the pump body and drain the fuel oil.
151. Remove the quill shaft and mount the pump on the dismantling and assembly fixture, Part No. 7244/155, and secure the fixture in a vice.



152. Remove the two screws holding the governor casing to the pump casing; withdraw the governor assembly and discard the joint washer.

153. The current type reversible governors have the stop plate brazed to the throttle shaft.

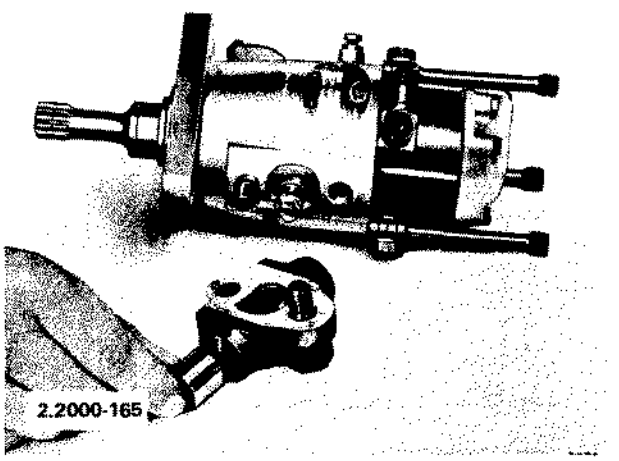


2.2000-153

154. Before dismantling an early type governor scribe a line across the edge of the stop plate, the vernier plate and the throttle lever as a guide to correct assembly. Note whether the throttle shaft is fitted on the left or right.
155. To dismantle the governor, proceed as follows:
156. Withdraw the shut-off shaft.
157. Remove the throttle shaft.
158. Withdraw the metering valve assembly.
159. Using tool, part Number 7044/895 to hold the metering valve, remove the securing nut from the upper end of the valve stem. Dismantle the shut-off washer, the idling spring if fitted, the control sleeve, the metering valve spring and the multi plate damper or the spring plate whichever is fitted.

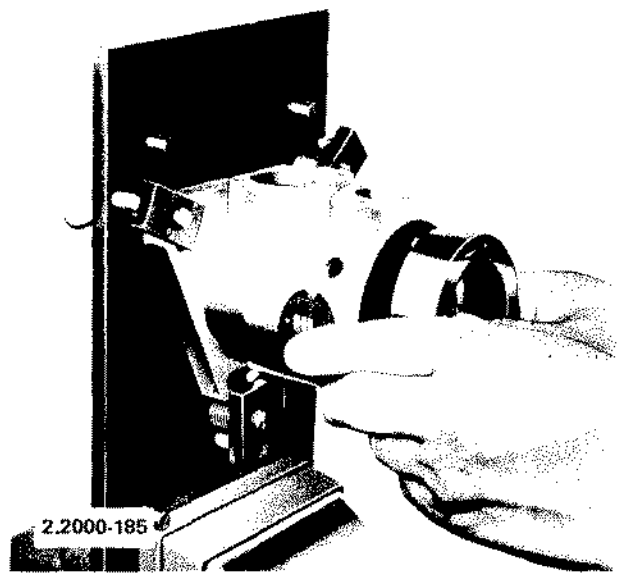
NOTE: The idling stop and the maximum speed stop screw positions are interchangeable. To avoid confusion, do not remove the screws unless renewal is necessary.

160. The advance device must next be removed, as follows:
161. Reverse the fixture in the vice, to bring the advanced device uppermost.
162. Slacken the piston plug. Remove the spring cap and springs.
163. Unscrew the head locating fitting, remove cap nut and withdraw the advance device housing as the fitting is unscrewed.
164. Remove the head locating fitting from the housing, taking care not to drop the steel ball. Remove the washer and lower oil seal.
165. Remove the piston plug and withdraw the piston.

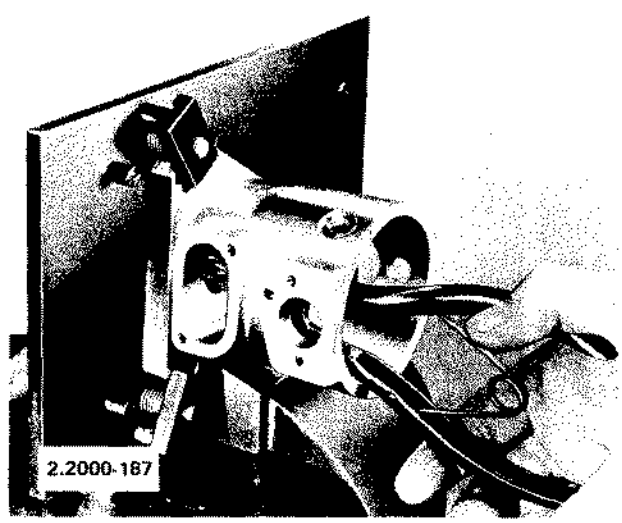


166. Remove the 'O' seal from the head locating fitting.
167. Unscrew the four screws holding the end plate to the hydraulic head, remove the end plate and the seal.
168. To dismantle the end plate, proceed as follows:
169. Remove the fuel inlet connection and the spring fitted immediately below it.
170. Remove the four hexagon head screws which secure the end plate to the hydraulic head, also the clamp plates.
171. Lift off the end plate and remove the synthetic rubber seal.
172. Invert the end plate and the complete regulating valve assembly will fall clear from the valve chamber.
173. Lift the fuel transfer pump blades from the slots in the rotor (see Fig. 2.2000-56) and withdraw the transfer pump liner.
174. Remove the pump outlet connections.
175. Hold the splined drive shaft with tool 7144/733 and using tool 7044/889, slacken but do not remove, the transfer pump rotor by turning in the direction indicated by the arrow on the rotor face. If the rotor is unmarked, slacken in the direction of pump rotation.
176. Remove the two head locking screws.
177. Remove the hydraulic head and rotor as an assembly.
178. Hold the drive plate with tool 7144/744 and slacken the two drive plate screws.
179. Remove the 'O' seal from the periphery of the hydraulic head.

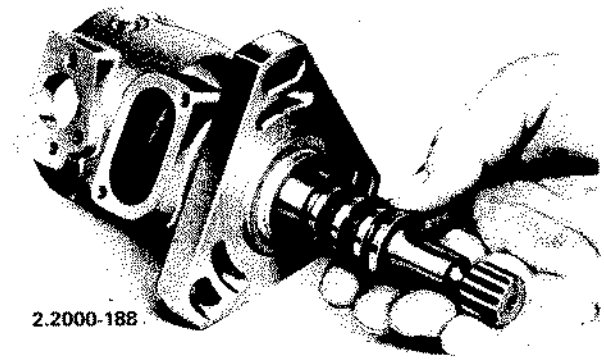
180. Remove the transfer pump rotor and separate pumping and distributor rotor from the hydraulic head. Do not allow the cam rollers to drop out.
181. Remove the drive plate screws to release the drive plate. Dismantle the top and bottom adjusting plates, the actuating rollers and the shoes from the rotor. Keep each roller with its respective shoe. Immerse the rollers and shoes in a bath of clean fuel oil to protect them.
182. Retain the twin pumping plungers in the transverse bore of the rotor by two corks inserted in place of the actuating rollers. The pump plungers are mated to the bore and should be retained therein to prevent incorrect replacement.
183. Fit the rotor in the bore of the hydraulic head to protect the working surfaces.
184. Remove the cam advance screw from the pump, using tool, part number 7244/125B. Lightly tap the advance screw before removal to free the cam ring.
185. Withdraw the cam ring.



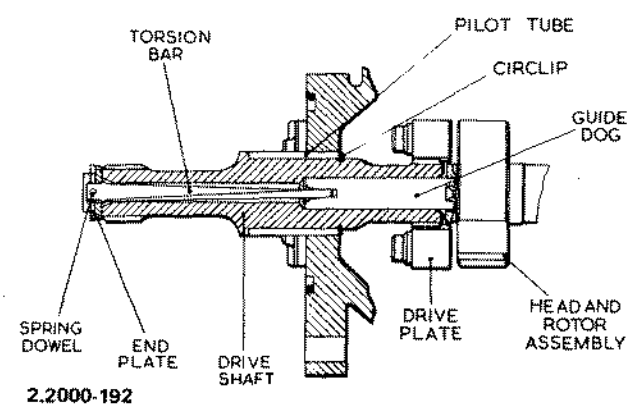
186. Compress the timing ring with circlip pliers and remove.
187. Remove the retaining circlip from the drive shaft, using circlip pliers.



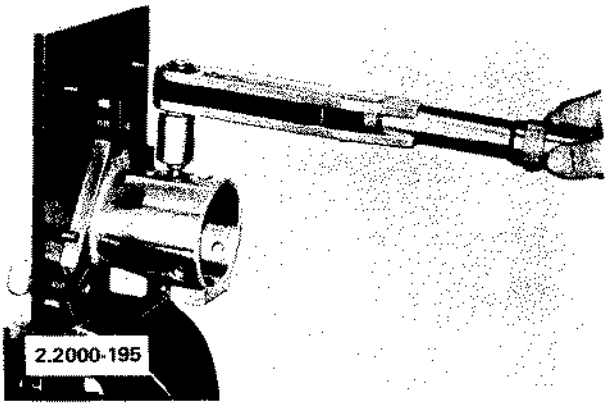
188. Withdraw the shaft from the pilot tube.



189. All dismantled parts should be kept in a covered bath of clean fuel oil until they are immediately required for reassembly. Then they must be assembled wet. Any parts showing signs of scoring or wear should be replaced also all seals and gaskets must be replaced with new parts.
190. The pump should then be assembled in the following sequence.
191. Slide the shaft into the pilot tube and secure it in position with the circlip. (No seals are fitted to the drive shaft on this type of drive).
192. Insert the guide dog, open end first, into the pump end of the drive shaft, and line up the slot in the guide dog with the master spline on the drive shaft. The torsion bar and end plate engage when fitting the pump to the engine on the test bench.



193. Compress the timing ring or circlip with the circlip pliers and seat it against the shoulders in the bore of the pump housing. Rings should be positioned so that the open ends of the circlip are at 180° to the inspection aperture.
194. Place the cam ring in position against the timing ring. The direction indicated by the arrow in the visible face of the cam ring must conform with the direction of pump rotation marked on the name plate.
195. Screw the cam advance screw into the cam ring and tighten to a torque value of 25 lb./ft. (3.45 kg.m.) using the special tool, Part No. 7244/125B and a standard torque wrench. Check the cam ring for freedom of movement after the cam advance screw has been fitted.

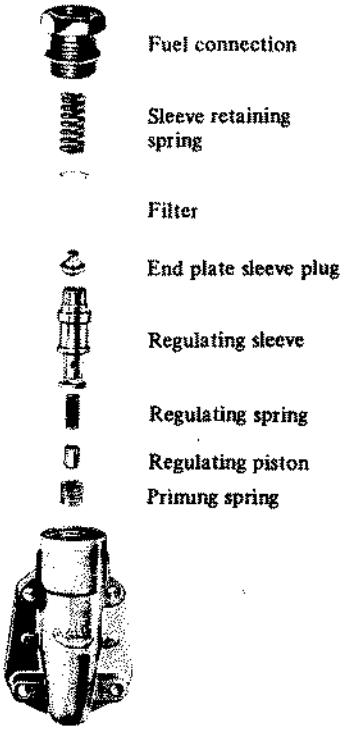


196. Place the bottom adjusting plate in position, chamfered edge uppermost, on the pumping and distribution rotor with the small cut-out in the periphery of the adjusting plate aligned with the cut-out flats in the rotor, and the eccentric slots in the plate in line with the roller shoe guides.
197. Fit the rotor in the bore of the hydraulic head, secure it by fitting and partly tightening the transfer pump rotor.
198. Remove the corks retaining the twin plungers in the transverse bore of the rotor. Insert the roller and shoe assemblies in the roller shoe guides. The projecting ears on the shoes must be placed in the eccentric slots on the adjusting plates and the contour of the ears must follow the contour of the slots.
199. Fit the top adjusting plate, engage the lugs with the cut-outs in the bottom adjusting plate, locate the two plates so that the adjusting slot coincides with the scribed line.
200. Secure the drive plate to the end of the rotor with the two drive plates screws partly tightened. The underside of the drive plate is recessed, and the holes are machined so that the plate can be assembled in only one way.
201. Fit tool No. 7144/262A to two of the high pressure outlet ports on the hydraulic head and connect it to a nozzle testing unit. Operate the nozzle testing unit to raise the pressure to 30 atmospheres. Turn the pump rotor until the plungers and rollers are forced to the maximum fuel position. Set the overall roller to roller dimension to the test specification figure by moving the adjusting plates.
202. Hold the drive plate with Tool, Part number 7144/744 and tighten the drive plate screws to a torque value of 13.3 lbs./ft. (1.85 kg.m.) where plunger diameter is up to 7.5 mm. then slacken and re-tighten to the same torque value. Drive plate screws must be tightened evenly to avoid rotor distortion which can cause sticking plungers.

NOTE: For plunger diameters longer than 7.5 mm. reference must be made to local C.A.V. dealer for torque value.

203. Disconnect the nozzle testing outfits and remove the stirrup pipe from the high pressure outlets on the hydraulic head.

204. Fit an external 'O' seal on the hydraulic head and lubricate the portion of the head which fits into the pump housing.
205. Check that the guide dog slot is aligned with the master spline on the drive shaft. Slide the hydraulic head into the pump housing and engage the drive shaft splines and guide dog with the guide plate splines and the two slots in the face of the rotor. Rotate the head and rotor assembly to prevent damage to the 'O' seal as it enters the pump housing.
206. Insert the pilot tool, Part No. 7144/508B or /508C into the metering valve bore to accurately locate the hydraulic head in the pump casing. To determine the correct pilot tool to fit the metering valve bore, examine the hydraulic head between the delivery outlets adjacent to the metering valve bore. If the number 6.375 is etched into the head use pilot tool 7144/508C. When no number is etched into the head pilot tool 7144/508B is the correct diameter for the metering valve bore.
207. Secure the hydraulic head to the housing by the two head locking screws only. Tighten these screws finger tight and remove the pilot tool.
208. Hold the drive shaft with tool 7144/773 and using tool 7044/889, tighten the transfer pump rotor to a torque value of 5.5 lb./ft. (0.75 kg.m.).
209. Fit the transfer pump liner in the counter bore in the end of the hydraulic head and the pump vanes in the slots in the transfer pump rotor. Rotate the liner to ensure that the vanes do not bind on the liner.
210. Assemble the end plate as follows:



211. Place the priming spring in the base of the end plate chamber.
212. Fit a new joint washer to the regulating sleeve.
213. Insert the regulating piston into the bore of the regulating sleeve.

214. Holding the regulating sleeve so that the larger diameter is uppermost insert the spigoted end of the sleeve plug or transfer pressure regulator if fitted.
215. Pass the nylon filter over the regulating valve assembly, small end first, into the end plate ensuring that the regulating piston is retained within the regulating sleeve.
216. Fit the retaining spring. Fit a new washer on the inlet connection, screw it into the end plate and lightly tighten.
217. Fit a new 'O' seal in the recess in the end face of the hydraulic head.
218. Engage the dowel on the inner face of the end plate with the slot in the transfer pump liner, and then secure the end plate and the clamp plates to the hydraulic head by fitting the four end plate screws to a torque value of 4 lb./ft. (.55 kg.m.).
219. Fit a new washer to the fuel inlet connection, assemble to the end plate, and secure by tightening the fuel inlet connection to a torque value of 30 lb./ft. (4.15 kg.m.).
220. To reassemble the Automatic Advance Device proceed as follows:
221. Invert the pump on the assembly fixture in the vice.
222. Fit a new 'O' seal to the piston spring cap and the piston plug, using protection cap 7044/898.
223. Screw the piston plug into the fuel passage end of the device.
224. Insert the piston in the bore of this device with the counterbored end outwards. Check for freedom of movement.
225. Fit the upper 'O' seal on the head locating fitting, protect the seal from damage with the protection cap 7044/897.
226. Place the steel ball on its seating in the head locating fitting and pass the fitting through the advance device housing.
227. Fit the 'O' seal on the head locating fitting, using the protection cap 7144/18 then fit the steel washer.
228. Place the sealing gasket in position against the pump casing.
229. Engage the cam advance screw in the piston. Screw the head locating fitting into the hydraulic head. The advance device should be drawn onto the joint face progressively as it is tightened. Fit the washer and cap nut on the advance device housing stud.
230. Tighten the head locating fitting to a torque of 300 lb./in. (3.45 kg.m.) if a rubber gasket is fitted or 350 lb./in. (4.03 kg.m.) where a cork gasket is fitted. On two bolt fitments used on later models 350 lb./in is the required torque. Tighten the cap nut to a torque of 130 lb./in.
231. Tighten the two head locking screws to a torque of 14 lb./ft. (1.95 kg.m.).
232. Move the piston to check the freedom of movement of the advance device.
233. Re-check the alignment of the head with the pilot tool.
234. Insert the springs in the counterbored end of the piston. Fit the spring cap.
235. Fit the sealing washer to the spring cap screw.
236. Tighten the spring cap and the piston plug to a torque value of 21 lb./ft. (2.90 kg.m.).
237. Assemble the governor as follows:
238. Using Fig. 2.2000 – 153 as a guide, assemble the thin bottom washer on the metering valve stem, then the dished floating washer with the open face uppermost and then the stepped damper washer with the smaller diameter uppermost. Fit the metering valve spring, the control sleeve (and the shim and idling spring if fitted) and finally the shut-off washer. Hold the metering valve with tool 7044/895 and screw the nut onto the thread of the metering valve stem and secure.
239. Insert the metering valve assembly into the metering valve orifice in the governor housing.
240. Using protection cap Part No. 7144/458A and 7244/186, fit a new 'O' seal to the throttle shaft. Insert the throttle shaft into the governor housing with the eccentric lug uppermost, and engage between the top surface of the control sleeve and the shut-off washer.
241. Fit a new 'O' seal in the shut-off shaft, using protection cap 7144/11. Fit the stop plate (if not a brazed on type), the vernier plate and the throttle arm to the throttle shaft, using the line scribed on the edge of the plate for accurate location. Ensure that the throttle shaft is not inadvertently inverted through 180°.
242. Press the 'shut-off' shaft into the housing ensuring that the 'flat' engages the lower face of the shut-off washer. This can be accomplished by pressing the metering valve stem fully into the housing when fitting the shaft.

NOTE: DO NOT fit the "shut-off" shaft so that the lug engages above the "shut-off" washer.

243. Fit the "shut-off" lever to the shaft and ensure that the shaft has not been rotated during fitting.
244. Fit a new jointing gasket on the face of the pump casing.
245. Insert the metering valve into the hydraulic head and seat the governor against the joint face on the pump casing. Check that the governor is located correctly and secure in place by fitting and tightening the two securing screws.
246. Fit new inspection cover gasket then fit and secure the inspection cover.
247. The identification label on the pump body indicates the correct rotation of the pump. To check that the label has not been incorrectly fitted, hold the pump with the drive end downwards, the lettering should then read the right way up.
248. After an overhaul both mechanical and hydraulically governed D.P.A. pumps should be subjected to the following tests. A separate test plan, quoting the dispatch numbers of the range of pumps to which it may be applied, is published for each different model manufactured.

PRESSURE TESTING

249. All pumps must be pressure tested after assembly both before and after being mounted on the test machine. This is accomplished as follows:-
250. Drain all fuel from the pump and connect an air line to the pump inlet connection. Do ensure that air supply is clean and free from water.

251. Seal off the low pressure outlet connection on the pump and completely immerse pump in a bath of clean fuel oil. On pumps fitted with the proportional pressurizing valve, which must be sealed off when pressure testing, take care not to disturb the joint between the outer connection and body of the valve which is sealed with "Loctite".
252. Raise the air pressure in the pump to 20 lb./sq. in. Leave pump immersed in oil for 10 minutes (no visual observations to be made during this period) so as to allow any trapped air in external pockets – such as the cavities in the end plate – to escape.
253. Observe for leaks after pump has been immersed for 10 minutes, if the pump is not leaking reduce the air pressure to 2 p.s.i. for 30 seconds; if there is still no leak increase the pressure to 20 p.s.i. If the pump is still leak free after 30 seconds it can be passed as satisfactory.

NOTE 1: Mechanical governor pump with single piece drive shaft and two oil seals. In addition to the above, the outer oil seal must be tested as described in Service Bulletin 6234 (SIN 12158) using tool 7144-760.

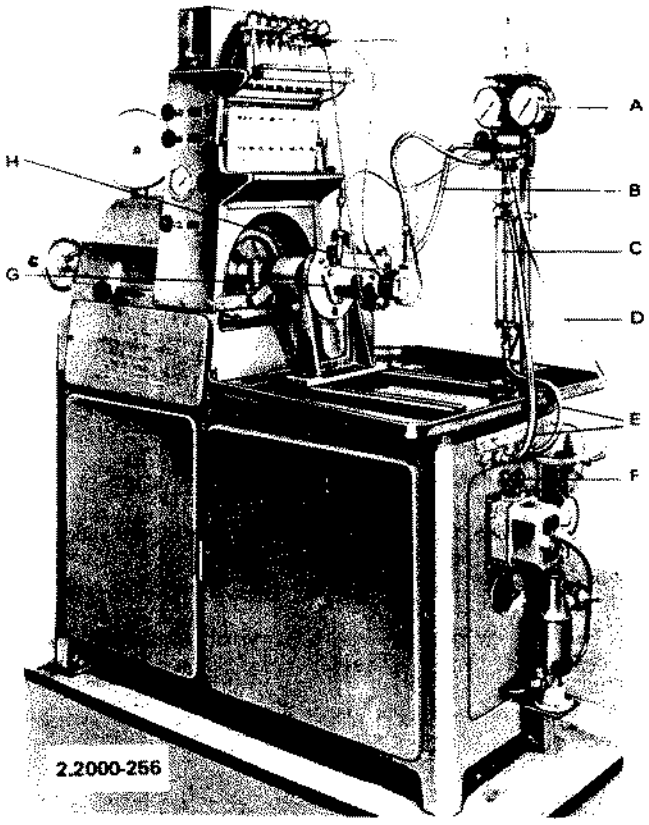
NOTE 2: Hydraulic governor pumps without drive shaft oil seal. It is necessary to stop the oil leaking past the drive shaft whilst pressure testing. Use sealing cap 7144-890 which fits over the pilot tube.

NOTE 3: Mechanically governed pumps without drive shaft oil seal. It is necessary to stop the oil leaking past the drive shaft whilst pressure testing. Tool 7144-760 may be used but it will be necessary to blank off the threaded connection (12 x 1.5 mm.) of the tool.

SEAL TESTING

254. Certain mechanically governed pumps have a single-piece drive shaft with two inward facing lipped oil seals. The gap in the circlip between the seals, line up with a tell tale hole in the pump body. The inner seal, nearest to the governor sleeve, is checked by the normal pressure test, leakage being indicated at the tell tale hole.
255. A special tool 7144/760 is used for testing the outer seal, and this consists of a flanged cylinder with three fixing studs, an air pressure connection and a sealing gasket. The tool is attached to the pump mounting flange and a supply of filtered air applied to the connection. The D.P.A. pump and the tool are immersed in a bath of fuel oil and air pressure applied at 4 lb./in.^{2} (0.28 kg./cm.^{2}) for 20 seconds. Bubbles at the tell tale hole will normally indicate an oil seal failure but first ensure that these are not caused by a faulty gasket.

CALIBRATING (see appropriate C.A.V. Test Plan on page 19-23).
256. A typical test machine, adapted for use with D.P.A. pumps is shown below incorporating the following features:



A Vacuum gauge.
B Transfer pressure pipe.
C Leakage measuring glass and cocks.
D Feed pipe.
E Return pipes.
F Fuel cock.
G Special drive adaptor.

257. A set of high pressure pipes each 34 inches (865 millimetres) in length, 6 millimetres in diameter and of 2 millimetre bore which coupled the outlet connections on the pump to matched set of injectors (type BDN 12SD12) set at 175 atmospheres opening pressure.
258. A fuel system which ensures an adequate fuel supply at constant pressure at the pump inlet. Delivery at pump inlet should be a minimum flow of 1,000 cm^3 per minute. If this figure is not obtained it is permissable to use 2 lb./in.^{2} pressure feed.
259. One pressure gauge and one vacuum gauge for testing the output and efficiency of the transfer pump.
260. The following precautions must be observed when testing the D.P.A. fuel pumps.
261. Ensure that the test machine is set to run in the corresponding direction of rotation to the pump undergoing test. Reversal of the pump prevents entry of oil and seizure may result from lack of lubrication.
262. Do not run the pump for long periods at high speed with low fuel output.

263. Do not run the pump for long periods with the 'shut-off' control in the closed position.
264. The correct test machine adaptor plate must be used. A plate with 50 mm. hole must never be used with a pump with 46 mm. spigot as seizure is probable.
265. Standard radial high pressure connections must be fitted prior to testing. Information is given in the test data and explanatory notes.
266. Prime the pump thoroughly before commencing test and at other times when indicated in the test plan.
267. To prime a pump, proceed as follows:-
268. Slacken the vent valves on the governor control casing and the head locking screw.
269. Connect the fuel feed pipe to the pump inlet; connect the back leakage pipe.
270. Turn on the fuel supply to fill the pump and run the pump at 100 rpm. When fuel oil free from bubbles issues from the vent retighten the valve.
271. Slacken the connections at the injector end of the high pressure pipes.
272. Run the pump at 100 rpm. When the fuel oil free from bubbles issues from all high pressure pipes, retighten all the connections.
273. Examine the pump after priming for oil leaks at all jointing faces, connections and oil seals. Pumps must be free from leaks both when running and when stationary.
274. Testing and adjustment are effected by carrying out the series of operations tabled in the test plan in the specified order. The purpose of each operation is indicated, and it will be noted that in addition to testing the overall efficiency of the pump, certain other functions are checked independently.

PUMP OUTPUT

275. The fuel delivery is checked at one or more speeds of rotation at full throttle by measuring the volume passing through each injector during 200 pump cycles. The pump test data quotes the average delivery, overall tolerance and the maximum permissable delivery variation (spread) between injectors.

SHUT OFF CONTROL

276. This is checked by running the pump at a specified speed (see test plan) with the 'shut-off' control closed. A maximum fuel delivery is quoted.

MAXIMUM FUEL SETTING

277. The maximum fuel delivery is checked at a specified speed, with the throttle and the 'shut-off' controls fully open. If the fuel delivery is not within the specified limits, adjust as follows:-
278. Slacken the screws securing the inspection cover and drain the pump.
279. Remove the inspection cover.
280. Slacken the two drive plate screws.
281. Engage tool, Part No. 7144/875 with the slot in the periphery of the adjusting plate.
282. Adjust the plate by lightly tapping the knurled end of the tool. The direction in which the drive plate is turned to increase or decrease fueling depends on the type of adjusting plates fitted.
283. Tighten the drive plate screws evenly to 18 lb./ft. then slacken and retighten to a direct torque of 21 lb./ft. using the adaptor 7144/482, spanner 7144/511A and a torque wrench. These torque figures are for use only when plungers up to 7.5 mm. diameter are used.
284. Replace and secure the inspection cover, refill the pump, vent as necessary and recheck the maximum fuel delivery. Repeat until the volumes are within the specified limits.

NOTE: Adaptor 7144/482 is used with the non-cranked ring spanner 7144/511 or 511A.

285. The centre of the ring spanner must be 66 mm. or 127 mm. from the centre of the adaptor.
286. The torque spanner and ring spanner must be in line when tightening the screws, and care must be taken to ensure that the spanner does not contact the side of the inspection aperture.

GOVERNOR TESTING

287. With the pump running at a speed greater than half the maximum permissible speed of the engine to which it will be fitted, the maximum speed stop is adjusted until a specified fuel delivery is obtained. The volume of fuel specified is considerably less than the volume of fuel at the maximum fuel setting.
288. The speed of rotation is then reduced and the fuel delivery should increase to a specified volume approximately equal to the maximum fuel delivery.

NOTE: Final governor setting must be carried out on the engine, using a tachometer.

TRANSFER PUMP

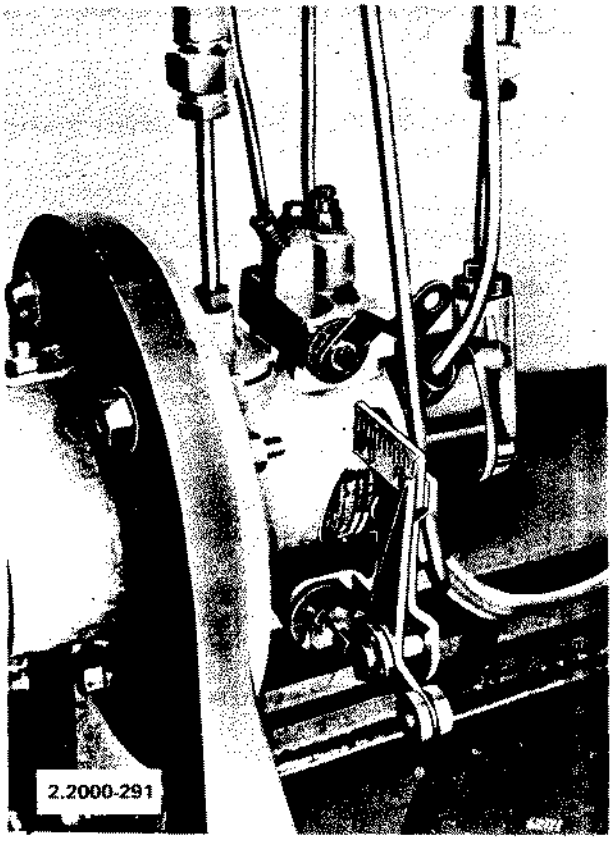
289. Transfer pump vacuum is checked while running the pump at low speed, with the two-way cock in the fuel feed pipe turned to the position which cuts off the fuel supply and connects the pump inlet to the vacuum gauge. A given depression must be attained in a specified time.

NOTE: The pump may need to be re-primed after this test.

290. Transfer pressure is checked at one or more specified speeds. A special adaptor Part No. 7044/892, is screwed into the thread normally occupied by one of the head locking screws to enable a pipe to be fitted between the pump and the pressure gauge on the test machine. Transfer pressure can thus be read directly from the gauge.

SPEED ADVANCE DEVICE

291. The operation of this device is indicated on a special tool 7244/59 which consists of a gauge with a scale covering 0–18° and a feeler pin 7244/70. To fit these tools, proceed as follows:-



292. Remove the small screw from the piston spring cap on the advance device.

293. Pass the threaded bush of the feeler pin assembly through the hole in the tool bracket.

294. Insert the end of the plunger in the hole in the spring cap and screw the bush into the spring cap hole. This will clamp the bracket between the spring cap and the shoulder on the threaded bush.

295. Zero the gauge by moving the scale relative to the pointer.

296. A specified advance must be obtained at a number of different speeds of rotation, this checking the speed at which the device becomes effective, and the speed at which full advance is obtained.

297. Adjustment is made by increasing or decreasing the thickness of shims fitted between the piston spring and the spring cap. A single shim 0.5 millimetres in thickness is fitted during manufacture and must not be removed.

298. On completion of these tests, the drive shaft screw of a mechanically governed pump must be slackened and retightened three times to the required torque value of 24 lbs./ft. (3,3 kg.m.) where screw is 28,5 mm. long, or 27 lb./ft. (3,7 kg.m.) where screw is 31,7 mm. long. This is to prevent any risk of the screw slackening in service.

TIMING

299. After testing, remove the pump from the test machine and drain by slackening the screws of the inspection cover. Tighten the screws. Connect the stirrup pipe 7144/262A (Part Number 7144/262) to the final outlet specified on the test plan and to the outlet diametrically opposite. Fit the relief valve 7144/155 (Part Number 7144/262) to the stirrup pipe and connect the complete tool through a high pressure pipe to a nozzle testing unit.

300. A pressure of 30 atmospheres applied by the pump forces the pump plungers apart as the pump is turned. Such movement brings the actuating rollers to a position where they will strike the cam lobes. When contact is made, resistance to further movement is encountered. With the pump held in this position the timing ring is moved until the scribed line on the ring is aligned with a specified mark on the drive plate.

301. The timing mark on the pump flange is made while the pump is held in the same position.

302. Tool Number 7244/26 is set to the specified indexing figure and is then engaged with the splines on the pump drive shaft. The line is scribed by passing a scriber down the scribing guide on the tool.

NOTE: When timing mechanically governed pumps, it is imperative that the pump's own quill shaft be used to compensate for any possible wear on the splines.

DPA FUEL INJECTION PUMP (Refitting)

303. Rotate the engine flywheel in the normal direction of rotation until its timing mark is aligned with the pointer in the flywheel housing timing aperture. The timing marks on the flywheel are as follows:-

U/C – Top dead centre.
2/6 – 26° B.T.D.C. 220 cu. in. engines – Mechanical governor.
1/6 – 16° B.T.D.C. 330 cu. in. engines – Mechanical governor.
2/4 – 24° B.T.D.C. 330 cu. in. engines – Hydraulic governor.
1/2 – 12° B.T.D.C. 330 cu. in. engines (turbocharged) – Mechanical governor.
2/0 – 20° B.T.D.C. 330 cu. in. engines (turbocharged) – Hydraulic governor.

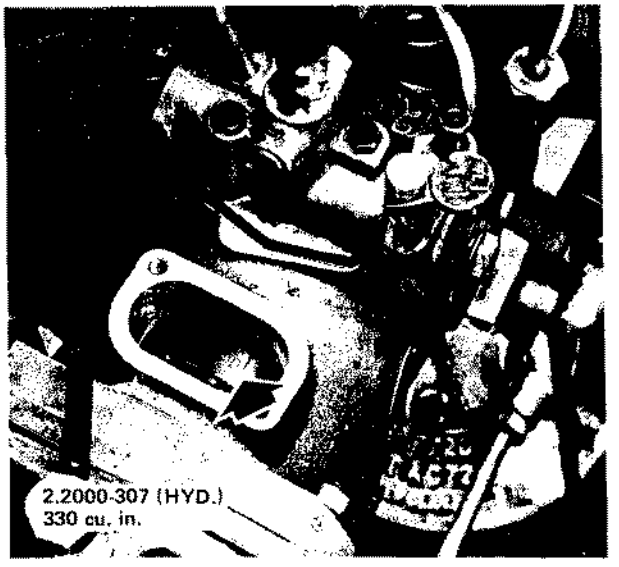
304. Fit the torsion bar into the splines on the timing gear shaft coupling, care must be taken to line up with master splines.

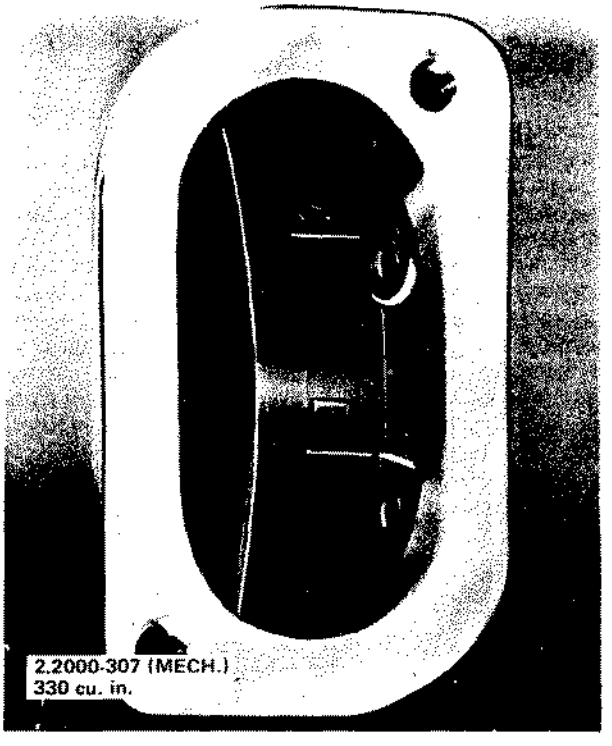
305. Rotate the fuel pump shaft in the correct direction until the master spline on the pump is parallel with the narrow edge of the torsion bar, care must be taken to ensure accurate alignment or it will prove possible to knock the peg from the coupling, this would destroy all means of accurately timing the engine.

306. Slide the fuel injection pump onto the splines, aligning it with marks on the pump carrier and fit three nuts and washers which secure the pump to the carrier bracket, do not tighten at this time.

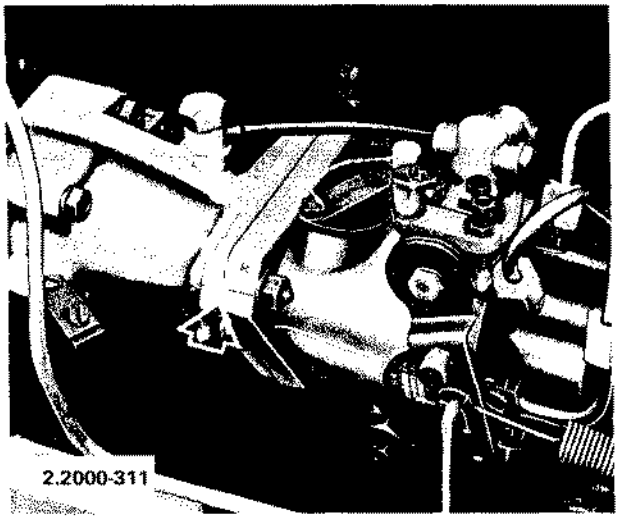
307. Remove the cover plate from the pump body and ensure that the timing mark on the pump rotor is aligned with the squared end of the circlip.

i.e. – B – 330 cu. in. hydraulic governed pump.
– D – 330 cu. in. mechanical governed pump.
– G – 220 cu. in. mechanical governed pump.





308. The engine must be held in the position detailed in paragraph 303, and the pump can be adjusted, it will be noted that the fixing studs enter into slots in the fuel pump which allows a radial adjustment. The shaft will be held in a fixed position by the engine and a radial movement of the fuel pump will enable the internal timing marks to be aligned.
309. Tighten the three pump securing nuts to a torque of 14 lbs./ft.
310. Fit the cover to the fuel pump and tighten to a torque of 7 lbs./ft., seal the two screws with wire through the two holes in the screw heads.
311. Mark the fuel pump carrier with a scribed line which will line up with the mark on the fuel pump. Should the fuel pump carrier housing already have a timing mark on, this must be eradicated before making a new mark.

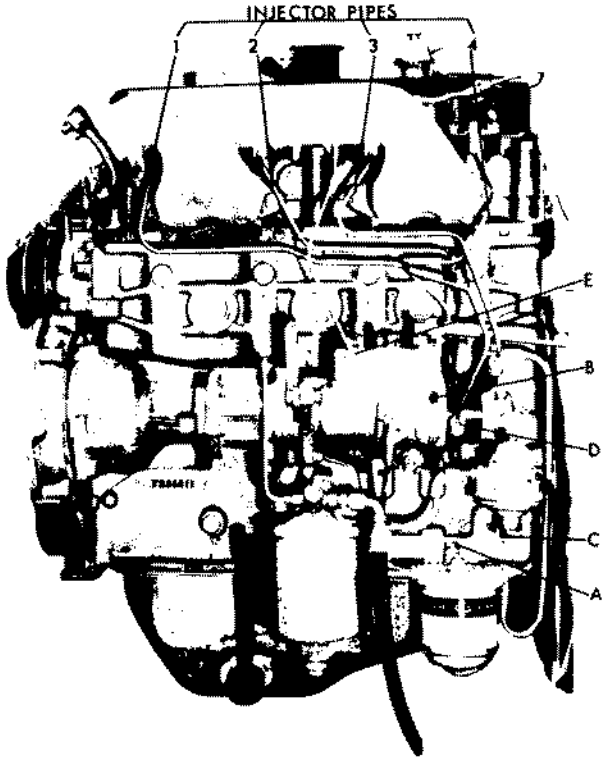


312. Refit the fuel injection pipes and fit the pipe clamps into the original positions to prevent vibrations.
313. Refit the control rods to the throttle arm.
314. Vent the entire fuel system.

PRIMING AND VENTING THE FUEL SYSTEM

315. Whenever the fuel pipe lines are disconnected, such as when cleaning or renewing the filter elements, or if the fuel tank has been allowed to run dry, it will be necessary to air vent the system before attempting to start the engine.
316. Before priming and venting the system, ensure that the vent screws and surrounding areas are thoroughly clean so that dirt or other foreign matter does not enter the system. Ensure also that the glass bowl of the pre-filter (if fitted) has been cleaned, and refilled with new fuel by operating the feed pump priming lever.
317. 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.
318. Ensure adequate fuel is within the fuel tank and stop cock is open,.
319. Paragraphs 320 to 325 refer to hydraulically governed fuel pumps and paragraphs 326 to 330 refer to mechanically governed fuel pumps.
320. Carry out the following while operating the priming lever on the fuel feed pump.
321. Slacken the injection pump feed pipe banjo screw and allow fuel to flow until free of air. Tighten the banjo screw.
322. Slacken plug in unused outlet of the main filter bleed and then tighten plug.
323. Slacken the vent screw on the injector pump hydraulic head. Slacken the vent screw on the governor housing. When fuel, free from air, flows from the two vents, first tighten the hydraulic head vent screw, then the governor vent screw.
324. Slacken the banjo screw on top of the main filter, bleed, then tighten screw. This operation should remove the air from the drive housing, the leak back pipe and the filter.

325. Slacken any two high pressure injector pipe top unions, crank the engine (which may run on the other four cylinders), tighten the unions as soon as fuel, free from air begins to flow.
326. Slacken the hexagonal headed bleed (9/16 in. A.F.) on fuel filter head (Reference A), operate priming lever, on fuel lift pump (Reference C), 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.



2.2000-326

327. Slacken the hexagonal headed bleed screw (5/16 in. A.F.) (Reference B) and operate priming lever (Reference C) until air free fuel is expelled from bleed screw. Leave ½ turn open, crank for 5 seconds, then tighten.
328. Slacken the banjo pipe attachment (Reference E) actuate priming lever until air free fuel is expelled and leave slightly slack at this point.

NOTE: Omission of this operation will materially increase cranking time.

329. Slacken one or more injector pipes at the injector end, and the fuel pump at No. 4 pressurising valve (Reference D).

330. With the slackened pipes set stop lever to run position, de-activate any automatic shut-down system and crank engine until air free fuel is expelled from the slackened pipes. Tighten all pipes to No. 4 injector and its associated pressurising valve (Reference D), and attempt to start engine by cranking, and when engine commences to run, retighten pressurising valve connection at (D) and No. 4 injector line at injector end. Operate speeder lever to required engine speed and check that no leaks exist in the fuel system. Stop engine. Wipe clean any spilt fuel on engine or equipment.

IDLING ADJUSTMENT

331. The engine idling speed is controlled by a hexagon-head stop screw which contacts the throttle control lever on the governor housing.
332. With the engine at normal operating temperature, check the idling speed with a tachometer. If necessary adjust the idling screw so that the engine idles at the specified speed.
333. On vehicles equipped with an idling control knob on the instrument panel, ensure that the knob is screwed right in and that a small clearance exists between the nipple on the control wire and the throttle control lever, before adjusting the idling speed.

MAXIMUM SPEED ADJUSTMENT

334. The engine maximum speed is set by a hexagon headed stop screw on the governor housing. This screw is encased by a cover which is sealed against unauthorised interference.
335. With the engine running at normal operating temperature, move the throttle control lever on the governor housing by hand to the maximum speed position and check the engine speed with a tachometer. If the speed is not as specified, break the seal, remove the cover and adjust the screw. It is important that the specified maximum speed is not exceeded, therefore, this adjustment must not be attempted without a tachometer. Install and seal the cover.

D.P.A. TEST DATA PLANS

Basic Pump Specifications

220 cu. in. engine with mechanically governed DPA fuel pump.

Types 3249380 to 3249760.
Hydraulic head and transfer pump liner modified to provide for self venting.
Cambox pressurising valve.
Automatic speed advance device.
Clockwise rotation (looking on drive end).
Uprated drive with floating shaft (types 3249550 to 3249769 only)
Governor link length 53.5 mm. nominal ± 1.0 mm. (Types 3249380 – 3249429 only).
Governor link length 53.5 mm. nominal ± 0.5 mm. – 1.0 mm. (Types 3249550 – 3249589 only).
Governor link length 55.0 mm. nominal ± 0.5 mm. (Types 3249760 – 3249769).
Roller to roller dimension 49.9 mm.
Plunger diameter 8.0 mm. (types 3249380 to 3249429).
Plunger diameter 9.0 mm. (types 3249550 to 3249769).

330 cu. in. engines with hydraulically governed DPA fuel pump.

Types 3266540 to 3266739.
Automatic speed advance device.
Transfer pressure adjuster.
Anti-backlash torsion bar.
Clockwise rotation (looking on drive end).
Roller to roller dimension 49.8 mm. (49.7 mm. on types 3266730 to 3266739 only).
Plunger diameter 9.0 mm.

330 cu. in. engines with mechanically governed DPA fuel pump.

Types 3268780 to 3268809.
Uprated drive with floating shaft.
Automatic start retard with speed advance device.
Clockwise rotation (looking on drive end).
Governor link length 53.0 mm. nominal ± 1.0 mm.
Roller to Roller dimension 49.9 mm.
Diameter of Plungers 9.0 mm.

Before Commencing Tests

Fit auto-advance measuring device and set the scale to zero.
Screw out anti-stall device (where fitted).
On hydraulically governed pumps, screw back transfer pressure adjuster in end plate to the minimum extent and then screw in 1½ turns minimum.

Shimming of Automatic Speed Advance Device

(1) A 0.5 mm. shim is fitted to the piston spring cap on assembly. This must not be removed.
(2) The amount of additional shimming that may be added to meet test requirements may vary from 0 to 3.0 mm.
(3) On hydraulically governed pumps, the throttle lever must point downwards. Fuel increase should be attained by a clockwise movement of the lever when looking directly upon it. The idling setting screw is therefore the one nearest to the end plate and the maximum speed setting screw is the one nearest the pump flange.

NOTE: The governor setting speed quoted is for test purposes only. The governor maximum speed screw must be finally set on the engine.

Test No.	Description	3249380 – 3249389	3249390 – 3249399	3249400 – 3249409	3249420 – 3249429	Requirements
		R.P.M.				
1	Priming	100 Max.	100 Max.	100 Max.	100 Max.	Fuel delivery from all injectors
2	Transfer pump vacuum	100	100	100	100	Note time to reach 20 ins (508 mm.) Hg. Max time allowed 20 seconds
3	Transfer pressure	100	100	100	100	11 lb/in^2 (0.8 kg/cm^2) minimum
4	Transfer pressure	800	800	800	800	65 to 80 lb/in^2 (4.6 to 5.6 kg/cm^2)
5	Cambox pressure	800	800	800	800	4 to 10 lb/in^2 (0.3 to 0.7 kg/cm^2)
6	Advance position	800	800	800	800	2¾° – 3¼° (Shim as required)
7	Advance position	1100	1100	1100	1100	3¾° – 4¼°
8	Back leakage	800	800	800	800	5 to 100 cc for 100 stroke time cycle
9	Max. fuel delivery	Set to code shown on pump Name Plate*				Delivery tolerance +0 –0.2 cc Spread between lines not to exceed 1.2 cc
10	Max. fuel delivery check	100 *	100 *	100 *	100 *	Average delivery to be not less than average at (9) minus 2.5 cc
11	Cut-off operation Shut-off lever closed	200	200	200	200	Average delivery not to exceed 0.8 cc
12	Throttle operation Throttle lever closed	200	200	200	200	Average delivery not to exceed 1.5 cc
13	Fuel delivery check	600	1300	900	1200	Record average delivery
14	Governor setting	650	1500	950	1270	Set throttle by maximum speed adjustment screw to give maximum average delivery of 2.0 cc. No line to exceed 3.0 cc
15	Fuel delivery check	600	1300	900	1200	With throttle set as at (14) average delivery to be not less than average at (13) minus 0.4 cc
	Spring position code	8	1	7	7	
16	Governor setting	At half speed stated on Name Plate set throttle to give average delivery of 2.0 cc				
		Lock stop screw				
17	Timing	Using outlet 'U' (30 atm Pressure) set timing ring to letter 'G' on Drive Plate With the pump in this position set indexing tool to 113° and scribe a line on the housing flange				
*	Use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking reading					

Test No.	Description	3249550 – 3249559		3249560 – 3249569	3249570 – 3249579	3249580 – 3249589	3249760 – 3249769	Requirements
		R.P.M.						
1	Priming	100		100	100	100	100	Fuel delivery from all injectors and control cover vent orifice
2	Transfer pressure	100		100	100	100	100	11 lb/in^2 (0.8 kg/cm^2) minimum
3	Cambox pressure	900		600 †	900	900	850 ††	6 to 10 lb/in^2 (0.4 to 0.7 kg/cm^2)
4	Advance setting	600		600	600	600	600	2¾° to 3¼° (Shim as required)
5	Full advance position	900		900	900	900	850	4¾° to 5¼°
6	Transfer pressure	900		600 †††	900	900	850 ††††	60 to 80 lb/in^2 (4.2 to 5.6 kg/cm^2)
7	Transfer pump vacuum	100		100	100	100	100	Note time to reach 20 in (508mm) Hg. Max. time allowed 20 seconds
8	Back leakage	600		600	600	600	600	5 to 100 cc for 100 stroke cycle time
9	Max. fuel delivery	Set to code shown on pump Name Plate*						Delivery tolerance +0 –0.2 cc. Spread between lines not to exceed 1.2 cc
10	Max. fuel delivery check	100 *		100 *	100 *	100 *	100 *	Average delivery to be not less than average at (9) minus 2.0 cc
11	Cut-off operation Shut-off lever closed	200		200	200	200	200	Average delivery not to exceed 0.8 cc
12	Throttle operation Throttle lever closed	200		200	200	200	200	Screw back anti-stall device and lock. Average delivery not to exceed 1.0 cc
13	Fuel delivery check	900	750	600	1270	1100	850	Record average delivery
14	Governor setting	960	810	640	1450	1170	900	Set throttle by maximum speed adjustment screw to give max average delivery of 2.0 cc. No line to exceed 2.5 cc. Lock stop screw
15	Fuel delivery check	900	850	600	1270	1100	850	With throttle set as at (14) average delivery to be not less than average at (13) minus 0.4 cc
	Spring position code	5	7	1 & 2	4	4	7	
16	Governor setting	At half speed stated on Name Plate set throttle to give average delivery of 2.0 cc						
		Lock stop screw						
17	Timing	Using outlet 'U' (30 atm. pressure) set timing ring to letter 'G' on Drive Plate With pump in this position set indexing tool to 113° and scribe line on Housing Flange						
*	Use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking reading							
†	5 to 10 lb/in^2 (0.35 to 0.7 kg/cm^2)							
††	6 to 11 lb/in^2 (0.4 to 0.8 kg/cm^2)							
†††	45 to 65 lb/in^2 (3.2 to 4.6 kg/cm^2)							
††††	58 to 78 lb/in^2 (4.1 to 5.5 kg/cm^2)							

Test No.	Description	3268780 – 3268789	3268790 – 3268799	3268800 – 3268809		Requirements
		R.P.M.				
1	Priming	100 Max.	100 Max.	100 Max.		Fuel delivery from all injectors
2	Transfer pump vacuum	100	100	100		Note time to reach 16 in (406 mm) Hg Max time allowed 60 seconds
3	Transfer pressure	100	100	100		11 lb/in^2 (0.8 kg/cm^2) minimum
4	Advance position	200	200	200		4¾° to 5¼°
5	Transfer pressure	700	700	700		48 to 62 lb/in^2 (3.4 to 4.4 kg/cm^2)
6	Advance position	700	700	700		8¼° to 8¾°
7	Advance position	1000	1000	1000		9½° to 10½°
8	Transfer pressure	1000	1000	1000		58 to 72 lb/in^2 (4.1 to 5.1 kg/cm^2)
9	Back leakage	800	800	800		5 to 50 cc for 100 stroke time cycle
10	Max fuel delivery	Set to code shown on pump Name Plate*				Delivery tolerance +0 –0.2 cc Spread between lines not to exceed 1.2 cc
11	Max fuel delivery check	100 *	100 *	100 *		Average delivery to be not less than average at (10) minus 1.5 cc
12	Cut-off operation Shut-off lever closed	200	200	200		Average delivery not to exceed 1.0 cc
13	Throttle operation Throttle lever closed	200	200	200		Average delivery not to exceed 0.8 cc
14	Fuel delivery check	930 500 710	1100 750 1000	1000 1000 1300		Record average delivery
15	Governor setting	980 560 760	1180 820 1100	1140 1120 1460		Set throttle by max. speed adjustment screw to give maximum average delivery of 2.0 cc. No line to exceed 3.0 cc
16	Fuel delivery	930 500 710	1100 750 1000	1000 1000 1300		With throttle set as at (15) average delivery to be not less than average at (14) minus 0.4 cc
	Spring position code	3,6 4,7 1,2,5, 8,9	4 7 1	4 7 1		
17	Governor setting	At half speed stated on Name Plate set throttle to give average delivery of 2.0 cc				
		Lock stop screw				
18	Timing	Using outlet 'Y' (30 atm. pressure) set timing ring to letter 'D' on Drive Plate. With pump in this position set indexing tool to 331° and scribe line on Housing Flange.				
*	Use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking reading					

Test No.	Description	3266540 – 3266549	– 3266569	3266570 – 3266579	3266730 – 3266739	Requirements
		R.P.M.				
1	Priming	100 Max	100 Max	100 Max	100 Max	Fuel delivery from all injectors
2	Transfer pump vacuum	100	100	100	100	Note time to reach 16 in. (406 mm.) Hg Max. time allowed 60 seconds
3	Transfer pressure	100	100	100	100	11 lb/in² (0.8 kg/cm²) minimum
4	Transfer pressure	600/800 †	800 †	700 †††	800 ††	40 to 55 lb/in² (2.8 to 3.9 kg/cm²)
5	Transfer pressure	1100/ –	–	–	–	60 to 75 lb/in² (4.2 to 5.3 kg/cm²)
6	Transfer pressure Throttle lever fully open	1300/1100**	–	900***	1100**	Close cut-off lever to stop pump delivering. Set end plate pressure adjuster to give 35 lb/in² (2.5 kg/cm²) higher than (5)
7	Advance position Cut-off lever fully open	700	700	700	700	3° to 3½° (3¼° to 3¾° on 3266730 – 3266739)
8	Advance position	1300	1300	1300	1100	5¾° to 6½° (4¾° to 5¼° on 3266730 – 3266739)
9	Back leakage	800	800	800	850	5 to 70 cc for 100 stroke time cycle
10	Max fuel delivery	Set to pump code shown on pump Name Plate*				Delivery tolerance +0 – 0.2 cc Spread between lines not to exceed 1.0 cc
11	Max Fuel delivery check	100 *	100 *	100 *	100 *	Average delivery to be not less than average at (10) minus 1.2 cc (1.0 cc on 3266730 – 3266739)
12	Cut-off operation Throttle lever fully open	200	200	200	200	Average delivery not to exceed 0.8 cc
13	Throttle cut-off operation with cut-off lever fully open	200/ –	–	–	–	It must be possible to adjust the idling screw and position the throttle lever to give an average delivery not exceeding 1.0 cc
14	Fuel delivery check	1100/1000	1000	1100	1200	Record average delivery
15	Governor setting	1300/1250††††	1250††††	1250††††	1400††††	Set throttle by max. speed adjustment screw to give maximum average delivery of 1.8 cc. No line to exceed 2.8 cc
16	Fuel delivery check	1100/1000	1000	1100	1200	With throttle set as at (15) average delivery to be not less than average at (14) minus 0.4 cc
17	Transfer pressure Throttle lever fully open	1300/1100	1100	900	1100	Close cut-off lever to stop pump delivering. Set end plate pressure adjuster to give (see table) higher than (5)
18	Governor setting	See table ††††				Set throttle by maximum speed adjustment screw to give maximum average delivery of 1.8 cc. No line to exceed 2.8 cc. Lock max. speed screw.
19	Timing	Use outlet 'Y' (30 atm pressure), set timing ring to letter 'B' on Drive Plate. With pump in this position set indexing Tool to 336° and scribe line on Housing Flange.				

Note: on tests 3, 4 & 5, end plate sleeve plugs of different thickness are available to vary the load on the regulating spring.
Final transfer pressure and governor setting are related to the coding details shown on the pump name plate and must be obtained from the following table.

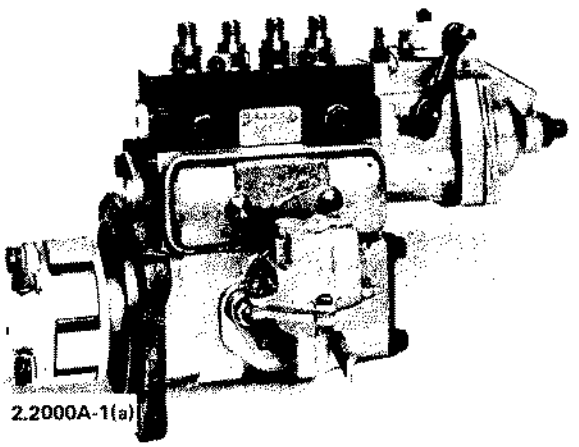
Coding details shown on pump name plate	Test 17 Transfer pressure difference	Test 18 Governor setting R.P.M.	Coding details shown on pump name plate	Test 17 Transfer pressure difference	Test 18 Governor setting R.P.M.
A53/800/0/3000	35 lb/in² (2.5 kg/cm²)	1400	A53/800/0/2530	36 lb/in² (2.5 kg/cm²)	1160
A53/800/0/2070	30 lb/in² (2.1 kg/cm²)	940	A53/800/0/2900		
A66/800/0/3070	35 lb/in² (2.5 kg/cm²)	1430	A52/850/0/3000	36 lb/in² (2.5 kg/cm²)	1400
A44/800/0/2600	36 lb/in² (2.5 kg/cm²)		A50/800/0/2530	36 lb/in² (2.5 kg/cm²)	
A51/800/0/2600	35 lb/in² (2.5 kg/cm²)		A52/850/0/2900		
A66/800/0/2464	36 lb/in² (2.5 kg/cm²)		A66/850/0/3070		

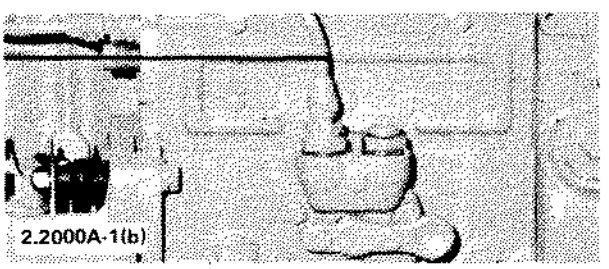
*	Use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking reading.
†	48 to 62 lb/in² (3.4 to 4.4 kg/cm²).
†††	45 to 59 lb/in² (3.1 to 4.1 kg/cm²).
††	44 to 62 lb/in² (3.1 to 4.4 kg/cm²).
**	Set end plate pressure adjuster to give 36 lb/in² (2.5 kg/cm²) higher than (4).
***	Set end plate pressure adjuster to give 30 lb/in² (2.1 kg/cm²) higher than (4).
††††	Set throttle by max. speed adjustment screw to give maximum average delivery of 1.5 cc. No line to exceed 2.5 cc.

2.2000A

FUEL INJECTION PUMP INLINE TYPE

INLINE TYPE FUEL INJECTION PUMP (Description)
1. The Inline type of fuel injection pump used on 220 cu. in. engines is manufactured by Simms (a), while that used on 330 cu. in engines is manufactured by C.A.V. (b).

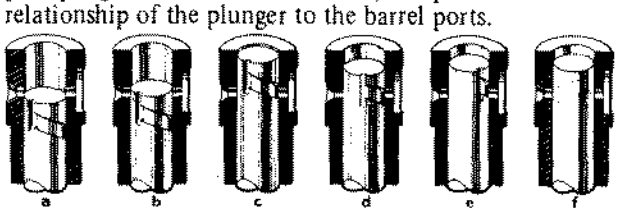

2.2000A-1(a)


2.2000A-1(b)

2. Both types of pump are of the cam operated spring return plunger design with a separate pumping element for each cylinder of the engine. The elements are arranged in line and operated vertically by the camshaft and roller tappet arrangement within the pump housing.
3. The injection pump has an eccentric on the camshaft to operate the fuel lift pump.
4. A pneumatic or mechanical type of governor can be fitted, the choice being dependent on the application for which the engine will be used.

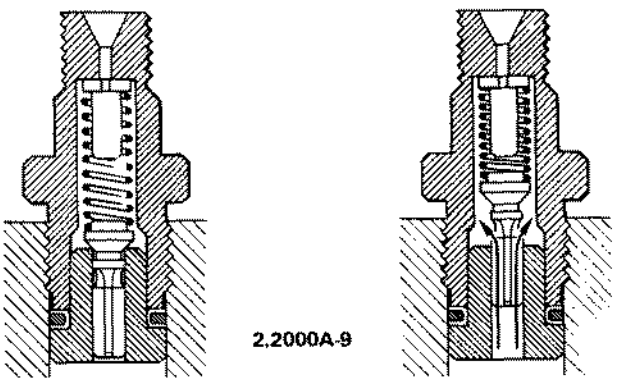
Operation of C.A.V. In-line Fuel Pump

5. Fuel is supplied from the fuel lift pump to a fuel oil filter, after which it enters the fuel injection pump body and then the pump element, where the fuel is pressurised and fed via pipes to the injectors.
6. The stroke of each element plunger is constant and determined by the pump camshaft; the effective pumping movement however, depends on the relationship of the plunger to the barrel ports.



2.2000A-6

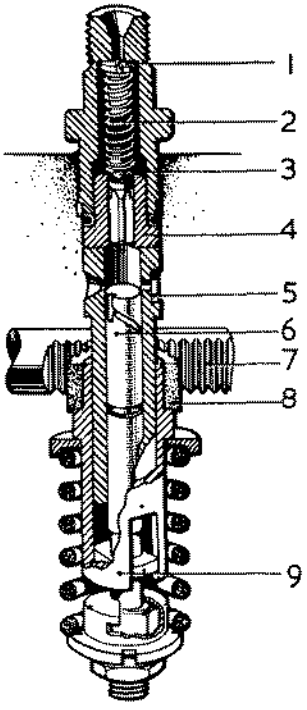
7. When the plunger is at the bottom of its stroke (see 'a' 2.2000A-6), fuel under pressure in the pump gallery flows through the two ports to fill the interior of the barrel.
8. As the plunger moves upwards, some of this fuel is forced out of the ports, until the plunger reaches the position shown at 'b' (2.2000A-6) when both ports are covered.
9. At this point further upward movement of the plunger increases the pressure on the fuel and causes the delivery valve to be opened, and the fuel enters the pipe connected to the injector.


2.2000A-9

Closed Open

10. The pipe and drillings in the injector are kept constantly filled, by previous operations of the plunger and delivery valve, and the extra fuel forced in raises the pressure in the pipe until it is sufficient to lift the injector valve off its seat. This enables the fuel to be discharged as an atomised spray from the holes in the injector nozzle and penetrate the compressed air charge in the combustion chamber.
11. The fuel discharge continues until the edge of the helical plunger recess uncovers the spill port (see 'c' 2.2000A-6) when the fuel in the barrel flows down the vertical slot in the plunger and returns through the spill port to the fuel gallery.
12. The resulting drop of pressure in the barrel allows the delivery valve to close (see 2.2000A-9). In closing the delivery valve draws a small quantity of fuel out of the pipe connected to the injector. This reduces the residual pressure in the pipe and enables the injector valve to snap quickly on its seat, thus preventing dribble into the combustion chamber.
13. The effective stroke of the plunger is varied by the movement of the pump control rod, which simultaneously rotates all the plungers within their barrels, so that a wide or narrow section between the top of the plunger and the helical groove is in alignment with the spill port. Commencement of fuel delivery is therefore constant, but the end of the delivery stroke will depend on the load and speed at which the engine is operating. At 'c', 'd' and 'e' (2.2000A-6) a plunger is shown in the position for full load, half load and idling speeds respectively, whilst at 'f' the plunger is in the position required to stop the engine.
14. To enable the correct intervals between the commencement of delivery of fuel from the plungers to be maintained, the plungers can be raised or lowered by the adjustable tappets. Adjustment of the plungers to

ensure an equal delivery of fuel for a given control rod position is effected by slackening the quadrant clamp screw and turning the plunger within the barrel. These operations, known as phasing and calibrating, call for a high degree of skill by specially trained personnel and the use of specialised equipment, and should not otherwise be attempted.



1. Spring Peg.
2. Spring.
3. Delivery Valve.
4. Delivery Valve Seat.
5. Barrel.
6. Plunger.
7. Control Rod.
8. Quadrant.
9. Sleeve.

2.2000A-14

Operation of Simms Inline Fuel Pump

15. The Simms fuel injection pump operates on the same principle as the C.A.V. pump but there are some exceptions. Fuel delivery is controlled in the conventional manner by the helix on the element plunger, but instead of having a vertical slot on its periphery the plunger is drilled along its axis. Rotation of the plungers to vary the amount of fuel delivered is effected by forks clamped to the control rod and engaging arms projecting from the lower ends of the plunger.

16. Calibration is effected by slackening the clamping screw in the control fork and moving the latter along the control rod. Adjustment of the tappets for phasing the pump is carried out by exchanging spacers of graded thickness. These spacers are secured in the top of the tappet by a circlip. Clearance between the bottom of the plunger and the tappet is controlled by the use of bottom spring plates of graded thickness.

Inline Fuel Injection Pump (Removal)

17. Thoroughly clean the area of engine which surrounds the fuel injection pump, this will prevent the ingress of dirt into the fuel system.

18. Slacken the pinch bolt on the fuel pump coupling, access to this bolt is obtained through the coupling housing, it may be found necessary to rotate the engine before a spanner can be fitted.

19. Remove all fuel pipes to the fuel injection pump and lift pump. Care should be taken to ensure that no dirt enters the pump when the pipes are disconnected. Also remove the throttle linkage or pneumatic pipes as appropriate.

20. The two vertical bolts located underneath the fuel injection pump support at the governor end must next be removed. Do not take the bracket from the engine or the fuel injection pump will be left unsupported.

21. Remove the four bolts which secure the fuel injection pump to the coupling housing and withdraw the fuel pump from the engine. It may prove necessary to lever the coupling from the timing gear shaft, this will avoid any undue strain on the coupling.

22. Remove the key from the timing gear shaft.

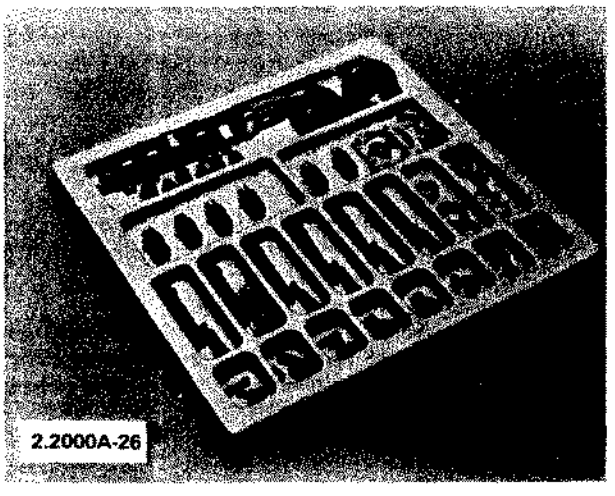
Inline Fuel Injection Pump (Inspection & Overhaul)

23. **Dismantling, assembly, testing and adjustment of the pump are operations which demand the services of specially trained personnel and the use of certain special tools and test apparatus.**

24. Fuel injection equipment is manufactured to extremely fine tolerances and for this reason the components must be kept perfectly clean and not contaminated with dirt.

25. Ideally, the bench top should have a surface of either linoleum or zinc plate, if these are unobtainable a surface which can be easily cleaned and then covered with greaseproof paper.

26. It is important that all components pertaining to each element should be kept together in a separate container, filled with clean test oil to facilitate correct reassembly. These components include barrel and plunger, plunger spring, lower spring disc, delivery valve and guide, delivery valve holder and tappet etc.



2.2000A-26

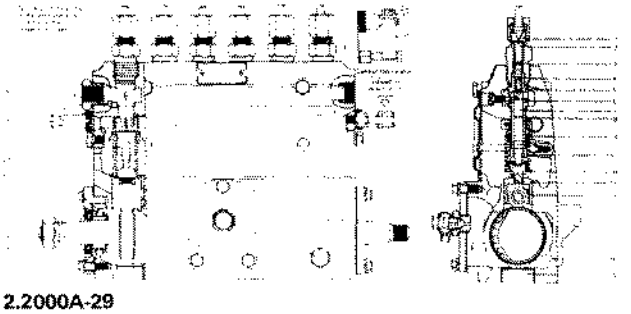
27. Under no circumstances should any component come into contact with files or scrapers, the use of grinding paste is also to be avoided.

C.A.V. Inline Fuel Injection Pump

28. A calibration check should be carried out prior to dismantling, see page 8.

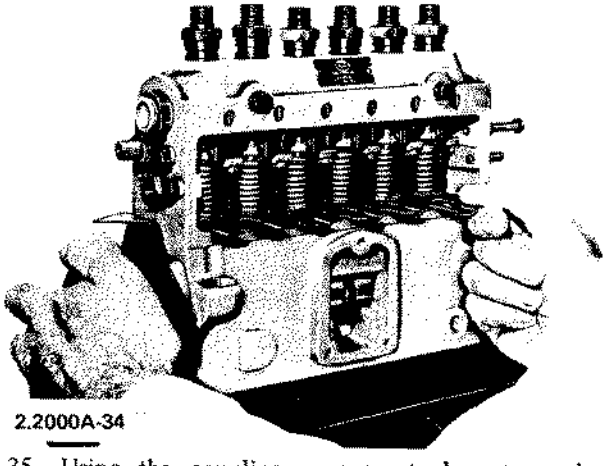
29. Annotations refer to 2.2000A-29.

1 Delivery valve holder
2 Delivery valve spring peg
3 Delivery valve spring
4 Delivery valve
5 Delivery valve seat and joint washer
6 Barrel locking screw and washer
7 Plunger
8 Plunger barrel
9 Upper spring plate
10 Plunger spring
11 Lower spring plate
12 Tappet assembly
13 Tappet adjusting screw and locknut
14 Pump housing
15 Base sealing cup
16 End plate
17 Oil seal
18 Camshaft
19 Key
20 Oil seal shim
21 Camshaft bearing
22 Camshaft shim
23 Cover plate
24 Drain plug and washer
25 Control sleeve
26 Control rod
27 Control quadrant
28 Inspection cover
29 Guide block bolt
30 Tab washer
31 Guide block



2.2000A-29

30. Remove drain plug and washer (24) and drain the lubricating oil from the lower chamber of the pump housing (14).
31. Remove the inspection cover (28) from the pump housing.
32. Remove the feed pump or cover plate (23) and the excess fuel device if fitted.
33. Mount the pump on the base plate, tool part number 7044-6A and secure in a bench vice with the pump housing vertical.
34. Turn the camshaft (18) and when each tappet assembly (12) reaches maximum height insert a tappet lifter, tool part number 7144-122, between the lower spring plate (11) and the locknut on the tappet assembly (12).

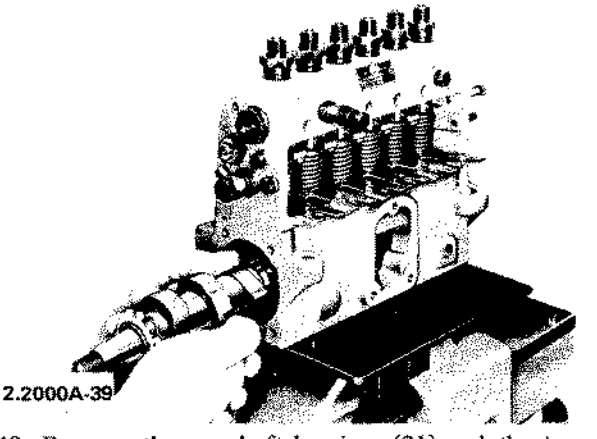


2.2000A-34

35. Using the coupling spanner, tool part number 7044-11, to hold the pump half-coupling, unscrew the camshaft nut with a box spanner.
36. Remove the half-coupling with the coupling extractor, tool part number 7044-8 and remove key (19).
37. From the coupling end of the camshaft remove the four bolts, spring washers and end plate (16).

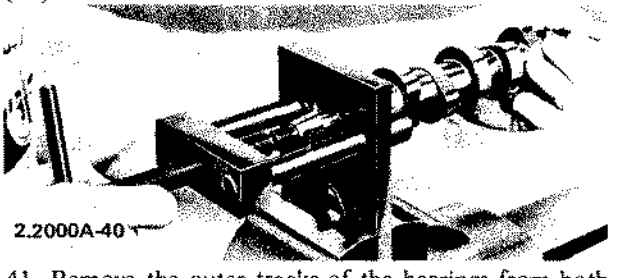
NOTE: The position of the small notch on the end of the camshaft; this must be located at the same end of the pump on assembly. If the camshaft assembly is at variance with the nameplate symbol its application must be checked with the test data sheet.

38. Remove governor, this is detailed on page 11 for mechanical or page 14 for pneumatic governors.
39. Withdraw the camshaft (18) complete with bearings (21) from the pump housing.



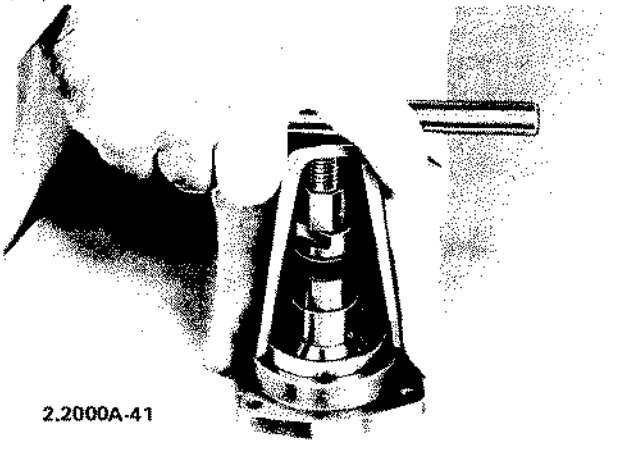
2.2000A-39

40. Remove the camshaft bearings (21) and the inner tracks of the bearings from the camshaft using the extractor tool part number 7144-436A. Note end position and thickness when removing camshaft shims (22).



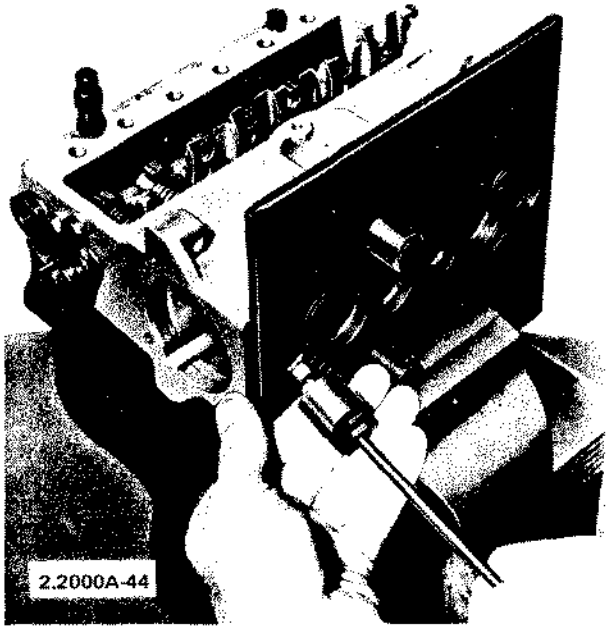
2.2000A-40

41. Remove the outer tracks of the bearings from both end plates using the collet type extractor, tool part number 7144-436B and then remove the oil seal shims (20).



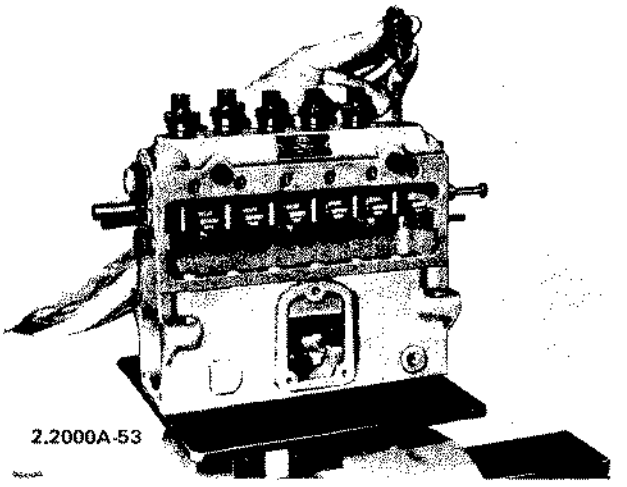
2.2000A-41

42. Turn the pump to a horizontal position, inspection window uppermost and securely lock the base plate in the bench vice.
43. Using tool part number 7044-815A tap the base sealing cups (15) into the cambox and remove.
44. Holding the tappet assembly (12) with the tappet holder, tool part number 7144-743A exert an upward pressure and withdraw tappet lifter and then the tappet assembly.

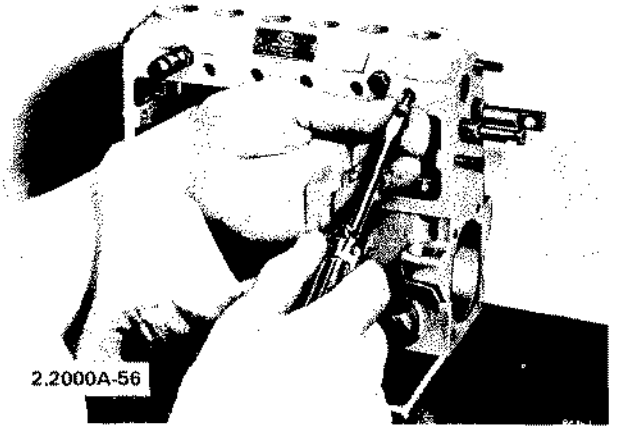


45. With the element plunger forceps, tool part number 7044-569, withdraw the plunger (7) and lower spring plate (11) through the base sealing holes.
46. Immerse the plunger (7) in a bath of clean test oil to protect the surfaces from damage. Place each plunger in sequence for assembly to its mated barrel.
47. Withdraw the plunger spring (10) and upper spring plate (9).
48. Keep the control quadrant (27) locked to the control sleeve (25) and do not disturb the setting.
49. After disengaging the control quadrant and sleeve assembly from the control rod (26) slide the assembly from the plunger barrel (8).
50. During complete dismantling it is convenient to carry out sequence 44 for each cylinder in turn, followed by 45, 46, 47, 48 and 49 in a similar manner, keeping the components of each element assembly together in a small clean container.
51. Turn the pump housing to the vertical position and securely lock in the bench vice.
52. Remove guide block bolt (29), tab washer (30) and guide block (31), and slide the control rod (26) from the pump housing.

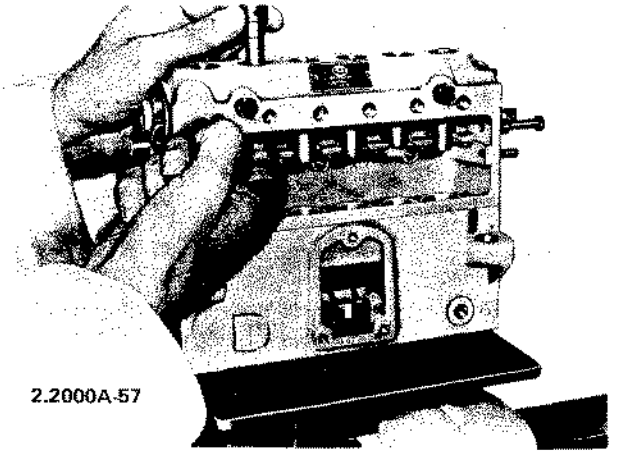
53. Carefully unscrew the delivery valve holder (1) of each element from the pump housing and withdraw the delivery valve spring (3), delivery valve spring peg (2) and delivery valve (4).



54. Remove delivery valve seat and joint washer (5) using the delivery valve extractor, tool part number 7144-903C.
55. Assemble each delivery valve (4) to its mated delivery valve seat (5) and immerse in clean test oil to prevent damage.
56. Unscrew and remove barrel locking screw and washer (6).



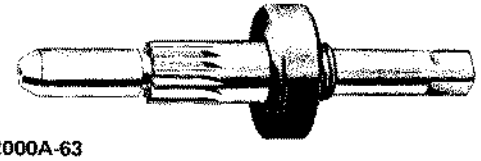
57. Push plunger barrel (8) upwards and withdraw from pump housing. Ensure the element bore is undamaged by this operation.



58. Assemble each plunger to its mated barrel and immerse in clean test oil.
59. When a pump is completely dismantled thoroughly clean all components. Do not use abrasive or fluffy cleaning materials.
60. The pump components should be inspected for scoring, pitting, corrosion and excessive wear. Discard defective parts.
61. The following components should be carefully inspected for signs of overheating and must be changed if this has taken place:-

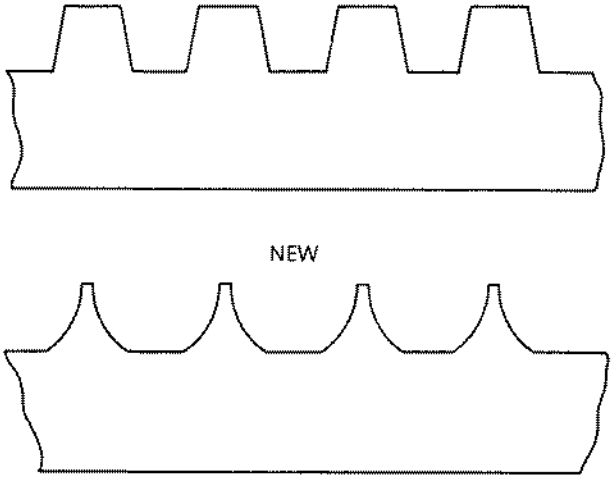
the camshaft, camshaft bearings, outer and inner tracks, tappet rollers and bearings.

62. At each overhaul fit new oil seals, gaskets and sealing washers.
63. The barrel seats in the pump housing must be inspected for pitting or other signs of damage. If the surfaces are damaged or scored they should be **lightly skimmed** with the element barrel seat cutter, tool part number 7144-202. The minimum of material should be removed during this operation and in no circumstances must this exceed 0.25 mm. total depth.



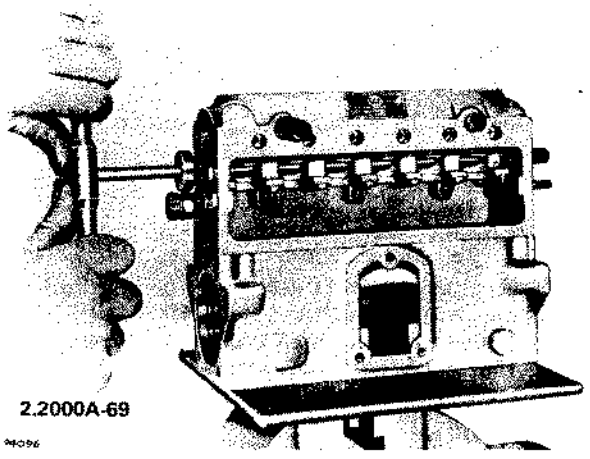
2.2000A-63

64. Check the control quadrant and control rod for excessive wear on the teeth which gives the appearance of knife edging.



2.2000A-64 WORN-KNIFE EDGE

65. Control rod bushes must be checked for wear and ovality by fitting a new control rod. Comparison of the sliding fits will show the state of the bushes.
66. If necessary worn bushes can be extracted after the locking rings have been removed with the bush locking key, tool part number 7044-658 and by using the control rod bush extractor, tool part number 7144-632.
67. New control rod bushes and locking rings can be assembled and secured using tools part numbers 7144-632 and 7044-658, and must then be reamed in-line. The freedom of the control rod depends on the accurate alignment of the bushes. The final fit must permit the control rod to slide easily, but not loosely in the bushes.
68. A special long shanked reamer, tool part number 7044-563 is used in conjunction with two reamer guides, tool part numbers 7044-562 and 7044-562A. These guides differ only in external diameter, 7044-562A being the smaller, is a snug fit in the new bush before reaming and 7044-562 a snug fit after reaming.
69. Reamer guide 7044-562A is fitted into one control rod bush. The shank of the reamer is then passed from the outside through the further bush, the pump housing and the core of the guide. Secure a wrench to the shank of the reamer and ream by carefully drawing-and-rotating in direction of the cutting edges through the bush.



2.2000A-69

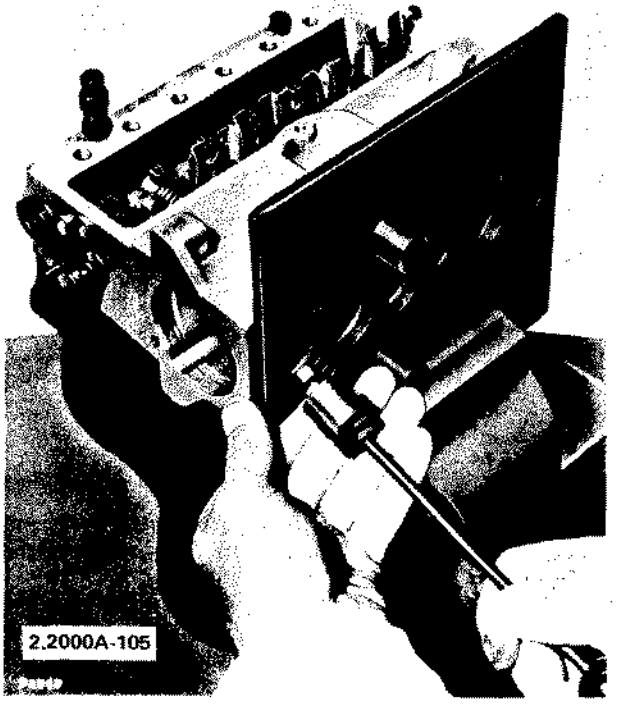
70. This operation is repeated at the opposite end using the larger reamer guide 7044-562 fitted in the newly reamed bush. On completion remove all swarf from the pump housing.
71. When checking the elements, all plungers should normally slide down the barrels under their own weight.
72. Thoroughly clean all components and prior to assembly drain and dip in clean test oil. Do not use cotton waste or cloth wipers of any kind.
73. Mount the pump housing on the base plate, tool part number 7044-6A.
74. Secure in a bench vice with the pump housing vertical.
75. Fit the plunger barrel (8) into its appropriate pump housing bore with the vertical groove in alignment with the barrel locking screw hole.
76. Assemble barrel locking screw and washer (6) ensuring they engage in the plunger barrel grooves before tightening. When tightened it should still be possible to move the plunger barrels (8) vertically until the locking screws contact the end of the groove.
77. Fit a new joint washer to the delivery valve and seat (5), seating each assembly on the upper face of the plunger barrel (8) by lightly tapping it into position using a dummy delivery valve holder and mallet.

78. Care must be taken to ensure that the delivery valve and seat are located squarely.
79. A dummy delivery valve holder is made by machining the lower thread off a spare delivery valve holder till the holder is an easy sliding fit into the pump housing bore.
80. Assemble the delivery valve spring peg (2) and delivery valve spring (3) into each delivery valve holder (1) and screw into position by hand.
81. Using a torque spanner tighten all the delivery valve holders to 54 Nm (5.5 kg.m. or 40 lb.ft.) when the pump is cold.
82. Turn the pump to a horizontal position, inspection window uppermost.
83. Dip each plunger (7) in clean test oil and using the element plunger forceps, tool part number 7044-569, carefully insert the plungers into their mating plunger barrels (8) gently rotating each one several times. Rotation must be free, without binding.
84. Put a piece of plastic or other suitable material over the tappet bores to prevent the plungers from falling out.
85. At this stage of the assembly, the pressure test for the element barrel seat leakage and pump housing porosity can be carried out.

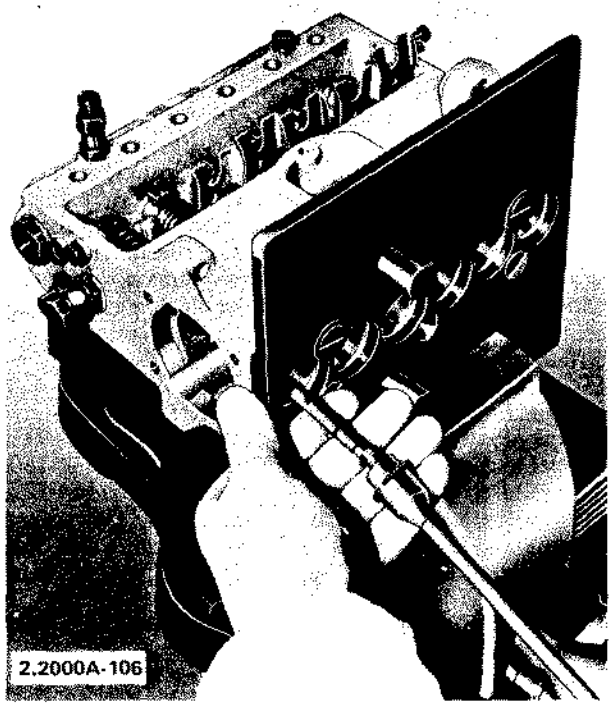
Barrel Seat Leakage & Pump Housing Porosity Test
86. Connect an air line to the fuel feed inlet.
87. Blank off any openings in the fuel gallery which allow air to escape into the atmosphere.
88. Turn on the air supply. Make sure the pressure does not exceed 207 kN/m^2 (2.1 kg/cm^2 or 30 lb/in^2).
89. Immerse the pump in a bath of clean test oil and examine the housing and barrel seat for leakage.
90. Air bubbles will indicate the position of fuel leakage points and these must be cured before proceeding further with the assembly. A slight leak past the plunger can be ignored.

NOTE: When it is necessary to skim the barrel seats, remove only a light skim of material which must not exceed 0.25 mm. using the element barrel seat cutter, tool part number 7144-202. (Fig. 2.2000A-63).

91. If an air supply is not available carry out the following procedure using a C.A.V. nozzle setting outfit.
92. Change the setting outfit standard gauge for a 1379 kN/m^2 (14.1 kg/cm^2 or 0 to 200 lb/in^2) gauge.
93. Wipe off all oil from the housing and connect the nozzle setting outfit to the pump fuel inlet using a suitable adaptor. Blank off all vents subsequent to venting the system.
94. Pump the nozzle testing outfit up to a pressure of 207 kN/m^2 (2.1 kg/cm^2 or 30 lb/in^2).
95. Examine the housing for signs of oil leakage and repair as necessary.
96. When the leakage test is satisfactorily completed remove the pieces of plastic covering the tappet bores and withdraw all plungers keeping them in their correct sequence.
97. Mount the pump horizontally in the bench vice, inspection window uppermost.
98. Slide the control rod (26) into the control rod bushes and assemble the guide block (31) tab washer (30), guide block bolt (29) and tighten.
99. Centralise the control rod (26) lengthways in the pump housing by aligning the drill indentations equidistant at each end with the pump housing.
100. If the control quandrants (27) have been removed from the control sleeves (25), they should be assembled, taking care that the scribed lines on the sleeve and quadrant are aligned before the clamping screw is tightened. The quadrant lug should be in line with the adjusting holes on the quadrant sleeve. New quadrants will not be scribed and the clamping screw heads should always be positioned towards the governor.
101. Holding the quadrant lugs vertical, slide the control sleeve assembly onto the plunger barrel (8) engaging the teeth of the quadrant and control rod so that the quadrant is in mid travel position.
102. Check that the control rod has complete freedom of movement after fitting each sleeve.
103. Slide the upper spring plate (9) onto the top of the control sleeve (25) and seat it against the shoulder in the pump housing.
104. Assemble the plunger springs (10) in position against the upper spring plates.
105. Dip in clean test oil and assemble the lower spring plates (11) and plungers (7) to their mated barrels, through the pump housing base sealing holes, using the element plunger forceps, tool part number 7044-569.



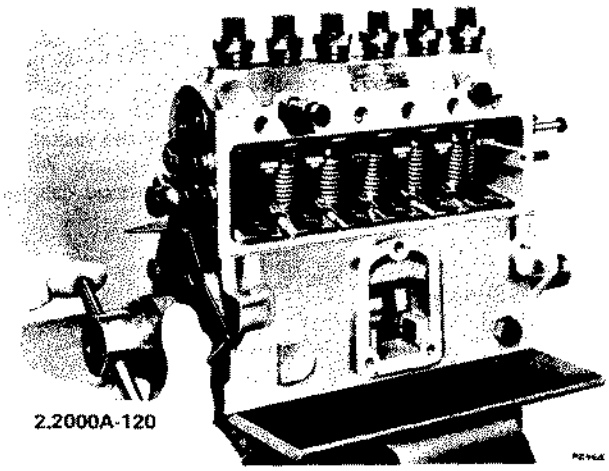
106. Using the tappet holder, tool part number 7144-743A, align the tappet assembly (12) in a horizontal position with the tappet bore in the pump housing.



107. Engage the hexagon of the head clearance adjusting screw on the tappet assembly (12) with the hexagon in the bore of the lower spring plate (11).
108. Correctly assembled, the plunger helix will be at the front facing the inspection window.
109. Press the tappet assembly upwards against the plunger spring until it is possible to insert a tappet lifter, tool part number 7144-122, under the lower spring plate (11). Withdraw the tappet holder.

NOTE: Operations 101 to 107 are applied to each element.

110. Assemble new oil seals (17) to both end plates. Replace the oil seal shims (20) and press in the outer tracks of the camshaft bearings.
111. Assemble the camshaft end float adjustment shims (22) of equal thickness to each end of the camshaft (18).
112. Fit the bearing inner tracks to the camshaft (18).
113. Press the camshaft bearings (21) onto the bearing inner tracks.
114. Assemble and secure the governor housing or one end plate to the pump housing.
115. With reference to the test data sheet locate the small notch on the camshaft at the correct end of the pump.
116. Fit protection cap, tool part number 7044-684 and pass the camshaft through the pump housing end plate without damaging the oil seal.
117. Remove the protection cap and fit it to the opposite end of the camshaft.
118. Slide remaining end plate over the protected camshaft without damaging the oil seal and secure with spring washers and bolts.
119. Remove the protection cap from the camshaft.
120. Check the camshaft end float using the camshaft end play gauge, tool part number 7044-634.



121. The camshaft end play gauge consists of a steel barrel and thimble. The barrel is graduated from 1 to 10 mm. The thimble is graduated in hundredths of a mm.

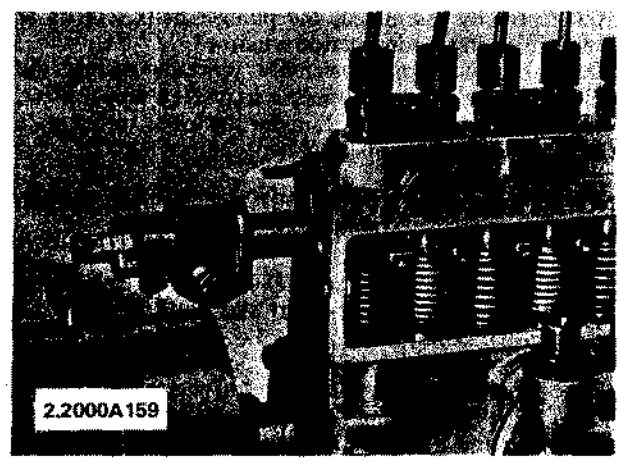
Operation
122. Turn the thimble to zero on the barrel and screw the gauge securely onto the end of the camshaft.
123. Strike the end of the gauge squarely and firmly with a hide mallet to position the camshaft at the further end of its movement.
124. Turn the thimble till it lightly touches the end plate and take a reading.
125. Strike the opposite end of the camshaft squarely and firmly with a hide mallet.
126. Turn the thimble clockwise until it lightly touches the end plate and take a second reading.
127. The difference between the two readings gives the dimension of the camshaft end float.
128. The end float must be within 0.05 to 0.15 mm., and is controlled by the thickness of the shims between the inner bearing tracks and the shoulders on the camshaft. Make sure the full end float of the camshaft is measured.
129. If shimming is required, it must be arranged equally at each end of the camshaft.
130. When the end float is within the specified limits turn the camshaft several times by hand to ensure it is free.
131. With the key (19) securely fitted into the slot in the camshaft (18), assemble the half-coupling and secure with spring washer and nut, using the coupling spanner, tool part number 7044-11 and box spanner.
132. Complete the assembly of the governor if fitted.
133. Withdraw the tappet lifters after rotating the camshaft till each cam is top dead centre for each element.
134. Turn the camshaft by hand and at the same time move the control rod backwards and forwards through its full travel. There must be no tightness or binding with the control rod or camshaft in any position.

135. For convenience the plunger head clearance can now be set, for details see section on Phasing.
136. Fit a new set of base sealing cups (15) into the pump housing base using the base closing plug punch, tool part number 7044-815A.
137. The base sealing cups must be inserted by the shouldered end of the punch to ensure they are set to the correct depth in the pump housing base.
138. Remove the pump from the assembly plate.
139. Assemble the blanking cover plate (23) drain plug and washer (24) and the excess fuel device, if specified.
140. Assemble the inspection cover (28) and a new gasket. Use Cascosel M1168 adhesive to fix the gasket to the cover before assembly to the pump housing. When Cascosel is not available a good quality grease can be used.

Adhesive Supplied by:
ARABOL EDWARDSON ADHESIVES LTD
RIVERSIDE HOUSE
AMWELL END
WARE
HERTS.

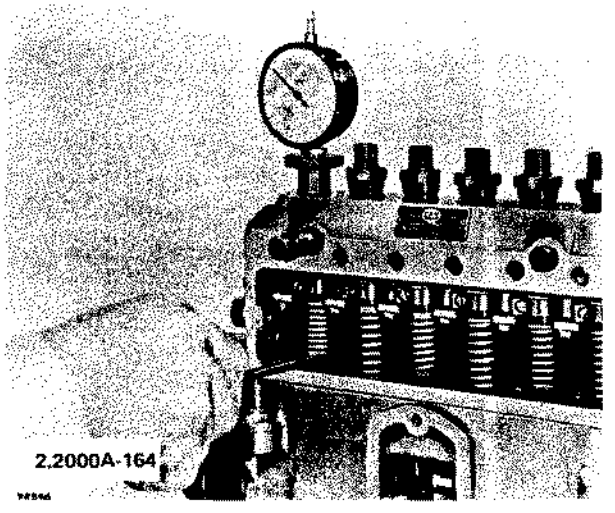
PUMP TESTING
141. The injection pump must accurately meter minute quantities of fuel under all conditions of engine load and speed, and it must deliver the fuel to each cylinder at the exact time at which the engine requires it. To ensure these functions are carried out efficiently, each C.A.V. fuel injection pump is tested and accurately adjusted before it leaves the works.
142. The final setting is indicated by a line scribed across each quadrant and control sleeve.
143. After a pump has been overhauled it should be tested and re-adjusted before it is fitted to the engine.
144. The test data required to adjust and set a pump for its particular application is published by C.A.V. in the form of test plans. It is essential that reference be made to the particular test plan before any attempt is made to set a pump.
145. Special equipment is required to carry out the tests correctly and it is recommended that the work is done by a C.A.V. agent.
146. Pump testing is carried out in two parts PHASING and CALIBRATION.
147. Phasing consists of adjusting the pumping elements so that they start to inject fuel at the correct angular interval in camshaft degrees. The interval for in-line pumps is 360 degrees camshaft angle divided by the number of elements in the pump.
148. It is also necessary to determine the point at which the adjustment has to be made. This is the 'port closed' position the point at which the rising plunger closes the ports through which fuel has entered the element barrel.
149. The injection of fuel into the engine begins after the port closes, following an interval which depends on plunger diameter, cam profile, speed of camshaft, pipe length, the setting of the injector spring and volume of unloading valve.
150. Calibrating the pump consists of making an adjustment for the equalising of fuel output from each pumping line.
151. When the pump is working, the output of each element depends on the position of the helical edge of the plunger helix in relation to the spill port of the barrel, a position which can be varied by turning the plunger in the barrel.
152. When the engine and pump are running, the governor moves the control rod, turning the quadrants, control sleeves and plungers together.
153. For adjustment each element must be calibrated separately.

Phasing the Injection Pump
154. Adjustment of the phase of AA pumps is effected by increasing or decreasing the head clearances of the plunger in its barrel by means of the tappet adjustment screw. During this adjustment the plunger at the top of its travel must NOT strike against the bottom face of the delivery valve seating or considerable damage will result.
155. Adjustment is correct when the plunger at top dead centre has a head clearance of 0.5 ± 0.15 mm., unless a different figure is given in the test plan.
156. The following tools are available for tappet adjustment:
Tappet adjusting spanner – tool part number 7044-914.
Tappet locknut spanner – tool part number 7144-180.
Tappet lifter – tool part number 7144-122.
157. Adjustment is made by slackening the tappet locknut and turning the lower spring plate which has small notches to take the tappet adjusting spanner, tool part number 7044-914.
158. Remove the inspection cover (28) and excess fuel device if fitted.
159. Fit control rod indicator and set to zero. After setting the zero position open the control rod to 10 mm. and lock the indicator by means of the knurled locking screw.

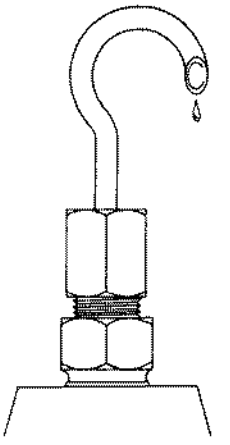


160. Secure the injection pump to a suitable test bench.
161. Set plunger head clearance if not already carried out on assembly.
162. The direction of the camshaft rotation and the amount of head clearance is detailed on the pump test plan, these instructions must be strictly followed.
163. Remove the delivery valve holder (1), delivery valve spring peg (2), delivery valve spring (3), delivery valve (4) and delivery valve seat and joint washer (5).

164. Set the plunger head clearance gauge, tool part number 7044-838 to zero on a surface plate and screw it into the tapped hole normally occupied by No. 1 delivery valve holder until the stem touches the top of the element barrel.



165. Turn the camshaft until the top dead centre mark on the coupling is aligned with the vertical line on the bearing end plate. No. 1 plunger is now at top dead centre.
166. Loosen the tappet lock nut (13) using the tappet locknut spanner, tool part number 7144-180.
167. With the stem of the plunger head clearance gauge resting on the top face of the element plunger, carefully raise or lower the lower spring plate by the tappet adjusting screw, using tappet adjusting spanner, tool part number 7044-914 until the gauge registers the required head clearance.
168. Tighten the tappet locknut.
169. Remove the plunger head clearance gauge from No. 1 element. Replace delivery valve seat complete with joint washer (5) on the upper face of its appropriate plunger barrel (8) and seat the delivery valve seat by lightly tapping it into position using a dummy delivery valve holder and mallet.
170. This operation must be carried out whenever the delivery valve seats are returned to the pump housing.
171. Care must be taken to ensure that the delivery valve and seat are located squarely.
172. A dummy delivery valve holder is made by machining the lower thread off a spare delivery valve holder till the holder is an easy sliding fit into the pump housing bore.
173. Assemble delivery valve holder (1).
174. Do not replace the delivery valve (4), delivery valve spring peg (2) and delivery valve spring (3).
175. Connect a short length of pipe, swan neck in shape, to the delivery valve holder, with the outlet end chamfered to improve the observation of the fuel cut off point.

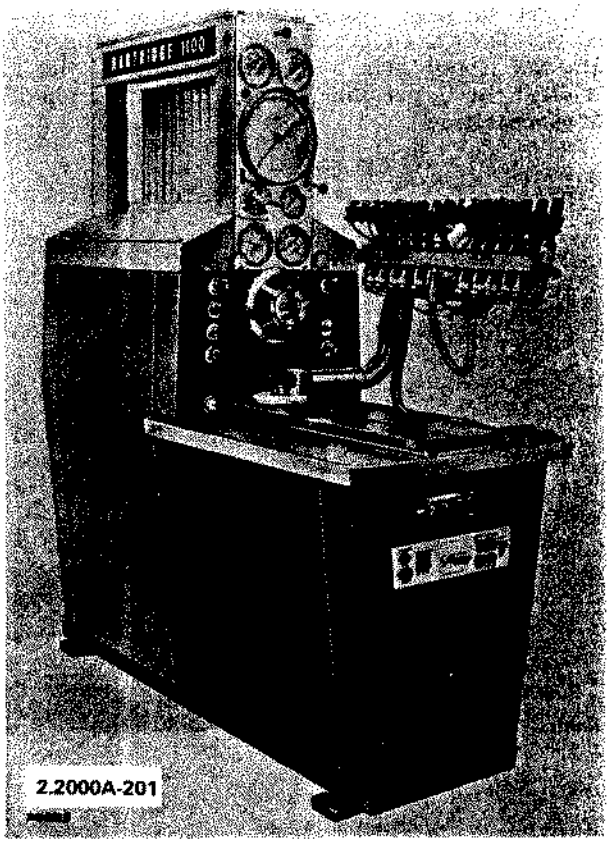


176. The point of injection must now be found and the complete phasing operation carried out as follows:
177. Ensure that No. 1 cam is at top dead centre.
178. Connect the pump fuel inlet to the fuel supply of the test bench and loosen one of the air vent plugs. Allow fuel to flow until it is free of air bubbles then tighten the air vent plug.
179. Rotate the camshaft until No. 1 plunger is at bottom dead centre, fuel will now flow from the fuel chamber into No. 1 element and out through the swan neck pipe. Fuel cannot pass through the remaining elements since their delivery valves are in position.
180. Turn the camshaft in the direction of rotation until No. 1 plunger starts to lift.
181. As the plunger gradually closes the barrel port, the flow of fuel from the swan neck pipe will diminish. Continue to rotate the camshaft very slowly until the exact point at which the flow ceases is established. This is the point of port closure.
182. Take care that the plunger is rising in its stroke or a false reading will be obtained.
183. Set the graduated disc to zero, taking care not to disturb the camshaft.
184. Check that the camshaft has not turned by repeating the operation in sequences 180, 181, and 182. Turn off the fuel.
185. Remove the swan neck pipe, wash No. 1 delivery valve (4), delivery valve spring (3) and spring peg (2) in clean test oil, and assemble to the pump. Tighten the delivery valve holder to a torque of 54 Nm (5.5 kg/m or 40 lb/ft.).
186. The camshaft is now set on No. 1 element at the point to which the adjustment of the remaining elements is correlated and they must now be set to inject at their correct intervals.
187. **In the following instruction the pump is assumed to be a six cylinder type with an injection sequence of 1-5-3-6-2-4.**
188. Remove the delivery valve holder (1), delivery valve spring peg (2), delivery valve spring (3), and delivery valve (4), but not the delivery valve seat and joint washer (5) of No. 5 element. Replace the delivery valve holder (1) and fit the swan neck pipe. Turn on the test oil, which will now flow from the pipe outlet.
189. Turn the camshaft and check the point of port closure for this element.

190. It should be within a few minutes of 60 degrees, but if the difference is in excess of ± 0.5 degrees for a 4 stroke engine or ± 1 degree for a 2 stroke engine, adjustments must be made to the lower spring plate by adjusting the tappet screw as described in paragraph 167.
191. Adjustment is made by slackening the tappet locknut and turning the lower spring plate which has small notches to take the tappet adjusting spanner, tool part number 7044-914.
192. Check the port closed position against the phasing disc. If the point of port-closure is found to be early, the lower spring plate (11) must be lowered; if the point of port closure is late, the lower spring plate (11) must be raised. Lock the tappet nut (13) after adjustment.
193. Turn off the test oil.
194. Remove the swan neck pipe and holder and delivery valve seat (5). Check that the head clearance is 0.5 ± 0.15 mm. with the plunger head clearance gauge tool part number 7044-838 as described in paragraph 167, unless otherwise detailed in the Test Data sheet.

NOTE: When adjusting No. 1 element, the head clearance is determined first, and then the point of port closure. When succeeding elements are adjusted, the correct port closing point is set first and the head clearance checked afterwards.
195. If the head clearance of any element is not within the required limits after phasing, the clearance on No. 1 element must be increased or decreased within the tolerance of ± 0.15 mm. and the pump must be completely rephased.
196. Remove the gauge, and assemble the delivery valve seat and joint washer (5), delivery valve (4), delivery valve spring (3), delivery valve spring peg (2) and delivery valve holder (1).
197. Tighten the delivery valve holder to a torque of 54 Nm (5.5 Kg/m or 40 lb./ft.).
198. Phase and check the head clearance of the remaining elements in the correct firing order.
199. Finally recheck the setting of No. 1 element in relation to the disc marking. If any discrepancy is found, the complete phasing operation must be repeated.
200. Assemble the feed pump to the injection pump.

Calibrating the Injection Pump
201. When the phasing tests have been completed the next operation is to ensure that all the elements will supply equal amounts of fuel. 'Calibration' is the term applied to the process of obtaining this balanced output. A test machine is essential for this process and a typical test machine is illustrated.



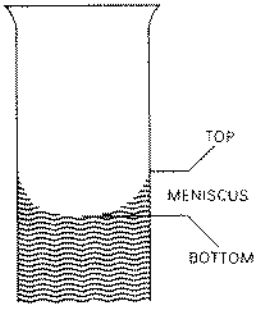
202. Before a pump leaves the factory it is accurately adjusted and the final setting is indicated by a line scribed on each control quadrant and control sleeve.
203. Slight alterations to the original setting may be needed after extended running, due to wear on the element, quadrant and delivery valve. The adjustment will be small and the new setting lines should be scribed after the calibration of fuel deliveries.
204. The quantity of fuel delivered by each element, and the point at which these quantities are balanced and checked will depend on the pump specification detailed in the test plan for a given application.
205. Accurate measurement and adjustment of output can be made only by trained and skilled personnel using a suitable power driven calibrating machine, and it is strongly recommended that the work is carried out by a C.A.V. agent.
206. The test machine must be capable of driving the pump at the speeds given in the test plan and should be able to maintain any selected speed within close limits. It must supply filtered test oil to the injection pump by gravity or pressure feed, and the filter must be of a quality which will give complete protection to the pump.
207. Each pump has a specific output according to its application and care must be taken to ensure that the correct test plan is to hand before calibrating.
208. A study of the test plan will show the different outputs which must be obtained at different control rod settings for given speeds.
209. The output from each pumping element during calibration is measured over 100 pumping strokes, unless otherwise specified in the test plan.

210. The test machine is fitted with an automatic trip mechanism which diverts the fuel away from the measuring glasses when the required number of strokes are completed.
211. Mount test nozzle BDN 12SD 12B set at 175 atmospheres on the test machine.

NOTE: The following sets of test injectors are available on the unit exchange system direct from Leslie Hartridge Limited, Buckingham, England.

Set of 6	Part Number 7244-106
Set of 8	Part Number 7244-108

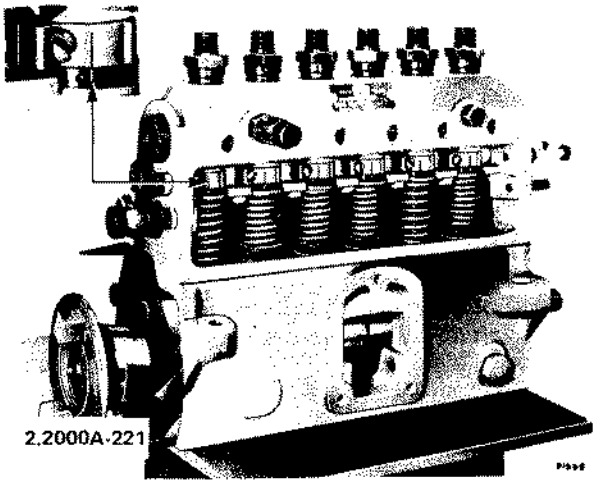
212. The connection between the test nozzle and the high pressure outlet of the pump is made by a pipe 6 mm. outside diameter x 2 mm. internal diameter and 600 mm. long, or as specified in the test plan.
213. Before setting the control rod opening position, as specified in the test plan, the zero position of the control rod indicator must be checked.
214. Before calibration, the pump, injectors and injector pipes must be thoroughly vented; an operation normally carried out with the pump driven at 200 rpm.
215. After venting, set the control rod to the first position given in the test plan and lock it with the control rod indicator locking screw. The test plan shows the fuel outputs that must be obtained at the different control settings for specific speeds.
216. The pump is now driven at the prescribed speed and the individual element outputs checked over 100 pumping strokes or as specified in the test plan. When recording the level of the fuel in the measuring glass, take care to read the level at the lowest point of the meniscus.



2.2000A-216

217. Minor adjustments to individual elements must be followed by a complete check at the same control rod opening rpm and over 100 strokes.
218. Calibration is now carried out at the other control rod openings specified in the test plan, and adjustments made as necessary.
219. Individual element output is adjusted by slackening the quadrant screw and moving the quadrant sleeve so that it alters the position of the plunger control helix in relation to the fuel port. The quadrant clamping screw must be tightened after the adjustment has been made.
220. When carrying out adjustments it should be noted that to increase fuel delivery the control sleeve is rotated towards the governor. Only a small movement of the control sleeve is necessary to alter the fuel supply.

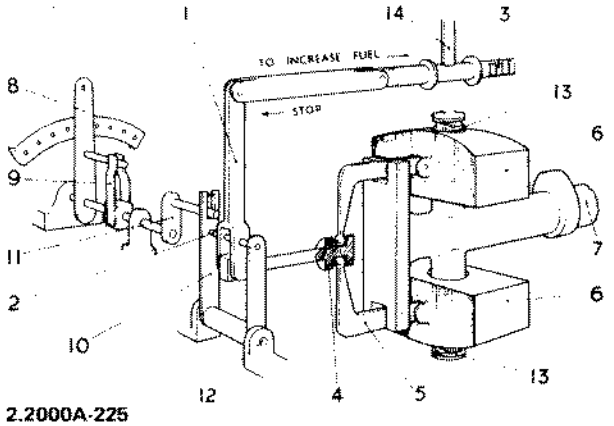
221. When the adjustments have been carried out and the tests completed, new setting lines should be drawn on the control sleeve and quadrant. Camera black can be used to remove the old setting line on the control sleeve.


2.2000A-221

222. Refit excess fuel device if specified.
223. Maximum fuel output must now be set in accordance with the test plan and pump application. The method varies with the type of governor.

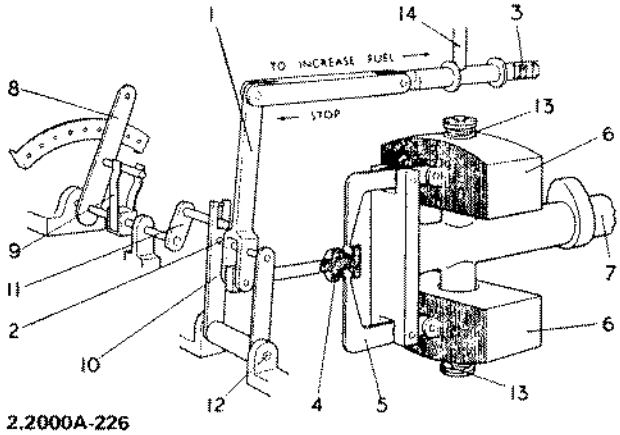
C.A.V. Mechanical Governor

224. The speed of a diesel engine is determined by the load and amount of fuel delivered. The governor is arranged to control the latter, increasing or decreasing it to compensate for any changes in load which tend to cause variation in speed. The C.A.V. unit is a conventional centrifugally operated spring opposed fly-weight type. A suitable linkage converts the changing position of the weights to a longitudinal movement operating the rod controlling the fuel output of the injection pump. The position of the throttle lever also affects the fuel output of the fuel injection pump, the two controls being interconnected with a series of links and moving pivots, to understand this we must consider a series of sketches (2.2000A-225, 2.2000A-226 and 2.2000A-228).
225. The important feature which must be clearly grasped if the governor operation is to be understood, is that lever (1) floats on two pivots (2) and (4) and can be moved by thrust at either point. It is the combination of these two — from the governor (via 4) and from the control lever (via 2) — operating on the fuel control rod (3), which enables the speed to be held at any desired point anywhere within the range. The following examples show how this is effected.



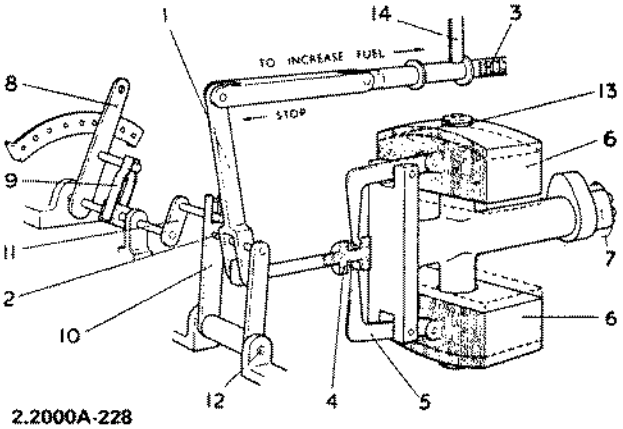
2.2000A-225

226. In Figure 2.2000A-225 assume that the engine has settled down to run steadily at approximately half speed. Any variation in speed will result in a change of position of the fly-weights (6) which will shift point (4) to the left if speed decreases or to the right if speed increases. This will swing lever (1) on pivot (2) and so move the fuel control rod (3) to alter the quantity of fuel injected. It should be clear from the sketch that an increase of speed will cause rod (3) to move to the left, to reduce fuel supply to check the speed and vice versa if speed increases. Under these conditions therefore, the governor acts as a normal fixed speed Hartnell type. It is now desired to increase speed and control lever (8) is moved to the right to the three-quarter position.



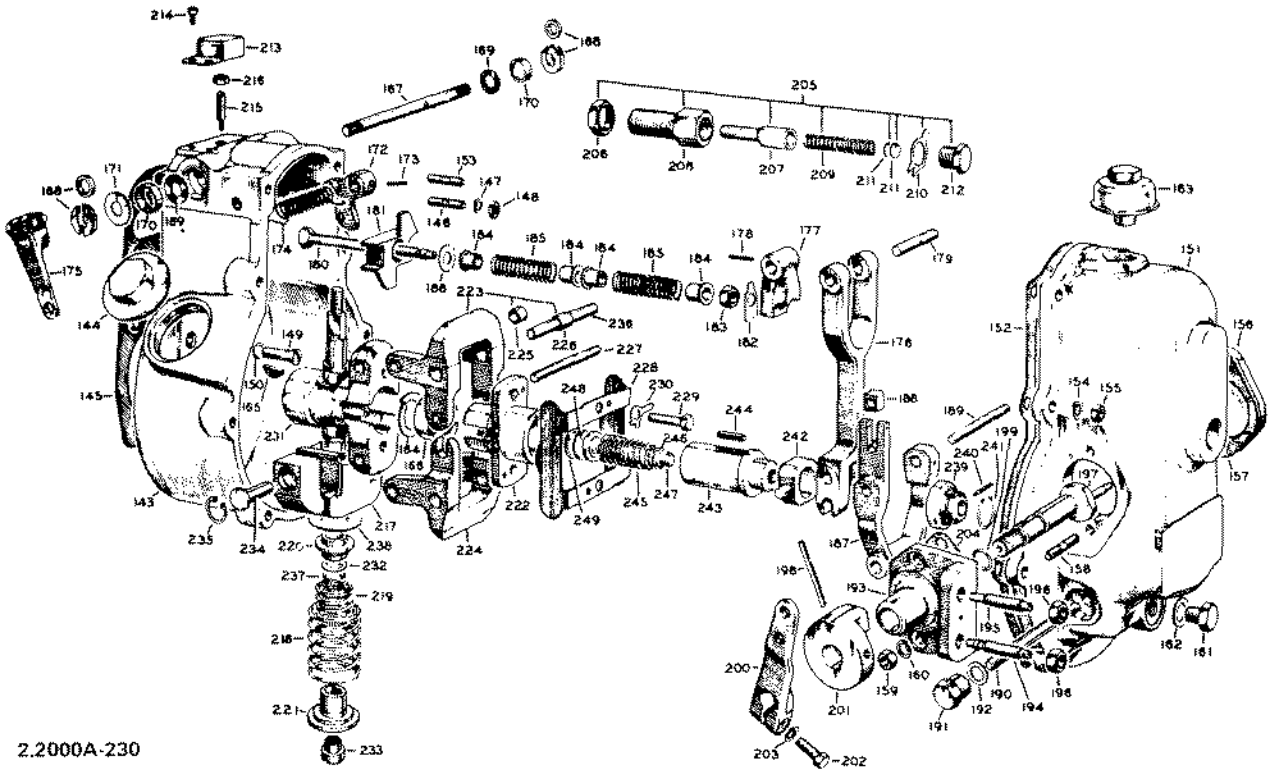
2.2000A-226

227. The results of this are:-
(a) Pivot (2) is thrust to the right, causing lever (1) to swing on pivot (4) and push control rod (3) to the right, increasing the fuel supply. Owing to the relative lengths of lever (1) above and below pivot (2) a small movement of the control lever (8) will cause a relatively large movement of rod (3) and the engine will accelerate rapidly.
(b) The relatively large movement of the top end lever (1) may force rod (3) to the maximum fuel stop (14) at the limit of its travel before the desired amount of movement of the control lever (8) has been effected. The remaining movement of lever (8) could then only be obtained by moving pivots (4) to the right, which would mean forcing the fly-weights apart against their spring pressure. This would apply heavy loading on the linkage and is obviously undesirable. Spring loading (9) of the control lever (8) is therefore provided to absorb this excess movement until the fly-weights move outwards normally with increasing speed.
228. As the engine accelerates, the fly-weights will move outwards to a position corresponding to the desired higher speed range, and the results of this (2.2000A-228) will be:-
(a) Pivot (4) and pivot (2) will move to the right, thereby allowing spring (9) to regain its equilibrium and take up its normal position.
(b) The flyweights (6) now turning through a greater radius and acting on pivot (4) will move lever (1) about the new centre of pivot (2) causing fuel control rod (3) to shift to the left, decreasing the fuel supply as the speed rises.
(c) The governor is now operating at the selected higher speed range. The positions of pivot (2) and pivot (4) which are now to the right of the half-speed position will be retained by spring (9) and any movement of the fly-weights (6) due to speed variation will be transmitted through pivots (4) and (2) and lever (1) to the control rod (3).



2.2000A-228

229. When it is desired to run the engine at a lower speed, the control lever (8) is moved to the left. The governor weights and linkage will move to the positions required, following a reverse sequence of events, and give satisfactory control over the selected lower speed range.
230. The numbers in brackets in the following pages refer to illustration 2.2000A-230.



231. The main essential to guarantee satisfactory operation of the C.A.V. mechanical governor is that all moving parts are free from any binding within the joints.

232. The linkage which transmits the movement from the weights to the control rod should be free, it is advised to visually check all pivots and bearings for wear.

233. Check the bushes fitted to the bellcrank levers (223) and (224) also the element support sleeve (231). Should these bushes (225) and (226) require replacement remove existing bushes from the casting and press new ones into place, ream to the correct size using reamer C.A.V. tool number 7044-114.

234. Check the bores into which the pivot pins (234) locate in the weights (217) should these show any wear the weights should be replaced, these are not serviced singularly, only in matched pairs.

235. Remove from the governor all external connections also the oil filler plug (144) and the oil level plug (161).

236. Drain all the oil from the governor.

237. Two hexagon nuts (191) will be noted sealed with wire, this wire should be removed and the nuts removed, this will allow the timing lever and fork fulcrum pin (190) to be withdrawn.

238. Remove the two nuts (159) which secure the control lever (200) and flange assembly (193) the entire assembly can be withdrawn from the end cover (151).

239. Remove the eight screws which secure the end cover and remove end cover (151) this will expose the operating components of the governor.

240. The control rod linkage (177) can now be unscrewed from the control rod and the assembly withdrawn by swinging down through 90° and unhitching the forked lever.

241. Examination of the governor weights will show two screws (229) which are located parallel to the pump camshaft. These screws should be removed, in order that the plate (228) which they secured can be withdrawn towards the governor linkage hence exposing a pin (227) which the plate secured.

242. Turn the pump camshaft until such time as the pin (227) is in a position opposite to the extension of the housing, the pin can then be pressed upwards and finally removed using only fingers. This will enable the governor linkage to be withdrawn from the governor weights.

243. Remove the brass element guide bush (222) from the end of the camshaft, at this point of the dismantling procedure the bush should not be attached in any way and can be lifted out, exposing the governor weight assembly securing nut (166).

244. Remove the nut (166) which secures the governor weight assembly to camshaft using tool (C.A.V. Tool number 7044-112B) and withdraw the governor weights assembly using extractor (C.A.V. Tool number 7044-8). The large portion of the extractor is screwed into the governor weight assembly as far as possible, the hexagon screw is then tightened against the camshaft which will result in the weight assembly being drawn from the camshaft. During this operation care must be taken that the weights are in fact being removed and not the threads failing.

245. Remove the key (150) from the keyway in the camshaft.

246. Remove linkage from control rod, this can be achieved by removing the lock tab and one screw.

247. Remove from the rear cover housing (151), the auxiliary idling stop (205). Should this require further

disassembly, grip the unit in a vice and remove the plug (212) which will expose the spring (209) and the plunger (207).
248. In order to disassemble the weights further for possible overhaul, proceed as follows:-
(a) Place weights in a vice (with jaws protected) and compress springs with pressure on upper spring plate (221) remove the adjusting nut (233) with C.A.V. tool number 7044-65, repeat for the other weight.
(b) Remove circlips (235) which retain pins (234) this will enable the two bellcrank levers (223 and 224) to be removed from the element support sleeve (231).
249. Remove the excess fuel hood (213) which will expose the excess fuel adjusting screw (215) remove this screw. Remove from the spindle the stop lever (175). With a screw driver remove the spring clip (168) and discard the clip. The pawl (172) is located on the spindle (167) by a pin (173) this pin must now be driven from the pawl which will allow the spindle to be withdrawn from the housing. The pawl spring (174) can now be removed. Remove all seals and discard.
250. During the assembly of the governor, check for freedom of all moving parts.
251. Assemble the bellcrank levers (223) and (224) to the element support sleeve (231) using the pivot pin (236).
252. Fit the weights (217) to the bell crank levers (223) and (224) using pins (234) and fit the pin retaining circlip (235).
253. The excess fuel device spindle seals (170) can now be fitted to governor housing also the pawl spring (174) and pawl (172) located in the housing, these being held in position whilst the spindle (167) is passed through the housing. Locate the pawl to the spindle with pin (173). Fit new spring clips (168) to spindle, refit the control lever (175).
254. Re-fit the control linkage assembly to the fuel injection pump control rod with one screw and one lock tab, tighten screw and lock the tab.
255. Re-fit the woodruff key (165) to key way on fuel injection pump cam and fit the governor weight assembly to the camshaft, fit the spring washer and nut (166) and tighten to a torque of 500 lbs./ins. (5.7 kg.m.). (Use C.A.V. tool number 7044-112B).
256. Fit the brass element guide bush (222) taking care to fit the correct way, the slotted end fitting nearest to the fuel injection pump camshaft.
257. Screw the forked control link assembly to the control rod assembly.
258. Slide the assembly to fit the overide element inside the element guide bush, rotate the governor weight assembly and camshaft until such time as it is possible to insert the element bell crank swivel pin (227), retain this pin with the element retaining case (228). Fit the two locktabs and screws which secure the element retaining case and tighten, lock the locktabs.
259. Fit with a new gasket in the rear housing cover and secure with eight lockwashers and nuts.
260. Insert through the lower pair of holes in the rear housing cover the timing lever and fork swivel pin (190). Fit new sealing washers (192) and cap nut (191). It will be noted that the cap nuts are screwed to the timing lever and fork swivel pin, not the rear housing cover, when tightening grip one cap nut with a spanner and tighten the other.
261. Fit the lever and flange assembly (193) with a new gasket taking care to locate the eccentric on the camshaft adjusting lever (197) into the hole on the block (188). Secure assembly with two spring washers and two nuts, tighten nuts.
262. Replace the oil filler plug and drain plug with a new sealing gasket.

C.A.V. Pneumatic Governor

263. This governor operates through its sensitivity to pressure variations between two pitot tubes situated at a butterfly valve in the intake manifold venturi. To obtain a full understanding of the operation of the pneumatic governor it must be realised that as the airspeed increases over a body the pressure falls, this is called depression the converse also being true, the application of this information will be understood at a later time.
264. The butterfly valve located in the air intake venturi is controlled via the throttle linkage and the pneumatic governor in its turn controls the position of the pump control rod, thus metering the fuel delivery according to the load imposed on the engine. This type of governor controls both the idling speed and the maximum speed of the engine.
265. At idling speed, the air to the engine is drawn mainly past the front pitot tube of the venturi, and a depression is created in the pipe leading to the rear chamber of diaphragm unit. As the front chamber is maintained at atmospheric pressure, the diaphragm contacts the stem of the damper valve and progressively admits an increasing supply of air from the rear pitot tube of the venturi. This has the effect of damping out any tendency for the control rod to oscillate excessively and cause the engine to hunt.
266. As the butterfly valve is opened, the depression at the front pitot tube is reduced, allowing the diaphragm and control rod to move towards the maximum fuel position, thus increasing the fuel supplied to the engine. With the consequent increase in engine speed, the depression felt at the front pitot tube is restored and the control rod is withdrawn until a state of balance is obtained with the diaphragm return spring. When the engine is under load, continued opening of the butterfly valve produces a progressive increase in the quantity of fuel delivered until the control rod contacts the maximum fuel stop screw.
267. When the stop control is operated, the toggle lever pushes against the diaphragm pull rod, causing the pump control rod to turn the element plungers to the no-delivery position.
268. To obtain extra fuel for starting under extremely cold conditions, the stop control lever is pulled outwards, this allows the governor mechanism to move the pump control rod further forward and provide the extra fuel required.
269. The C.A.V. Pneumatic Governor is a very simple device using very few moving parts, and it is advised that the unit be tested as follows before disassembly is commenced.
270. Disconnect the flexible pipes from the governor. NOTE: the engine MUST NOT be started whilst these pipes are disconnected.
271. Remove the inspection cover from the fuel injection pump, this will enable the position of control rod to be observed.

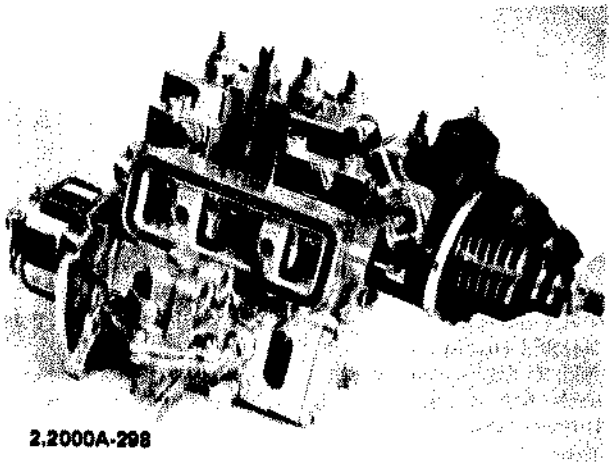
272. Operate the stop control, thus moving the diaphragm and control rod to the 'no fuel' position.
273. Place fingers over the unions to seal the diaphragm.
274. Release the stop control.
275. Observe the movement of the control rod, after a small initial movement the control rod should remain stationary. Should the rod continue to move, check for any sign of air leaks, if none are visible the diaphragm must be inspected.
276. Remove the four screws which secure the governor diaphragm cover, taking care to hold cover carefully as it retains the main spring, remove cover and spring.
277. Insert a small screwdriver blade into the slot which will be noted in the upper right hand corner of the governor housing, carefully prise the diaphragm ring from its seat, taking care not to damage the diaphragm assembly. The diaphragm assembly is located in the guide block by two dogs which pass through a slot in the block, the diaphragm assembly should, therefore, be removed by exerting a twisting action to enable the dogs to be withdrawn through the slot. Should the diaphragm be damaged the entire assembly should be replaced, the leather diaphragm not being serviced individually.
278. Remove the stop lever and also the shaft retaining clip. On the shaft is a pawl which is located by a pin which should be driven out, this will enable the shaft to be withdrawn, also the pawl and spring to be removed. This operation need not be carried out if this portion of the governor needs no attention or the housing is not to be removed from the fuel pump.
279. Remove the locktab and one screw which secures the guide block to the control rod, with finger pressure, push the control rod to the full fuel position, this will enable the guide block to be removed by sliding it to a position which would be attained when the engine is idling. Should the latch spring or latch be damaged the entire guide block assembly should be renewed.
280. Remove the control rod guide bolt and the three screws which attach the governor housing to the pump, remove and discard the gasket.
281. Position the governor housing complete with a new gasket against the fuel injection pump and fix with three screws.
282. Fit the control rod guide bolt and tighten.
283. Push the control rod to the full fuel position, place the guide block into position and pull the control rod to the no fuel position, fit the screw and locktab, tighten screw and lock.
284. Place the pawl and spring in their respective positions in the housing and renew the seal on shaft and fit the shaft. Drive the locating pin into place. Fit a new spring retaining clip and the control lever.
285. Slide the dogs in the diaphragm connecting rod through the slot in the guide block, rotate the diaphragm assembly until it is possible to locate the tab, on the diaphragm assembly, into the slot in the governor housing. Lock the tab.
286. Replace the main spring, also the governor diaphragm cover, secure with four screws.
287. It is most important that satisfactory operation of the governor is ensured before starting the engine, with the inspection cover off the pump operate the stop control, thus moving the diaphragm and control rod to the 'no fuel' position.
288. Place fingers over the unions to seal the diaphragm.
289. Release the stop control.
290. Observe the movement of the control rod, after a small initial movement the control rod should remain stationary. Should the rod continue to move, check for air leaks which must be located and rectified.

CAUTION

291. After completion of an engine overhaul ensure that there are no air leaks between the venturi unit and the induction pipe on the engine, and that the flexible pipe is correctly fitted and the unions tightened. Check the diaphragm unit for leaks and ensure that the controls are connected and function correctly when the throttle is operated. The air filter must be fitted before the engine is started.
292. The fuel pump with the governor attached should be mounted on the test machine and connected to the air system.
293. Run the test machine at 600 rpm and ensure that the fuel injection pump is delivering fuel.
294. With the pump, evacuate the air in the system, the control rod should commence to move away from the maximum fuel position when a depression of between 15 in. and 16 in. of water is obtained.
295. Should the control rod not move at the required depression the diaphragm should be checked for leaks and all leaks found, cured. The pneumatic governing system relies on the air connections all being perfect and this should always be remembered when testing a pneumatic governor.
296. THE ENGINE MUST NOT BE STARTED BEFORE THE VENTURI UNIT, FLEXIBLE PIPES, OR THE AIR FILTER ARE FITTED AND THE RECOMMENDED CHECKS FOR AIR TIGHTNESS ARE CARRIED OUT.
297. Failure to observe this warning may result in serious damage to the engine caused by over-speeding. Should the engine be inadvertently started under these conditions, pull the stop control knob on the instrument panel or the stop lever at the side of the governor and hold in 'stop' position until the engine ceases to run.

SIMMS INLINE FUEL INJECTION PUMP

298. Before disassembly of the fuel injection pump the governor must be removed, this is detailed on page 21 for pneumatic and page 18 for mechanical.



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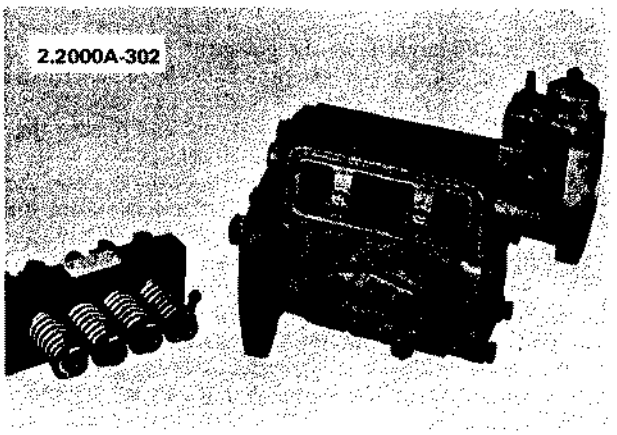
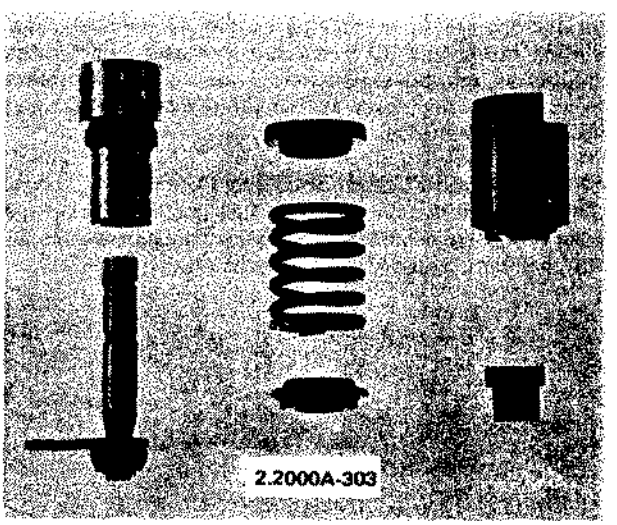
299. Remove the fuel lift pump which is secured by two nuts.
300. Remove captive bolts which will enable the inspection cover and sealing ring to be removed.
301. With a hand maintaining a pressure on the pump body, slacken the Allen screws which secure the pump body to the pump unit housing. The screws should be slackened off evenly around the pump body. It should be realised that the plunger return springs will be exerting an upwards force on the pump body.
302. Lay the pump on its side and gently ease off the pump body, making sure that the plungers, lower spring discs and plunger return spring do not fall off.



303. Remove plungers, lower spring discs and plunger return springs and keep in groups for each fuel element. Remove the delivery valve holder clamps, screws and spring washers.



304. Unscrew the delivery valve holders using Riteway Tool Z8473 and remove, together with volume reducers and delivery valve springs, keeping items for each fuel element together.
305. Remove delivery valves, keeping items belonging to each fuel element together. Use a mallet to tap the bottom ends of the barrels. This will free the barrels from the serrations in the pump body and at the same time push out the delivery valve guides and joint rings.
306. Remove the tappets, lifting them out and taking care to keep them in their correct order so that when reassembled they go back into the tappet bores from which they were removed.
307. Remove from inside the cambox the two 'T' pieces which are located between each pair of tappets. These 'T' pieces are not fixed in any way.
308. At the drive end of the pump is a control rod cover with a bush attached, this is located with a screw which attaches it to the cambox, remove this screw, the cover can then be withdrawn.
309. Slacken with an Allen Key the screws which locate the forks onto the control rod, the control rod can now be removed from the cambox via the bush which was removed from the end of the cambox. Remove forks from inside cambox.
310. Unscrew and remove camshaft nut. Remove flange, then remove the Woodruff Key from the camshaft.

NOTE: It is not necessary to dismantle the coupling. When all securing bolts etc. have been removed, the in-line pump can be removed by pulling the two halves of the coupling apart. When replacing, the insert is assembled between the two halves which can only be located in the correct position due to the dowel pin on the end of one of the two screws.

311. On pneumatic governed pumps remove the screws which retain the bearing housing located at the governor end of the fuel pump, and tap the camshaft with a soft mallet at the coupling end. This action will break the liquid jointing seal and remove bearing housing from cambox.
312. Remove the four screws which retain the bearing housing at the coupling end of the pump and tap the camshaft from the governor end with a soft mallet. This action will break the liquid jointing seal and remove bearing housing from the cambox. The camshaft can now be removed from the cambox.
313. The components should next be subjected to the following inspection before reassembly.
314. Visually inspect the camshaft bearings, should they be coloured blue they are no longer serviceable due to overheating. Overheating can be caused by lack of lubricating oil or no end float when the pump was assembled. Should the bearing life appear to be short, check that the pump is aligned correctly to the engine.
315. Check the fit of the tappet with the cambox body. If excessive, worn parts must be replaced.
316. Check that the tappet pad is not worn. If it is required to renew a tappet pad, the spring circlip should be removed and tappet plate replaced, refit spring circlip.
317. Remove the pin from the tappet, this is just a push fit, and remove roller and bearing, replace any worn parts and assemble.
318. Use a new control rod and check that the bushes are not worn, if they are, they must be replaced, also the existing control rod should be checked for wear. Any worn parts must be replaced and when new components are fitted care must be taken to ensure that there is no binding as this will affect the operation of the fuel pump and governor.
319. Check all threads and examine castings for any sign of damage.

320. During the assembly great care must be taken to ensure absolute cleanliness of all parts, also replace all seals and gaskets.

321. Pack the camshaft bearing with grease (Mobilgrease MP) and replace the camshaft into the cambox.

322. Apply a sealing compound to the bearing housing (on pumps with pneumatic governor) or fit a gasket (on pumps with mechanical governor). Fit the bearing housing situated at the governor end of the cambox, tighten screws to a torque of 5-7 lbs./ft.

323. Apply a sealing compound (Wellseal Liquid Jointing or Hylomar L33 or equivalent) to the mounting flange. Fit with four screws the mounting flange situated at the coupling end of the cambox and tighten the screws to a torque of 5-7 lbs./ft.

324. Check the end float on the camshaft, using camshaft end float gauge Hartridge Tool 89559 and Extension 89559/3 also Dial Indicator Hartridge Tool 23764 as follows:-

325. Screw gauge assembly to threaded portion of camshaft.

326. Press the camshaft to the full limit of its travel and zero the dial Indicator Gauge, this is achieved by rotating rim of the instrument.

327. Pull the camshaft to the opposite extreme of travel, the travel should be between 0.002 in. – 0.006 in. Should adjustment be required, shims should be fitted, they are available in 0.004 in. and 0.008 in. sizes, it will be necessary to remove the bearing housing to insert the shims.

328. Fit the key and coupling.

329. Position the driving flange and secure with the camshaft nut. Tighten to a torque of 45.8 lbs./ft.

330. Insert the control rod into the cambox taking care that the chamfer in the hole where the link locates is on the correct side. Feed the control forks onto the control rod and fit rod into the bush at the governor end of the cambox. Fit control rod cover with bush attached and secure with screw. Locate No. 1 fork about 1.0 millimetre from the end of the squared section of the control rod. Space the remaining forks equally along the control rod then tighten the fork screws. Check that the control rod moves freely.

331. Insert 'T' pieces into the slots in the cambox, these are not retained in any way.

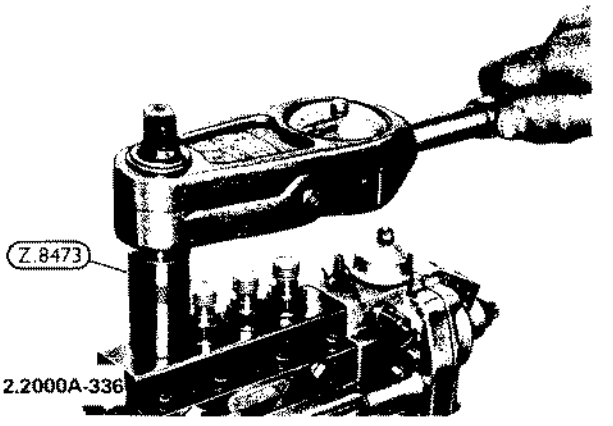
332. Fit the tappets ensuring that each one is fitted in its original tappet bore, it should be noted that the cut out in the tappet should go towards the inspection window.

333. The pump elements (Barrels and Plungers) and delivery valve assemblies are assembled wet from clean test oil.

334. Replace the element barrels into their original positions in the pump body noting the fitting of the master spline, also replace the delivery valve guides.

335. Fit new nylon joint rings onto the valve guides also fit the delivery valves. Fit the delivery valve springs, volume reducers and delivery valve holders.

336. Tighten the delivery valve holders to a torque of 40-45 lbs./ft.



337. Ensure that existing components are mated with any existing components which may have been used previously.

338. Should the pump being rebuilt consist of the original components, the following three paragraphs should be adhered to.

339. Place the lower spring disc into position on the plunger also the plunger return spring onto the lower spring disc. The lower spring disc has shoulders on it which enable it to be located accurately.

340. Insert each plunger into its orginal barrel.

341. Lay the cambox on its side (inspection cover side downwards). Then assemble the body (with plunger arms pointing downwards) on the cambox; ensure that the plunger arms locate in the control rod forks. Fit the body screws while maintaining a light pressure on the body (against the plunger return springs); tighten the screws equally in turn to 5 lbs./ft. Check that the lower spring discs are correctly seated and that the control rod moves freely.

342. Refit the fuel lift pump and secure with two nuts, tighten to a torque of 12-15 lbs./ft.

343. Should the pump being rebuilt have new components fitted, follow the instructions detailed in the following paragraph.

344. Lay the pump body on its side and then assemble each plunger, but without its return spring and lower spring disc, in its respective barrel. Assemble the body on the cambox so that the plunger arms locate in the control rod forks as described previously and secure it with two screws at diagonally opposite corners.

Phasing

345. The pump should be placed on a suitable test machine which is equipped with a device for measuring the angular rotation of the camshaft, also a supply of test oil.

346. Remove from No. 1 element the delivery valve holder and also the spring, delivery valve and volume reducer, replace with the plunger head clearance gauge (Hartridge Tool No. 89558/4), which should be used in conjunction with dial indicator (Hartridge Tool No. 23764).

347. Rotate the camshaft by hand until No. 1 plunger is at the bottom of its stroke also check that the control rod is in maximum fuel position. Zero the dial indicator and turn on the fuel supply.

348. Turn the camshaft very slowly by hand in a clockwise direction of rotation until fuel just ceases to flow through the plunger head clearance gauge, at this point the distance moved by the plunger should be checked on the indicator dial, the reading should be 2.9 to 3.1 millimetres. Turn camshaft until plunger is at the top of its stroke then set the dial indicator to zero and raise the plunger to its maximum travel. This distance is called the head clearance and should be 1.5 to 2.0 millimetres. Turn off the supply of fuel and remove the gauge assembly.

NOTE: The travel of the plunger can be adjusted by using graduated tappet spacers which are supplied in 12 different thicknesses.

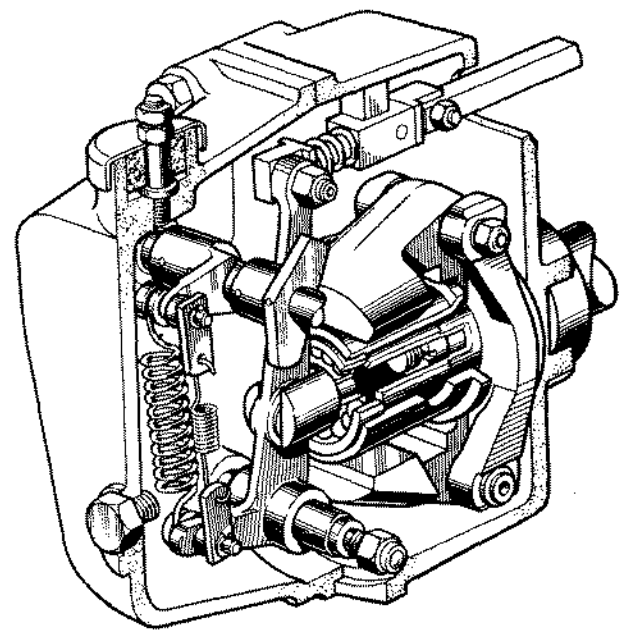
349. Fit spill pipe (Simplex Tool No. P.A.77610) in place of plunger head clearance gauge assembly and turn on supply of fuel. Rotate the camshaft slowly in a clockwise direction and watch for fuel to completely stop flowing from the spill pipe, at this point set the degree plate pointer to zero.
350. Remove the spill pipe from No. 1 element and replace the delivery valve holder parts. Tighten the delivery valve holder to a torque of 40-45 lbs./ft.
351. Refer to the element which supplies fuel to the next cylinder in the firing order which is 1, 3, 4, 2 and remove the delivery valve, fit the spill tube and check the point at which the fuel ceases to spill from tube as detailed in paragraph 349. This point should be 90° ± 0.5° from the previous point of port closure. It will be realised therefore that the spill points should be 0° 90°, 180°, 270°.
352. Should any adjustments be necessary the tappet spacers must be changed, varying the thickness by 0.1 mm. will make a change of 0.5° camshaft movement, it is possible to advance the timing by adding a thicker spacer and to retard the timing with a thinner spacer. If a particular element is incorrect it is advised that it be rectified before proceeding to the next element.
353. Recheck the point of port closure in the first element to ensure that the datum is still correct after setting all the other elements.
354. Check head clearance on elements 2, 3 and 4 as detailed in paragraph 348.
355. The fuel pump is now phased and the pump body should be removed from the cambox, it was only secured with two screws for the above operations.
356. Assemble the pump body to the cambox as detailed previously.
357. Fit governor to fuel pump, this operation is detailed fully in paragraph 435 page 22 for the pneumatic and paragraph 397 page 20 for mechanical governors.

Calibration

358. Mount the unit on a power driven test bench equipped with a tachometer and measuring vessels, so that the volume of fuel delivered by a given number of strokes can be measured.
359. Run test machine and thoroughly wet all pipes and glass tubes with test oil before attempting to take any readings. To obtain consistent readings the same procedure should always be followed. After completion of a test run the measuring cylinders should be left to drain for 30 seconds, another 15 seconds should be allowed for any fuel left in the tubes to drain back before commencing another test.
360. Adjust the maximum fuel stop screw on the governor so that number four element pumps the correct amount of fuel at the rpm stated on the test sheet. When this element is satisfactory lock the maximum fuel stop screw, the other three can be set to the same output by slackening the socket head screws and moving the control forks along the control rod.
361. Check the operation of the excess fuel device.
362. Set the control rod into the position given on test sheet at this point no fuel should be delivered.
363. Check that the control rod is free in movement, set the pump running at 250 rpm and with idling delivery set and the control lever in idling position, operate the stop control and return it to the run position, the control rod should immediately return and fueling start again.

SIMMS MECHANICAL GOVERNOR

364. The speed of a diesel engine is determined by the load being applied and the amount of fuel delivered. The governor is arranged to control the latter increasing or decreasing it to compensate for any changes in load which tend to cause a variation in speed.
365. The Simms mechanical governor is a conventional centrifugally operated spring-opposed fly-weight type. A suitable linkage converts the changing position of the weights to a longitudal movement operating the rod controlling the output of fuel from the injection pump. The position of the throttle lever also effects the fuel output of the injection pump the two controls being interconnected.



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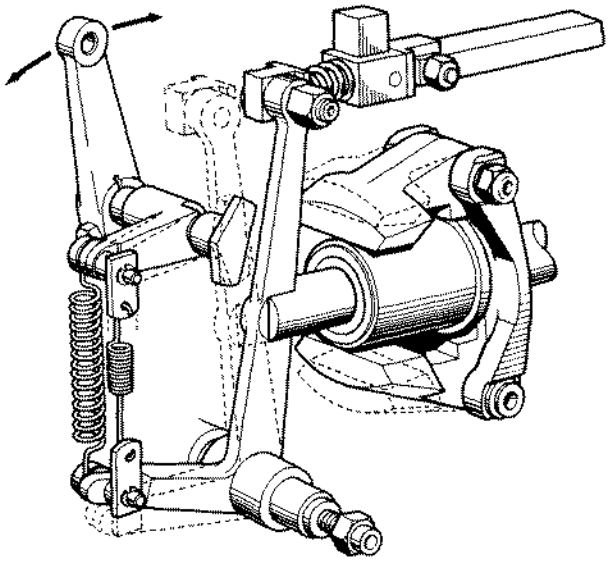
366. Movement of the throttle lever is transmitted via the governor springs to the crank lever which is directly acted by the governor fly-weights.

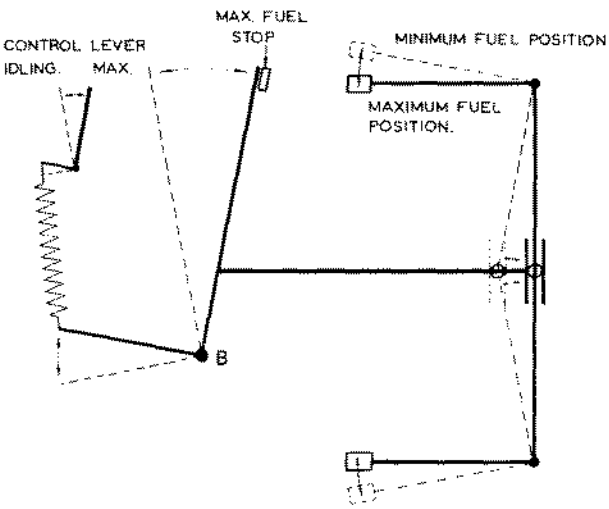
Operation

367. The mechanical governor operates due to a balance of forces generated between the governor spring tension and centrifugal force of the governor weights.



2.2000A-367

368. Let us now assume that we are about to start the engine, with no load on it, the throttle lever will therefore be moved to the full fuel position. Movement of this lever will result in a load being applied directly to the governor spring which will move point 'A' on the crank lever in a clockwise direction. The crank lever being pivoted at point 'B', will rotate in a clockwise direction, this will result in the fuel pump control rod being pushed to the full fuel position, also the governor weights which are connected to the hub sleeve will be pressed inwards to the furthest extent of their travel.



2.2000A-368

369. When the engine starts and accelerates the governor weights will rotate, the centrifugal force throwing the governor weights outwards, the toe on the weight being so arranged that when the weights move, the motion is transmitted to the hub sleeve, which moves in a horizontal direction. The hub sleeve, which is in contact with the crank lever will, therefore, move the crank lever to the position shown dotted in Fig. 2.2000A-368. This position of the lever will move the control rod in the fuel injection pump towards the no fuel position.

370. To stop the weights moving outwards immediately the engine starts, two springs are fitted between the crank lever and the throttle lever, the light one controlling the idle speed of the engine and the other maximum speed. It will be noted that the light spring is operating all the time whilst the heavy spring only operates at higher speeds, this is achieved by providing elongated hooks at each end, therefore allowing the crank lever to move only under the influence of the light spring during initial movement.

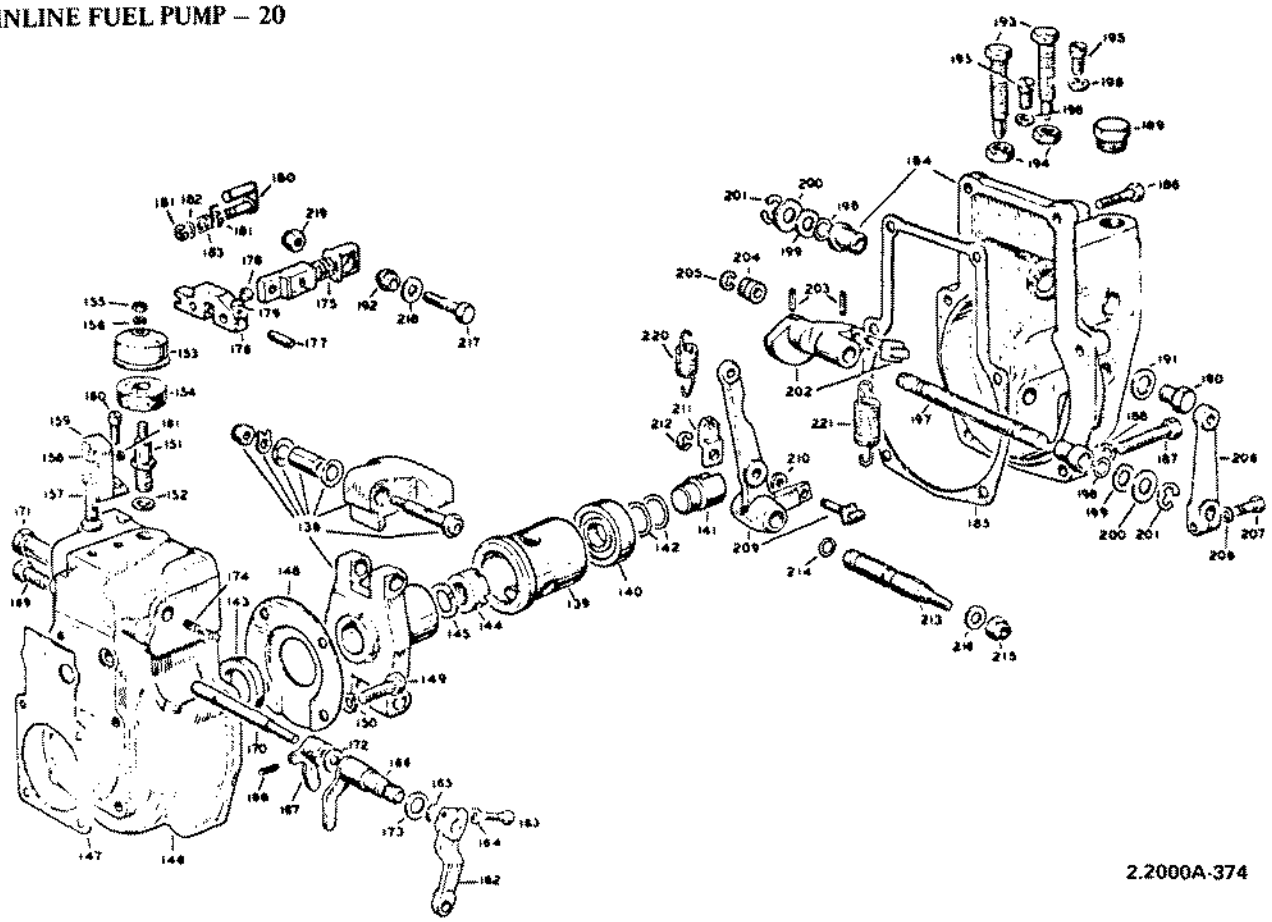
371. As the fuel injection pump control rod moves towards the no fuel position, the engine rpm will be reduced due to the decrease in the amount of fuel being supplied, this reduction in rpm will result in the governor weights generating less centrifugal force, which allows the springs to exert a force on the crank lever and push the control rod towards a full fuel position. Thus it will be realised that although the throttle lever has not been moved the engine speed will be kept constant, and will, in fact, keep constant at a speed relative to the throttle lever position.

372. When the excess shaft is pressed, the excess fuel catch is moved away from the control link allowing the control rod to move forward to the excess fuel position. When the engine starts and increases speed, the control rod moves to the closed position. The excess fuel catch is returned by spring pressure to its normal position, limiting the fuel to normal maximum delivery.

373. It can be seen, therefore, that the speed control lever position (limited by suitable stops) sets the maximum speed at which full power is developed.

Disassembly

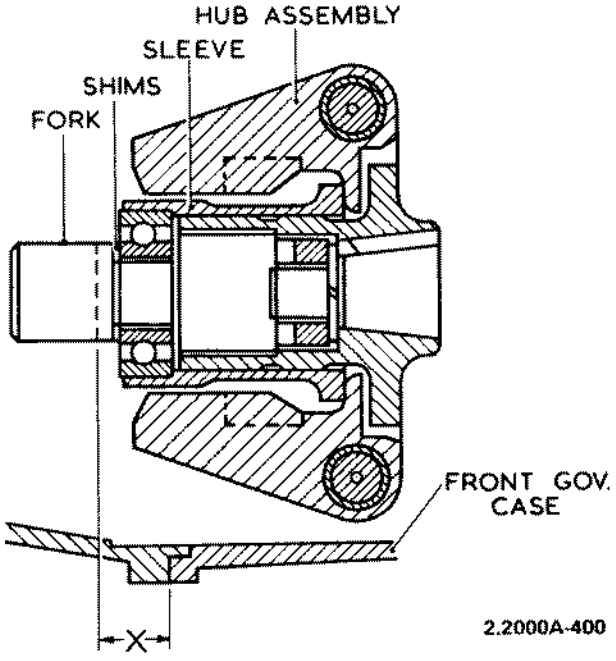
374. The numbers in brackets refer to Fig. 2.2000A-374.



2.2000A-374

375. Unscrew the bolt securing the control lever (206) to the cross shaft (197) and remove the lever.
376. Unscrew the six set bolts securing the governor rear half housing to the front half.
377. Pull away the governor rear half enough to allow the removal of nyloc nut (219) and bolt (217) which secures the crank lever (209) to the telescopic link (175). Remove governor rear half.
378. Withdraw the sleeve (139) containing the ball bearing (140) and fork (141) from the governor weight assembly.
379. Slacken screw (178) and remove the control rod link (176) from the control rod. Remove groverlock pin (168) from max. fuel stop lever (167).
380. Remove the excess fuel shaft bearing (171), and the shaft (170) can now be withdrawn, care should be taken not to drop the return spring (174) and the maximum fuel stop lever (167). Remove spring clip (163) and stop control assembly (166) can now be removed. The stop lever (162) may now be removed from the stop control assembly (166).
381. Remove the governor weight assembly by means of a governor hub key, (Hartridge tool 87744) which will remove the retaining nut (144) and pull governor mass from the camshaft using Hartridge Tool No. 7044-8.
382. Remove the governor front half by unscrewing the four set bolts.
383. To dismantle the governor rear half, remove the lower spring plate (211) which secures the idling spring to the lower crank lever, by removing the 'E' clip. Note which way the springs are looped in the spring plates.
384. The two governor springs (221 and 220) may be removed now.
385. Unscrew the nyloc nut (215) holding the crank lever fulcrum shaft (213), withdraw the shaft and remove the crank lever (209).
386. Remove the maximum and idling stops (193).
387. To dismantle the control lever cross shaft assembly (194), tap out the taper pins (203) from the stop control and spring arm assembly (202).
388. Remove arm (206) also the 'E' clips (208) and withdraw the cross-shaft (197) taking careful note of any shims that may be fitted.
389. Thoroughly clean all parts of the governor before attempting to re-assemble, use new gaskets and self locking nuts.
390. Insert control lever cross shaft (197) in the governor rear half, assembling the stop control (206) and spring arm (202) at the same time.
391. Replace the taper pins (203) which fix the cross shaft assembly, refit any shims (199) that are fitted and replace the 'E' clips (201) which hold the cross shaft in position.
392. If the cross shaft or bushes have been renewed, fit shims as required to give the cross shaft an end float of .05 to .25 millimetres.
393. Screw in the maximum and idling speed stop screws, ensuring that the control stop is the right way round.
394. Screw the crank lever-fulcrum shaft (213) into the rear half casing, assembling the crank lever (209) on it at the same time. Replace the old nyloc nut (215) with a new one and screw it onto the shaft.
395. Assemble the governor springs on the spring arm and crank lever, secure the spring plates holding the secondary spring with 'E' clips.

396. In the front half of governor housing, fit the stop lever (166) locate this with washer (173) and spring clip (165). In the opposite side of the housing insert the excess fuel shaft (170) and at the same time, fit the maximum stop lever (167) also washer (172). The shaft should now be positioned so that the shoulder protrudes through the stop lever (166). Locate the maximum stop lever (167) with the groverlock pin (168). Fit the spring (174) and the bearing (171) which is screwed into the housing. Tighten bearing (171) to 15 to 17 lb./ft.
397. Assemble the front half of the housing with the gasket to the fuel pump, also the oil baffle (148) and secure with four screws and spring washers tightened to a torque of 5-7 lbs./ft.
398. Fit the link (176) to the control rod, tighten the locating screw and lock nut.
399. Replace the governor weight assembly and secure with the governor hub key (Hartridge Tool No. 87744).
400. Insert the sleeve containing the bearing and fork between the governor weights and on to the governor hub. If a new hub, sleeve, bearing or fork has been fitted, add or remove shims to give the correct dimensions 19.5 – 19.7 millimetres between the front governor case face and fork, with the weights fully open and without the governor gasket fitted. Dimension is marked X on Fig. 2.2000A-400.



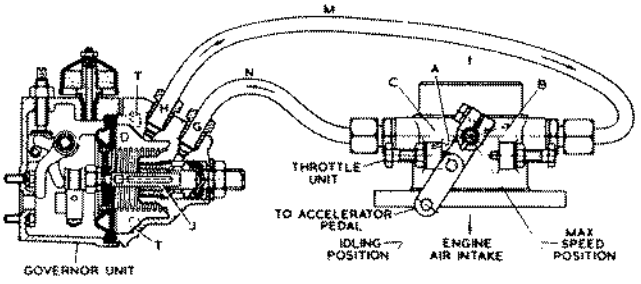
2.2000A-400

Governor Type	Dimension "X"
B. N. Z. Weights closed.	13.7 – 13.9 mm.
A. Weights closed, with excess fuel device in gov.	13.7 – 13.9 mm.
A. Weights closed and no excess device in gov.	10.7 – 10.9 mm.
M. Weights open.	19.5 – 19.7 mm.

401. Connect the telescopic link to the crank lever in the governor rear half and secure the two halves together by means of the six set bolts, tighten to a torque of 5-7 lbs./ft.
402. Replace the control lever (206) on the cross shaft (197) and tighten the fixing bolt.
403. When re-assembly has been completed, the governor and its linkage must move with freedom but without undue slackness.
404. Lubricate by filling to the oil level plug, with clean engine lubrication oil, over filling should be avoided.
405. The pump and governor should be tested together on a fuel injection test bench. The complete unit should be set to the appropriate specification giving speed and delivery settings as follows:-
406. To set the maximum delivery stop, hold the control lever on the governor in the full delivery position by means of a tension spring.
407. Run the pump at the correct speed and take readings in calibrating glass for number of strokes stated on the data sheet. Adjust the maximum stop screw until the correct delivery is obtained. Screw the stop down to reduce, and up to increase delivery.
408. Seal the maximum stop screw.
409. The maximum and idling speeds can be adjusted within the designed speed range of the governor by the stop provided. Do not adjust when the stops have been sealed.

SIMMS PNEUMATIC GOVERNOR

410. The Simms G P pneumatic governor fitted to the 'Minipump' uses the suction created in the engine induction pipe to control the fuel pump.
411. The governor consists of the throttle control unit mounted on the air intake of the engine, the governor unit mounted on the injection pump and the suction pipes connecting the throttle and governor units.



2.2000A-411

412. The throttle unit is mounted between the engine air intake and the air cleaner and contains a butterfly throttle valve 'A' which is connected to the driver's throttle lever.. This throttle controls the speed of the engine, there being no direct connection between the driver's control and the fuel pump.
413. The governor unit is mounted on the end of the injection pump and comprises a housing containing a diaphragm which is attached to the pump control rod by the governor link, when the pump is at rest, this is held in the maximum fuel delivery position by the governor spring.
414. The pneumatic governor units are fitted with a soft leather cup. In this type of unit, the circumference of the leather cup is held in a pressed alloy rim, the centre of the cup being riveted between two dished plates and mounted on the governor guide and damping valve.

415. The diaphragm assembly is retained in the governor front half by the pressure between the front and rear halves when they are bolted together, the alloy rim acting as a jointing. The governor guide engages the link assembly, which is connected to the control rod by the link screw, transmits the movement of the diaphragm assembly, to the injection pump.

416. The governor spring is positioned between the dished plate and the rear wall of the governor, keeping the control rod in the maximum delivery position when the pump is at rest. The damping valve guide assembly is screwed into the rear of the governor housing for anti-surge adjustment, an external locknut secures it in position.

417. The stop control lever, when operated, causes the stop lever bearing upon the link to move the control rod to the 'no delivery' position, the position of the maximum fuel stop screw and trip limiting the backward motion of the maximum stop lever.

418. Under very cold climatic conditions, starting of diesel engines may be difficult unless a certain amount of excess fuel is available, and in order to provide this extra fuel an excess fuel device is embodied in the governor and Minipump as applied to the 220 cu. in. Bedford Engine. This device is designed to control the maximum fuel position of the injection pump control rod during normal operation and, at the time of starting from cold to permit the control rod being moved to a position in which excess fuel for easy starting will be delivered.

419. A stop lever is provided which moves the pump control rod to the no delivery position when it is desired to stop the engine.

420. When the throttle valve is moved to the closed position an increased suction is created on the engine side of the throttle valve. This is transmitted through the suction pipe 'M' to the diaphragm which is drawn back against the pressure of the spring, thus moving the pump control rod so as to reduce the fuel delivery. Closing the throttle therefore, reduces the engine speed, while by opening the throttle, the suction on the diaphragm is reduced so that the spring moves the pump control rod towards the increased fuel delivery position, thus increasing the speed of the engine.

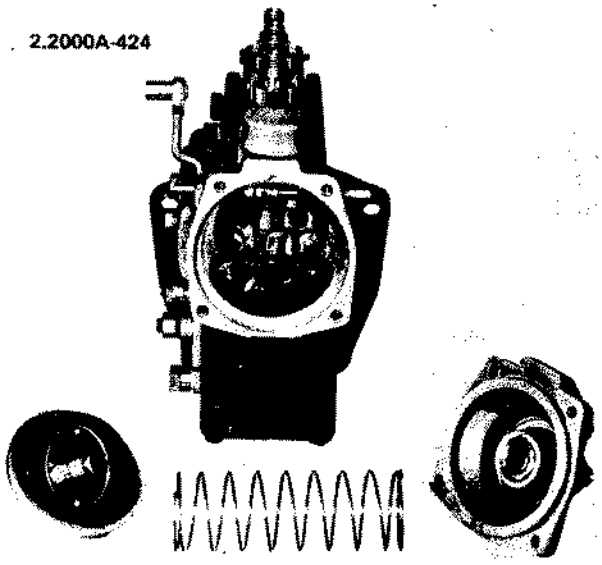
421. If the throttle is held in a fixed position the engine will run at a correspondingly constant speed with a variation of only 5 to 10 per cent between full load and no load on the engine. The governor is therefore, of the variable speed type, for it will govern at any selected speed within the designed speed range of the engine.

422. The purpose of the damping valve is to prevent hunting or surging of the engine at idling speeds. This is accomplished by adjusting the valve guide 'J' so that when the diaphragm is in the slow running position, the tapered portion of the valve will admit air from the port 'G' via the external groove and cross holes in the valve guide 'J' into the chamber 'D', if the diaphragm moves too far towards the stop position due to surges in the engine speed. As the valve guide is connected to the auxilliary suction pipe 'N', it is therefore at approximately atmospheric pressure. The damping valve, therefore, acts in the same way as a buffer spring and prevents excessive oscillations of the diaphragm at idling speeds.

423. To understand this, consider the operation of the governor at maximum speed, that is, with the throttle valve fully open. The depression in the air intake will then be very small, and the maximum speed of the engine is determined by the increasing air velocity, which as the engine speed increases, causes a gradual increase on the port 'B', and this, transmitted to the diaphragm draws back the pump control rod and limits the speed of the engine.

424. To dissasemble the governor, remove the Phillips type screws securing the governor rear half to the front half and remove the rear half and governor spring. The diaphragm can be withdrawn by lifting the diaphragm rod and disconnecting from the control rod linkage, the rod slots into the linkage and is not retained in any way. Care must be taken not to damage the leather diaphragm or the rim.

2.2000A-424



425. Slacken the locknut and unscrew the tapered locking screw, this screw is visible when viewed from the underside of governor and locates the link to the control rod. Removal of screw will enable the link to be withdrawn from the control rod.

426. Slacken the pinch bolt which clamps the stop lever and remove the lever from splines.

427. Remove groverlock pin, then unscrew from the opposite side of the governor housing the bearing, which also contains the excess fuel device return spring. This will allow the excess shaft to be withdrawn. Remove the clip which locates the fuel shut off lever and its associated bush. The bush assembly can now be removed from the governor housing. Remove three hex headed screws and remove governor front housing.

428. To remove the filter element for cleaning or renewal the retaining nut should be unscrewed and the breather cap lifted clear, when the filter element may be withdrawn.

429. Should further dismantling be considered necessary, the maximum stop lever trip pin may be unscrewed from the governor body, this stop is located on the opposite side of the governor to the stop lever. The maximum fuel stop can be removed after removal of

the locknut from the upper surface of the governor housing. The actual maximum fuel stop may be removed by unscrewing from the governor housing and removed from inside the governor.
430. Inspect the diaphragm for tears, perforations or other signs of wear or damage, if there is the slightest doubt about its condition the diaphragm assembly must be replaced as detailed in paragraphs 431, 432 and 433.
431. Remove the damaged diaphragm from the shaft, which is fitted by two nuts.
432. Soak a new diaphragm for at least half an hour in oil (Shell Calibration Fluid 'C'), this will soften the leather and keep it pliable.
433. Assemble the new diaphragm assembly onto the shaft, the washer fitting against the shoulder on the shaft, the diaphragm, the lock nut and finally the special nut which also engages on the linkage.
434. The filter element should be washed in paraffin and allowed to dry and then dipped in Gargoyle Vactric Extra Heavy Oil, and allowed to drain before fitting.
435. Fit front of governor housing to the fuel injection pump with three hexagon head screws, tighten to a torque of 5 lbs./ft.
436. Fit the maximum fuel stop, the screwdriver slot should be positioned on the outside of the governor housing also fit the locknut.
437. Fit the bush and control lever assembly and locate with a spring clip.
438. Place the maximum stop lever into position and hold with fingers, pass the excess fuel spindle through the bushes and fit the groverlock pin which locates the maximum stop lever on the spindle.
439. Fit the bush and return spring to the governor housing.
440. Place the link into its guide shaft and onto the fuel injection pump control rod, fit the tapered screw and lock nut and tighten.
441. Set the pump control rod to 23.0 millimetres.
442. Coat the damping valve and guide bush with colloidal graphite 'Oildag'.
443. Fit the diaphragm ensuring that it is correctly located within the slot in the link.
444. Fit the governor spring and rear of governor housing taking care that the spring is correctly located in the metal centre disc of the diaphragm. Ensure that the shaft enters into the damping valve, tighten the Phillips head screws carefully.
445. The screws should be tightened gradually, first tightening one a little then its opposite number thus ensuring an even pressure on the diaphragm rim.
446. The governor should be tested for leakage by pushing in the diaphragm so as to compress the spring, seal the two suction pipe connections by placing finger and thumb over the inlet connections and then release the diaphragm. If no leakage exists, the diaphragm will remain extended with the spring compressed; but if the diaphragm returns to the compressed position, then a leakage, in or around the diaphragm exists, which will affect the operation of the governor.

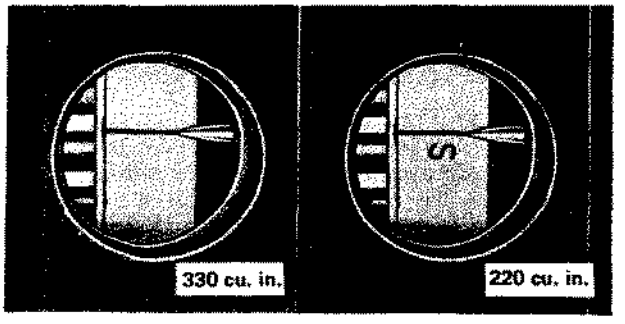
Adjustment of Governor
447. Before the injection pump is fitted to the engine, the maximum fuel stop, on the front end of the pump control rod, must be set on a test bench, so that the pump delivers the correct quantity of fuel for the type of engine to which it is to be fitted.
448. The adjustment of the governor can only be carried out on the engine as follows:-
449. Set the maximum speed stop on the throttle unit so that the engine develops the maximum specified speed, running light.
450. Set the idling stop screw on throttle unit to obtain slow running speed, when fitted, slacken locknut and adjust damping valve guide 'J' until steady idling is obtained.
451. Finally re-tighten locknut.
452. 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.

NOTE: In no circumstances should the engine be run without the throttle unit (venturi), inlet manifold or with either of the two suction pipes disconnected.

453. The governor requires no lubrication or attention in service, except that in dusty conditions of operation the gauze pad in the air cleaners should be removed and washed in paraffin. If defective operation of the governor is suspected, the rear half of the governor unit can be removed by unscrewing the four Phillips head screws and diaphragm inspected.

Inline Fuel Injection Pump (Refitting)
454. Place the key onto the keyway of the drive shaft and slide the pump coupling onto the drive shaft, fit the four bolts which secure the fuel injection pump to the coupling housing and also the two bolts which secure the pump to the bracket, tighten the bolts to a torque of 25 lbs./ft.
455. Tighten pinch bolt.
456. Refit all fuel pipes, throttle linkage and pneumatic pipes as appropriate.

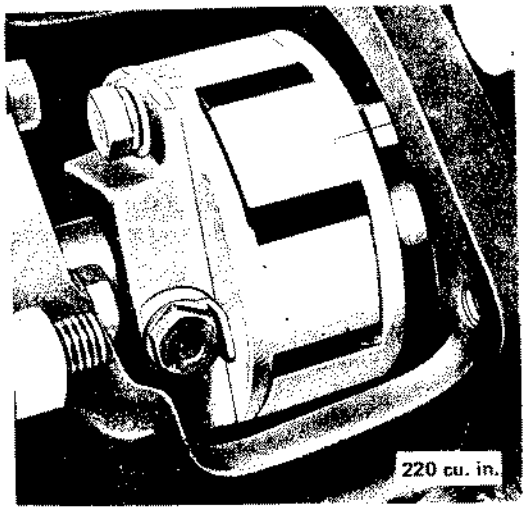
Fuel Injection Pump Timing
457. Rotate the engine until the spill timing mark on the pump coupling approaches the pointer on the pump.
458. Continue to rotate the engine until the spill timing mark on the flywheel is in the centre of the clutch housing timing aperture.

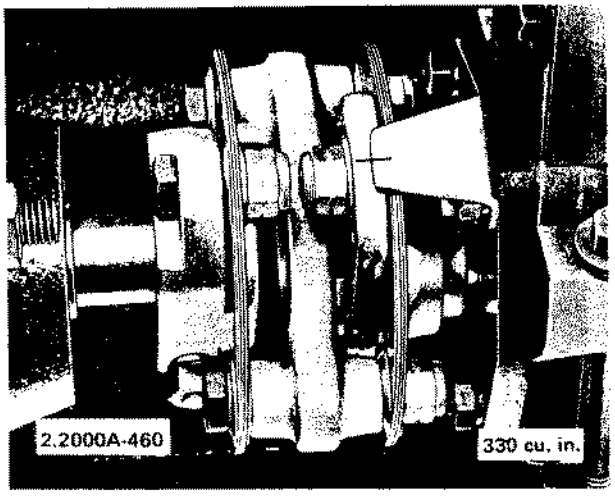


2.2000A-458

459. With the engine in this position, the timing mark on the pump coupling should be in line with the pointer on the pump. If necessary, reset the pump timing as detailed below.

460. Slacken the two bolts through the pump coupling rear flange on the six cylinder engine or coupling front flange on the four cylinder engine, and rotate the pump coupling to bring the marks in alignment.





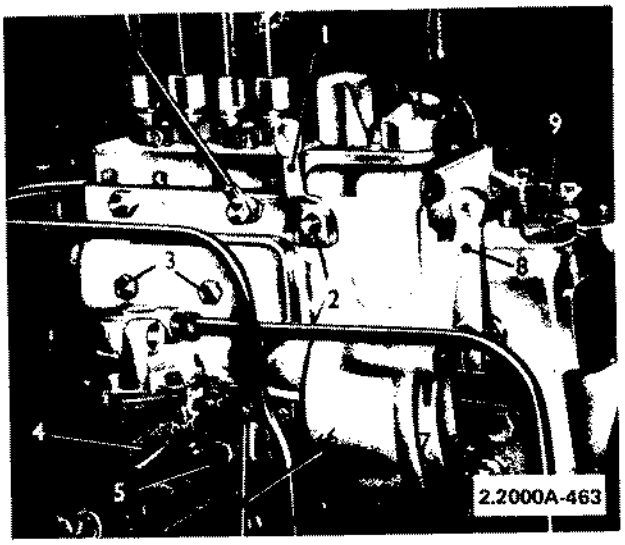
461. Re-tighten the two bolts.

Air Venting the Fuel System

462. Whenever the fuel pipe lines are disconnected such as when cleaning or renewing the filter elements, or if the fuel tank has been allowed to run dry it will be necessary to air vent or bleed the system before attempting to start the engine. The air venting procedure is as follows:-

Engines fitted with AC Fuel Filter and Simms 'In-line' Fuel Injection Pump

463. Slacken off the 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.



1. Stop Control Lever.
2. Excess Fuel Device.
3. Side Cover Bolts.
4. Fuel Feed Pump Priming Lever.
5. Drain Plug.
6. Oil Level Tube.
7. Mechanical Governor Level Plug.
8. Speed Control Lever.
9. Filler Plug — Mechanical Governor.

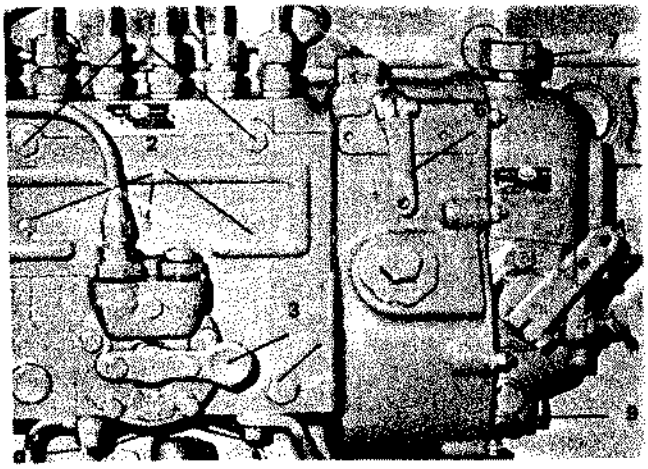
464. Slacken the plugs directly above the pump side cover, operate lift pump until fuel, free from air, is being discharged. Tighten screw as air free fuel is being discharged.

Engines fitted with C.A.V. In-Line Type Fuel Pump

465. Slacken the air vent plug at the top of the fuel filter.

466. 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.

467. 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.



2.2000A-467

1. Air Vent Plugs.
2. Side Cover Screws.
3. Feed Pump Priming Lever.
4. Pump Drain Plug.
5. Oil Level Tube.
6. Stop Control and Excess Fuel Device.
7. Breather and Oil Filler – Mech. Governor
8. Speed Control Lever.
9. Level Plug – Mech. Governor.

2.2020

FUEL LIFT PUMP

Fuel Lift Pump (Description)

1. The spring loaded diaphragm type pumps are mounted in one of three positions, dependent upon the type of fuel injection pump fitted. The pumps can be of either AC or CAV manufacture.
2. Engines fitted with inline fuel pumps have the lift pump fitted directly onto the side of the injection pump.
3. DPA injection pumps fitted to 330 cu. in. engines have the lift pump mounted on the right hand side of the crankcase operated by an eccentric on the camshaft.
4. The 220 cu. in. engines fitted with DPA injection pumps, the lift pump is mounted on a bracket which is in turn fitted to the left hand side of the crankcase at the rear of the injection pump.
5. A hand priming lever is provided on the side of all lift pumps for use in venting the fuel system.

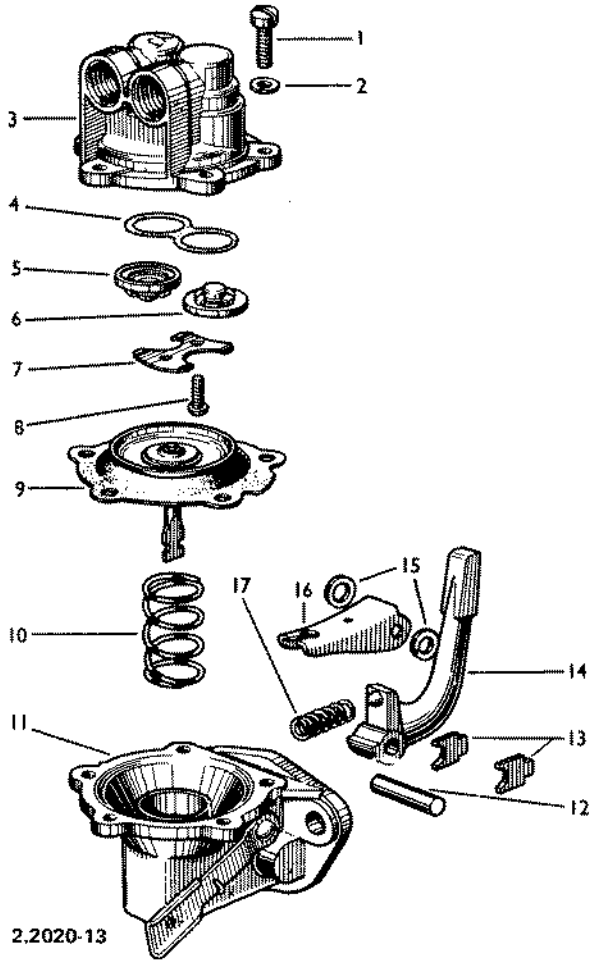
Fuel Lift Pump (Removal)

›. Clean all dirt from the pump casing and fuel pipe unions.
7. Disconnect the fuel pipes from the pump. It is advisable to plug the ends of the pipes to stop the ingress of foreign matter.
8. Remove the securing nuts and lockwashers, and withdraw the lift pump from its mounting.

Fuel Lift Pump (Inspection and Overhaul)

AC FUEL LIFT PUMP USED ON INLINE FUEL PUMPS FITTED TO 220 CU. IN. ENGINES

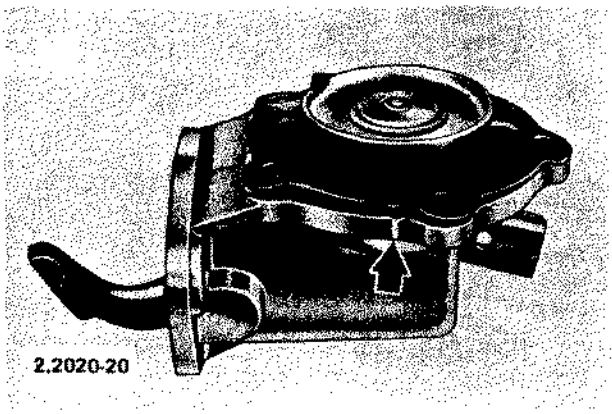
9. Before separating the cover from the body, mark the flanges to enable the two components to be located correctly when reassembling.
10. Remove the screws securing the cover to the body and separate the two components.
11. Disengage the diaphragm pull rod from the link by turning the assembly through 90°. Remove the diaphragm and spring.
12. Remove the screws securing the valve retainer plate to the cover and remove the plate and valve. On some pumps the valves are fixed and should not be removed.
13. Remove the staked metal and retainers securing the rocker arm pin. Remove the rocker arm assembly and spring, and disassemble the pin and spacing washers.



1. Cover Screw.
2. Lockwasher.
3. Pump Cover.
4. Gasket.
5. Inlet Valve.
6. Outlet Valve.
7. Valve Retainer Plate.
8. Retainer Plate Screw.
9. Diaphragm and Pull Rod.
10. Diaphragm Spring.
11. Pump Body.
12. Rocker Arm Pin.
13. Pin Retainers.
14. Rocker Arm.
15. Spacing Washers.
16. Rocker Arm Link.
17. Rocker Arm Spring.

14. Wash all parts in clean paraffin or fuel oil.
15. Examine the contact faces of the rocker arm for wear.
16. Examine the diaphragm for hardness, cracks or deterioration.
17. Check the condition of the diaphragm spring.
18. Check the pump attaching flange for distortion and reface if necessary.
19. Replace the diaphragm spring.

20. Locate the pull rod in the slot in the link. Press down and turn the diaphragm through 90° so that the pip on the diaphragm is in line with the location mark cast on the pump body.



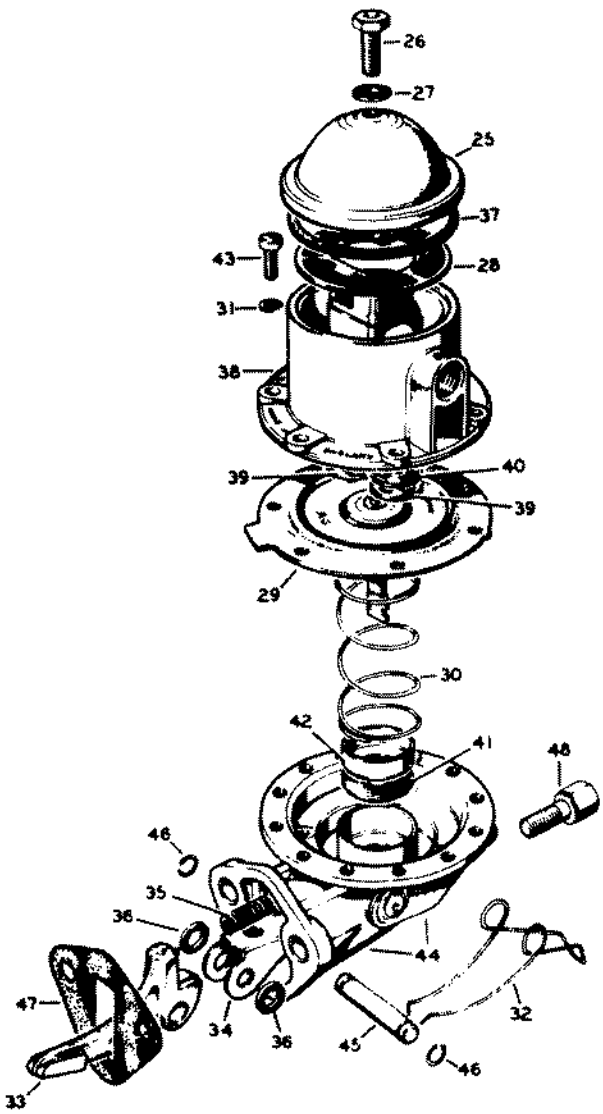
21. Replace the valves and unions. The valves are identical in construction but the inlet valve should be installed with the spring towards the bottom of the pump, and the outlet valve with the spring upwards.
22. When assembling the cover to the pump body, depress the rocker arm until the diaphragm is level with the body face. Install the cover, screws and lock washers and tighten only sufficiently to just engage the heads of the screws with the lockwashers. Release the rocker arm and finally tighten the screws diagonally and evenly.
23. Secure the rocker arm pin retainers by staking the body metal on both sides.

AC FUEL LIFT PUMP USED WITH DPA INJECTION PUMPS

24. Inspection and overhaul of these lift pumps is similar to the previous AC lift pump with the exception of the filter cover, filter and gasket fitted above the valves.
25. These parts should be washed in clean paraffin or fuel oil, inspected and renewed if necessary.

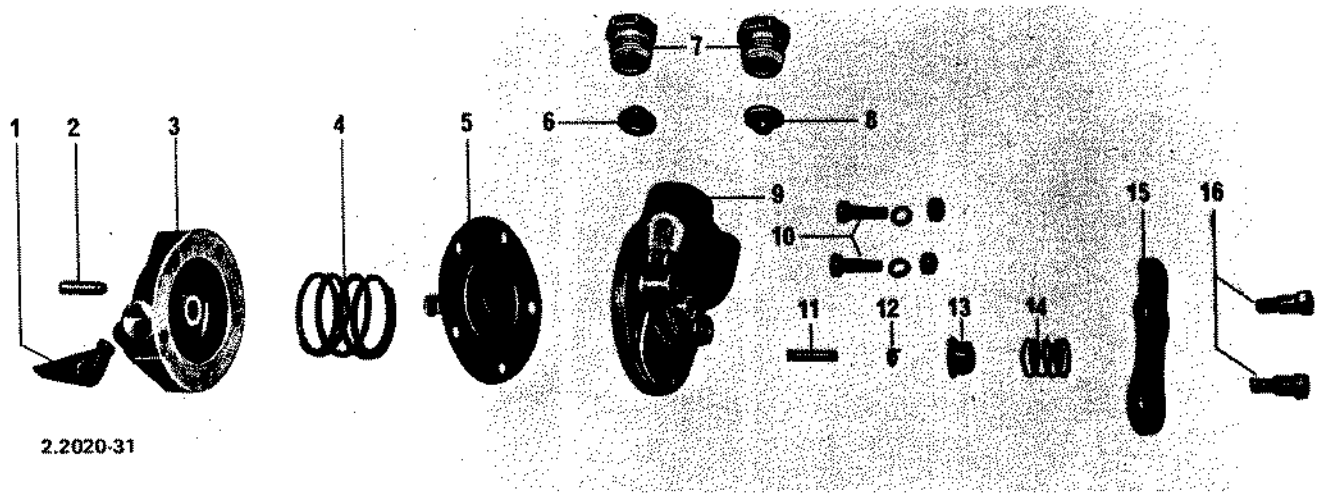
CAV FUEL LIFT PUMP USED ON INLINE FUEL PUMPS FITTED TO 330 CU. IN. ENGINES

26. Break the locking wire and remove the two shouldered screws which secure the pump hand operating lever, remove the lever and also the spring, push rod, spring cap and sealing ring.
27. Remove the two bolts which secure the two halves of the fuel pump together, separate the two halves.
28. Drive the pivot pin from the pump body and remove the bellcrank lever.
29. Carefully remove the diaphragm, complete with spindle, also the operating spring.
30. Remove the inlet and outlet valves from the front portion of the pump.
31. Wash all parts in clean paraffin or fuel oil.



2.2020-24

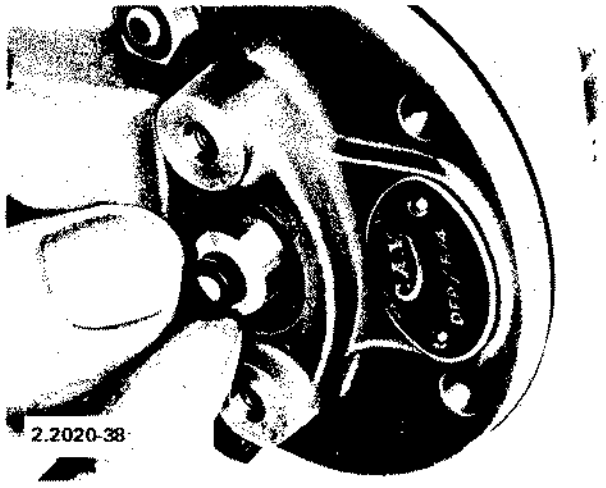
25. Cover Filter.
26. Screw – Filter Cover.
27. Washer Filter Cover.
28. Screen – Filter.
29. Diaphragm Assy.
30. Spring Diaphragm.
31. Lockwasher – Upper Casting Screw.
32. Spring – Primer Lever.
33. Rocker Arm.
34. Rocker Arm Link.
35. Rocker Arm Spring.
36. Washer – Rocker Arm Pin.
37. Gasket – Filter Cover.
38. Body – Upper Casting.
39. Valve Assy.
40. Gasket Valve.
41. Oil Seal.
42. Retainer – Oil Seal.
43. Screw – Upper Casting.
44. Body – Lower Casting.
45. Pin Rocker Arm.
46. Clip – Rocker Arm Pin.



2.2020-31

32. Examine the contact faces of the bellcrank and diaphragm push rod for signs of wear, should excessive wear be visible the worn parts should be renewed.
33. Examine the diaphragm for hardness, cracks or deterioration. Check the condition of the diaphragm spring.
34. Check the pump attaching flange for distortion and reface if necessary, also check the fuel injection pump mating surface.
35. Fit the inlet and outlet valves, the valves are interchangeable but must be fitted as follows, outlet valve dome upwards, inlet valve dome downwards, fit the valve retaining union.
36. Fit the diaphragm operating spring, locate the diaphragm push rod into pump body. Care must be taken to line the holes in the diaphragm with the holes in the pump cover, also note that groove in the diaphragm push rod is parallel with the holes for the bellcrank pivot pin.
37. Press the diaphragm until such a time as the groove in the push rod is visible, engage the bellcrank lever and insert bellcrank pivot pin through holes in the pump body casting and bellcrank.
38. Replace the 'O' ring seal, for the push rod which is actuated by the hand priming lever. Fit the push rod.
39. Join the two halves of the pump and secure with two special nuts and bolts.
40. Fit the spring and spring cap for the hand priming pump lever, fit lever, also the shouldered screws which retain the lever, prevent screws from turning by locking with wire.

Fuel Lift Pump (Refitting)
41. Remove all traces of old gasket from the face of the fuel injection pump or cylinder block and fit a new gasket.
42. Fit the fuel lift pump over the studs (retaining), take care that the rocker arm of the lift pump is on the front of the camshaft where applicable.
43. Tighten lift pump securing nuts to a torque of 5-7 lbs./ft.
44. Ensure that both fuel feed pipes are clean and refit to the fuel lift pump.
45. On Simms fuel injection pumps, remove the inspection cover and top up the camshaft chamber with engine oil until the oil flows from the leak-off pipe at the rear of the feed pump. Replace inspection cover and tighten nuts to a torque of 4 lbs./ft.
46. Air Vent the fuel system.



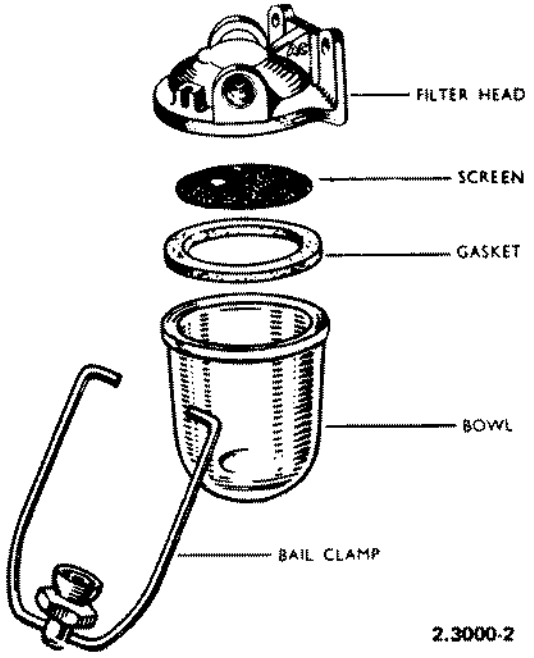
2.2020-38

2.3000

FUEL FILTER

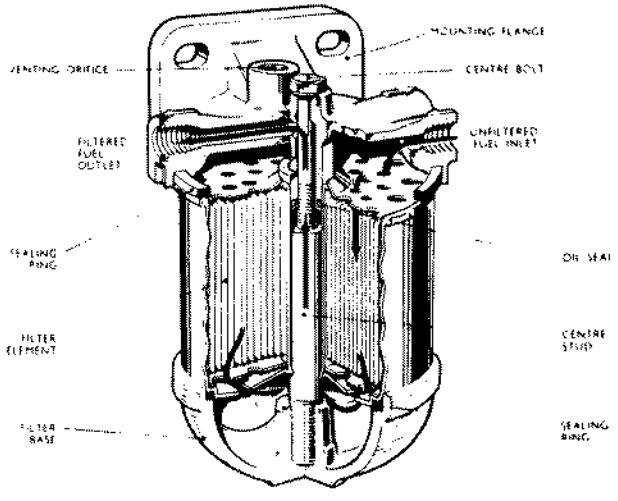
Fuel Filter (Description)

1. The fuel system incorporates two filters, a pre-filter and a main filter.
2. The pre-filter consists of a glass bowl sediment trap and filter screen clamped to the filter head which embodies inlet and outlet pipe connections.



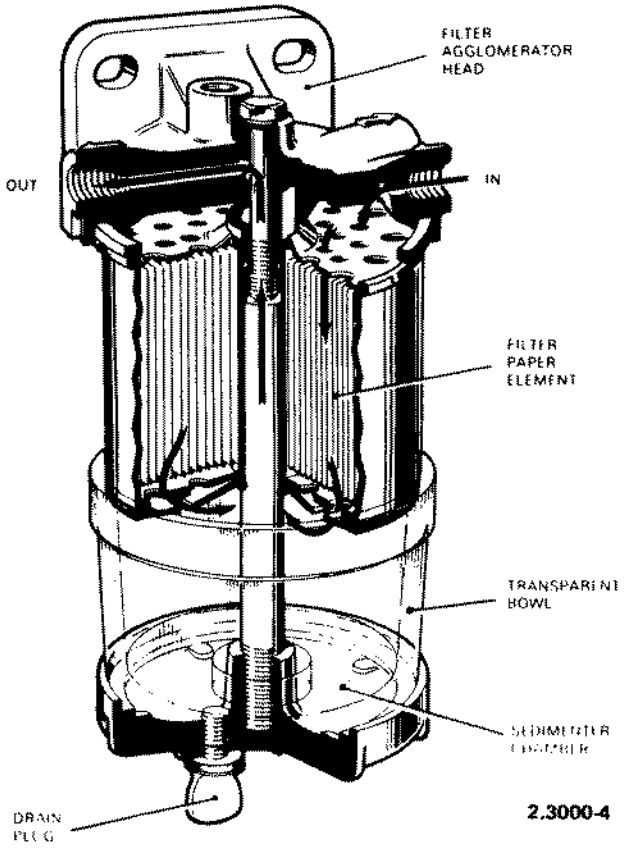
2.3000-2

3. The main filter incorporates a paper type element carried in a detachable filter casing. Inlet and outlet connections are provided in the filter head which also includes the air vent plugs. A drain plug is located in the bottom of the element casing on some filters.



2.3000-3

4. Some engines incorporate an agglomerator in place of the main filter. This consists of the standard filter with either a glass or aluminium bowl fitted below.



2.3000-4

5. The agglomerator element is designed to carry out a dual function of filtration and water separation. The fuel flows downwards through the element, the fine pores of which isolate and retain the solid particles. Simultaneously the fine water droplets which are forced through the pores of the filter, agglomerate into larger droplets which are then deposited in the base. The fuel, free from dirt and water, flows up the centre tube to the outlet connections in the filter head.

Fuel Filter (Removal)

6. Clean the exterior of both the pre-filter and the main filter.
7. Disconnect all fuel pipes to the inlet and outlet parts of the filters. To stop the ingress of foreign matter the ends of the pipes should be plugged.
8. Both the pre-filter and the main filter are retained by two screws through the filter heads into the crankcase.
9. Remove the retaining screws and lift the complete filter assemblies from the crankcase.

Fuel Filter (Inspection and Overhaul)

10. The only overhaul necessary on the fuel filter assemblies is a periodic examination of the components and replacement of any defective parts. However the following points on maintenance should be noted.

Cleaning the Pre-Filter

11. To clean the pre-filter remove all dirt from the exterior of the filter.
12. Remove the bowl and filter screen and clean in paraffin or fuel oil.
13. Examine the bowl, gasket and filter screen for damage and replace where necessary.
14. Reassemble the parts to the filter head and air vent the fuel system as described in 2.2000 page 23.

Flushing the Main CAV Filter

15. To flush the main fuel filter remove the drain plug from the bottom of the filter casing.
16. Operate the priming lever on the fuel feed pump until clean fuel oil flows from the filter.
17. Replace and tighten the drain plug.
18. Air vent the fuel system.

Renewing the Main Filter Element

19. To renew the main filter element it is not necessary to remove the complete filter assembly.
20. Remove all dirt from the exterior of the filter.
21. Unscrew the centre bolt at the top of the filter and remove the casing.
22. Drain the casing, remove and discard the element.
23. Wash the casing in clean paraffin or fuel oil and dry with compressed air. Do not use a rag for this purpose.
24. Where supplied, install a new gasket and/or sealing ring. Check that the gasket is correctly located and free from kinks.
25. Check the condition of the element spring.
26. Install the spring and on the AC filter, the steel washer in the casing.
27. Install the element, replace the casing and tighten the centre bolt.
28. Air vent the filter.

Fuel Filter (Refitting)

29. Using a new gasket refit the filter assembly and tighten the two retaining screws to a torque of 22-27 lbs./ft.
30. Unplug the fuel pipes and reconnect.
31. Air vent the complete fuel system.

2.5000

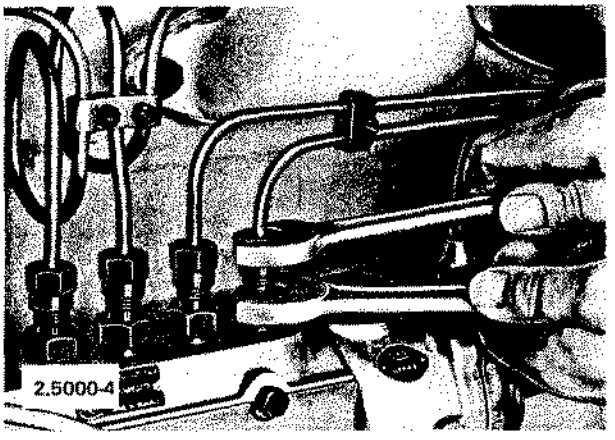
FUEL LINES

Fuel Lines (Description)

1. The fuel lines are manufactured from special bundy tubing, which is seamless. The pipes are connected to both the fuel injection pump and the injectors with a union and a nipple.

Fuel Lines (Removal)

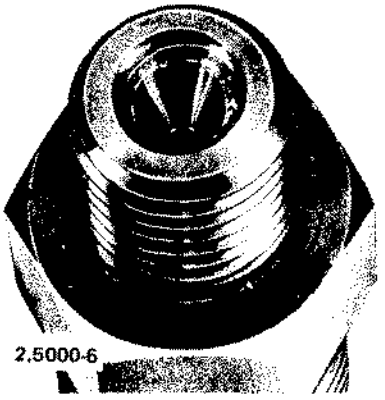
2. Before disconnecting the pipes, clean the area in the vincinity of the pipe unions, to prevent foreign matter entering the feed drillings of the injector or the delivery valve holder. A small particle of dirt on the lapped finished surfaces of an injector or delivery valve is sufficient to render them inoperative.
3. Disconnect the union nuts from the injectors.
4. Disconnect the union nuts from the delivery valve holders. Use one wrench to hold the delivery valve holder and another to unscrew the union nut.



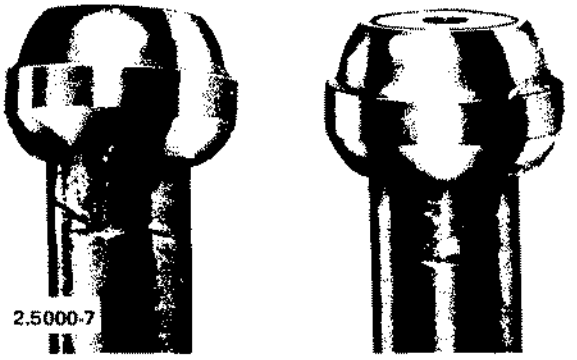
5. Remove the clips securing each pair of pipes. Remove the pipes, and seal the injectors and delivery valve holder union orifices.

Fuel Lines (Inspection and Overhaul)

6. Inspect the seating in the delivery valve holder, and in the pipe adaptor of the injector. These seats may be distorted due to previous overtightening of the unions. An example of this distortion is shown below. Renew the part if distortion is seen. Otherwise uneven pressure on the nipple and a bending stress on the pipe will occur.

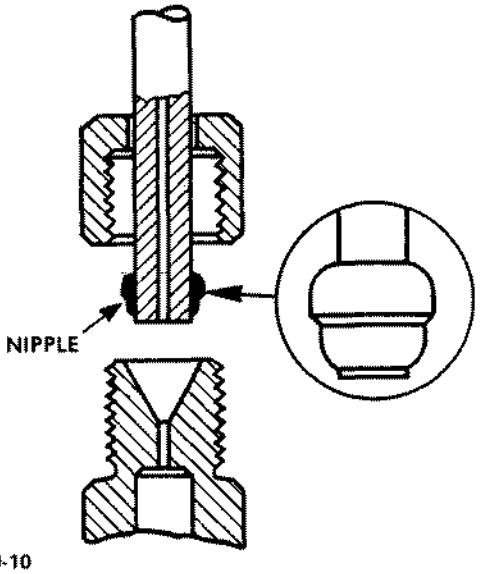


7. Inspect the pipe for damage, especially the area close to each nipple and ensure that the pipe has not been grooved by contact with the union nut. A pipe so grooved or marked by a blow or deep scratch must be rejected. Such a groove can develop into a crack as shown at 'A' and 'B' in Fig. 2.5000-7.



Fuel Lines (Refitting)

8. When installing a pipe the following precautions MUST be taken:-
9. Whether the pipes are new or used they must be throughly cleaned both inside and outside. Wash off in clean fuel oil or paraffin and blow dry with clean DRY compressed air. Finally, flush the bore of the pipes with fuel oil or Shell Fusus oil from a filtered supply. Check that the contact surfaces and threads of the valve holder and adaptor are clean.
10. Place the pipe in position and check that each end enters its seating along the centre line of the valve holder or adaptor. Tighten the union nuts finger tight only, and check that the pipe is centrally disposed where it emerges from each nut. Also ensure that the pipe remains in a true line with the valve holder or adaptor.



11. Offer up a clip to the pipe and check that the pipe is in such relationship to its adjoining pipe that the clip will span the two without either being strained.

12. If any adjustment of the pipe is necessary, never attempt this while the pipe is installed. The pipe must be reformed, by hand, over as much of its length as possible. Local bending will cause failure.
13. If it is necessary to reform the pipe, ensure that the bore of the pipe is flushed before installing.
14. When satisfied with the disposition of the pipe, tighten the union nuts carefully, adopting the following procedure:-
15. Screw down the union nuts finger tight, then tighten a further third of a turn with a wrench. This applies to existing or new pipes. Over tightening will lead to early failure of the pipe.
16. Install the pipe clips, noting that the pipes must not be strained into the clips.

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2.0000
FUEL SYSTEM SPECIFICATIONS

INJECTORS

TYPE	GM PART NUMBER	MANUFACTURER
4 & 9	6388187	CAV
5	6388149	CAV
6	2681736	SIMMS
7	3351073	CAV
8	3351346	CAV
10	91039524	CAV
11	2708286	CAV

NOZZLE	SIMMS	CAV
Seat Angle	58° 30′	59° 25′
Spray Holes - Number	4	4
- Diameter	.25 mm (.01″)	.25 mm (.01″) (Inline Fuel Pump) .27 to .29 mm (.0106″ - .0114″) (DPA Fuel Pump)

NOZZLE VALVE		
Seat Angle	60°	60°
Valve Lift	.127 - .178 mm (.005″ to .007″)	.203 - .254 mm (.008″ to .016″)

TESTING AND SETTING DATA (NEW INJECTORS)

BACK LEAKAGE (INLINE PUMPS)	Pressure to drop from 150 to 125 atmospheres on gauge at temperature of 10° to 21°C (50° to 70°F) in not less than 10 seconds and not more than 45 seconds.
BACK LEAKAGE (DPA PUMPS)	Pressure to drop from 150 to 100 atmospheres on gauge at temperature 10° to 21°C (50° to 70°F) in not less than 6 seconds and not more than 60 seconds.
DELIVERY PRESSURE	175 ATMOSPHERES
SEAT TIGHTNESS	Nozzle tip to be dry at sustained pressure of 165 atmospheres.
SPRAY FORM	Sprays to be of equal form and completely atomised at 90 injections per minute.

FUEL INJECTION PUMPS

SIMMS IN LINE - 220 cu in ENGINE

CAMSHAFT END FLOAT ..... .051 - .152 mm (.002″ to .006″)
COUPLING END CLEARANCE ..... .508 mm (.020″)

PHASING

Travel from bottom of stroke to inlet port closure (Number 1 plunger) ..... 2896 - 3099 mm (114″ to 122″)
Plunger head clearance (all) ..... 1.5 - 1.98 mm (.059″ to .078″)
Plunger vertical end float (all) ..... .051 - .178 mm (.002″ to .007″)
Intervals between spill cut-off ..... 90° ± 1°

CALIBRATION

Set number 4 control fork 0.5 mm (.02″) from the end of squared section of control rod and adjust maximum fuel stop screw to give 10.0 to 10.2 cc (220 cu in engine) per 200 strokes at 600 rpm, using test injectors with

BDN12, SD12 nozzles set at 175 atmospheres and with pipes 6×2×600 mm (.24" × .08" × 23.64"). Balance remaining elements to Number 4.

Pumps must not deliver fuel at 600 rpm when control rod is set 4 mm (.16") from zero position.

Excess fuel setting ..... 100% increase on maximum setting per 100 strokes at 100 rpm (min).

SPILL TIMING ..... 22° B.T.D.C.

CAV IN-LINE - 330 cu in ENGINE

CAMSHAFT END FLOAT ..... .051 - .102 mm (.002" to .004")

PHASING

Plunger head clearance - Number 1 Plunger ..... .457 - .559 mm (.018" to .022")

Plunger head clearance - Numbers 2, 3, 4, 5 & 6 Plungers ..... .356 - .660 mm (.014" to .026")

Intervals between spill cut-off ..... 60° ± 30'

CALIBRATION

All delivery readings are in c.c. per 100 strokes, using test injectors with BDN12, SD12 nozzles set at 175 atmospheres and with pipes 6×2×600 mm (.24" × .08" × 23.64").

TEST	PUMP RPM	CONTROL ROD OPENING	DELIVERY LIMITS	MAXIMUM SPREAD
1	200	9 mm (.3546")	1.2 to 2.2 cc	.4 cc
2	800	11 mm (.4334")	5.2 to 5.9 cc	.4 cc
3	1,400	11 mm (.4334")	6.9 to 7.7 cc	.5 cc
4	1,400	1 mm (MIN) (.0394")	ZERO	

MAXIMUM FUEL OUTPUT SETTING

NORMAL 12.1 to 12.3 cc per 200 strokes at 800 rpm

With excess fuel device operated - 10.0 cc per 100 strokes at 100 rpm (min).

SPILL TIMING ..... 26° B.T.D.C.

SIMMS PNEUMATIC GOVERNOR

DIAPHRAGM SPRING

Load when compressed to 13.5 mm (.532") ..... 0.84 to 0.92 kg. (1.86 - 2.03 lb)

Identification colour ..... White - Blue

VENTURI DIAMETER ..... 44 mm (1.5")

ENGINE GOVERNED SPEED

Idling ..... 450 to 550 rpm

Maximum (full load) ..... } As specified

Maximum (no load) ..... } see table below

CAV PNEUMATIC GOVERNOR

Load when compressed to 46 mm (1.8") ..... 2.2 to 2.4 kg. (4.9 - 5.3 lb)

Identification colour ..... White-Blue

Load when compressed to 40 mm (1.6") (Revised Spring) ..... 2.3 to 2.5 kg. (5.1 - 5.5 lb)

Identification Colour ..... Red - Red

VENTURI DIAMETER ..... 50 mm (1.97")

ENGINE GOVERNED SPEED

Idling	450 to 550 rpm
Maximum (full load)	As specified see table below
Maximum (no load)	As specified see table below

CAV MECHANICAL GOVERNOR

Idling	450 to 550 rpm
Maximum (full load)	As specified see table below
Maximum (no load)	As specified see table below

GOVERNOR TYPE	ENGINE RATED SPEED	PERCENTAGE GOVERNED	NO LOAD GOVERNED SPEED
Pneumatic	2,600 r.p.m.	13%	2,936 r.p.m.
Mechanical	2,400 r.p.m.	4%	2,496 r.p.m.
Mechanical	2,000 r.p.m.	4%	2,080 r.p.m.
Mechanical	1,800 r.p.m.	4%	1,872 r.p.m.
Mechanical	1,500 r.p.m.	4%	1,560 r.p.m.
Mechanical	2,600 r.p.m.	10%	2,860 r.p.m.

CAV DPA - 220 & 330 cu in ENGINE

SPILL TIMING

220 ENGINE MECHANICAL GOVERNING	26° B.T.D.C.
330 ENGINE MECHANICAL GOVERNING	16° B.T.D.C.
330 ENGINE HYDRAULIC GOVERNING	24° B.T.D.C.
330T ENGINE MECHANICAL GOVERNING	12° B.T.D.C.
330T ENGINE HYDRAULIC GOVERNING	20° B.T.D.C.

FUEL FEED PUMPS

A.C. TYPE YJ

LOAD OF DIAPHRAGM SPRING WHEN COMPRESSED TO 12 mm (.47")	5.39 to 5.50 kg (11.9 - 12.2 lb)
FUEL DELIVERY	1 litre (1.76 pints) in 42 seconds at 2,000 RPM (Engine)
DELIVERY PRESSURE	41 to 69 KPa (6 - 10 P.S.I.)

CAV TYPE DFP6A/4

LOAD OF DIAPHRAGM SPRING WHEN COMPRESSED TO 16 mm (.63")	5.49 to 6.12 kg (12.1 - 13.5 lb)
FUEL DELIVERY	1 litre (1.76 pints) in 100 seconds at 2,000 RPM (Engine)
DELIVERY PRESSURE	14 to 31 KPa (2 - 4½ P.S.I.)

AC TYPE UF

LOAD OF DIAPHRAGM SPRING WHEN COMPRESSED TO 16 mm (.63")	6.7 to 6.9 kg (14.8 - 15.2 lb)
FUEL DELIVERY	1 litre (1.76 pints) in 42 seconds at 2,000 RPM (Engine)
DELIVERY PRESSURE	34 to 55 KPa (5 - 8 P.S.I.)

FUEL FILTERS

PRE-FILTER 220/330	AC - 7950001
MAIN FILTER 220	AC - BD 510
MAIN FILTER 330	AC - AD 510
MAIN FILTER ELEMENT 220/330	AC - ACD 51

TORQUE WRENCH DATA

INJECTOR SECURING NUTS	10-14 Nm (7 - 10 ft lbs)

D.P.A. Pumps (Mechanical)

DRIVE HUB SECURING SCREW	32 Nm (285 lb/in)
CAM ADVANCE SCREW	33 Nm (300 lb/in)
DRIVE PLATE SCREWS	18-19 Nm (160 lb/in)
TRANSFER PUMP ROTOR	7-8 Nm (65 lb/in)
END PLATE SCREWS	4-5 Nm (45 lb/in)
FUEL INLET ADAPTOR	81 Nm (720 lb/in)
FUEL INLET CONNECTION (STEEL END PLATE)	47-48 Nm (420 lb/in)
FUEL INLET CONNECTION (ALUMINIUM END PLATE)	41 Nm (360 lb/in)
HEAD LOCATING FITTING (WITH RUBBER GASKET)	33 Nm (300 lb/in)
HEAD LOCATING FITTING (WITH CORK GASKET)	39 Nm (350 lb/in)
HEAD LOCKING SCREWS	19-20 Nm (170 lb/in)
COVER SECURING NUTS	4-5 Nm (40 lb/in)
DRIVE SHAFT SCREW (28.5 mm Long)	33 Nm (24 lb ft)
DRIVE SHAFT SCREW (31.7 mm Long)	36-37 Nm (27 lb ft)

D.P.A. Pumps (Hydraulic)

CAM ADVANCE SCREW	34 Nm (25 lb ft)
TRANSFER PUMP ROTOR	7-8 Nm (5.5 lb ft)
DRIVE PLATE SCREWS	18 Nm (13.3 lb ft)
END PLATE SCREWS	5 Nm (4 lb ft)
FUEL INLET CONNECTION	41 Nm (30 lb ft)
HEAD LOCATING FITTING (RUBBER GASKET)	33 Nm (300 lb/in)
HEAD LOCATING FITTING (CORK GASKET)	39 Nm (350 lb/in)
CAP NUT	15 Nm (130 lb/in)
HEAD LOCKING SCREWS	19 Nm (14 lb ft)
SPRING CAP & PISTON PLUG	28-29 Nm (21 lb ft)
PUMP SECURING-NUTS (BOTH TYPE GOVERNORS)	19 Nm (14 lb ft)
FUEL PUMP COVER (BOTH TYPE GOVERNORS)	10 Nm (7 lb ft)

In-Line Pumps

DELIVERY VALVE HOLDERS	54 Nm (40 lb ft)
BEARING HOUSING SCREWS	7-10 Nm (5-7 lb ft)
MOUNTING FLANGE SCREWS	7-10 Nm (5-7 lb ft)
CAMSHAFT NUT	62 Nm (46 lb ft)
BODY SCREWS	7 Nm (5 lb ft)
LIFT PUMP SECURING NUTS	16-20 Nm (12-15 lb ft)
BEARING	20-23 Nm (15-17 lb ft)
HOUSING SCREWS TO PUMP	7-10 Nm (5-7 lb ft)
REAR HOUSING TO FRONT HOUSING SCREWS	7-10 Nm (5-7 lb ft)
PUMP TO BRACKET	34 Nm (25 lb ft)
LIFT PUMP SECURING NUTS	7-10 Nm (5-7 lb ft)
INSPECTION COVER NUTS	5 Nm (4 lb ft)

Fuel Filter

FILTER TO BLOCK	30-37 Nm (22-27 lb ft)

Fuel Lines

FUEL LINE UNION	FINGER TIGHT + ⅓ TURN WITH WRENCH

SECTION 3

AIR SYSTEM

Contents

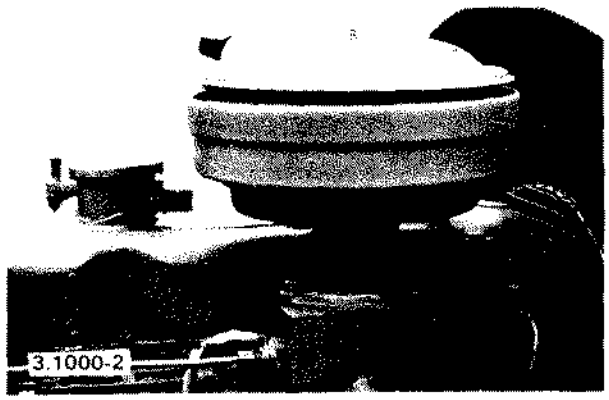
3.1000

AIR CLEANER

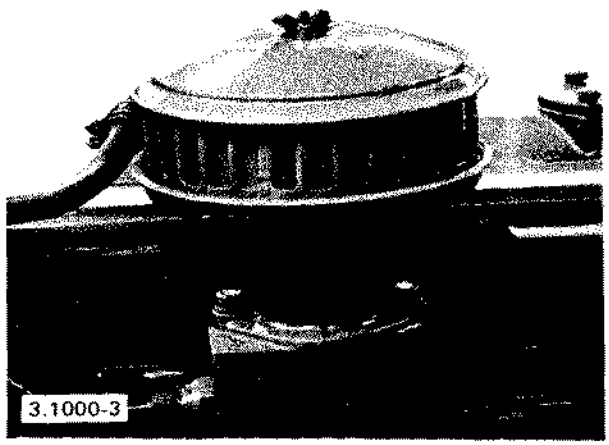
AIR CLEANER (Description)

1. There are three types of air cleaners fitted to the 220/330 cu. in. engines – standard, marine and heavy duty. The cleaner is mounted onto the inlet manifold or venturi assembly and secured with a clip.

2. The standard air cleaner is of the oil bath type comprising an oil bath, filter element, seal ring, cover and retaining nut.

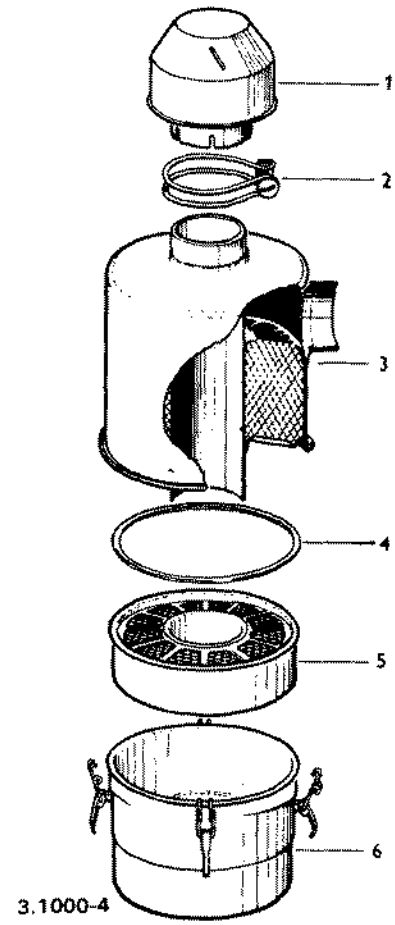


3. The marine air cleaner is of the wire mesh type and is fitted the same as the standard duty air cleaner.



4. The heavy duty type comprises a main body containing a fixed filter element, a detachable oil bath, filter element and centrifugal pre-cleaner. These are arranged so that air entering the intake manifold first passes through three separate stages of filtration.

5. Entering the centrifugal pre-cleaner at the top of the air cleaner assembly, a whirling motion is imparted to the ingoing air. A high proportion of the dust particles in the air are thrown outwards, by centrifugal force to the periphery of the casing where it is ejected through the two outlet slots. After leaving the centrifugal casing, the whirling motion of the air stream is converted to a straight directional flow by vanes and it passes down the central tube in the main body of the air cleaner.



1. Centrifugal pre-cleaner
2. Clip
3. Main body & Fixed filter element
4. Gasket
5. Detachable filter element
6. Oil Bath

6. On reaching the lower end of the central tube, the air impinges on the surface of the oil contained in the oil bath at the base of the air cleaner and the air flow is then deflected upwards to the lower (detachable) wire mesh filter element. Heavy particles of dust are deposited directly into the oil while lighter particles are trapped by the filter element and subsequently washed back into the oil bath by oil which is carried upward into the filter with the air stream. To ensure that the later stages of cleaning are effective, it is essential that the correct grade of oil, see paragraph 19, is contained in the oil bath and that it is maintained at the level marked on the inside of the oil bath casing.

7. After passing through the lower filter element the air is finally filtered by the fixed element in the main body of the air cleaner.

AIR CLEANER (Removal)

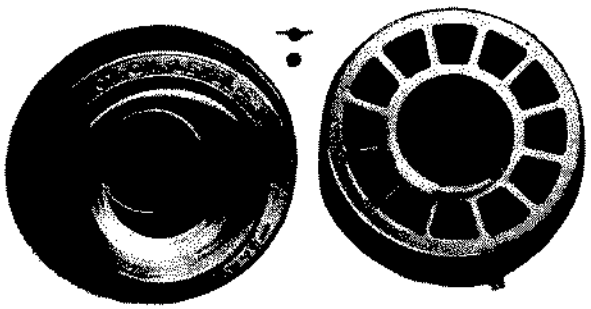
8. Detach the crankcase ventilator pipe, where fitted, and the support bracket from the air cleaner.
9. Slacken the securing clip and lift away the air cleaner from the inlet manifold or venturi assembly. Ensure the cleaner is kept vertical to avoid spilling the oil.

AIR CLEANER (Inspection and Overhaul)

10. Air cleaners should be cleaned at least every one hundred hours or at more frequent intervals, depending on the operating conditions.

Standard Duty Air Cleaners

11. Remove the nut and lift off the cover and gasket. Lift out the filter element and rinse in clean paraffin. Blow out the element to remove all traces of cleaning fluid. Drain the oil from the oil bath and clean out any sediment. Check the condition of the gasket and renew if necessary. Refill the oil bath, with one of the recommended lubricants on page 3, to the level indicated and install the filter element, gasket and cover.



3.1000-11

NOTE: It is not necessary to re-oil the filter element as this is done automatically when the engine is running.

Marine Air Cleaner

12. Unscrew the wing nut at the top of the cleaner and remove the cover and filter element. Rinse the element in clean paraffin (Kerosene) and shake it to remove all traces of paraffin (Kerosene).
13. Replace the element and refit the top cover.

Heavy Duty Air Cleaner

14. Slacken the clip securing the centrifugal pre-cleaner to the main cleaner, and remove any dust or foreign matter from the side of the cowl, and the vanes in the inlet tube.
15. Remove the detachable bottom element and oil container by releasing the four toggle clips fitted around the rim of the oil container. Lift out the element and rinse in clean paraffin (Kerosene). When clean, allow the element to drain thoroughly. Drain the oil from the oil bath and, if necessary, remove any sludge which may have accumulated in the base. Refill the oil container with fresh oil to the level indicated on the case. For recommended oil see paragraph 19.

Note: It is important to ensure that the paraffin (Kerosene) used in cleaning the filter has completely dried off before re-assembling. Failure to observe these precautions may lead to uncontrolled racing of the engine caused by the paraffin or oil being drawn into the air supply.

16. It is not necessary to re-oil the element as this is done automatically when the engine is running. When installing the element ensure that the gasket fitted on top of the flange is in good condition and correctly located.
17. Depending on the operating conditions it will be necessary to periodically clean out the upper element, which is attached inside the main body. To do this remove the main body from the engine and after dismantling the oil container and element, wash the main body in a container of clean paraffin (Kerosene), draining thoroughly before reassembly.

AIR CLEANER (Refitting)

18. Place the air cleaner back onto the inlet manifold or venturi assembly. Refit the crankcase ventilation pipe and then retighten the air cleaner securing clip.

Recommended Lubricants

UNITED KINGDOM

19. The order in which the following recommended brands are listed does not imply any preference. All lubricants shown are equally recommended.

BP	CASTROL	DUCKHAMS	ESSO	GULF	MOBIL	REGENT	SHELL
Energol SAE 50	Castrol Grand Prix	NOL 50	Essolube 40/50	Gulflube 50	Mobiloil B.B.	Havoline 50	Shell X-100 50

OVERSEAS

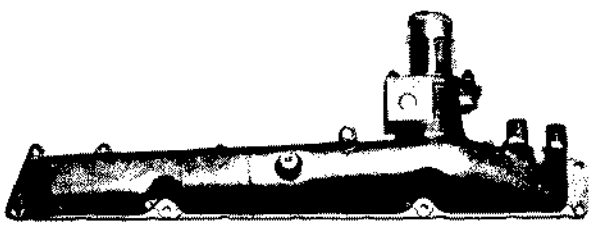
TEMPERATURE RANGE	SAE VISCOSITY No.	GM SPECIFICATION No.
Above 0°C (32°F)	50	4602-M or 4506-M
Below 0°C (32°F)	20	4603-M or 4501-M

3.3000

AIR INLET MANIFOLD

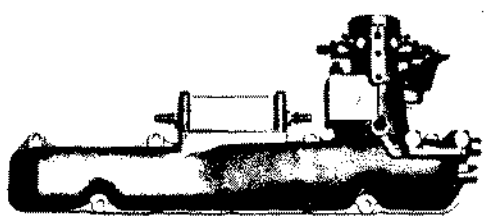
AIR INLET MANIFOLD (Description)

1. The air inlet manifold is an aluminium casting with an inlet onto which the air cleaner adaptor is fitted.



3.1000-1

2. The air cleaner can be directly mounted to the air cleaner adaptor, or remotely mounted with hoses of suitable diameters.
3. A tapped hole in the boss, situated on the inlet is provided to take the cold starting aid igniter. When a cold start aid is not required the orifice is fitted with a plug.
4. On some 220 cu. in. engines a pneumatically governed fuel injection pump is used, where this occurs a venturi is fitted between the air cleaner and the manifold inlet port in place of the air cleaner adaptor, and a damping chamber is located on top of the manifold.



3.3000-4

AIR INLET MANIFOLD (Removal)

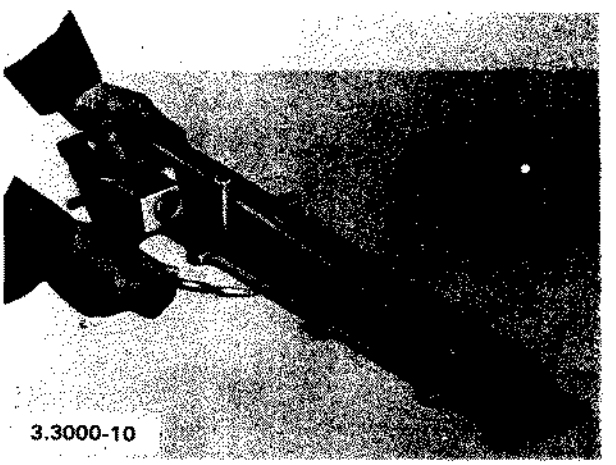
5. Remove the air cleaner as described in section 3.1000 and the breather pipe as described in 4.8000.
6. Disconnect the throttle and idling controls from the linkage on the venturi.
7. Disconnect the pipes from the pneumatic governor, venturi and damping chamber.
8. Plug the ends of the pipes and fuel pump governor to prevent ingress of foreign matter.

NOTE: On no account must the engine be rotated or started when the governor pipes are disconnected as no control on the engine speed can be exercised. Should the engine be inadvertently started under these conditions, pull the stop control knob on the instrument panel or the stop lever at the side of the governor, and hold in the stop position until the engine ceases to run.

9. Remove the securing nuts and washers and lift away the manifold.

AIR INLET MANIFOLD (Inspection and Overhaul)

10. Examine the manifold for cracks especially around the attaching flanges. Check the manifold joint face for distortion. Slight bowing of the face can be corrected by placing the manifold on a flat block of hard wood and applying light blows with a hide hammer. Correct local distortion with a fine cut file.



3.3000-10

AIR INLET MANIFOLD (Refitting)

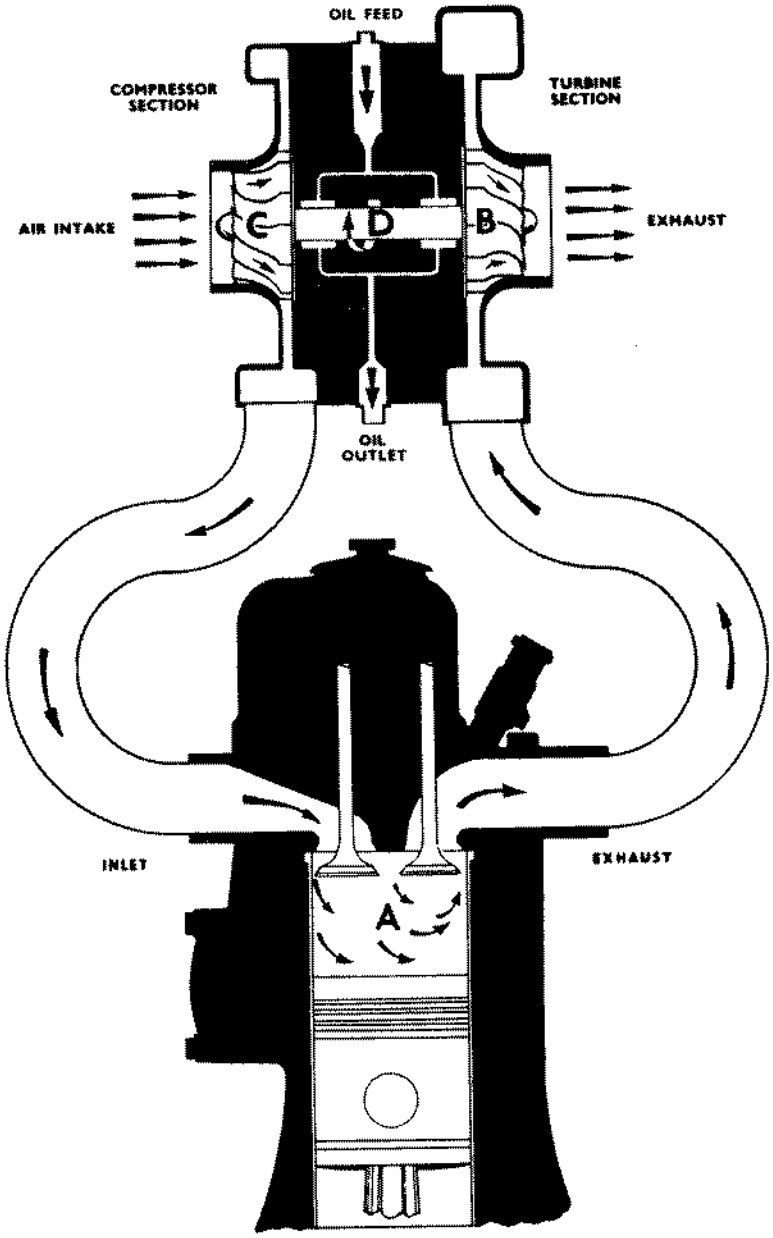
11. Replace the manifold onto the cylinder head ensuring that the faces are clean and tighten the nuts to a torque of 13-15 lbs. ft.
12. Remove the plugs from the fuel pipes and reconnect the pipes to the filter, venturi and damping chamber where fitted.
13. Reconnect the throttle linkage and replace the air cleaner and breather pipes as described in 3.1000 and 4.8000 respectively.

3.5000

TURBOCHARGER

TURBOCHARGER (Description)

1. Two types of turbocharger are fitted to 330 cu. in. engines. Up to serial number P & I 4665 a CAV turbocharger was used and at P & I 4666 a turbocharger manufactured by Holset Engineering Co. was introduced.
2. Turbochargers are mounted on the exhaust manifold of the engine and obtain their motive power from the exhaust gases expelled by the engine cylinders.
3. The turbine rotor (B) and the compressor rotor (C) are mounted on a common shaft (D). As the turbine is driven by the exhaust gases it drives the compressor rotor which delivers air under pressure to the engine. More air is fed to each cylinder (A), and therefore more fuel can be burnt in a given time than would be possible in a normally aspirated engine. This results in a proportionate increase in engine power.

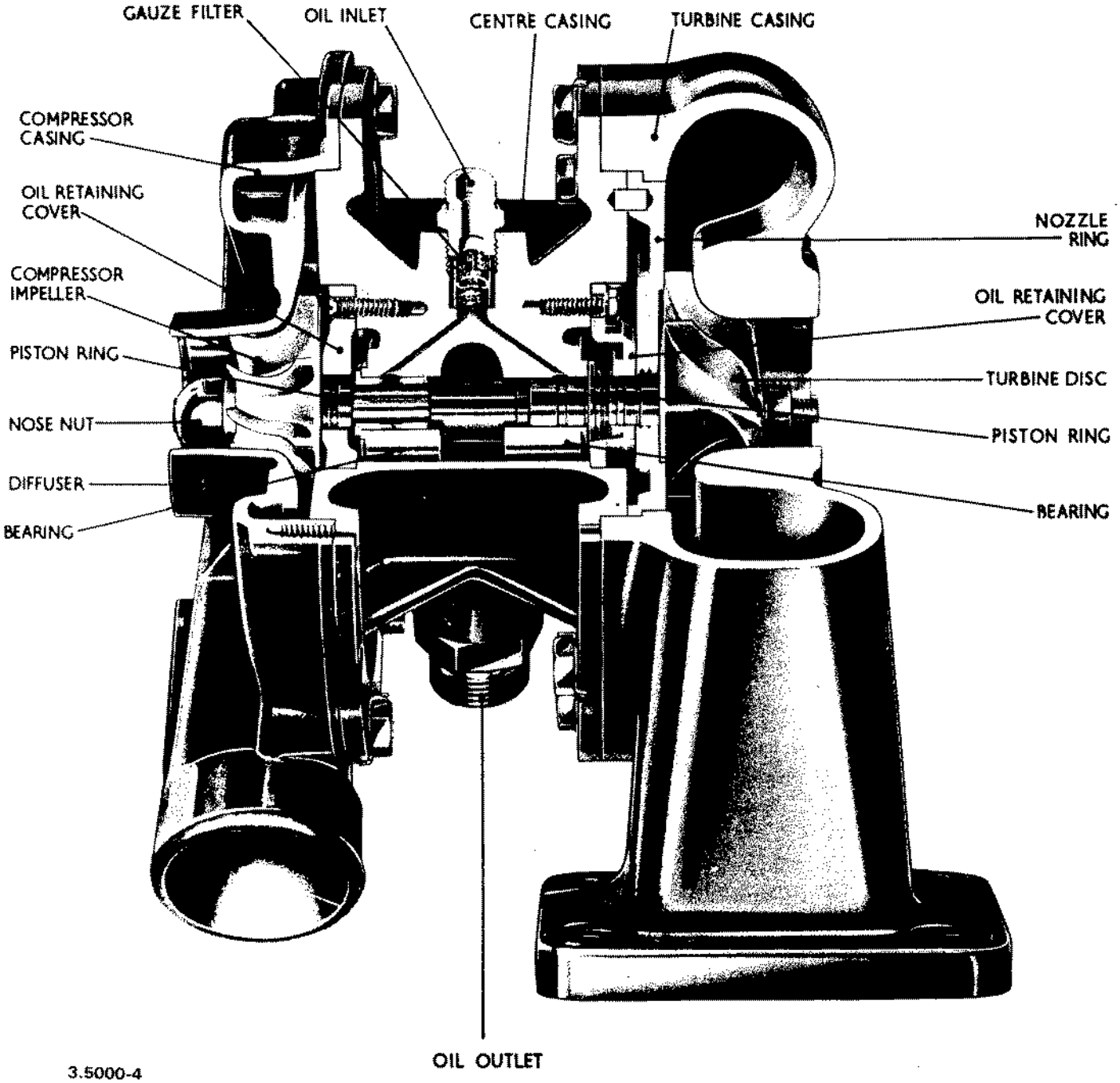


3.5000-3

DIESEL ENGINE CYLINDER

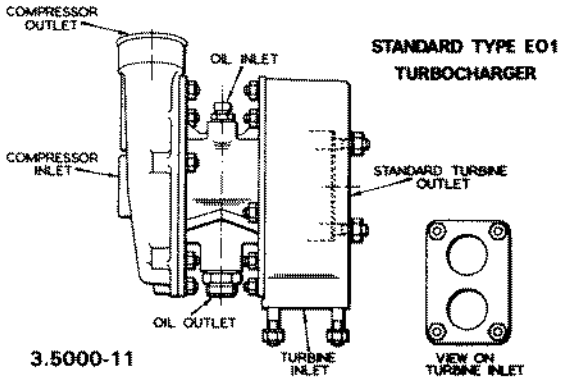
CAV TURBOCHARGER

4. The turbocharger casing comprises an aluminium or iron centre casing, a compressor housing of aluminium, a backplate and a turbine housing of chrome iron. The centre casing carries the rotating assembly and is interposed between the compressor and the turbine housing.



3.5000-4

5. The rotating assembly consists of a compressor turbine, drive shaft and exhaust turbine. The drive shaft and exhaust turbine being permanently fixed together.
6. High precision plain, fully floating bearings are used to mount the rotating assembly in the centre casing.
7. The bearings are lubricated and cooled by the engine oil system. Oil under pressure enters the turbocharger at the inlet union and is directed via a chip tray to each bearing via a gauze filter and an orifice washer. The oil is then drained back into the engine sump.
8. Between the centre casing and turbine casing is the nozzle ring, which is a flat plate fitted with vanes for deflection of exhaust gases. The angle at which the vanes are inclined is of a critical value varying according to the type of turbocharger and is included in the type symbol.
9. The nozzle ring also functions as a gas baffle to prevent gas entering the centre casing. The bore of the nozzle ring through which the drive shaft passes is grooved to form a gas seal.
10. Oil retaining covers at each side of the centre casing prevent the ingress of oil from the centre casing to the turbine and compressor casings. The piston rings fitted to the drive shaft, located in the bores of the oil retaining covers.
11. The inlet and outlet connections for the exhaust gases and charging air, and lubricating oil are shown in the next column.



12. An air cleaner is fitted to the air intake of the turbochargers, which has a capacity 50% greater than that used on the normal aspirated engines.

CAV Type Symbol Explanation

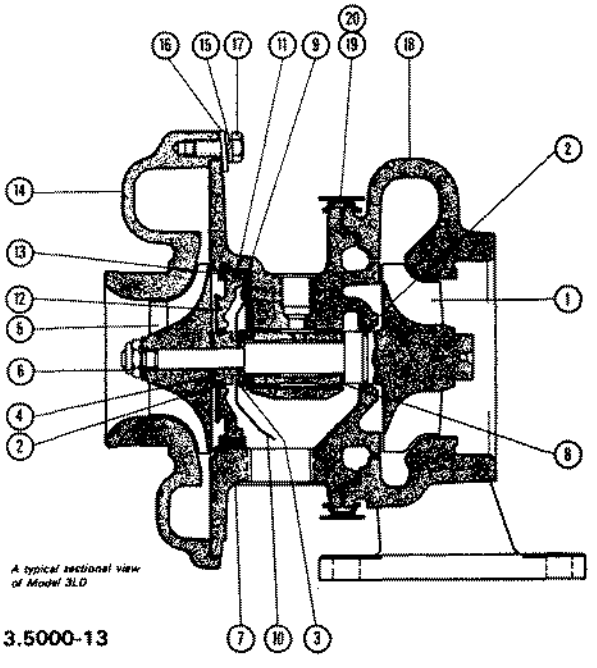
Example	E	01	A	77	A	5	51
Design Change Letter							
Basic Size							
Rotor Assy & Turbine Casing (See Flow Table)							
Nozzle Vane Angle in Degrees (Also stamped on nozzle ring)							
Radial Position of Turbine Casing (See Figure 3.5000-78)							
Radial Position of Compressor Casing (See Figure 3.5000-104)							
Symbol Number—Special Features							

Flow Table

Compressor Casing Flow	Number of Turbine Entries and Flow Sizes								
	0000			000			00		0
	Large	Standard	Small	Large	Standard	Small	Large	Standard	Small
Large		Q		V	P		U	N	
Standard		C	J	E	B	H	O	A	G
Small		M	T		L	S		K	R

HOLSET TURBOCHARGER

13. The Holset turbocharger is a robust and durable unit capable of giving high performance for many thousands of hours if the manufacturers simple recommendations are observed.



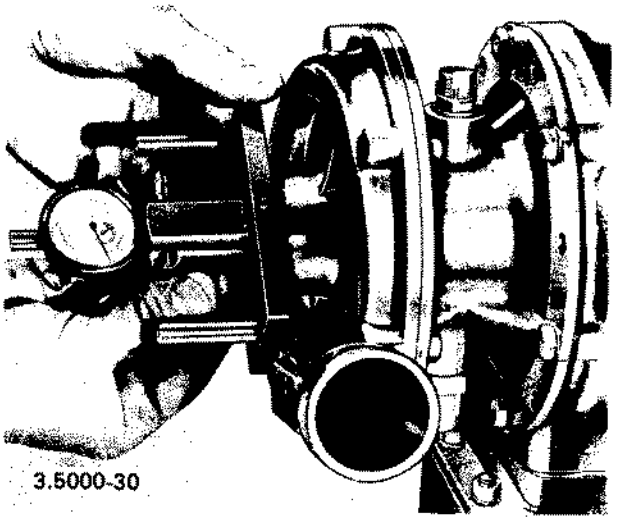
1. Shaft & Turbine Wheel Assembly
2. Piston Ring
3. Thrust Ring
4. Spacer Sleeve
5. Compressor Wheel
6. Locknut
7. Bearing Housing and Pin Assembly
8. Bearing
9. Thrust Plate
10. Oil Deflector
11. 'O' Ring
12. Insert
13. Retaining Ring
14. Compressor Cover
15. Lockwasher
16. Washer
17. Bolt
18. Turbine Housing
19. 'V' Clamp
20. Locknut–'V' Clamp

14. The compressor wheel and turbine wheel are fixed at opposite ends of a common shaft which rotates in a central bearing. The complete rotating assembly including thrust and sealing arrangements is known as the rotor assembly and is designed to rotate at speeds up to 120,000 revolutions per minute under normal conditions.
15. Welded together to form a single part, the shaft and turbine wheel is dynamically balanced as a combined unit. The compressor wheel is made as a separate component and is also dynamically balanced. A new compressor wheel can, therefore, be fitted to any new turbine wheel and shaft assembly without special balancing equipment, although it is advisable to check balance rotors after long service or possible damage.
16. Also mounted on the shaft is a thrust ring and grooved sleeve which accommodates a sealing ring at the compressor end. A piston ring type oil seal is provided at the turbine end.
17. Oil is supplied to the bearing from the engine lubricating system and enters the bearing housing at 'A' (Fig. 3.5000-13) draining back to the engine sump at 'B'.
18. The bearings are fully floating and the stability of the rotor assembly is maintained throughout its speed range by the oil films formed between the bearing, the shaft and the housing. Stabilising forces are generated upon the establishment of oil pressure and commencement of rotation; while the unit is stationery, however, a certain amount of play can be felt in the rotor which is normal.
19. Each turbocharger manufactured by Holset is individually tested on specially designed equipment. In view of the high rotational speeds the turbocharger housing is designed to retain a burst rotor, although the design of the bearing system would normally prevent the rotor reaching burst speed in service. There is, therefore, an adequate safety margin.

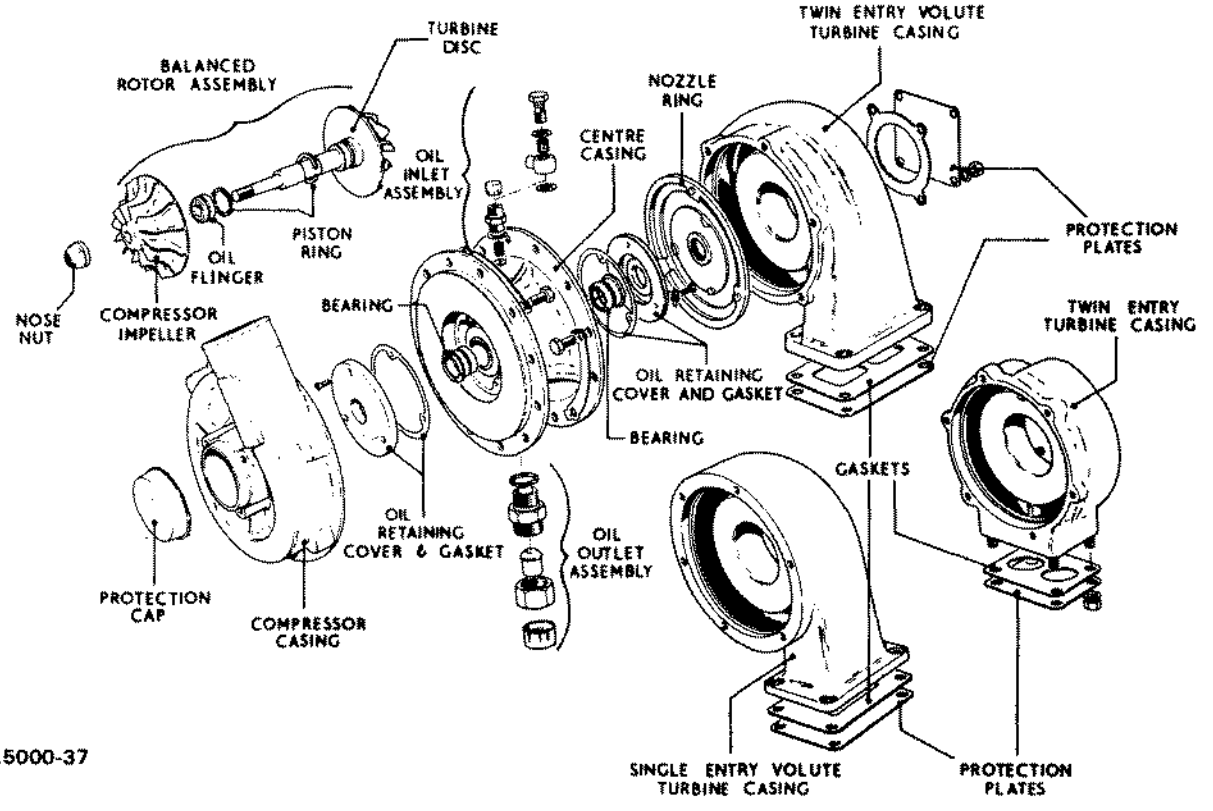
Turbocharger (Removal)
20. On marine engines, disconnect the breather pipe between the air cleaner and crankcase, by releasing the clips around the connecting hose, and then remove the air cleaner by releasing the clip attaching the air cleaner to the turbocharger.
21. Unscrew the banjo bolts to release the oil inlet pipe from the top of the turbocharger and also the two nuts securing the oil drain pipe.
22. The pipe connecting the turbocharger to the inlet manifold should next be removed. This is accomplished by releasing the two clips on the hose at the turbocharger end and securing nuts at the inlet manifold end.
23. On a marine engine, remove the two bolts which secure the turbocharger to its mounting bracket.
24. Finally, the four bolts securing the turbocharger to the exhaust manifold should be removed.

Turbocharger (Inspection and Overhaul)
25. Due to the simplicity of a turbocharger, very little maintenance is required between overhaul periods, which should be carried out every 3,000 hours under normal running conditions.
26. At this stage, the turbocharger should be completely dismantled and inspected as described below, however, the following routine checks should be carried out when the engine is undergoing its normal servicing.
27. Ensure that the air filter is thoroughly cleaned out. Dirty air filters cause restricted air flow and subsequent loss of performance. In severe cases the depression caused in the turbocharger casing due to the restricted air cleaner can be high enough to pull oil from the bearings, resulting in poor lubrication and excessive engine oil consumption.
28. Check all turbocharger hoses and pipe connections for air and exhaust leaks as these can result in reduced performance.
29. Ensure engine oil filter elements are changed regularly and that the oil supply lines to the turbocharger are in good condition and not leaking at unions. In conjunction with the oil filter element change, remove, clean and refit the gauze from the turbocharger oil inlet.
WARNING A turbocharger runs at very high speed and the bearings require a constant supply of clean oil for lubrication and cooling. Therefore, before starting an engine, after an oil change, or whenever the oil supply has been disconnected, it is essential that the turbocharger oil lines and filters are primed. Unless this action is taken, oil starvation and subsequent bearing failure will result. At normal working conditions of the engine, the lubricating oil feed pressure should never be allowed to fall below 30 psi.

CAV Turbochargers
30. Every 1500 hours a bearing check should be carried out in situ. This can be carried out on CAV turbochargers with an end float gauge, part number 7244-7, in the following manner.

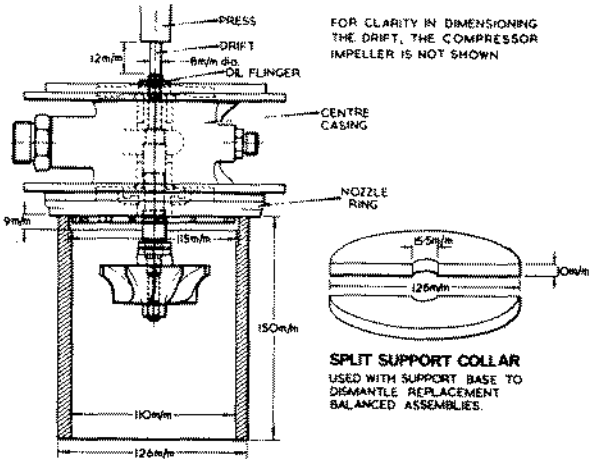

3.5000-30

31. Screw the plunger to the end of the drive shaft. Press on end of plunger, to take up end float of shaft, towards turbine end.
32. Fit the body and plate, (legs away from turbocharger) over the plunger so that the aperture in the body locates over the tapping provided for the plunger lifting screw.
33. Fit the lifting screw.
34. Ensure that the dial gauge arm is touching the end of the plunger and that the clamp screw is tight.
35. Zero dial gauge.
36. Move the plunger axially by means of the lifting screw and note the gauge reading which must be between 0.004"–0.012" (0.1mm–0.30mm). If end float exceeds maximum limits, the bearings are worn and must be replaced.
37. The following illustration will be of assistance in overhauling the CAV Turbocharger.



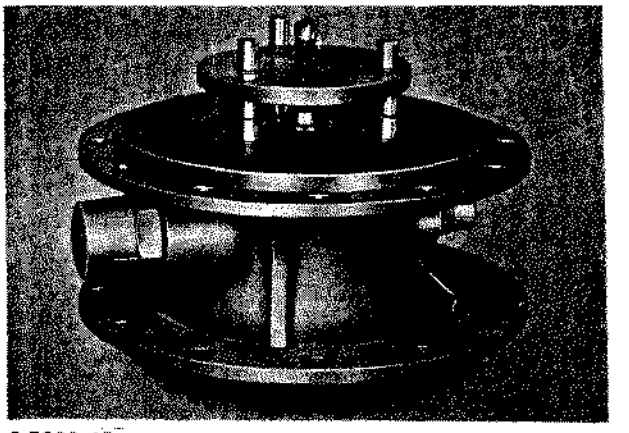
3.5000-37

38. Place the turbocharger on a bench and remove the six bolts and locking tabs from the compressor casing.
39. Remove the compressor casing. To avoid damage to the machined surfaces, sharp instruments must not be used to lever the flange faces apart. If necessary gently knock the casing with a hide mallet.
40. Remove the six bolts and locking tabs from the turbine casing. The turbine casing can be withdrawn by securing three 1" UNF bolts into the three tappings on the periphery of the centre casing. Gradual and even tightening of the bolts will lift the turbine casing away from the centre casing. On some earlier models the three tappings are not provided and the turbine casing should be gently knocked adrift with a hide mallet.
41. Hold the flats provided on the turbine disc or the end of the drive shaft in a vice and unscrew the compressor nose nut, using a special spanner CAV part number 7144-907.
42. Place the centre casing into a suitable support base and using a suitable drift, press out the drive shaft from the compressor impeller. Place a soft rag under the turbine disc to prevent damage.



3.5000-42

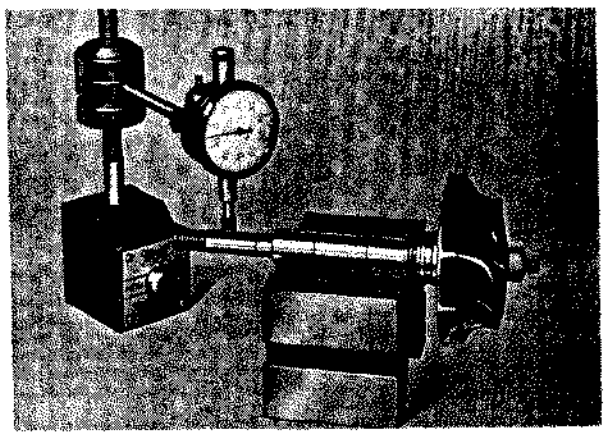
43. Remove the piston ring from the turbine end of the shaft. Carefully lever off the nozzle ring, which is held by dowels, from the turbine side of the centre casing. Place the centre casing into a vice and remove the oil outlet and inlet unions together with the inlet orifice, washer and filter.
NOTE: The centre casing must be held in the vice by the centre section not by the outer flanges.
44. With the centre casing in the vice, release the locking tabs and remove the three bolts securing the turbine oil retaining cover. Reverse the casing in the vice, and remove the three screws securing the compressor retaining cover.
45. Remove the centre casing from the vice and place face down on the bench. Screw the three legs of special tool CAV Part Number 7144-922 into the three holes of the oil retaining cover at the compressor end and place the adaptor (part of the special tool) into the centre bore of the oil flinger. Screw the centre bolt against the plug and slowly withdraw the retaining cover.



3.5000-45

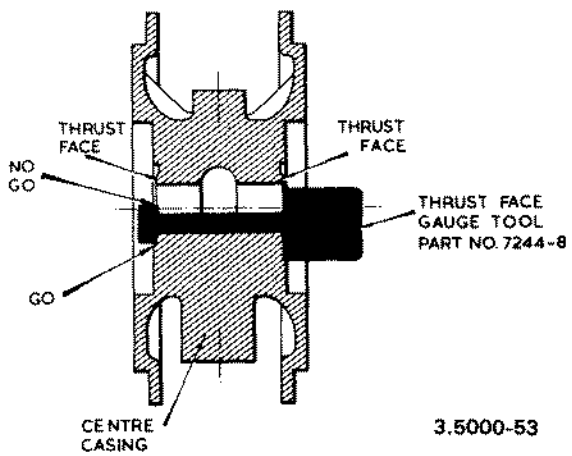
46. Remove the compressor end bearing and then hold the centre casing in the vice and remove turbine and oil retaining cover by using a suitable drift against the remaining bearing face. Discard both of the cover gaskets.
47. Having completely dismantled the turbocharger, all parts should be thoroughly washed, perferably in a proprietary brand of cleaning fluid. Highly carbonised parts may require soaking for 24 hours. All traces of grease must be removed before reassembly.
48. Visibly examine all parts for wear or fractures and renew where necessary.
49. The piston ring grooves of the drive shaft and oil flinger must be examined for thrust wear to the side faces. Thrust wear should only occur on the drive shaft groove furthermost from the turbine disc, and can be checked by the following method.
50. Using special tool (CAV part number 7244-11) insert a new, clean standard piston ring into the shaft drive groove. With the ring in a compressed position, insert a feeler gauge between the piston ring and the groove face. Check the reading at several positions. If the clearance exceeds 0.007" in any position the complete balanced rotor assembly must be returned to CAV Limited for a modification to enable an oversize piston ring to be fitted. Assemblies with this modification have an 'X' stamped on the centre of the drive shaft for identification purposes. Such an assembly must be fitted with an oversize piston ring when an overhaul becomes necessary.
51. Check the compressor impeller and turbine disc for evidence of rubbing on the edges of the blades. Ensure that the impeller is a tight fit, on the drive shaft and that the shaft is free from corrosion. Check the shaft journals for score marks and surface wear. Carry out a

concentricity test as shown below. Maximum eccentricity must not exceed 0.0002" (0.005 mm). Renew the complete assembly if the figure exceeds this value.



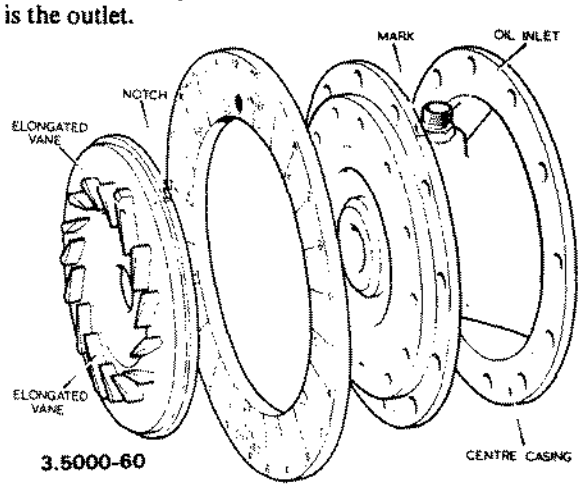
3.5000-51

52. Check for damage to the nose nut, shaft collar and oil flinger, also examine piston ring grooves for damage, as distinct from thrust face wear. If any part other than the piston ring is damaged or defective, the complete rotating assembly must be renewed. Rotating assemblies are supplied in the assembled form and must be dismantled before fitting to the turbacharger, using the split collar shown in Fig. 3.5000-45.
53. Check the centre casing for thrust face wear with the special tool, CAV part number 7244-8. Examine for evidence of rubbing of compressor impeller.



3.5000-53

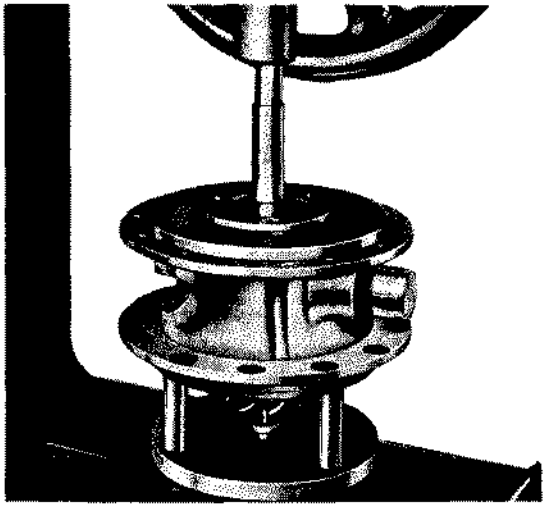
54. Check the compressor casing for signs of rubbing on intake radius and casing for signs of cracks.
55. Inspect the nozzle ring for cracks or distortion and replace if defective. The nozzle vane angle is stamped on the front face of the ring. When ordering a new ring ensure that the part number corresponding to the correct vane is given. Check gas seal bore with go/no-go gauge (part number 7144-906). The tolerance on the gas seal 0.957" Go, 0.964" No-Go. Clean the seal grooves with cleaning tool 7144-905.
56. Examine the turbine casing for heat cracks, particularly in the vicinity of the inlet dividing boss. Check the outlet radius for signs of rotor rubbing. If contact has taken place between the casing and rotor, both the casing and the balanced rotating assembly must be renewed.
57. Finally check the oil retaining covers and renew where necessary.
58. Place centre casing on a flat surface with the nozzle ring dowel holes uppermost. Using clean engine oil, lubricate each bearing surface and insert a new bearing into the turbine head of the centre casing bore. Ensure that the bearing is free to revolve.
59. Using a new oil retaining cover gasket, refit the spigotted oil retaining cover to the turbine side of the centre casing and secure in position with the three bolts and locking tabs.
60. Fit the casing positioning tool, part number 7244-4, to the turbine side of the centre casing, ensuring that the oil inlet and outlet marked on the tool, coincide with the inlet outlet on the centre casing.
NOTE: The large connection hole in the centre casing is the outlet.



3.5000-60

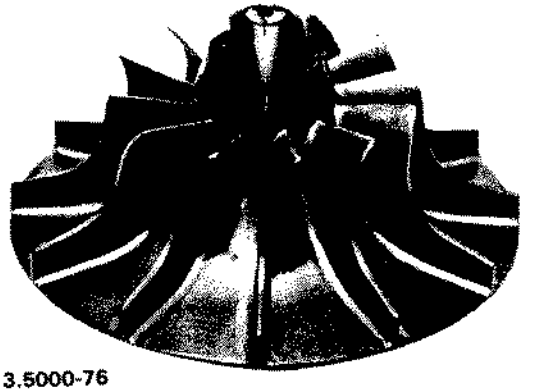
61. Ascertain from the type symbol stamped on the compressor cover outlet, the position code letter (e.g. E10A55B5SI). Fit the nozzle ring so that the notch on the circumference locates against the code letter marked on the tool. For two entry Volute type turbochargers, use letter marked on tool for Volute type. Remove tool after nozzle ring location.
62. Using tool 7244-11 fit a new piston ring on the drive shaft and where applicable to the oil flinger in the following manner.
63. Slide a new ring on the tapered end of the shaft.
64. Place the tool on the drive shaft or oil flinger so that the new ring is parallel to the piston ring groove on the shaft.
65. Gently push the piston ring into the groove, using a knurled ring to achieve a steady pressure. Ascertain the correct size of the piston ring beforehand. When the shaft is marked in the centre with an 'X', an oversize piston ring must be fitted (to turbine end only).
66. When fitting or handling piston rings, care must be taken not to distort them.

67. Fit the turbine and shaft into the turbine side of the centre casing.
NOTE: The piston ring must be centralised in its groove on the drive shaft before the shaft can be pushed fully home.
68. Place the centre casing on support base, part number 7144-937 and ensure that the adjustable stop on the support base is set so as to position the turbine and drive shaft **fully** into the centre casing.
69. Fit a retaining cover gasket to the centre casing.
70. With the bevelled edge uppermost, fit the oil flinger into the bore of the compressor end oil retaining cover. Place this assembly on the shaft and align the screw holes in the cover with those of the centre casing. Use tool 7144-936 to press the oil flinger and retaining cover into position.



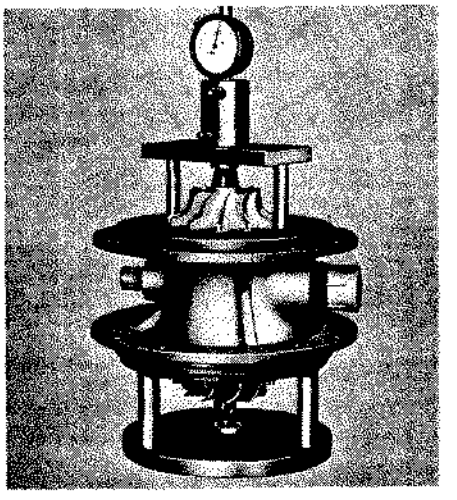
3.5000-70

71. Screw the retaining cover down, using new screws which must be lightly coated with 'Loctite' grade 'D' or a compound of similar specifications.
72. The compressor impeller is an interference fit on the drive shaft and must be heated before fitting, if the impeller will fit without heating, it will be unfit for service.
73. Heat the impeller to 180·C (356·F) maximum and place it onto the drive shaft. Ensure that the scribed line on the end of the drive shaft is aligned with the scribed line on the impeller and ease the impeller fully home.
74. Screw tool, part number 7144-933 on to the drive shaft.
75. Remove the centre casing assembly from the support base and place into a vice holding the flats at the end of the drive shaft or turbine disc. If the drive shaft is provided with flats the assembly must be held in a vice by these flats and not by the securing nut. On models fitted with a nut, welded into position, it is permissible to hold the assembly by the flats on the nut. Insert a torque wrench and tighten the impeller to a torque of 10 lbs. ft. Remove the torque wrench and tool, part number 7144-933.
76. Apply a small amount of sealer to shaft and fit nose nut. Using tool number 7144-907, tighten nut to a torque of 8 lbs. ft. After tightening, the scribed line on the nose nut and the scribed line on the impeller must be within $\frac{1}{4}''$ of each other.



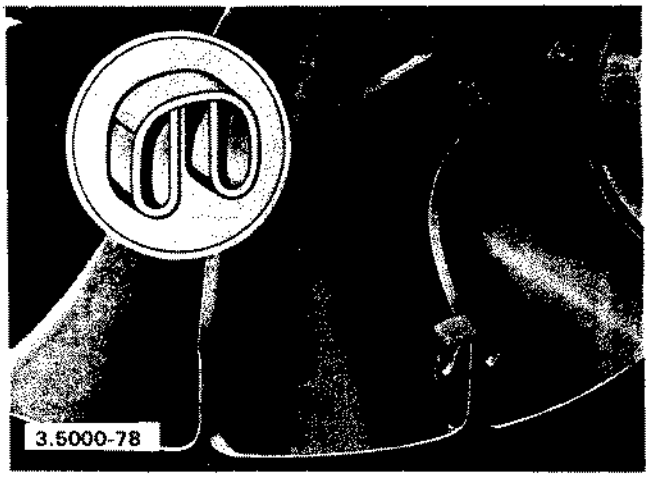
3.5000-76

77. Remove the assembly from the vice and fit it to the support base, part number 7144-937, with nozzle ring towards the base and check the end float by using gauge, part number 7244-7, illustrated below. End float must be between 0.004" (0.1 mm) and 0.008" (0.2 mm).

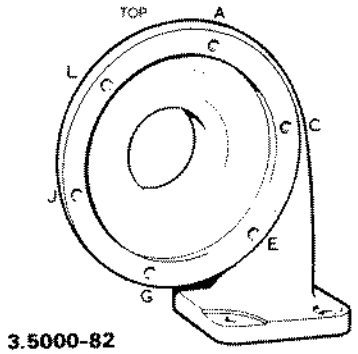


3.5000-77

78. Before final assembly of the turbine casing it must be established that a clearance of 0.011 to 0.024" exists between the turbine blades and the exhaust outlet radius on the casing. To do this, fit a 0.020" clip, part number 7144-727B to one of the turbine blades, see below, and refit turbine casing to centre casing. Tighten down on two opposite studs and check that the rotor assembly is free to turn. If it is prevented from doing so, remove the turbine casing and reduce the size of the clip. If there is no contact between 0.020" clip and the outlet radius when the casing is tightened down, a larger clip size must be fitted. When a clip between 00.11" and 0.024" just makes a brush contact (evident by a slight scraping noise) with the outlet radius, the clearance is correct.



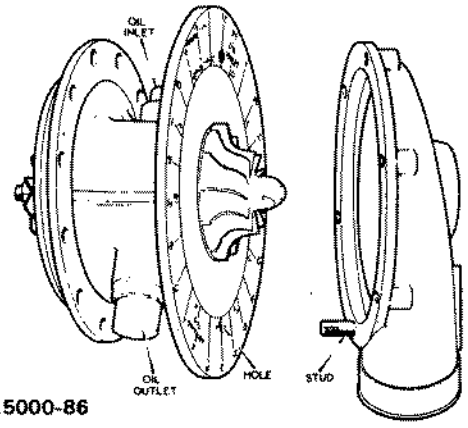
79. When clearance is satisfactory, unbolt the turbine casing **and remove the clip.** Refit turbine casing ensuring that the dividing webs cast in the casing locate against the elongated vanes on the nozzle ring. Bolt the casing in position using six bolts and locking tabs and tighten to a torque of 75 lbs. inch.
80. For positioning turbine casings where a plain nozzle ring without vanes is fitted the following procedure applies.
81. Ascertain from the type symbol, the turbine casing position (e.g. EO1A-A5V1).
82. Bring the centre and turbine casings together so that the oil inlet lies between the two uppermost fixing holes, L & A in Fig. 3.5000-82



3.5000-82

83. Move the centre casing until the fixing hole slightly to the right of the oil inlet on the centre casing matches with the fixing bolt marked with the appropriate letters as denoted in Fig. 3.5000-82.
84. Bolt the casing into position.
85. Fit a 0.020″ clip, part number 7144-727B, to a compressor blade, see Fig. 3.5000-78 and carry out the procedure described above, until a clip between 0.011″ and 0.030″ just makes a brush contact with the inlet radius on the compressor casing.
86. When the clearance is satisfactory, unbolt the compressor casing **and remove the clip.** Fit casing positioning tool, part number 7244-4, to compressor side of centre casing so that the oil inlet and outlet positions on casing and tool coincide. Ascertain from the positioning code stamped on the compressor outlet, the casing positioning code number (e.g. E01A55B5S1)

Note the stud hole in the centre casing corresponding to the code number marked on the periphery of the positioning tool. Remove tool and refit compressor casing so that the stud nearest to the compressor outlet is located in the stud hole corresponding to the code number.



3.5000-86

87. Bolt down compressor casing using six bolts and locking washer, to a final torque of 75 lbs. in.
88. Refit orifice washer and gauze filter (domed insert uppermost) to oil inlet bore. Refit oil inlet union using a new washer and a small amount of 'Loctite' grade AVV on union threads. (The union can be fitted either way).
89. Fit oil outlet union, using a new washer and Loctite grade AVV on union threads.
90. If the turbocharger is not to be fitted to the engine immediately, blanking covers must be fitted to both the compressor inlet and turbine outlet and also to the oil inlet and outlet. This is most important if foreign matter is to be prevented from entering the turbocharger during storage and transit. Similar care must also be taken when fitting a turbocharger or when working on the engine, to ensure that loose articles are not left where they could find their way into the turbocharger.

Overhaul Holset Turbocharger
91. Refer to the sectional view (Fig. 3.5000-13) for itemised parts in the following text.
92. Clamp the unit upright in a vice on the turbine inlet flange.
93. Mark the relative positions of the turbine housing (18), bearing housing (8), compressor cover (14) and V clamp (19).
94. Remove the eight bolts (17) and associated lockwashers (15) fastening the compressor cover (14) to the bearing housing (7) and lift off cover.
95. Remove the 'V' clamp locknut and spring the 'V' clamp (19) back on to the bearing housing (7). Lift the core assembly clear of the turbine housing (18).

96. Holding the turbine wheel at the hub with a 5/8" A/F ring spanner, remove the compressor locknut (7) with a ¼" A/F spanner.
97. Slide the compressor wheel (5) off the shaft.
98. Using circlip pliers Seeger A/1 remove the large retaining ring (13) which retains the compressor insert (12). Two screwdrivers should be used to lift the insert from the bearing housing (7). Remove the 'O' ring (11) from the insert.
99. The individual parts of the thrust assembly can now be lifted out.
(a) Spacer sleeve (4) which can be gently pushed out of the insert (12).
(b) Oil deflector (10) positioned by two groove pins.
(c) Thrust ring (3)
(d) Thrust plate (9)
100. The groove pins are a press fit in the bearing housing (7) and should not be removed.
101. Remove the shaft and turbine wheel assembly (1) together with its piston rings (2).
102. Insert fingertip into bore of the bearing (8) and remove.
103. Carefully expand and remove the piston rings (2) from both the spacer sleeve and turbine wheel and shaft assembly. Over expansion of the piston rings will cause a permanent set or breakage.
104. Soak all parts in a commercially approved cleaner until all deposits have been loosened. Caustic solutions **must not** be used as damage would be caused to certain parts.
105. Use a plastic scraper or bristle type brush on all aluminium parts. Vapour blast may also be used providing the shaft and other bearing surfaces are protected.
106. Clean all drilled passages with a compressed air jet.
107. Ensure surfaces adjacent to wheels on stationary housings are free of deposits and are clean and smooth.
108. After cleaning, all parts should be inspected as follows:
109. Shaft and Turbine wheel assembly (18)
(a) Inspect bearing journals for excessive scratches and wear. Minor scratches may be tolerated.
(b) Inspect the piston groove walls for scoring. Minor scratches are acceptable.
(c) Check carefully for cracked, bent or damaged blades, but do not attempt to straighten blades.
110. Bearings (8) must be replaced for excessive scratches and wear.
111. Replace spacer sleeve (4) if piston ring groove or spacer are damaged.
112. Replace the bearing housing (7) if the bearing or piston ring bores are excessively scratched or worn.
113. Thrust ring (3); Thrust plate (9)
(a) Replace if thrust faces are mutilated. Minor scratches are acceptable.
(b) Replace thrust plate if the faces are worn excessively, unevenly or are severely scratched and otherwise mutilated.
(c) The small feed grooves in the thrust plate must be clean and free from obstructions.
114. Compressor wheel (5). Check carefully for cracked, bent or damaged blades, but do not attempt to straighten blades.
115. Replace 'O' ring (11) if section through ring has taken a permanent set, indicated by flats on the sides of the ring.
116. When the turbocharger has been thoroughly cleaned, inspected and any damaged parts replaced, assembly can commence.
117. Assembly of the unit is the reverse of dismantling, but it is advised that the following points be noted, if a satisfactory re-build is to be obtained.
118. Lubricate bearings, thrust assembly, piston rings and rotor shaft, with clean engine oil.
119. When replacing the turbine wheel and shaft (1) into the bearing housing (7), and spacer sleeve (4) into the insert (12) do not force the piston rings into the bore as an off-centred ring will fracture, causing the shaft to bind.
120. The large retaining ring (13) should have the levelled side facing outwards.
121. Torque the locknut (6) to 13 ft/lbs (17.6 newton/metres), bolt (17) to 5 ft/lbs (6.8 newton/metres) and 'V' clamp locknut (20) to 10 ft/lbs (13.6 newton/metres).
122. On completion of assembly spin the shaft to ensure that it rotates freely.

Turbocharger (Refitting)

123. Before refitting the turbocharger to the engine, carry out the following installation checks.
124. Inspect the bore of the air intake tube and renew the tube if the rubber lining is loose or has deteriorated.
125. Check the air intake system for loose nuts and bolts.
126. Check the air intake system for cleanliness and foreign matter.
127. Inspect the exhaust manifold for foreign matter.
128. Inspect the oil drain line, ensure the line is not clogged.
129. Inspect the oil supply line for clogging, deterioration or possibility of leaks under pressure. Renew if serviceability is doubtful.
130. Check the turbocharger mounting pad on the manifold to make certain that all of the old gasket has been removed.
131. Place new gaskets between the turbocharger and exhaust manifold, ensure gasket does not protrude into the opening of the manifold.
132. Mount the turbocharger on the engine and secure with the mounting bolts.
133. Fill the bearing housing of the turbocharger with clean engine oil, through the oil inlet port, then connect the oil supply pipe. Leave the oil drain pipe disconnected.

134. Connect the air inlet pipe and outlet pipes, taking care to check all joints for possible leaks, also ensure that the piping is not producing strain on the compressor cover.
135. Connect the exhaust outlet flange, using a new gasket. It is recommended that an anti-seize compound be applied to the bolt threads.
136. If the engine lubricating oil change period is due, it is advisable to change the oil and renew the filter element before operating the turbocharger.
137. Crank the engine without firing until a steady flow of oil runs from the turbocharger.
138. Connect the oil drain pipe to the engine connections.