# Section C.6

## FUEL INJECTORS

### Description

The 2.2-litre diesel engine is fitted with a special injection nozzle known as the Pintaux type which has been developed primarily to give easy starting from cold. **A** feature of this nozzle is that on cold startingit directs the fuel spray through an auxiliary hole to the hottest zone of the combustion chamber.

In operation, the pressure in the annulus builds up during the pump delivery, lifting the needle from its seating and permitting a flow of fuel into the annulus below the seat from which the auxiliary hole leads. The needle is extended below the seat to fit into the comparatively large-diameter pintle hole. At starting speeds the needle is not lifted sufficiently to clear the pintle hole and the bulk of the fuel is therefore discharged through the auxiliary or starting hole. At normal running speeds, when the pressure in the fuel system is higher, the needle is withdrawn from the pintle hole in the normal manner. A small proportion of fuel continues

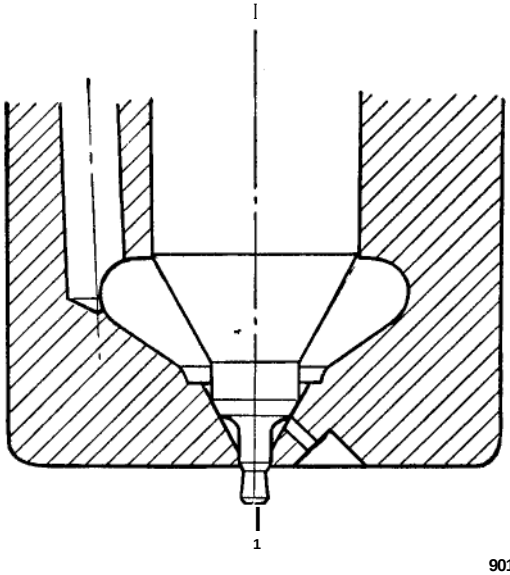


*Fig.* **C.13**

***The C.A.V. Pintaux nozzle***

to be discharged through the auxiliary hole, which prevents carbon formation therein and does not affect engine performance adversely.

Nozzle-testing

If the injector nozzles are to be tested correctly or it is desired to adjust the opening pressure, then the use of nozzle-testing machine 18G 109 A is necessary.

A fuel which does not affect the skin of the person handling the injectors, such as Shell Calibration Fluid 'C', should be used; the oil has about the same viscosity as diesel oil and also prevents stickiness of the needle after long periods of injector storage.

Before using this testing machine ensure that the fuel tank is full. There is no necessity for air-venting as the pump is self-priming.

Before removing an injector from the testing machine close the check valve to prevent damage to the pressure gauge, which may result from a sudden drop in pressure.

WARNING.—It cannot be stressed too strongly that when a nozzle is spraying the nozzle holder must be turned away from the operator.

**1.** ***Testing for spray***

In order to test this type of nozzle for spray it is necessary to use a special test adaptor, 18G 109 B, which is connected between the injector testing machine and the injector under test. The adaptor consists of an additional nozzle holder fitted with a special nozzle, and a modified cap nut, into which the injector under test is fitted. The adaptor assembly is used to simulate high rates of injection so that the main spray can be observed.

Attach adaptor 18G 109 B to the testing machine and set to an opening pressing of 220 atmospheres. A fine spray formation from the test adaptor must not be expected in view of its special nozzle.

Now screw the Pintaux injector to be tested into the test adaptor; close the check valve to cut off the pressure gauge and operate the test machine several times to expel any air.

***(a)*** ***Auxiliary spray.*** With the pressure gauge out of circuit operate the testing machine slowly at about 60 strokes a minute; it is possible to cut out the main spray almost entirely and produce only the auxiliary spray. When this condition has been achieved the auxiliary spray can be observed. This should be well formed and free from splits and distortions, although there may be present a slight central core, which may be disregarded.

***(b)*** ***Main spray.*** Operating the hand lever more rapidly —at about **140** strokes per minute —the main spray can be observed. The same remarks apply to its formation as in ***(a)*** above.

**2.** ***Seat tightness test***

Remove the test adaptor and connect me injector under test direct to the injector testing machine. Open the check valve and set the nozzle to an opening pressure of 115 atmospheres as described in paragraph **(4).**

Depress the lever of the testing machine until a pressure of 105 atmospheres is obtained. Hold this pressure for 10 seconds and examine the nozzle seat for dryness. Reject if wet. If in doubt, maintain this pressure for a period of 60 seconds, when the diameter of the wet spot on a piece of blotting-paper held below the nozzle tip must not exceed ½ in. (13 mm.).

***3. Back-leakage test***

The pressure gauge of the injector testing machine must be in circuit and the injector under test set to open at between 160 and 170 atmospheres as described in paragraph **4.**

Operate the lever of the testing machine until the gauge registers a pressure of 160 atmospheres. Release the lever and time the pressure drop from 150 to 100 atmospheres. For a nozzle in good condition this time should not be less than six seconds nor greater than **40** seconds, using Shell Calibration Fluid 'C' at a temperature of 10 to 21" C. (50 to 70° F.). At higher temperatures a somewhat lower figure may be obtained.

When carrying out this test ensure that no leakage occurs at the lapped joint of the valve. If leakage at the lapped joint is suspected, do not overtighten the cap nut in an effort to rectify, but remove the nozzle and re-examine the pressure faces for signs of dirt or surface imperfections. Clean thoroughly, and if all appears in order replace the components and re-test. If the pressure drop time is still low, this indicates excessive leakage past the lapped portion of the valve. Nozzles not passing the above test should be renewed complete.

**4.** ***To check and adjust the nozzle opening pressure***

After carrying out the foregoing tests the Pintaux nozzle must be set to open at a pressure of 115 atmospheres as follows:

***(a)*** Remove the injector from the testing machine.

***(b)*** Remove the injector cap nut and copper joint,, washer.

***(c)*** Release the locknut and turn the spring cap nut' clockwise to increase or anti-clockwise to reduce the opening pressure.

***(d)*** Lock the spring cap nut and re-check the nozzle opening pressure on the testing machine.

***(e)*** Repeat operations ***(c)*** and ***(d)*** until the correct opening pressure of 11***5*** atmospheres is obtained.

***(f)*** Refit the injector cap nut and joint washer.

Fault diagnosis and rectification

The first symptoms of nozzle trouble usually manifest themselves under one or more of the following occurrences:

**(1)** Cylinder knock. (2) Engine overheating.
(3) Loss of power. **(4)** Smoky (black) exhaust.
***(5)*** Increased fuel consumption.

It should not be immediately assumed that the nozzles are faulty, for such features as incorrect engine valve timing, leaking valves, incorrect pump timing, dirty or damaged fuel filters, wrong fuel or water in fuel, defective engine lubrication, or incorrect fuel pump maximum fuel setting may give rise to similar symptoms.

With all other possible causes eliminated, the particular nozzle giving trouble can usually be determined by

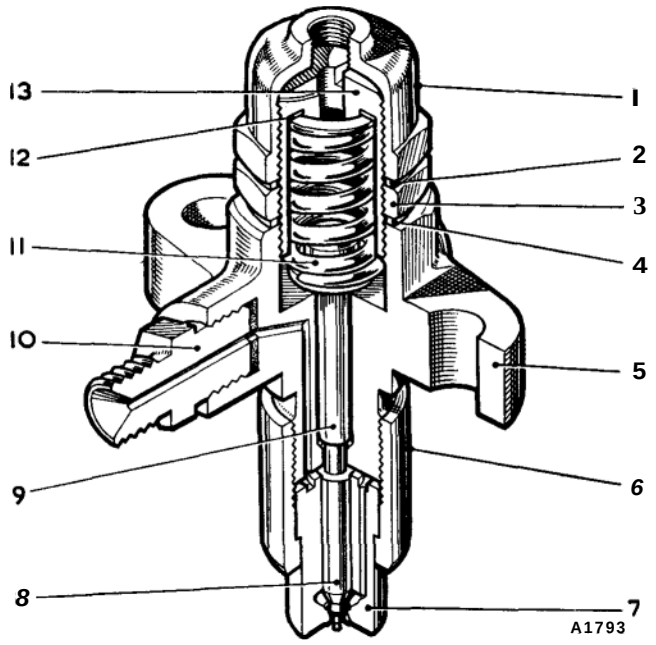


*Fig.* C.14

*A fuel injector*

1. Injector cap nut.
2. Cap nut washer.
3. Locknut.
4. Locknut washer.
5. Nozzle holder.
6. Nozzle nut.
7. Nozzle body.
8. Nozzle valve.
9. Spindle.
10. Inlet union.
11. spring.
12. Washer.
13. Spring cap nut.

releasing the piping union nut on each nozzle holder in turn while the engine is running and listening to the idling performance of each of the other cylinders.

To test a doubtful nozzle remove the injector as described below and refit to its fuel feed pipe so that the nozzle is pointing outwards, away from the engine. Slacken the unions of the other nozzle fuel feed pipes (to prevent fuel being sprayed into the cylinders). Using the starter, turn the engine until the suspect nozzle sprays into the air. If the spray is unduly wet or streaky, or obviously to one side, or the nozzle dribbles, renew the complete unit (nozzle and nozzle holder).

NOTE.—The nozzle holder must be turned away from the operator and the hands must not be allowed to come into contact with the fuel spray, as the injection pressure will cause oil to penetrate the skin with ease.

To remove

Nozzles should be removed from the engine and examined at regular intervals, the frequency of attention being as recommended in the Driver's Handbook.

Disconnect the injector feed pipe and all the injector leak-off unions.

Remove the two nuts securing the injector to the cylinder head and withdraw the injector, using tool 18G 491 A. Immediately plug the hole in the cylinder head to prevent the ingress of foreign matter.

If the injectors are to be removed for any length of time the fuel feed unions should be sealed with sealing caps 18G216.

The nozzle should then be wrapped in greaseproof paper.

To dismantle

As in the case of injection pump dismantling, absolute cleanliness is essential, therefore the same facilities must be available and the same precautions taken for injector maintenance as those described at the beginning of the Section for the injection pump.

Fit the injector in the dismantling fixture 18G 388 and secure in a vice.

Unscrew the injector cap nut and remove the copper joint washer.

Release the locknut and unscrew the spring cap nut.

Remove the copper joint washer, spring, and spindle.

If the complete dismantling of the nozzle holder and nozzle is being carried out remove the fuel inlet union (early injectors only).

Unscrew the nozzle nut, using spanner 18G 210, which is used in conjunction with a standard ratchet wrench. Remove the nozzle body, taking care not *to* let the needle valve drop out.

NOTE.—The nozzle components are mated and must always be kept together.

To view and overhaul

***Nozzles***

All the tools required for the cleaning operations set out in the following paragraphs are contained in cleaning kit 18G 487.

Remove any carbon from the valve, using the brass wire brush, and polish with a piece of soft wood. Use considerable care when cleaning the needle valve as a scratch or a burr may cause leakage or spray distortion. All polished surfaces should be relatively bright and should not appear 'blue' due to overheating.

Using the wire brush, remove all loose carbon from the outside of the nozzle. Clear the pintle orifice by passing a suitably sized probe down the nozzle bore

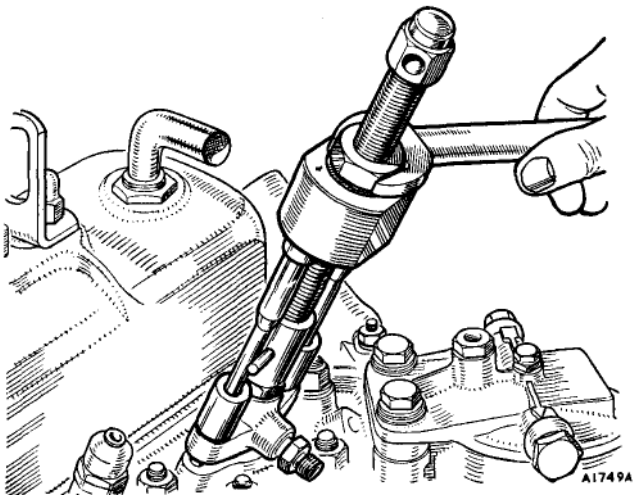


*Fig. C.15*

***Withdrawing an injector nozzle, using tool*** 18G 491 *A*

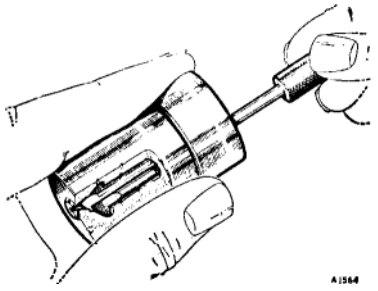

*Fig. C.16*
*Cleaning the carbon from the fuel gallery*

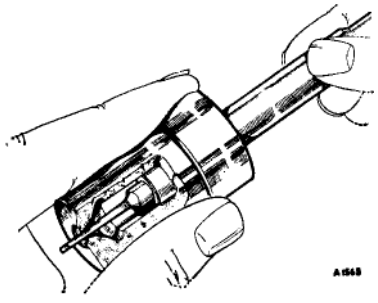

*Fig.* C.17
*Clearing the pintle orifice*

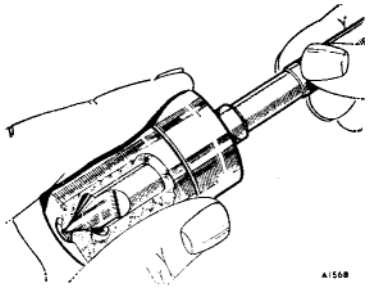

*Fig.* **C.18**
*Cleaning the nozzle seating*

until it protrudes through the orifice. Rotate the probe until all the carbon is removed.

Insert the special groove scraper until the nose locates in the fuel gallery (see Fig. C.16). Press hard against the side of the cavity and rotate to clear away all carbon deposit.

Clean the pintle orifice by passing a suitably sized probe down the nozzle bore until it protrudes through the orifice (see Fig. C.17). Rotate the probe until all the carbon is removed.

With the seat scraper clean all carbon from the valve seating (Fig. C.18) by rotating and pressing the tool onto the seating.

Clear the auxiliary spray hole by use of the probing tool fitted with the appropriate size cleaning wire (Fig. C.19). The wire should be fitted into the tool so that it protrudes only approximately $\frac{1}{16}$ in. (1.6 mm.) to give maximum resistance to bending. Extreme care must be exercised to obviate the danger of wires breaking in the hole, as broken particles are extremely difficult to remove.

Clean out the small feed channel bores, as shown in Fig. C.20, with a drill or wire of ·067 in. (1.7 mm.) diameter.

Ensure that the lapped pressure faces on the upper end of the nozzle are clean, perfectly smooth, and free from burrs.

Assemble the nozzle into adaptor 18G 109 E with the nozzle end towards the small thread connection (see Fig. C.21). Attach the adaptor to testing machine **18G** 109 A and operate the pumping lever several times. This forces oil through the spray holes in the reverse direction and flushes out the gallery and internal passages to remove any loose carbon.

In cases where the carbon build-up is particularly hard this may be softened in the following manner, thereby reducing time: prepare a 10 per cent. solution of caustic soda with a detergent added by dissolving 2 oz. (56.7 gm.) of caustic soda in 1 pint (,57 litre) of water and add $\frac{1}{2}$ oz. (14.2 gm.) of an ordinary washing detergent. Place the nozzle bodies in the liquid and bring it to the boil for a minimum of 1 hour and not more than 13 hours. Care must be taken not to allow the water to evaporate too much, because if the percentage of caustic soda rises above 15 per cent. the surface of the guide bore and seal may be roughened, making it impossible to service the injectors correctly. Remove the nozzle bodies from the solution, wash them in running water, and then immerse them in a de-watering oil such as Shell Ensis 254. Remove the surplus oil by draining or compressed air.

The carbon may now be removed, using the standard tools provided in the cleaning kit, or in some cases blown clean with compressed air.

**If the nozzle is blued, or the seating has a dull circumferential ring, indicating wear or pitting, the complete unit should be set aside for special attention.** (See under **'Nozzle reclamation'.)**

*Nozzle holders*

Wash all the components in clean paraffin. Examine the spring for signs of weakness, rusting, or fracture. Ensure that the ends are perfectly square. The spindle should be perfectly smooth and straight. Examine the recessed end of the spindle which accommodates the top of the nozzle valve; the recess should be perfectly clear and free from abnormal wear. Clear out the feed hole in the nozzle holder, using an air jet; the copper seating of the feed pipe union must be in good condition.

Examine the bottom pressure facing of the nozzle holder, which should be perfectly smooth and flat.

To reassemble

Thoroughly wash the nozzle body and needle valve in Shell Calibration Fluid 'C' and test the fit of the valve in

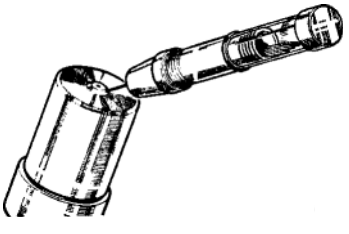

*Fig.* C.19
*Clearing the auxiliary spray hole*

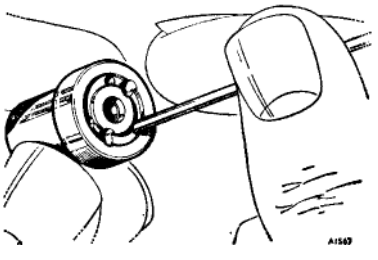

*Fig. C.20*
*Cleaning the feed channel bores*

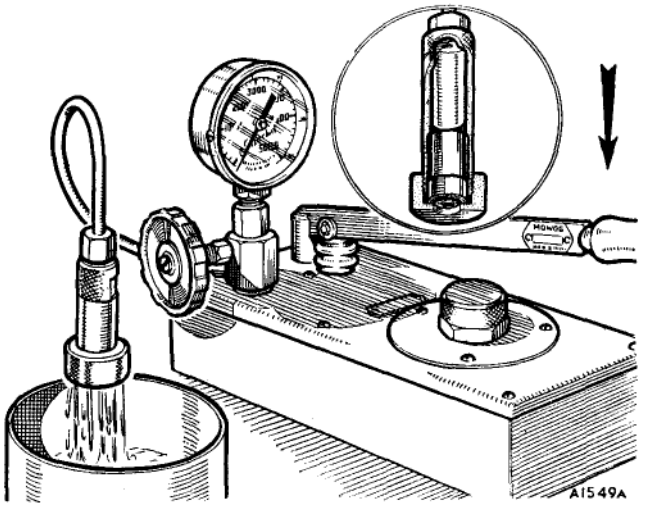


*Fig.* C.21

***Reverse-flushing an injector nozzle with testing machine*** 18G 109***A*** ***and udaptor*** 18G 109***E***. ***Shown inset is a sectioned adaptor with a nozzle in position***

the nozzle body. The valve should just fall into position under its own weight when lubricated with fuel oil.

Immerse both in a bowl of clean Shell Calibration Fluid 'C' and assemble under the liquid.

Thoroughly wash the nozzle holder and component parts in Shell Calibration Fluid 'C'.

Mount the nozzle holder in fixture 18G 388 and secure in the vice. Make sure that the pressure faces of the holder and nozzle body are perfectly clean. Place the nozzle assembly in position on the holder, ensuring that the dowels locate in the holes.

Fit the nozzle nut and tighten carefully, using spanner 18G210, which is used in conjunction with a standard ratchet. **Do not overtighten this nut,** since distortion and subsequent seizure of the nozzle may result.

Reassemble the spring and spindle, using a smear of grease to prevent rusting. Replace the spring cap nut, locknut, and copper joint washer.

Fit the cap nut with its copper joint washer.

Test the injector for spray and opening pressure as described on page C.18, and, if the nozzle is to be stored, lightly smear it with grease before packing.

**To install**

Thoroughly clean the aperture in the cylinder head. Replace the copper sealing washer.

Place the injector in position in the cylinder head; fit the securing nuts and tighten evenly to a torque of 12 lb. ft. (1.6 kg. m.).

Connect the fuel feed pipe and leak-off unions.

**Nozzle reclamation**

Clean the nozzles in the normal manner. If they are then not satisfactory it is probably due to faulty seats caused by scoring or wear. The fundamental requirements of the nozzle operation are:

**(1)** Oil-tight seating.

**(2)** Correct angular fitment of the nozzle body and nozzle valve seat.

**(3)** Good fitting of the valve in the body; it must be able to move perfectly freely, yet not permit excessive back-leakage of fuel oil.

**(4)** The clearance between the pintle and the spray hole must not be excessive. If the nozzle is taken out and the pintle end reversed and inserted in the orifice or spray hole, it should not tilt at a greater angle than about 20" from the centre-line of the body.

Assuming correct adjustment of opening pressure, a nozzle lacking the conditions required in **(1),** (2), or **(4)** will have a distorted or wet spray, leaking seat, etc., when tested on a nozzle-testing machine. If **(3)** is leaking, then the valve will either stick open or an excessive amount of oil will leak back from the nozzle holder leak-off connection. This will also be shown by the rapid return of the needle in the pressure gauge of the nozzle-testing machine.

If the clearance between the needle and body, and/or pintle and orifice, is excessive, then the nozzle should be scrapped. Similarly, units must be scrapped if damage has been sustained at the pintle end or lapped face of the nozzle body or the needle valve. Finally, the appearance of fuel abrasion at the top of the seat core may render the nozzle unrepairable. This sometimes has the effect of rounding off the seat angle: thus lapping becomes ineffective.

Assuming that it has been determined that the nozzle is dribbling or spraying badly due to lack of quality (1) or (2) above, then the seat should be relapped as follows:

(1) **A** lap of suitable diameter according to size of nozzle should be selected. It should be noted that the nozzle bore varies slightly in diameter, and it is necessary to choose a lap which will fit the nozzle body in the same manner as the needle valve. This will ensure concentricity of the body seat after lapping. As a guide it will be found that new laps have a marking indicating a variation in diameter, but the operator will be able to determine the correct fit by feel.

**(2)** Mount the lap in the lathe of the nozzle grinding and lapping machine and grind the conical tip to the correct nozzle seat angle of 59°. Remove the extreme tip of the lap to prevent damage to the pintle hole.

**(3)** Fit the lap into the lapping chuck of the machine and apply a coating of tallow to the lap guide surface for lubrication purposes. With a match-stick apply a fine speck of lapping paste to the conical tip of the lap.

**NOTE.—Take care to keep all lapping paste off the sides (i.e. restrict it to the extreme tip) as otherwise the bore of the body will be increased and thus too much clearance will exist between the valve and body, causing excessive back-leakage.**

(4) Start the machine and slide the nozzle carefully over the rotating lap, ensuring that the lapping paste does not contact the bore of the nozzle. Oscillate the nozzle over the lap, using short strokes, and engage the lap with the nozzle seat at the end of each stroke. The lap should not remain in contact with the nozzle seat for more than five seconds at a time.

(5) After 30 seconds withdraw the nozzle; clean the lap and examine its conical tip, which will have a mat surface where it has made contact with the nozzle seat. In the early stages of lapping the width of this mat surface will probably be narrow or may have a bright ring in the middle, which indicates the extent of the wear on the nozzle seat.

(6) Continue lapping as above, examining the lap every 30 seconds, until a mat surface over the majority of the lap conical tip is obtained.

**NOTE.—The lap must be refaced, as described in paragraph** (2), **after every 1½ minutes of lapping time.**

(7) Thoroughly clean the nozzle by reverse-flushing; dry out with compressed air and examine its seating through a nozzle microscope. The seat must be free from scores and pitting.

(8) Examine the needle valve conical tip under the nozzle microscope for scoring and pitting. If wear is evident the valve tip must be refaced on the nozzle grinding and lapping machine.

(9) Ensure that the grinding-wheel has been dressed and is perfectly true. To prevent damage to the pintle when refacing a Pintaux needle valve dress the edge of the grinding-wheel which will be adjacent to the pintle to an angle of 45°.

(10) Mount the needle valve in the lathe of the machine and reface the valve conical tip at the correct angle, i.e. 60°.

**NOTE.—Remove only the absolute minimum of material; sufficient to change the colour of the valve tip is all that is necessary, otherwise the needle lift will be affected. As a guide, there must be no sparks or audible hiss from the grinding-wheel when carrying out this operation.**

(11) In the event of the needle being a tight fit in the nozzle body, due to slight distortion or deposits on the valve guide surface, it is possible to restore the fit, using the adjustable collet provided as part of the equipment supplied with the nozzle grinding and lapping machine.

(12) Mount the needle valve in the lapping chuck and apply a very small quantity of fine lapping paste to the valve guide surface. Start the machine and thread the lapping collet over the rotating valve. Oscillate the collet over the valve guide surface, and after every 10 to 15 seconds of lapping time clean the valve and test it for correct fit in the nozzle body. A correctly fitting needle valve will just slide into the nozzle body under its own weight when lubricated with fuel oil.

(13) Using a suitably adapted dial gauge, check the needle lift, which should be .032 to .038 in. (.80 to ·95 mm.).

If the needle lift is found to be in excess of these limits it can be restored by lapping the top face of the nozzle body on a surface lapping plate.

**When lapping the nozzle face extreme care must be taken not to tilt the nozzle, as this face makes a high-pressure joint with the nozzle holder and must therefore be true and at right angles to the nozzle axis.**

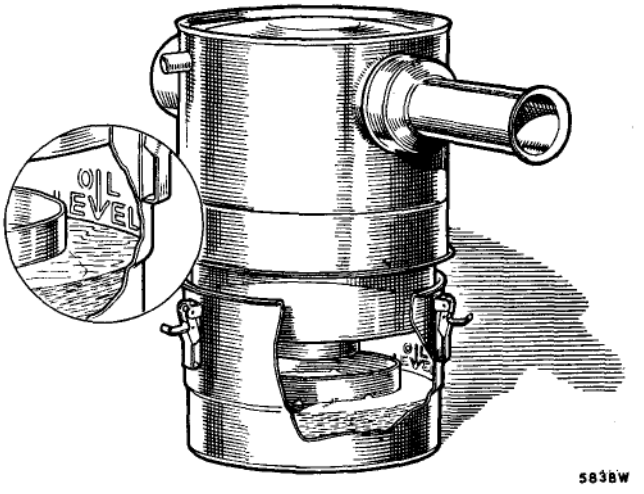


**Fig. C.22**

*The oil-bath-type air cleaner*

(14) Reassemble, test, and set the injector nozzle as described on pages C.18, C.19, C.20, and C.21.

**It will be found that, owing to the lowering of the seating in the nozzle body, that it is impracticable to reclaim a nozzle more than three times.**

## Section C.7

### AIR CLEANER

**To remove and dismantle**

Drain, clean, and refill the air cleaner at the recommended intervals. These periods must be reduced if excessive sludge accumulates in the base of the cleaner. Sludge must not be allowed to exceed ½ in, (13 mm.) in depth. Proceed as follows.

Release the two rubber hoses from the air cleaner.

Remove the bolts securing the air cleaner to its supports, and withdraw it, taking care to avoid spilling the oil.

To **view and overhaul**

Wash the filter element thoroughly in petrol and allow it to dry out,

Empty the container base and clean out all oil and sludge.

Refill the container with new engine oil up to the level indicated.