CONTENTS

FUEL INJECTION NOZZLES AND NOZZLE HOLDERS

THE performance of a modern high-speed oil engine depends largely upon the proper functioning of its fuel injection system. For maximum efficiency in operation, it is essential that the engine be not only provided with fuel in quantities exactly timed and proportional to the amount of work it is required to do, but also that it should receive each charge of fuel in a condition such that it can be completely consumed, without causing smoke in the exhaust. This, briefly, is the function of the nozzle, which is held in position in the cylinder head by the nozzle holder. As the nozzle may have to deal with many hundreds of fuel charges per minute, with widely varying conditions of pressure and temperature, the unerring precision necessary in the production of these parts will be appreciated.

NOZZLES—MODELS "S," "T," "U" and "V"

The C.A.V. nozzles described in this booklet are of the "closed" type, so called because the nozzle is closed with a valve after each injection of fuel into the engine combustion chamber. They are available in a wide range of sizes and designs to suit the needs of all types of oil engines, whatever their speed, capacity or combustion conditions. The following description is chiefly concerned with the two most common sizes, "S" and "T" (see Figs. 2 and 3), but further details of any other item in the range will be gladly sent on request.

Size "S" nozzles have either 5 mm. or 6 mm. diameter valves and are designed for use with "S" type nozzle holders and BPE/A, BPF/A, BPE/B, BPF/B (and sometimes BPE/C, BPF/C, BPE/Z and BPF/Z) fuel injection pumps.

Size "T" nozzles are fitted with 6 mm. or 7 mm. diameter valves and are suitable for "T" type nozzle holders in conjunction with BPE/C, BPF/C, BPE/Z and BPF/Z (and sometimes BPE/B and BPF/B) fuel injection pumps.

Sizes "U" and "V." These are designed for use with large engines of the marine or stationary class and have 8 mm. and 10 mm. diameter valves respectively. They are used with type "U" or "V" nozzle holders and BPF/D and BPF/E pumps.

A complete C.A.V. nozzle consists of two parts, the nozzle valve and nozzle body, shown separately in Fig. 1. The nozzle valve takes the form of a plunger, accurately lapped into the nozzle body to the closest possible fit, within which it will work freely. The inner end of the nozzle valve is reduced in diameter to produce a stem upon which a valve face is formed, while the outer end is provided with a stalk.

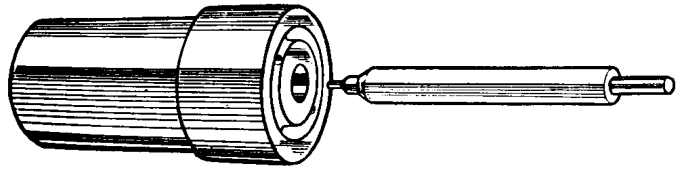


Fig. 1. C.A.V. nozzle body and valve

Fuel is fed to the mouth of the nozzle through small holes drilled vertically in the nozzle body, which terminate in an annular gallery (or reservoir) just above the valve seating (see Fig. 5). The nozzle valve is raised from its seating in the nozzle body by the pressure of fuel fed from the injection pump. Thus the fuel in the gallery is forced by the upward movement of the plunger in the pump, through the hole or holes in the nozzle, to form a spray in the engine combustion chamber.

The type of nozzle to be used depends upon the particular requirements of the engine combustion chamber, and as the nozzles vary considerably in respect of diameter and length of hole, spray angle, valve lift, etc., it is absolutely essential that only the correct type of nozzle is used.

TYPES OF NOZZLE

Single Hole Nozzles

The single hole nozzle (see Fig. 2) has one hole drilled centrally through its body which is closed by the nozzle valve. The hole can be of any diameter from 0·2 mm. (0·008 in.) upwards. A variation of this type, shown in Fig. 3, is known as the conical end nozzle. In this case the single hole is bored at an angle to the vertical centre line of the valve as required.

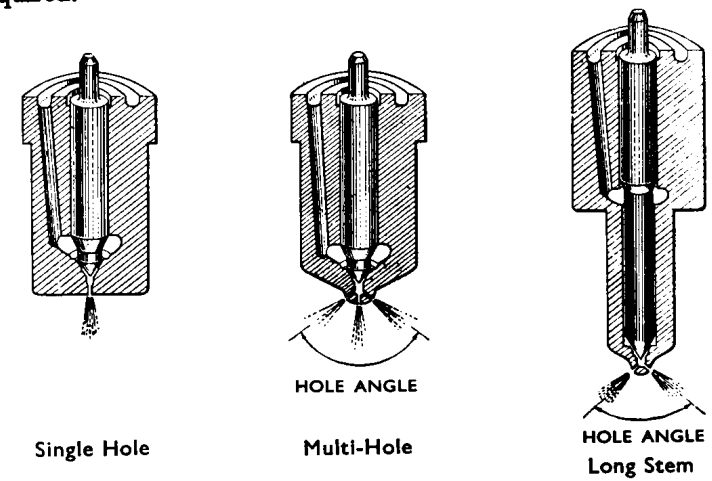


Fig. 2. C.A.V. fuel injection nozzles (see also Fig. 3).

Multi-Hole Nozzles

Multi-hole nozzles (see Fig. 2) can have a varying number of holes drilled in the bulbous end under the valve seating, their actual number, size and disposition being dependent upon the requirements of the engine concerned.

Long Stem Nozzles

For direct injection engines where, owing to limited space between the valves in the cylinder head, it is not possible to provide adequate cooling for the standard short stem nozzle, an alternative form of nozzle

with a small diameter extension has been developed. This type is known as the "long stem" nozzle and has an extended body, in the tip of which is provided the usual valve seating and dome for the injection holes. The valve stem is similarly elongated, but is a clearance fit in the body, the lapped portion of the barrel being confined to the section located above the fuel gallery (see Fig. 2). Thus, not only is the lapped guide raised to a higher level in the cylinder head, where adequate cooling facilities usually exist, but, by virtue of the smaller diameter, it is also possible to provide cooling at the lower end.

Pintle Nozzles

In the case of the pintle nozzle (see Fig. 3), which is designed for use in engine combustion chambers of the air cell, swirl chamber or pre-combustion type, the valve stem is extended to form a pin or pintle which protrudes through the mouth of the nozzle body. By modifying the size and shape of this pintle, sprays varying from a hollow parallel-sided pencil form up to a hollow cone with an angle of 60° or more can be provided (see also Fig. 5).

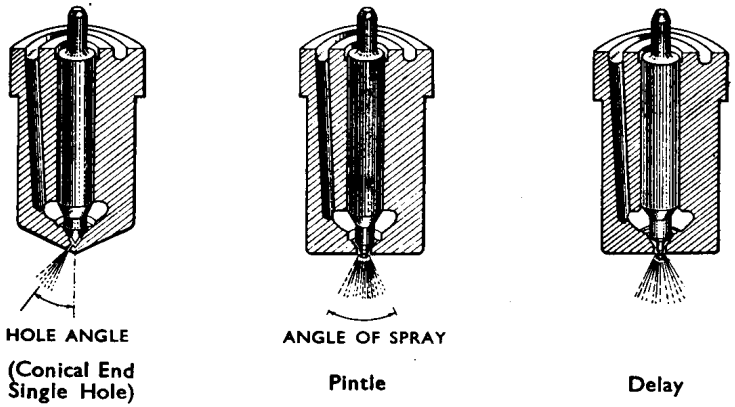


Fig. 3. C.A.V fuel injection nozzles (see also Fig. 2).

Delay Nozzles

Certain pre-combustion chamber type engines, while requiring a pintle nozzle, demand different spray characteristics in order to obtain quieter running at idling speeds. This is accomplished by modifying the design of the pintle so that the rate of injection is reduced at the beginning of the delivery, the resultant effect being to reduce the amount of fuel in the combustion chamber, when combustion commences, thus diminishing "diesel knock." The modified nozzle is referred to as a "delay" nozzle. It should be noted, however, that this type of nozzle does not necessarily improve idling in every pre-combustion chamber engine, and should be selected only after prolonged tests embodying other considerations.

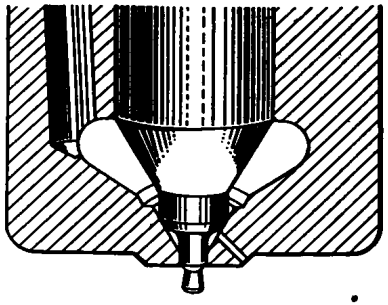


Fig. 3a.
C.A V. Pintaux
fuel injection nozzle

Pintaux Nozzles

The Pintaux nozzle is a development of the pintle type, having an auxiliary spray hole to assist easy starting under cold conditions (see Fig. 3*a*). At engine starting speeds the needle valve is not lifted sufficiently to clear the pintle hole and the fuel is discharged through the auxiliary hole. At normal running speeds, however, when pressures in the fuel system are higher, the needle valve is withdrawn from the pintle hole, allowing the bulk of fuel to be discharged through it.

NOZZLE MAINTENANCE

All nozzles, irrespective of type, should be removed from the engine for examination at regular intervals. Just how long this interval should be, however, is difficult to generalise, because of the widely different conditions under which engines operate. On certain installations, such as generating plant or pumping station sets, where operating conditions of the engine are good and the fuel tank and filtering systems are maintained in first-class order, it is often sufficient if the nozzles are tested as infrequently as twice yearly.

In other cases, however (for example, omnibuses and coaches covering upwards of 1,000 miles per week), more frequent attention to the nozzles may be required. As a general guide, therefore, we would say that no attention should normally be required at intervals of less than 10,000 miles.

The nearer the ideal conditions of good combustion with adequate cooling and absolutely clean fuel are realised, the less attention the nozzles will need, and so the longer their efficient life. In this connection, since the efficiency of this equipment vitally affects the performance of an oil engine, it will repay the user handsomely to see that it never runs with any of the nozzles out of order.

Troubles in Service

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

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

Do not immediately assume, however, that the nozzles are the cause of the trouble, for such features as faulty engine valve timing, badly leaking engine valves, incorrect pump timing, dirty or damaged fuel filters, unsuitable fuel filtration, wrong fuel, water in fuel, defective engine lubrication, " hot " bearings, or incorrect fuel pump maximum fuel setting, may cause similar signs of distress.

Assuming, therefore, that everything else is in order and the nozzles are still suspect, the particular nozzle causing trouble can often be determined by releasing the pipe union nut on each nozzle holder in turn, with the engine running, and listening to the idling performance of each of the other cylinders.

In order to test the doubtful nozzle, first remove the nuts from its flange, and then withdraw the complete unit (i.e., nozzle holder and nozzle) from the cylinder head, turning it round the oil feed pipe so that the nozzle is pointing outwards, away from the engine. Next slacken the unions of the other nozzle holder oil feed pipes (to prevent fuel being sprayed into their cylinders) and turn the engine with the starter until the suspected nozzle sprays into the air, when it will be seen at once if the spray is in order. If the spray is unduly " wet " or " streaky," or obviously to one side, or if the nozzle " dribbles," disconnect the unit and replace it with the complete spare unit (nozzle holder and nozzle) from the tool kit.

Great care should be taken to prevent the hands from getting into contact with the spray, as the working pressure will cause oil to penetrate the skin with ease.

After fitting the spare nozzle holder and nozzle unit, the faulty unit should be placed in the tool kit securely wrapped in clean grease-proof paper or rag for attention at the maintenance bench. The cleaning of nozzles should on no account be attempted " on the spot."

Cleaning and Assembling

The most suitable bench for nozzle maintenance is one that is zinc or linoleum covered, absolutely free from dust, dirt, filings, grease or acids, where no other work is done and where the use of cotton waste and fluffy rags is forbidden. It should also be provided with a small vice (the jaws being protected with clean soft copper or aluminium shields) and a dust-proof drawer for holding the nozzle cleaning tools, etc., described below.

Tools Required

" S " and " T " Type Nozzles

ET.122PA	Nozzle Setting Outfit (" S " type nozzles).
ET.410	Connection for above to suit " T " type nozzles.
ET.841	Spanner for " S " type nozzle cap nut.
ET.117	Spanner for " S " type nozzle spring cap nut.
ET.118	Spanner for " S24 " type spring cap nut.
ET.119	Spanner for compression screw
ET.121	Spanner for " T " and " S24 " type nozzle cap nut.
ET.137	Flushing device for long stem nozzles.
ET.427	Flushing device for short stem nozzles.

ET.142 Safety petrol container.
ET.537 Bench plate.
ET.812 Bench plate for BKB50S22 and BKB30S50 nozzle holders.
ET.533 Cleaning Kit complete in canvas hold-all comprising :—

(1) Brass wire brush ET.068
(2) Pintle hole cleaner with probes ET.069
(3) Nozzle body seat scraper ET.070
(4) Nozzle body groove scraper ET.071
(5) Nozzle pin cleaner ET.072
(6) Probing tool with cleaning wires .. ET.120
(7) Dome cavity scraper (1·8 mm. dome)—long stem ET.138
(8) Dome cavity scraper (1·2 mm. dome)—long stem ET.531
(9) Angular cavity scraper—long stem .. ET.532
(10) Nozzle body seat scraper—long stem .. ET.124

ET.140 Cleaning kit for pintle nozzles only, comprising items (1) to (5) inclusive from ET.533.
ET.141 Cleaning kit for pintle and hole type short stem nozzles, comprising items (1) to (6) from ET.533.
ET.561 Cleaning kit for hole type short stem nozzles only, comprising ET.141 Kit less ET.069.
ET.613 Nozzle pin cleaner ("T" type, 7 mm. valve).

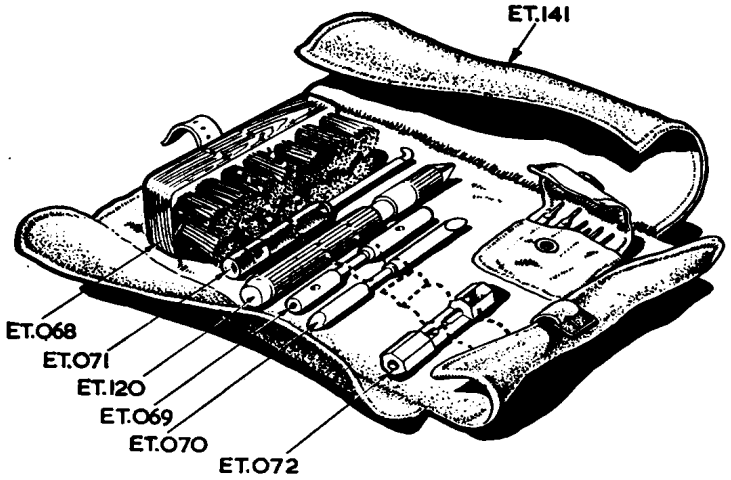
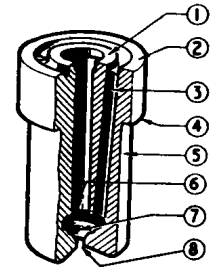


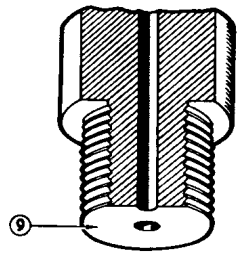
Fig. 4. C.A.V. cleaning kit ET.141 for pintle and hole type short stem nozzles

Additional for "U" and "V" Type Nozzles

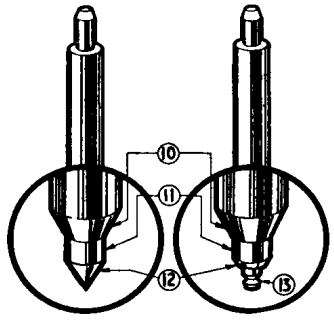
ET.538 Connection for nozzle setting outfit to suit "U" and "V" type nozzles.
ET.539 Nozzle body seat scraper for "U" and "V" nozzles.
ET.540 Nozzle pin cleaner for "U" and "V" nozzles.
ET.541 Nozzle body groove scraper for "U" and "V" nozzles.



NOZZLE BODY

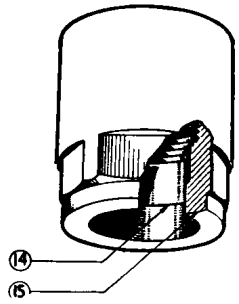


NOZZLE HOLDER PRESSURE FACE



HOLE NOZZLE NEEDLE VALVE

PINTLE NOZZLE NEEDLE VALVE



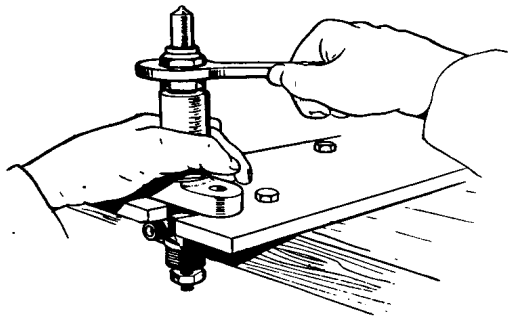
NOZZLE CAP NUT

1. Pressure face
2. Pressure face
3. Fuel feed hole
4. Nozzle shoulder
5. Nozzle trunk
6. Fuel gallery
7. Valve seating
8. Pintle orifice
9. Pressure face
10. Valve cone
11. Valve stem
12. Valve seat
13. Pintle
14. Nozzle retaining shoulder
15. Pressure face

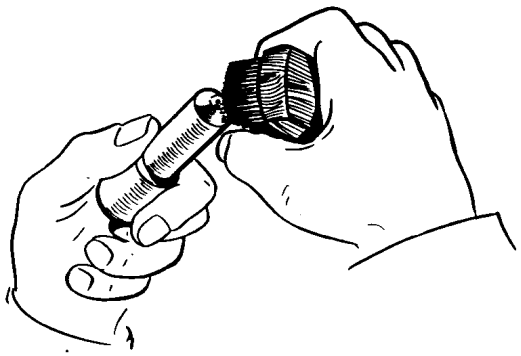
Fig. 5. Diagrams of various parts of C.A.V. nozzles and nozzle holders

Method of Cleaning Nozzles

1. Check complete injector on nozzle setting outfit ET.122PA for nozzle pressure setting and seating leakage.



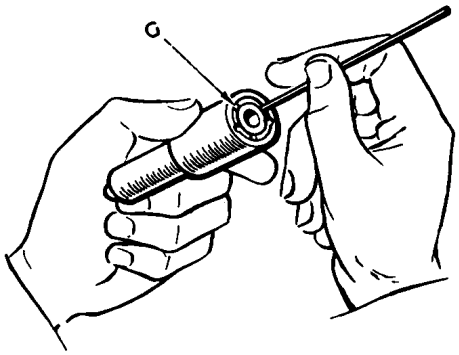
2. If nozzle is faulty, release pressure on nozzle holder spring by undoing adjusting screw, then remove nozzle cap nut and nozzle with spanner ET.841 or ET.121.

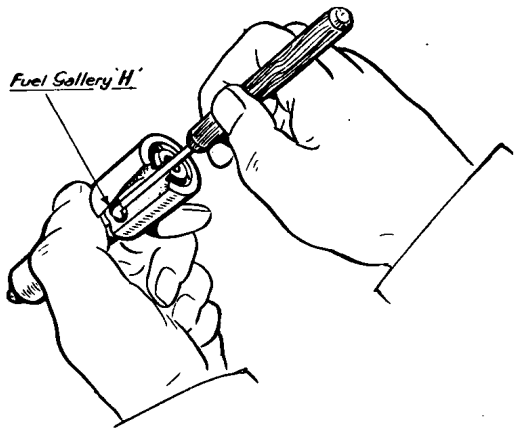


3. Examine nozzle for carbon and whether the valve lifts out freely. Brush all carbon from outside with brass wire brush ET.068. Place body and valve in clean petrol, fuel oil or Shell FUSUS "A" oil to soak and soften carbon.

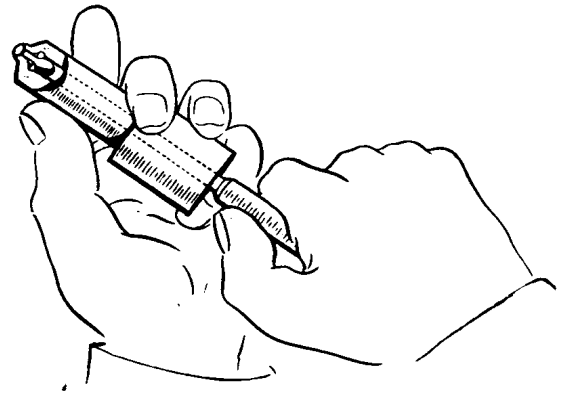
Note—The nozzle should be free from all damage, and it is important that it is not " blued " due to overheating. All polished surfaces should be relatively bright without scratches or dull patches. It is essential that the pressure surfaces (1), (2) and (9) (Fig. 5) are absolutely clean, as these must register together to form a high pressure joint between the nozzle holder and nozzle.

4. Clean out small feed channel bores " G " with drill or wire of 1·70 mm. diameter. These bores are rarely choked and insertion of drill or wire by hand will be sufficient.



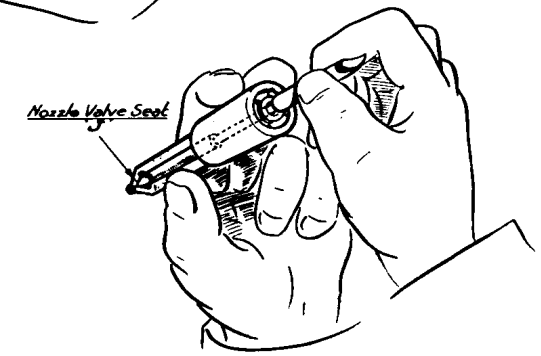


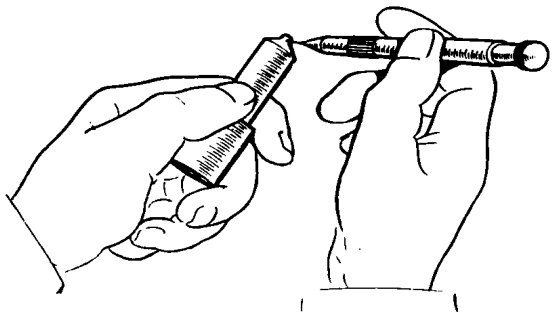
5. Insert special groove scraper ET. 071 until nose locates in fuel gallery " H." Press hard against side of cavity and rotate to clear all carbon deposit from this area.



6. Insert dome cavity scraper ET.138, ET.531 or ET.532 according to nozzle type, and in the same manner as operation 5, remove any carbon deposit adhering to inside of dome.

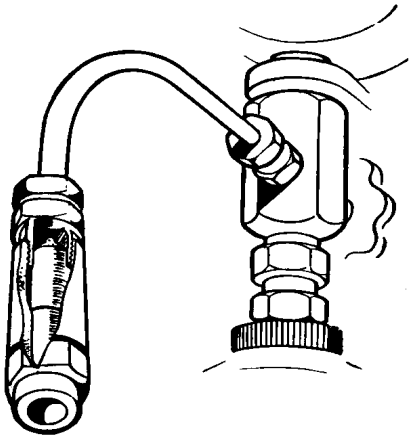
7. With seat scraper ET.070 or ET.124 according to nozzle type, clean all carbon from valve seating " J " by rotating and pressing tool on to the seating.





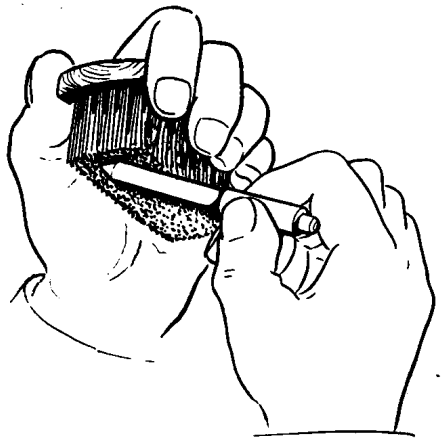
8 (*a*). **Hole Type Nozzles.** Clear spray holes by use of probing tool ET.120 fitted with appropriate size cleaning wire. All kits are supplied with the most popular sizes of cleaning wires, but if correct size is not known, it can be ascertained by careful trial of wires in holes. Extreme care must be taken, however, to obviate the danger of wires breaking in holes, as such particles are almost impossible to remove. The cleaning wire should be fitted in the tool chuck so that it protrudes for only about 1/16", thus giving maximum resistance to bending.
Enter wire into hole, pushing and rotating gently until hole is cleared. The auxiliary hole of a Pintaux nozzle may be cleaned in the same manner.
8 (*b*). **Pintle Type Nozzles.** For cleaning the orifice of a (BDN) pintle type nozzle, select the appropriate size probe from the pocket of the cleaning kit ET.533, ET.140 or ET.141, and insert this in the nozzle body pintle hole cleaner ET.069. Pass the probe down the

bore of the nozzle until it protrudes through the orifice, then turn with a rotary motion until all carbon is cleared.
To clean the pintle end of a pintle valve, use the wire brush ET.068, dislodging any hard pieces of carbon with a piece of wood or brass strip. It is important that care is exercised with the nozzle valve, and in particular the pintle, to prevent damage to either, as a scratch or burr may cause valve leakage or spray distortion.



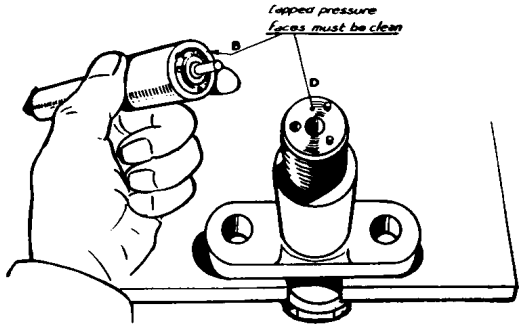
9. Assemble the nozzle into flushing tool ET.427, or ET.137 if a long stem type, with the nozzle end towards the smaller thread connector which should be coupled to the nozzle setting outfit ET.122PA. The flushing tool should be arranged with the open end pointing downwards to facilitate particles being washed out.

Force test oil through vigorously. This is most important, as it has the effect not only of thoroughly cleaning out the inside of the body cavity and bores, but also washes away any loose particles of carbon that may still be present in the spray holes.



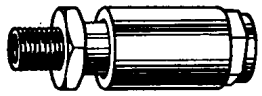
10. Clean needle valve tip carefully by brushing away carbon with brass wire brush ET.068. To assemble valve into nozzle, immerse both items in clean fuel oil or Shell FUSUS "A" oil and fit them together under the surface, so as to prevent the closely fitting lapped surfaces from being touched by hand.

Note—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 by a C.A.V. depot or agent. In no circumstances must an attempt be made to lap the nozzle valve and body, as this is a specialised process and any attempt to perform this may render any subsequent effort useless.



11. Ensure that the lapped pressure faces "B" on the nozzle and "D" on the holder are clean and free from dirt or metallic particles. If the holder has been dismantled, all parts should be thoroughly washed in petrol, fuel oil or Shell FUSUS "A" oil before reassembly, and particular care given to the pressure faces.

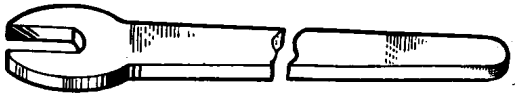
12. Place the nozzle on the pressure face of its holder and secure in position by the nozzle cap nut. It is important to remove tension of the nozzle holder spring during this process, particularly where the holder carries locating dowels, as otherwise false locations may be obtained and damage sustained by the pressure faces. Finally, tighten



ET.137 & 427

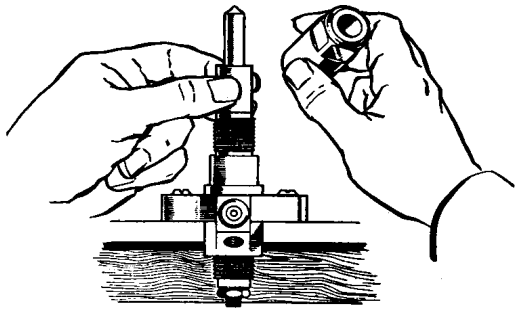
ET.117, 118, & 841

ET.121



ET.119

Fig. 6. C.A.V. spanners and nozzle flushing device



cap nut with spanner ET.841 or ET.121 taking care not to over-tighten, as this may cause distortion and lead to seizure of the nozzle valve. Fit assembled unit to nozzle setting outfit and adjust pressure to engine maker's recommended setting. If the nozzle is to be stored, smear lightly with Vaseline before packing away.

Cleaning " U " and " V " Type Nozzles

The whole of the foregoing instructions relate to " S " and " T " type nozzles, but exactly the same procedure can be followed with " U " and " V " types, except that the additional tools as given on page 8 will be required.

NOZZLE HOLDERS

In order to locate the nozzle in the correct position in the engine cylinder head, a specially designed nozzle holder (Figs. 7 and 8) is provided. This carries a valve spring (5) and a spindle (6) by means of which the nozzle valve is held down on its seating.

Compression on the spring can be adjusted by the compression screw (3), thus the pressure at which the nozzle is forced off its seating can be regulated. At the lower end of the holder is a highly finished face which forms a joint with the flange of the nozzle body when tightened by means of the nozzle cap nut (7).

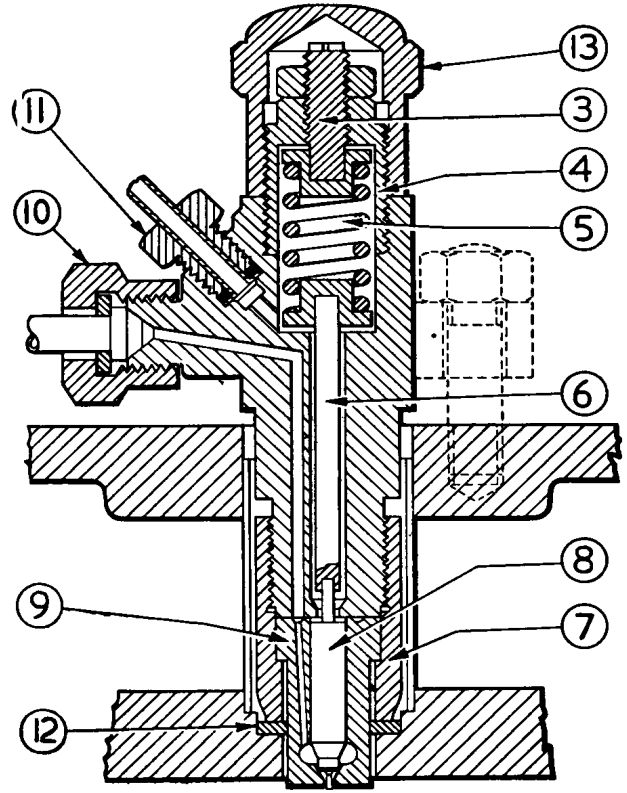
Oil is fed through the piping connected to the fuel inlet connection (10) via a boring in the nozzle holder, which connects with an annular semi-circular groove on the ground face of the nozzle body. The slight leakage of oil which accumulates within the nozzle holder is sufficient to lubricate the nozzle, and can be led away via a pipe fitted to the leak-off connection (11).

Nozzle holders are provided in sizes " S," " T," " U " and " V " to suit the corresponding type nozzles, and vary in barrel length according to the depth of cylinder penetration required.

The service life of the valve spring can be increased by careful treatment. To avoid damage likely to be caused by moisture corrosion during storage, handling, or condensation due to temperature change in service, it is recommended that these springs are inspected, cleaned and greased whenever the nozzles are removed.

Fitting

When preparing to fit a nozzle holder into the cylinder head, care should be taken to see that the special copper washer (12) (Fig. 7)—obtainable from all C.A.V. depots—is provided to make the joint between the nozzle cap nut and the cylinder head (Fig. 7). Where engines have an integral copper face in the injector pocket, no washer is required.



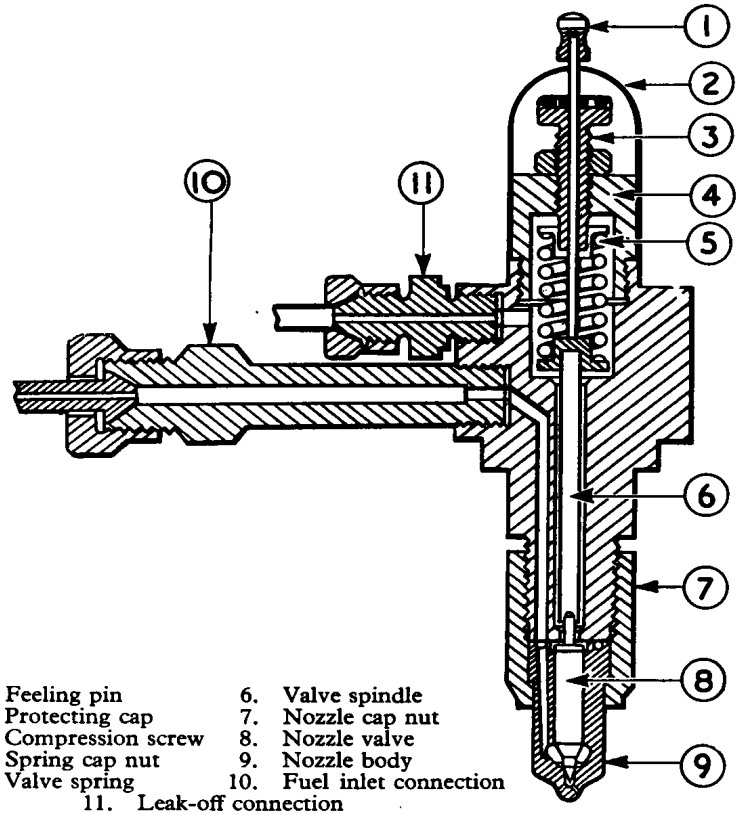
3.	Compression screw	7.	Nozzle cap nut	11.	Leak-off connection
4.	Spring cap nut	8.	Nozzle valve	12.	Special copper washer
5.	Valve spring	9.	Nozzle body		
6.	Valve spindle	10.	Fuel inlet connection	13.	Protecting cap

Fig. 7. Section through C.A.V. nozzle holder—type BKB . . . S24

This joint washer should be an easy but not loose fit on the nozzle body, and as this is quite an important feature, on no account should normal sparking plug type washers be used.

The metal of the cylinder head, the faces of the copper joint washer and the face of the nozzle cap nut should be cleaned in order to facilitate the making of a leak-proof joint. It is also advisable to fit a new joint washer whenever the nozzle holder is replaced after having been removed for cleaning.

When fitting the nozzle holder in position, care should be taken to see that it is an easy fit in the cylinder head tunnel and on the holding-down studs, so that it can be placed down on the copper joint without force of any kind. If the nozzle end seems tight in the injector pocket, the pocket should be cleaned out with a piece of hardwood. The securing nuts should be tightened down evenly in order to prevent the nozzle being canted and so " nipped " in the cylinder head. This is very important, since any unevenness in tightening down may cause distortion of the nozzle, and subsequent failure of the latter.



1. Feeling pin
2. Protecting cap
3. Compression screw
4. Spring cap nut
5. Valve spring
6. Valve spindle
7. Nozzle cap nut
8. Nozzle valve
9. Nozzle body
10. Fuel inlet connection
11. Leak-off connection

Fig. 8. Section through C.A.V. nozzle holder—type BKB . . . S1

Nozzle Holder Maintenance

The nozzle holder should be washed in clean paraffin, care being taken to protect the pressure face. This face must register with the nozzle pressure faces cleanly and squarely to form a high pressure joint, and should be handled in such a way as to avoid damage to it. The exterior of the nozzle holder should be cleaned of dirt and rust in the usual manner. Periodically, it is advisable to dismantle the interior and examine the spring (5) and spindle (6) (Figs. 7 and 8).

To dismantle, proceed as follows:—

1. Mount nozzle holder on bench plate ET.537. Remove protecting cap (2) and feeling pin (1), or where cap nut (13) is fitted, use spanner ET.841 or ET.121.
2. Unscrew spring cap nut (4) with spanner ET.117 or ET.118 according to type, take out upper spring plate, spring (5) and spindle (6). The lower spring plate is a press fit on the spindle.
3. Thoroughly clean all parts in petrol or clean Shell FUSUS "A" oil. If any parts are damaged, replace.

4. To assemble, reinsert spindle (6), spring (5) and upper spring plate. Screw on spring cap nut (4) and tighten with spanner ET.117 or ET.118.
5. Relieve spring pressure by releasing lock nut and unscrewing compression screw (3) with spanner ET.119, or with spanner and screwdriver.
6. Mount nozzle on nozzle holder pressure face, making sure both surfaces are absolutely clean and undamaged, and screw on nozzle cap nut (7). Tighten well, but not excessively, with spanner ET.841 or ET.121; too great a leverage may result in constriction or distortion of the nozzle.
7. Reset injection pressure by means of compression screw (3) and its lock nut, and test on nozzle setting outfit ET.122PA.
8. Finally replace protecting cap (2) and feeling pin (1), or cap nut (13).

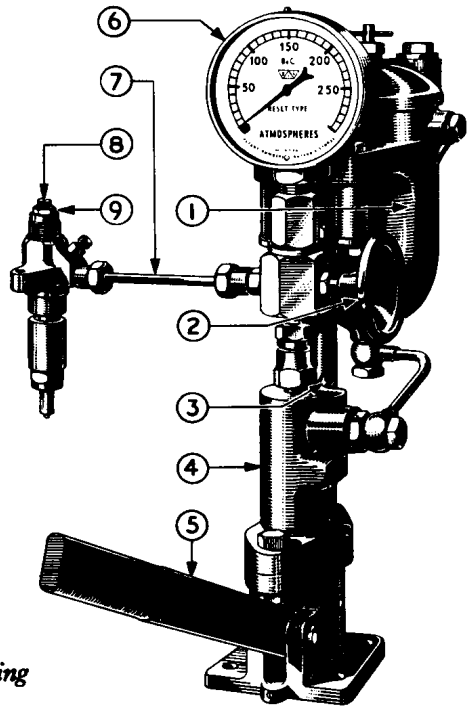
NOZZLE SETTING OUTFIT—Hand Lever Type

The nozzle setting outfit (Fig. 9) is a necessity when it is desired to adjust the opening pressures of nozzles and to inspect their spray qualities. The model described is suitable for " S " type nozzles and holders : that is, for those normally fitted to commercial vehicle, tractor and smaller marine engines, but an adaptor is available for use when it is desired to test the " T," " U " and " V " types as fitted to larger stationary and marine installations. It is built from components of the quality, accuracy and finish which characterise all C.A.V. products, and will prove thoroughly reliable and trouble-free in service.
Note—The injection pump (4) incorporated in the outfit has been specially designed for its particular function, and is not intended to be used for other purposes.
When assembling the handle to the nozzle setting outfit, the adjusting screw on the base casting which limits the downward travel of the handle should be screwed in until the screw head is level with the red line marked on the casting. The adjusting screw should then be secured by tightening the horizontal locking screw.
The fuel tank has a capacity of approximately 1½ pints and contains a felt filter element to ensure cleanliness of fuel delivered through the pumping element to the nozzle under test.

Maintenance

The nozzle setting outfit requires little maintenance, but attention should be given to the following points:—

Always protect the pressure gauge (6) from varying fluctuations of pressure by closing the check valve (2) when operating the pump rapidly and before releasing pressure by disconnecting units after testing.
The tappet gear should be lubricated periodically, although it is probable that sufficient oil will penetrate to keep this in good condition.
If the outfit is to be left unused for any length of time, see that a quantity of fuel remains in the tank in order to protect the filter element and delivery valve from corrosion. Periodically remove the element from the container and cleanse thoroughly by soaking in clean paraffin. Before doing this, close each end of the element with clean corks.



1. Fuel container and filtering unit
2. Check valve
3. Air vent screw
4. Injection pump
5. Hand lever and mounting base
6. Pressure gauge.
7. Pressure feed pipe
8. Nozzle holder injection pressure adjusting screw
9. Locking nut for (8)

Fig. 9. C.A.V. nozzle setting outfit—hand lever type

On no account should the felt pads be removed during the cleaning operation, as this will result in spreading the dirt across the pads and so increase the possibility of it getting through to the injection pump.

Filter elements will last a long time on this duty, but replacements are obtainable at all C.A.V. depots. Periodic checking and adjustment of the pressure gauge is also desirable, and this service can be obtained at any C.A.V. depot at a nominal charge.

NOZZLE TESTING OUTFIT—Rotary Type

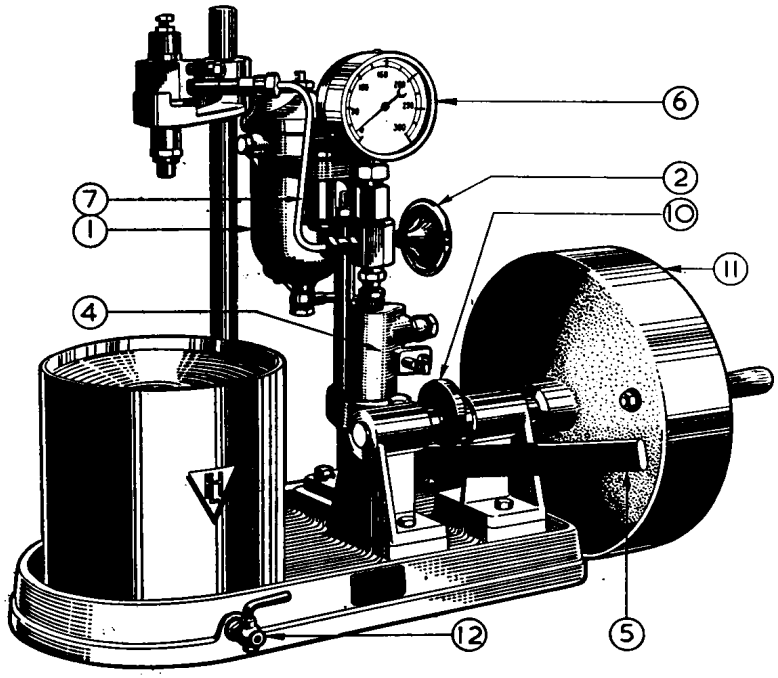
This is an adaptation of the ET.122PA, the hand lever being actuated by means of a cam and flywheel as illustrated in Fig. 10. This mechanism is so designed that when the flywheel is rotated at a natural hand turning speed of 85-90 r.p.m., the pump plunger velocity is equivalent to that obtained on an engine running at 25 r.p.m., with normal tangential cam profile.

The advantages of this scheme are twofold in that it is easier to maintain a speed of 85-90 r.p.m. by hand than 25 r.p.m., and that 85-90 separate injections per minute instead of only 25 are provided—thus a clear and fairly constant picture of the spray form can be obtained.

The rotary apparatus enables a much more satisfactory test to be applied to the nozzle than the hand lever type, as the speed of operation of the latter is dependent upon the "feel" of the operator, and is usually much lower than was obtained during the operation of the nozzle in the engine. It is thus not possible to regularise a satisfactory " pass " test with the hand lever apparatus.

NOZZLE TESTING

The prime requirements of a satisfactory nozzle are :—(*a*) pressure tight seats, (*b*) freedom from excessive back leakage, (*c*) satisfactory spray performance or atomisation. Setting Outfit ET.122PA (Fig. 9, enables checks to be made of (*a*) and (*b*), but, because of its limitations, can only give a general indication of actual spraying qualities and cannot be relied upon for item (*c*). This check can, however, be carried out on the rotary type outfit (Fig. 10) as described in para. 8 (*a*) on page 21. Otherwise the nozzle should be put aside for special attention by a C.A.V. depot or agent.



1. Fuel container and filtering unit
2. Check valve
4. Injection pump
5. Hand lever
6. Pressure gauge
7. Pressure feed pipe
10. Eccentric cam
11. Handwheel
12. Fuel drain cock

Fig. 10. Nozzle testing outfit—rotary type (not supplied by C.A.V.)

Pintle and Hole Type Nozzles

Test Procedure

1. **Test Oil.** Fill the fuel tank by pouring through the filler cap approximately 1½ pints of Shell FUSUS "A" oil.
2. **Air Vent.** Before operating the outfit, air vent the system by removing air vent screw (3) to allow oil to flow freely for a few seconds. Replace screw while oil is still flowing and operate pump several times until oil flows from pipe (7).
3. Connect complete injector to be tested to the outfit by means of pressure piping (7). The length and bore of this piping are important, and if a new piece is fitted this should be 75 mm. approx. between the union nuts, and of 2 mm. bore.
   Examine the lapped pressure faces of the nozzle holder and nozzle when assembling, to ensure that they are perfectly clean, otherwise leakages may occur.
4. Close check valve (2) to keep the pressure gauge (6) out of circuit, and smartly operate hand lever (5) several times in order to expel all air from the system.

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

ON NO ACCOUNT SHOULD THE HANDS BE BROUGHT INTO CONTACT WITH THE SPRAY, which has very great penetrating force.

A notice bearing this warning should be prominently displayed. Suitably printed cards are available upon request.

5. **Back Leakage.** Open check valve (2) to bring pressure gauge (6) into circuit. Remove nozzle holder cap nut, loosen lock nut (9) and by means of adjusting screw (8) set injector opening pressure to between 160 and 170 atmospheres.
   With check valve still open, pump up sufficient pressure to open injector and then pump up again to just below this pressure. Release hand lever and allow to fall naturally, timing the drop of the gauge needle from 150 to 100 atmospheres. For a nozzle in good condition, this time should be not less than 6 seconds using Shell FUSUS "A" oil as specified above, at a temperature of 50-70°F. At higher temperatures, a somewhat lower figure may be obtained.
   When carrying out this test observe that no leakage occurs at the lapped pressure faces of the nozzle holder and nozzle. Leakage may be external, when it is visible at the nozzle cap nut screw thread, or internal, in which case it cannot readily be distinguished from excessive leakage past the lapped portion of the valve. If leakage at the lapped joint is suspected, do not over-tighten the cap nut in an effort to cure such leakage, 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 components and re-test. If the pressure drop time is still low, this indicates excessive leakage past the lapped portion of the valve.

6. **Pressure Setting.** To set the pressure at which the nozzle should open, slowly move the hand lever downwards and carefully watch the pressure gauge for the highest recorded pressure before the needle " flicks," indicating opening of the valve. Any necessary adjustment is effected by loosening lock nut (9) and moving adjusting screw (8) inwards to increase pressure, or outwards to decrease pressure, on the spring.
7. **Seat Tightness.** Wipe nozzle tip dry, and with check valve (2) open, build up the pressure to 10 atmospheres below the opening pressure set in para. 6. The nozzle tip, or in the case of single hole or pintle type nozzles, the flat bottom face, must remain substantially dry and there must be no tendency for blobs of fuel to collect or drip. A slight dampness can be ignored.
8. **Spray Form (Setting Outfit ET.122PA).** With check valve (2) closed, operate the hand lever smartly at a speed of 90-100 strokes per minute. With normal types of hole and pintle nozzle, an atomised spray free from irregular streaks should be observed. This outfit is not regarded as providing a suitable test for atomisation under working conditions, but merely gives an approximate indication of the working of the nozzle.

8 (*a*). **Spray Form (Testing Outfit—Rotary Type).** With the check valve (2) closed, operate the hand wheel at 85-90 r.p.m., and carefully observe the shape and nature of the spray. In the case of multi-hole nozzles the sprays should be finely atomised and have equal penetration into the surrounding atmosphere. In the case of pintle type nozzles the spray should be finely atomised, equally distributed around the axis of the nozzle and free from coarse or solid streaks.
Note—Delay type nozzles such as BDN12SD12, and poppet nozzles such as PN/150/1, cannot be tested for spray form on this apparatus, as they require a higher plunger velocity for complete atomisation.

9. **Pressure Gauge.** Before removing the nozzle holder from the outfit, close the check valve (2) to prevent damage to the pressure gauge which may result from a sudden drop of pressure.

Pintaux Nozzles

In order to check the required injection rate and delivery of this type of nozzle, it is necessary to use the special test adaptor ET.846 which is connected to the nozzle setting outfit in place of the normal nozzle holder. This consists of an additional nozzle holder fitted with a BDN8S1 nozzle with the pintle end removed (ET.847). A modified cap enables the injector, complete with the Pintaux nozzle under test, to be screwed on to the end as shown in Fig. 11. By setting the opening pressure of the BDN8S1 nozzle to a value where its closing pressure is higher than the opening pressure of the Pintaux nozzle, a sufficiently high rate of injection can be obtained on hand test to determine the quality and form of atomisation of both auxiliary and main sprays.

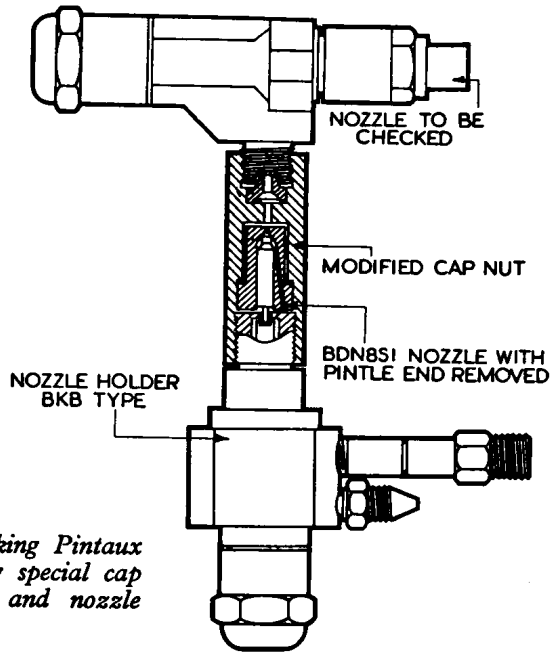


Fig. 11. *Rig for checking Pintaux nozzles, using special cap nut ET.846 and nozzle ET.847*

Test Procedure

1. **Seat Tightness.** Assemble Pintaux nozzle into a suitable holder, i.e., of type with which particular nozzle is used, and set to an opening pressure of 100 atmospheres.
   Connect to nozzle setting outfit and atomise several times to expel air from the system. Wipe face of nozzle dry and pump up pressure to 90 atmospheres, and hold for ten seconds. Wipe first finger across face of nozzle and inspect for wetness. Reject if wet.
2. **Auxiliary Spray.** Assemble nozzle holder with modified BDN8S1 nozzle and special cap nut ET.847 and ET.846; connect to nozzle setting outfit and set opening pressure to 220 atmospheres. Screw holder complete with Pintaux nozzle on to the end of special cap nut. Atomise several times to expel air from the system and then observe atomisation from auxiliary hole. This should be well formed and free from splits or distortions. A slight centre core may be disregarded.
   Note—The hand lever of the nozzle setting outfit should be operated at a minimum frequency of 60 strokes per minute during this test.
3. **Main Spray.** Operate hand lever at 140 strokes per minute and observe main spray. This should be well atomised and free from large splits or distortion. A slight centre core may be disregarded.

Fitting New Nozzles

When fitting new nozzles, after unpacking, remove grease and flush with fuel or test oil before use.

TESTING AND CORRECTION OF FAULTY NOZZLES

Fault	Possible Cause	Remedy
Nozzle does not buzz while injecting (rotary type testing outfit).	1. Needle valve too tight, binding, or valve seating leaky. 2. Nozzle cap nut distorted.	Clean nozzle. Examine cap nut. If necessary replace nozzle and needle valve.* N. B. — Delay type nozzles and Poppet nozzles do not usually buzz at slow plunger velocities given by testing outfit.
Excessive leak-off.	1. Needle valve slack. 2. Foreign matter present between pressure faces of nozzle and nozzle holder. 3. Nozzle cap nut not tight.	Replace nozzle and needle valve.* Clean. Tighten cap nut, after inspecting joint faces.
Nozzle blueing.	Faulty installing, tightening or cooling.	Replace nozzle and needle valve.* Check cooling system.
Nozzle opening pressure too high or too low.	1. Compression screw shifted. 2. Needle valve seized up, corroded. 3. Needle valve seized up, dirty, sticky. 4. Nozzle openings clogged with dirt or carbon.	Adjust for prescribed pressure. Replace nozzle and needle valve.* Clean nozzle. Clean nozzle.
Nozzle pressure too low.	Nozzle spring broken.	Replace spring and readjust pressure.
Nozzle drip.	Nozzle leak due to carbon deposit; sticking needle valve	Clean nozzle. If this does not clear the fault, replace nozzle and needle valve.*
Form of spray distorted.	1. Excessive carbon deposit on tip of needle valve. 2. Injection holes partially blocked. 3. Nozzle needle valve damaged (pintle type only).	Clean nozzle. Clean nozzle. Replace nozzle and pintle valve.*

**When it is found necessary to replace the nozzle, the faulty unit should be carefully packed and returned to a C.A.V. Service Depot for attention.*