GARDNER

Engine Forum

Spring 2006 Issue

No.10

Gardner Engine Forum Philosophy

"The aims of the Forum are to promote and foster interest in all Gardner engines"

Subscription

The annual subscription to the forum is £10.00 (This magazine will be published twice a year)

Price of each issue to non-members £2.75

Overseas subscription £18.00

Forum Officers

Chairman:

Colin Paillin
Ivy Cottage, 11 The Green, Hose,
Melton Mowbray, Leics. LE14 4JP
(Tel: 01949 869004)

Treasurer:

Mike Short
66 Queen Street, Weedon,
Northants. NN7 4RA

Membership Secretary:

Bob Heath,
6 Musgrave House, Bamford Mill, Bamford,
Hope Valley, Derbyshire. S33 0AU

Secretary / Editor

Lucy Short
66 Queen Street, Weedon,
Northants. NN7 4RA

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Advertising Rates:
Free to Members
£25.00 to Non-Members

Cover Picture

"John boy" out of the Hinchcliffe Fleet- Can anybody tell us any more?

Chairman's Jottings

The start of the year has seen changes at Gardner Parts with the sudden departure of our top supporter and Managing Director, Paul Crisp. The stores and office have been relocated to Leyland together with some members of staff. (For your information the old Gardner Parts telephone number now automatically transfers to the new office.) We wish Paul all the best in looking for a new position, but his departure means that we have lost the support of Gardner Parts together with the expertise that they brought to the judging at our rallies, and the last link has now left Barton Hall engine works. Paul has offered to write an article for us on his life at the works. We look forward to his insight.

The rebuilt 2LW on display at the Castlefields Rally (rebuilt by staff at the works on a volunteer basis) has been sold and is being installed in the former Fellows Moreton Clayton steamer, narrowboat "King". This will replace the 4LW currently in its engine room which is thought to be too big An article is to follow on this engine change.

The well attended AGM at the Anson Engine Museum this April, does show how much you like what we are trying to achieve Thank you all.

Following the AGM one of our members has volunteered to join the committee and will therefore be co-opted until the next AGM. Steven Gray will be taking over my role as Rally Secretary for the 2007 rally.

The forum now has its own website: www.gardnerengineforum.co.uk which will serve as a notice board worldwide. Details of the 2007 rally will be posted on this site shortly.

Reading the dictionary recently I checked the word 'forum' and under that heading it is a market place of debate or of a Roman town used for legal, political and other public business. Please let's see more input from the membership – that's what it's for.

On a personal note, we are planning to take Sharpness over the Leeds and Liverpool canal this year.

Regards

Colin Paillin
Chairman - Gardner Engine Forum

MARINE ENGINE WORKSHOP

UNDERSTANDING SMOKE SIGNALS

I am frequently asked to comment on the whys and wherefores of the characteristics of diesel exhaust smoke and thought an explanation of the various smoke colours and their causes may allow readers to accomplish some “self-diagnosis”.

Black Smoke

This is the most common adverse smoke condition encountered and is caused by localised oxygen starvation involving individual fuel particles. This results from either of two phenomena, an increase in fuel to air ratio or the inability of oxygen to fully penetrate the injected fuel mass.

High fuel to air ratio may be attributed to the following:

1. Choked air cleanser or exhaust system
2. Injection pump maximum fuel delivery too high
3. Engine operating at ‘overload’ e.g., fouled prop, over propped, etc.
4. Hot intake air temperature, e.g., engine air intake within an enclosed engine compartment. (Hot air = thin air!)
5. Low cylinder compression, resulting in reduced charge density.

Oxygen cannot fully penetrate fuel particles that are not ‘atomised’. Un-atomised globules of fuel are caused by:

1. Injector faults: Worn needle and nozzle or low-pressure setting will manifest itself by a wet nozzle seat and/or a heavy spray pattern
2. Faulty injection pump delivery valve: This will cause the injector to ‘dribble’ rather than cut cleanly at the cessation of injection.
3. Cold combustion chamber temperature, resulting in condensation and subsequent atomisation of the fuel mass.

A perfectly healthy engine should emit black smoke momentarily whenever the engine is ‘loaded up’, e.g., when cruising at idle speed and snapping the throttle open wide.

Blue Smoke

This can be attributed to two problems, one mechanical, one fuel related

If the blue smoke is accompanied by an 'oily' smell, then the condition is a mechanical one, usually a result of excessively worn cylinder bores or worn/broken piston rings. Worn valve guides, allowing ingress of lubricant in the combustion changer or exhaust port will exhibit the same signs.

If a 'diesel' smell is evident in the exhaust, then the problem is due to incomplete combustion of the fuel charge, resulting in particles of unburned fuel, up to 5 microns in diameter, being exhaled with the exhaust gas.

The common causes are engines running below normal temperature, under-loaded engines, engines running 'off-load'. Big traditional engines usually exhibit this condition on the canal due to the load demand on the engine being minimal.

Retarded injection pump timing is another cause of the problem and in all the examples mentioned, cold combustion change temperature is the common denominator and root of the problem. This condition is to be considered normal when warming up 'off-load'.

White Smoke

This again can be the manifestation of two problems. One cause is the ingress of water into the combustion chamber or exhaust system, resultant of head gasket failure, perforated cylinder liner or bore, internally corroded header tank/exhaust manifold unit, etc. In these cases the white smoke is actually steam in transit with the exhaust gases.

The other cause of white smoke and accompanied by a heavy diesel smell is resultant of large particles of unburned fuel, in excess of 10 microns in diameter. This problem is allied to extremely low combustion chamber temperature, radically retarded injection timing or gross ignition lag. A non-firing cylinder, due to loss of compression, etc., will also display this condition.

During cranking of the engine and initial run-up on a cold morning, a healthy engine can be expected to exhibit these signs.

Charles Mills
C♦M♦D Engineering

Continuing our transcript of:
Diesel Maintenance
T. H. Parkinson, AMIAE

INJECTION EQUIPMENT

Part II. Pump Adjustments; Timing; Phasing; Governor Setting; Controls

FUEL INJECTION PUMPS

Adjustment and repair of fuel pumps is not an operation to be lightly undertaken. In the first place the design and construction places them in the fine instrument category. The manufacturing degree of accuracy is extremely high and the finish of many of the parts is such that damage is certain to follow careless dismantling and handling. The pump manufacturers, recognising this only too well, have provided instructional courses for maintenance staffs and have prepared equipment and special tools for limited adjustment. It is obvious, therefore, that without these facilities and the necessary knowledge, small fleet operators will be well advised not to attempt pump repairs. Where service station facilities exist the small fleet owner should use them. Part of the following description of accepted pump adjustment practice may illustrate the limitation of efficient servicing and further emphasise why the benefits of specialist knowledge should be used. If, however, service facilities are not available the recognised method of approach will be explained to those who are notfamiliar with the work.

Before outlining service methods a knowledge of the symbols used in the designation of identification of injection equipment is important because considerable variations are present even if outside appearance suggests similarity. In ordering spares or asking for information from a pump service station the quoting of symbols is necessary. Some knowledge of their composition will be helpful to the operator. CAV Ltd publish a pamphlet on fuel injection equipment type formulae and the following is an extract:

"Before considering the injection pump formula in detail, it must be appreciated that when facing the pump inspection window, the left hand end of the housing is always referred to as No. 1 end, and the right hand as No. 2. Also a notch or saw cut will be found marked on the extreme end of one of the coupling threads of the camshaft fitted to either 4 or 6 cylinder BPE type fuel injection pumps. This notch plays an important part in the assembly, as if the camshaft is reversed from its original position, the firing sequence will be incorrect. On 2 and 3 cylinder camshafts, a notch is not normally provided when the cam profiles are symmetrical, as the firing order remains unchanged whichever way the camshaft is assembled. On certain special pumps using unsymmetrical cam profiles the notch is retained ".

To facilitate the understanding of symbols three examples are quoted with a tabulation giving the appropriate key.

PUMP SYMBOLS

The fuel pump is designated by a symbol of letters and number, the following being an example: BPE 6B70N320/3SI44. These can be sub-divided thus:-

B	P	E	6	B	70	N	320	3	SI44

B	..	..	British made
P	..	..	Fuel injection pump
E or F	..	..	With or without enclosed camshaft
No	..	..	Number of cylinders
B	..	..	Plunger stroke B = 10 mm
Nos.	..	..	Plunger diameter in tenths of mm
N	.		Design change letter
Nos	..	.	Assembly characteristics
			Hundreds" show position of camshaft notch and if fuel pump flange provided
			"Tens show position of governor.
			"Units" show fitting or otherwise of injection advance device.
			100 = Notch at No. 1 end. No fuel feed pump flange
			200 = Notch at No. 2 end. No fuel feed pump flange
			300 = Notch at No 1 end. Feed pump can be fitted
			400 = Notch at No. 2 end. Feed pump can be fitted
			00 = Without governor
			10 = Governor at No. 1 end
			20 = Governor at No. 2 end
			0 = Without advance device
			1 = Advance device at No. 1 end
			2 = Advance device at No. 2 end
/3			After assembly number indicates that a blanking plate is fitted over fuel feed pump flange
Letter & Nos			Special features. It is important to the makers (as is the design change letter) to ensure correct spare parts or service information

The complete symbol may now be interpreted thus:-

British made fuel injection pump with enclosed camshaft, with six plungers, 10mm stroke, 7mm bore, Camshaft notch at No. 1 end, with fuel pump flange, Governor at No. 2 end. No advance device. Blanking plate over fuel feed pump. The intermediate "N" and final "SI44" do not concern the user but quotation is essential when ordering spares or seeking information.

GOVERNOR SYMBOLS

Governors are designated by symbols of which the following is a typical example:-
B R 200/950 B C 62

This is sub-divided thus:-

B	R	200	950	B	C	62

B	..	British made
R	..	Regulator (or governor)
Nos.	..	Idling speed, pump rpm
Nos.	..	Max. speed, pump rpm
B	..	Plunger stroke (as pump)
C	..	Design change letter
Nos.	..	Special features (as pump)

The interpretation of the governor symbol reads, therefore:

British made government, idling speed 200rpm, maximum speed 950rpm for 10mm stroke pump. Design change letter and final group of numbers is only required by manufacturers for reference and identification.

Note: 200/950rpm pump speed represents engine speed range of 400-1,900 rpm.

Symbols for fuel feed pump are explained by the following key :-

FP	..	Fuel feed pump
K	..	Plunger type
Nos.	..	Plunger diameter in mm
B	..	Design change letter
56	..	Special features

The importance of knowledge of pump type formulae will be apparent but the value of the same principle applied to nozzle holders and nozzles is not always recognised. The comparatively simple process of dismantling injectors for nozzle cleaning inclines the mechanic to minimise the essential part they play in oil engine efficiency; much of the standard attained today is undoubtedly due to the development of nozzle design. The need for the correct type for a particular engine will be realised when it is pointed out that on pintle type nozzles variations in the size and shape of the pintle spray cones can be varied from 4 degrees to 40 degrees, while in the case of multi-hole nozzles comparatively wide variations in hole angles are possible.

Correct equipment, therefore is essential and the only basis for acquiring the necessary knowledge is an understanding of the manufacturer's symbols. Nozzle holders and nozzles are identified by similar type formulae to that applying to pumps. Examples of typical injectors as fitted to certain popular engines are set out and it will be seen how important the formulae become when replacement units or spare parts are required.

NOZZLE HOLDER SYMBOLS

Nozzle holder symbols are exemplified by:

(i) BKB 35S24 (ii) BKB 35SD51 (iii) BKBL 67S503

Which are subdivided thus:-

B	KB	35	S	24

B	..	British made
KB	..	Nozzle holder
L	..	Additional letter for long stem nozzle
Nos	..	Barrel length in mm
S, T, U, or V	..	Size letter (barrel diameter, 25, 32, 45 or 65 mm). Note that D added to size indicates delay nozzle
Nos	..	Special features

Applying this key to the examples, the interpretation is:-

(i) British made nozzle holder, barrel 35mm long, 25mm diameter. "24" is of importance only when ordering spares or seeking information.

(ii) British made nozzle holder, barrel 35mm long, 25mm diameter delay type. "51", see "24" above.

(iii) British made nozzle holder, barrel 67mm long, 25mm diameter. "503", see "24" above.

NOZZLE SYMBOLS

Nozzle symbols are exemplified by:-

(i) BDN 30S2 (ii) BDLL 150S523

Which are sub-divided thus :-

B	D	N	30	S	2

B	..	British made
D	..	Nozzle
N or L	..	Type letter, i.e., pintle or hole; a second L indicates long stem (only available in multi-hole type).
Nos.	..	Angle of spray
S, T, U, or V	..	Size letter (as nozzle holder)
Nos.	..	Special features

Interpretation of the example is :-

(i) British made nozzle, pintle type, 30 angle of spray, 25mm barrel diameter. "2" is of importance only to manufacturers for identification

(ii) British made nozzle, multi-hole type, 150 angle of spray, 25mm barrel diameter. "523" as "2" above.

ROUTINE ADJUSTMENTS

In classifying routine adjustments as applied to fuel pumps the following sequence is usual.

1. Timing check and phasing
2. Governors.
3. Calibration.

These three operations can to some extent be carried out without the elaborate equipment. It is obvious that to obtain really accurate governor adjustment results, bench test procedure will be necessary, but a check to define approximate performance is possible on the vehicle.

Methods of timing the fuel pump to the engine obviously do not present any difficulty, but it is necessary to have some knowledge of the principles followed in establishing the pump timing or coupling mark. Two methods are in use, one utilising engine tdc position with the appropriate injection advance allowed for on the pump, while the alternative provides for the appropriate advance allowance on the fly-wheel before tdc with the pump timing mark coinciding with the actual point of commencement of injection or as it is generally termed "spill cut-off". In practice the latter method, from a maintenance point of view, is the more satisfactory. But whichever method is used the importance of the pump timing mark will be seen and the check of this point is carried out in conjunction with pump phasing. Phasing sounds somewhat complicated although it does not imply much more than is intended. If the cams in an ignition contact breaker were not equally spaced, erratic firing intervals would result, and in the same way if the commencement of injection did not occur at precisely 60 degree intervals, in each unit of a 6 cylinder pump assembly, the firing intervals would be irregular or out of phase.

Due to certain component replacements, or possibly to excessive wear, it is possible for these intervals to vary. An incorrectly adjusted tappet might for instance produce a commencement of injection 2 or 3 degrees late or early. Provision is therefore, made to correct these inequalities and to phase or adjust to produce equal intervals in correct sequence on the respective pump elements.

To enable the procedure of phasing to be more easily followed, a brief description of the function of a pump element is an advantage. All fuel pumps in general use are of fixed stroke, therefore, the commencement of injection does not vary in relation to crank angle. The control of the amount of fuel injected at each stroke is achieved by rotating the pump plunger on its axis by means of a toothed quadrant and control rod. This movement of the plunger on its axis to obtain more fuel has the same effect as would lengthening the actual pumping stroke but does not alter the positions at which injection commences. The helical edge on the plunger masks the fuel port and the amount of masking is varied by rotation of the plunger. Thus in relation to the accelerator position, the amount of fuel delivered is controlled by the period the helix edge covers the fuel ports during the plunger working stroke. The moment the port is uncovered, the pumping pressure is relieved and the fuel above the plunger can travel back to the fuel ports via the vertical slot in the upper portion of the plunger. Briefly the commencement of the fuel delivery must be the point at which the plunger seals the fuel inlet ports as it ascends, and this is the plunger position which must be ascertained when phasing or checking spill point.

In its working form each element chamber is sealed by a non-return valve which, as a result of the pressure generated during the pumping stroke, is lifted off its seat and thus allows delivery through the connecting pipe to the injector.

The requirements for pump phasing, therefore, are a fuel supply to the pump in conjunction with a means to observe the actual point of injection of each element. The checking of phasing to the requisite 60° intervals for a six cylinder pump (90° for four-cylinder) are observed by readings from a circular protractor mounted on the pump camshaft in place of the coupling and indicated by a fixed pointer. In the course of instruction at the pump manufacturer's schools the set-up adjustment requires a substantial handle for rotation of the pump so that removal of the coupling is necessary. An alternative type of protractor is illustrated which was designed for time-saving where the volume of routine pump test warrants speeding up; with these there is no need to remove the driven half of the coupling from the pump camshaft and, moreover, the coupling timing mark can be verified. The camshaft can be hand turned by means of the protractor assembly for phasing, and is then passed over for calibration on the power test equipment with its coupling undisturbed.

In phasing with the standard equipment, the first operation after attachment of the protractor, operating handle, and fuel supply, is to detach No. 1 delivery valve holder, the valve being placed safely away in a suitable receptacle containing clean paraffin; the delivery valve holder alone is replaced and the fuel is turned on. The control rod is moved to the maximum delivery position and by turning the pump shaft in the direction of rotation fuel will flow freely through the delivery valve orifice until the pump seals the ports. At the precise point where fuel ceases to flow the plunger is commencing its pumping stroke. It is necessary at this stage to wipe with a clean finger the fuel collected in the delivery valve holder. This has the effect of leaving the collected fuel with a concave surface. A very slight movement of the pump shaft, usually by gently tapping the handle away from the direction of rotation, will cause the fuel cavitation in the delivery holder to move and flatten. This is the actual point of commencement of delivery or as it is known the "spill point". The fuel supply is turned off and the protractor adjusted against the pointer to read either 0o or 60o. The delivery valve is then correctly replaced although before doing this it is advisable to flush the delivery valve orifice by turning on the fuel again;

before inserting the delivery valve it should be flushed in clean paraffin. Under no circumstances should it be wiped with any form of fabric. Delivery valves are not interchangeable, they are very delicate, and apart from functioning as non-return valves they play an exceedingly important part in correct functioning of the injector system.

When the helical edge of the pump plunger uncovers the port in the pump barrel near the end of the delivery stroke, the pressure of fuel is immediately reduced so that the delivery valve at once drops on its seating, thus cutting off communication between the pump and the nozzle until the next delivery stroke takes place. At the same time it performs the highly important function of releasing pressure in the delivery pipe. This is effected by means of the novel but entirely simple construction of the delivery valve unit, and reference to the illustration will show that it is an ordinary mitre faced valve with a cylindrical guide with a circular groove dividing it into two parts. The lower part has four longitudinal grooves communicating with the circular groove. The upper part of the guide forms a small piston which is a highly ground plunger fit in the valve guide. When the pump is on its delivery stroke the valve is pushed up until the fuel can escape through the longitudinal grooves over the valve face to the nozzle. Under influence of its spring and the great difference in pressure between the pump barrel and the delivery pipe, the valve reseats immediately the pump pressure is released, and as the cylindrical part drops back, the space in the delivery pipe is thereby increased and the result is a rapid of drop pressure in the feed pipe so that the valve in the injector can snap to its seat, thus instantaneously terminating the spray of fuel in the cylinder and entirely eliminating any after-dribble at the nozzle.

But to revert to the phasing procedure. It is general practice in the manufacturer's instruction schools to continue the phasing in sequence, i.e., 1 to 6 on a six-cylinder pump. On the other hand many operators phase on firing order which presents a sequence of 60° intervals. The standard protractors are calibrated in single degrees, 0o to 90°. Additionally 60° intervals are marked, the latter being for six-cylinder units while the 90° is for four-cylinders. After checking No.1 element as outlined the same method must be followed with the remaining elements. If No.2 element check follows No. 1, the interval of movement will be 120o but as the circular protractor is completed marked in 60o spacing the appropriate reading is straightforward. It is quite usual to find no variations, and a succession of 60o intervals would be found on a correctly adjusted six-cylinder pump. Where derangement has occurred it will probably be due either to wear or to incorrect pump tappet setting and the procedure for rectification in either case is by tappet adjustment. As a guide to this, one flat on the tappet screw equals approximately one degree in phasing. When tappet adjustment is required it is vital that the limited clearance at the top of the pump stroke is understood. Normal clearance is only 0.3mm. It will be seen therefore, that any tappet alternation giving an earlier spill position must be carefully checked. It is necessary therefore, before rotating the pump to check the free lift or clearance at the end of the plunger stroke. This can be done by raising the assembly carefully by the use of a screwdriver.

At a later stage in the chapter particulars are given of average periods for phasing check under a known set of mileage conditions. It can be taken therefore, that phasing is not an operation that is necessary at frequent intervals unless some derangement has occurred such as dismantling or fitting new parts. It is sound practice however, to check spill point in relation to the coupling timing mark, particularly in the larger fleets where routine check and adjustment is a regular part of the maintenance scheme. This is a simple operation if the special timing protractors, referred to on another page, are used when it is possible to take the timing check on completion of phasing. Standard protractors cannot be used however as they necessitate removal of the coupling.

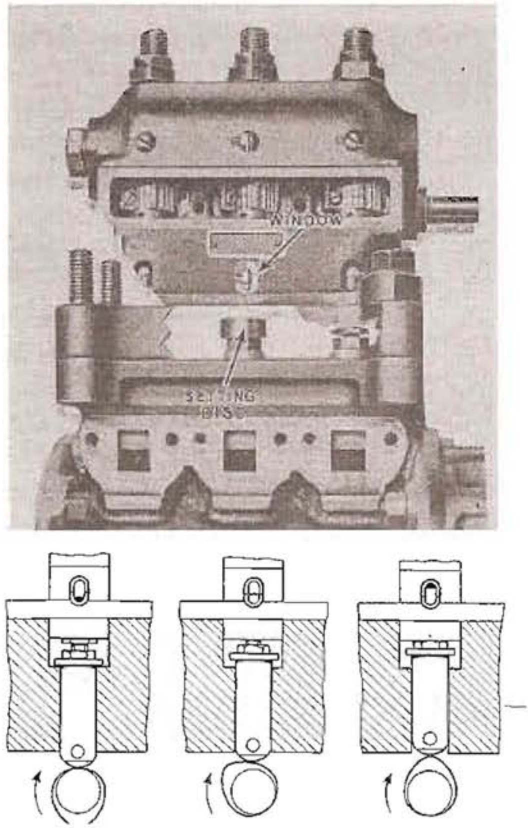
Taking a 7.7 litre AEC Comet engine as an example, prior to the adoption of the advance allowance marking on the flywheel, 13½o was the recommended amount of advance on the pump coupling. It will be obvious, therefore that if the spill point of No.1 plunger has been established, moving the pump shaft in the direction of rotation to 13½° on the protractor will coincide with the pump coupling timing mark. On the same type of engine with a 4¼ inches advance mark on the flywheel the pump position would be No.1 plunger at spill point and the mark on the coupling will correspond to this position. The flywheel figure of 4¼ inches applies to a CAV pump with cam profile PPZ6/I and 7mm elements. With the Simms old type pump 200079 2 7/8inches is the flywheel advance allowance.

Leyland Tiger and Titan engines also have the injection advance allowance on the flywheel, the timing mark on the coupling, therefore being co-incident with No.1 spill point. Actually the more recent Leyland engines are fitted with a timing plunger device under the near side of the flywheel housing. This is a spring plunger which on being released by turning an indicator knob, locks the flywheel at tdc position or injection position. Particulars of the timing allowances for various engines are given in tabular form.

Phasing details already outlined are applicable to CAV, CAV-Bosch and Bosch pumps on AEC, Crossley and Leyland. In the case of the Gardner however, the manufacturer's recommend a different procedure. The pump units are detachable from their respective cam boxes and in addition there are inspection windows on each plunger guide housing.

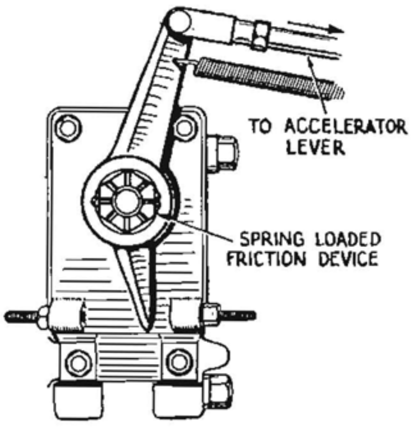
INJECTION TIMING			
Make	Type and Model	Advance inches on flywheel before tdc	Make of pump
AEC	9.6 litre, di (pot) A185 8.8 litre, di (pot) A180, A182	5 1/8th	CAV
	8.8 litre di (torroidal) A180, A18	3 1/2	CAV
	7.7 litre di (torroidal) A173	3 1/2 3 3/8th	CAV Simms (PA)
	6.6 litre di (torroidal) A186	3 3/4	CAV
	8.8 litre Comet I A165	2 1/2 3 1/2	Simms (old type) CAV
	7.7 litre Comet III A171	2 7/8 4 ¼	Simms (old type) CAV
	6.6 litre Comet III A172	3 1/2 3 5/8	Simms (PA) CAV
	6.6 litre Comet I A172	3 1/8	CAV
	6.6 litre Comet I A168	3 3/8 5	Simms (old type) CAV
	5.3 litre Comet 1 (four cylinder) A166	5	CAV
Albion	EN234 EN242	6 5/16 6 13/32	CAV CAV
Crossley	VR6	(20°)	CAV
Gardner	6LW, 5LW 4LK	(29° max) (35° max)	CAV – Gardner CAV - Gardner
Leyland	8.6 litre before 1936 after 193 Cub	4 1/2 4 3/4 (31°)	CAV CAV CAV (PEA)
Perkins	Wolf Lynx Leopard P. Series	4 1/8 to 5/16 5 3 to 3 3/8 3 3/8	CAV CAV CAV CAV (PEA)

A horizontal line is scribed on each plunger and as similar lines are marked on the side of the window, movement of the plunger can be observed and checked. If any derangement of phase angle occurs, necessitating tappet adjustment, the pump must be removed from the cam box and the cam shaft rotated until the tappet receiving attention is resting on the base of the cam. A setting disc is then placed on the top of the tappet screw, the fuel pump is refitted and a check on the plunger and window sight lines is taken.



Part of the pump base cut away to show how the setting disc is used whilst phasing Gardner pumps. When the tappet is correctly adjusted, it coincides the line on the spring thimble with that on the side of the "window". (If there are two window lines, the lower one is used.) Diagrammatically is shown the relationship of the lines to the cam position, the central sketch showing that the lines to the cam position, the central sketch showing that the lines coincide as the cam begins to lift the tappet, i.e., injection commencing.

When correctly set the plunger and lower window line, if there is more than one line (as found on some of the older pumps), must exactly coincide; if they do not the pump body must be removed from the cam box for tappet adjustment, then reassembled for check. Each plunger assembly must be dealt with separately, the remaining tappets being latched out of use by means of the priming levers. Under no circumstances must the cam shaft be rotated whilst a setting disc is in position. Setting disc thicknesses are: for LK engines 0.111 inches; for LW and L2 engines 0.140 inches.



Correct adjustment of the friction damping device on the Gardner injection timing advance and retard mechanism is important.

The Gardner injection timing advance is allowed for on the fly-wheel with a zero line on the crank case at the base of the cylinder block. No.1 tdc flywheel marking is preceded by a minimum and maximum advance line. In checking it will be noted that the point of the advance and the retard device must be moved to coincide with the appropriate minimum or maximum flywheel marking in use. The variable injection advance on Gardner engines is controlled by the accelerator, thus in checking minimum and maximum advance flywheel readings the position of the timing advance lever on the engine must be adjusted to coincide with the actual point of injection checked.

Variable injection timing devices although available, are not usually fitted, and in this respect, therefore, the Gardner differs from the majority. Injection is advanced as engine speed is increased and it is affected automatically in conjunction with the accelerator.

It must be appreciated that on oil-engined vehicles the accelerator is mainly a speed control while torque control is exercised by the governor either at maximum speed setting as in the case of high and low speed governors, or throughout the whole range as in the case of the Gardner governor. This is a very different state of affairs from the petrol engine and with the latter type it enables a direct linkage to be made to the accelerator so that injection is advanced or retarded as the pedal is depressed or released. This variation is effected by sliding a helical gear along splines on the pump camshaft. There is a slight reaction on the sliding mechanism from the cams and prevent this being transmitted to the accelerator connections and causing wear in the various pin joints, the advance lever is provided with a spring loaded cork-faced friction device. This must not be too tight otherwise the accelerator movement will be stiff. It should be adjusted just sufficiently to stop movement of the pointer extending from the boss of the lever when the engine is idling. Over-tightness can be checked by operating the accelerator preferably while the engine is running.

If it is tested while the engine is at rest all the pump priming levers should be pulled back to relieve the spring load on the cams. Should the timing device be disturbed or disconnected it is easily reset by bearing in mind that the maximum and minimum advance marks on the index plate under the lever pointer correspond to the out and in limits of travel of the accelerator lever on the governor.

Governors

In view of the available amount of published information, little difficulty need be anticipated in fully understanding the principle of the governor while the accompanying diagram clearly illustrates the layout and its relation to the control gear. The function of a governor as applied to a fuel pump is to govern or limit maximum and minimum speeds while at the same time allowing the regulation of speeds between these two points to be under the direct control of the accelerator pedal.

Given adequate lubrication, very considerable mileages are covered without the need for repairs but neglect or prolonged working life will necessitate adjustments and renewals. Minor attention is confined to spring renewal or adjustment, while major repairs may call for replacement of pivot and swivel pins, bell crank levers and the fixing sleeve.

Dismantling is necessary where major replacements are undertaken, while accurate check of governor functioning and adjustment calls for the use of bench test equipment. Under ordinary conditions however, it is unlikely that more than spring replacement will be needed and this is possible without complete dismantling, for, by removing the housing access plug and rotating the camshaft until the adjusting nuts are accessible, in situ removal of the governor springs is possible and although accurate check of maximum speed cut-off cannot be made without bench test facilities, a fairly close estimate of performance can be obtained by road test and the transposition of speedometer readings. Weak springs cutting off too early will to some degree curtail power output; a limited spring adjustment is provided, although its range represents only approximately 50rpm pump speed, therefore variation on the speedometer is fractional.

Excess wear on the inner spring lower plates at their point of contact with the abutment on the fixing sleeve on which they rest, interferes with the low speed governor sensitivity and where difficulty is experienced in obtaining steady slow running (and particularly if the engine peters out frequently) this is worth checking. In some cases replacement of spring plates affects a cure, although if the assembly has seen a good deal of use, wear is also likely to be present on the spacing discs of the fixing sleeve studs.

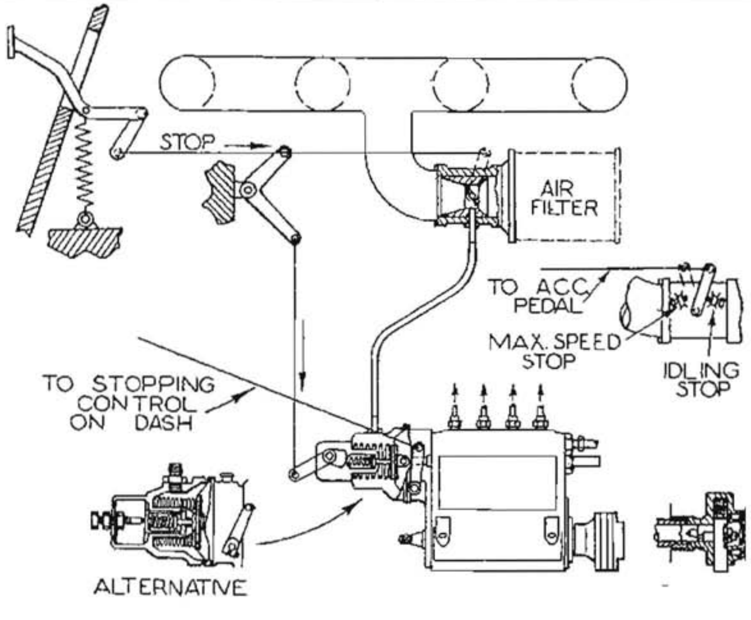
To test for reasonable slow speed sensitivity, with the engine idling the application of a very light load such as light clutch contact with gear engaged or engaging first gear against fluid flywheel on chassis with epicyclical transmission, is sufficient to produce a momentary slowing of the engine, followed immediately by a slight increase in engine speed due to the governor weights imparting movement to the control rod; this is an indication that the governor is functioning correctly.

The available spring adjustment is therefore, theoretically, only for high speed governor correction but it must not be overlooked that the slow speed spring setting is thereby slightly affected; the full adjustment of approximately 50rpm increase of pump speed will alter the slow speed governor operating at 180rpm speed to about 190rpm (i.e., from 360 engine rpm to 380rpm). Before adjusting the springs the special spanners required should be provided and the adjusting nuts should be moved half a turn at a time on each weight alternately. There is an automatic locking device operating only at the half turns. The nut should not be screwed out beyond the position where its face is flush with the stud end, nor in more than 4mm from this point.

The Gardner centrifugal governor differs somewhat from the CAV although the principle is similar, except that it is operative throughout the whole speed range. Movement of the control rod (or slider bar) towards the rear or flywheel end of the engine decreases the amount of injection while movement towards the front reduces the delivery until no fuel is injected when the limit is reached, this being the "stop" position. All movement of the control rod is effected through the governor by a lever coupled to the rod by an adjustable link; the control rod (slider bar) is normally held at the normal full delivery end of its travel by a tension spring and is closed by the governor. The accelerator, therefore does not directly regulate the delivery, but limits the extent to which the governor can close off the slider bar.

Pressure on the accelerator pedal moves a cam on a spindle above the governor housing and a roller link hinged to a lever is move thereby. The link makes contact with an abutment screw on the lever, causing the lower end of the lever to bear against the spring which resists the centrifugal out-throw of the governor weights. Meanwhile this action of the governor has caused a central push rod to travel outwardly to push the lever coupled to the slider bar, so that the latter is moved towards the closed position.

It will be seen therefore, that pressing the accelerator does not increase the fuel delivery, for the slider bar is normally pulled by its spring into the open position. But the increased loading of the governor spring by the accelerator pedal movement necessitates a higher speed to effect the centrifugal withdrawing action, thus with accelerator released i.e., "closed throttle" position) the governor acts immediately and cuts the fuel delivery to the requirements of the minimum rpm. When the accelerator is depressed ("throttle open") the governor spring is loaded to the maximum degree permitted by the fixed stops on the end of the cam lever, and the centrifugal force of the weights does not overcome the spring pressure until the maximum rpm are exceeded, when the slide bar commences to close off.



Layout of the CAV pneumatic governor system. Enlarged detail on the right shows the control rod stop adjustment and excess fuel starting device. On the left is the alternative fixed setting of the supplementary idling spring

Whatever the loading on the engine, the pump delivery will be at maximum if by reason of the accelerator position the governor spring pressure cannot be overcome by the centrifugal force of the weights, i.e., if the engine load is sufficient to hold down rpm below the figure corresponding to the accelerator pedal position.

Associated with the governor and control mechanisms are various adjustable stops. On the accelerator cam lever is a slow-running screw with a knurled nut for setting the idling speed, and on the opposite side is a stop screw (sealed) to determine the maximum power and delivery when the accelerator is fully depressed. Contact between the roller ended cam link and the lever carrying it is made through an adjustable screw and this also is sealed by the makers in relation to the maximum delivery stop on the accelerator lever during final engine power test. These two adjustments must not be interfered with. The considerable clearance at this point when the engine is at rest allows for ample adjustment of the slow running stop to secure steady idling without float of slider bar.

Another governor differing entirely from both the foregoing is the CAV pneumatic type which is used on small high speed engines for which it has specially suitable characteristics. The principle employed is quite different from that of the centrifugal governors, the operating power being derived from the varying depression in the induction manifold resulting from the passage of air through a restricted zone of venturiform in conjunction with a throttle valve.

The venture unit is mounted on the air intake pipe between the air cleaner and the inlet; it is connected by a pipe to the diaphragm unit on the pump and directly actuates the control rod which is normally held in the full-load position by springs. The narrow throat of the venture is the butterfly throttle, the connecting pipe also being taken from this point. The throttle is controlled by the accelerator pedal and two adjustable stop screws are provided to limit its idling and maximum speed positions.

The diaphragm unit is mounted on the end of the pump and it contains a sealed chamber closed at one end by a leather diaphragm. A light spring acts on the metal centre of the diaphragm pressing on the control rod and tending to move it to a full open position. Also pressing on the diaphragm is a smaller spring inside the other to provide additional control on four cylinder engines or other types in which the intake air is subject to wide pulsations; this spring has an external adjusting screw or a cam adjustment automatically actuated by the accelerator. The single spring however, is used for six cylinder engines with an idling speed of 350 to 400rpm. A stopping lever is mounted on the diaphragm casing and this is separately controlled by cable; it pulls the control rod to the "no fuel" position and so stops the engine. It is very necessary to keep this in good order and proper adjustment, as an air leak or disconnection between the venture and the governor results in maximum fuel delivery, therefore the stopping device must be always available to prevent engine racing in such circumstances. It is to be regarded as important and vital as the ignition switch on a petrol engine in the event of throttle stuck in the wide open position.

There is very little to do in maintaining the vacuum governor. The venture and the throttle are designed to suite the type of engine to which the equipment is fitted and the small range of adjustment on the control throttle stops for idling and maximum speeds is within the range of the possible requirements of the operator; their adjustment is obvious, bearing in mind however, that the maximum speed is determined by engine design and that the stop therefore is in effect, a means of reducing maximum, not of increasing it. If it is sealed, it can be assumed that the makers have determined the best position in relation to the characteristics of the engine.

Adjustment for increase or decrease of maximum fuel supply is effected at the combined control rod stop and excess fuel device on the opposite end of the pump to the governor. When the cover of this is removed, a lock nut and set screw are exposed. The lock nut is released by a special spanner when the screw can be screwed in to increase and out to reduce the fuel supply. A small amount of adjustment will have considerable effect so the process must be done cautiously, aiming at a colourless exhaust and low consumption, but not decreasing the fuel to the extent of unduly reducing the power required. After the best setting is obtained the set screw must be locked and the cover replaced. The excess fuel plunger projecting through the underside of the control rod stop housing is pressed up for starting. It allows the control rod to move slightly beyond the full-load position and so gives extra fuel injection; it automatically springs back to running position as soon as the engine starts.

The unions on the suction pipe from the venture to the governor must be kept tight and any air leak will be instantly noticed because of a tendency of the engine to race. Should there be racing when the pipe is above suspicion it is possible that the diaphragm is faulty and this can be checked by removing the vacuum pipe, pulling the stop lever to the stopped position and covering the union hole on the governor with the finger. If the diaphragm is punctured the control rod will move quickly to the full power position when the stop lever is released, but if it is in order it will make only a short initial movement quickly and then complete the rest of its traverse quite slowly. It is assumed that the governor housing joint is in good order.

An oil cap is located on the governor case and a tablespoonful of lubricating oil should be poured in occasionally in order to keep the diaphragm leather pliable. To relieve the maximum speed stop on the venture, an accelerator pedal stop is advisable and where one is fitted it should be adjusted correctly in relation to that on the venture.

HOW'S IT DONE?

On numerous occasions, I'm asked how is it possible to marry up a gearbox to the old Gardner 4LK and still achieve acceptable top speed suitable for the vehicle and also modern every day traffic conditions. It's comparatively simple really but you do require good basic engineering skills, access to a large lathe, plenty of time and lots of patience. Most importantly a suitable gearbox together with all the bits is essential.

One needs to spend some time selecting a suitable gearbox which must be man enough to transmit the power of the engine and have five or six forward gears which includes a high ratio overdrive. Ideally (as in my case) a comparatively new smashed up "right off" donor vehicle is the answer, because it will be comparatively clean and should be in excellent working order. It's essential to obtain not only the gearbox but all its fittings. This means universal joints and couplings, prop shaft, mounting brackets with suspension rubbers, all bell housing bolts, clutch complete and the engine flywheel. That's most important to simplify the matting up procedure. Don't forget the speedo drive and cable, you'll need that too! Though it may be necessary to change the little worm gear drive to suit back axle ratio and tyre size. This way you'll have virtually everything that's required which can be located at a breakers yard. It may also be possible to 'help yourself' then pay. This is by far the best and cheapest way if you don't want to handle a complete donor vehicle.

It's probably far easier to remove your own Gardner engine complete from chassis to enable free and quick access for the marriage procedure. A little measuring up and working out is necessary to transfer centre line accurately from crankshaft through the clutch to the gearbox. An adapter plate is obviously required and can be made using say 4mm thick mild steel which can be easily welded to modify further to form a bell housing depending on the particular set up required. This plate must be machined in a lathe and the centre line will be picked up at from the peripheral machined register of the original bell housing.

The donor flywheel which we know to be exactly right to suit the clutch needs to have the starter ring removed and be reduced in diameter as much as possible so as to loose excess weight. A register ring must be machined on one face to match the Gardner flywheel to ensure it runs perfectly true. After drilling the bolt holes, the two flywheels may be bolted together using longer high tensile bolts to suit. The clutch unit complete is now bolted to the modified Gardner flywheel taking care to centralise the friction disc with some form of mandrel, all should (in fact MUST) run perfectly true on centre.

Assuming the Gardner engine is fitted with a bell housing enclosing the flywheel, the adapter plate must be lined up for the bolt holes to be transferred through by using a blank stud machined in a lathe to have a centre point like a centre punch. With care, each hole in turn can be drilled (note some holes may be tapped with the thread).

Now it is most probable the bolt holes of the gearbox will be of smaller pitch circle diameter, so, follow the same procedure by picking up on the machined registers and drilling through the plate. Again, care must be exercised to insure the gearbox is correctly lined up with the engine in order that the gear lever comes out at top.

It's obviously far easier if the engine has been removed from the chassis for the purpose of fitting the gearbox because the stage is now reached whereby it is necessary to determine the depth for the engagement of the gearbox splined shaft to engage with the clutch drive plate and the supporting bearing. A little bit of measuring up will determine whether the adapter plate requires further modification to become fabricated bell housing and if so, more lathe work will be required to maintain the exact centre line register for mounting the gearbox. Machining the face of the donor flywheel to reduce its thickness may help obtain suitable tolerances for the internal fitting, (the running fit of gearbox shaft with clutch unit). If it proved necessary to modify the adapter plate to become a bell housing, then the drilling of the gearbox mounting bolt holes should be done at this latter stage.

With this work completed, the gearbox can be bolted in position and manually tested by hand winding the crankshaft to ensure correct functioning of clutch mechanism and free rotation. If this proves satisfactory then the task of marrying the engine to gearbox will have been completed. However the modified engine and gearbox unit now has to be reinstalled in the chassis, making any essential alterations as required. These may be mountings, clutch operating mechanism, prop shaft length, gear lever positioning and perhaps finally, modification to speedo drive ratio.

You'll now realise why it's of great benefit to have all the parts from one donor vehicle, preferably a common one where various bits are easily recognised. That's how I did it and my only help was with the welding of the new bell housing.

Peter Freakley

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