

P

Fuel & Carburetion

FACTORY

V Hubs

SERVICE INSTRUCTION LEAFLET

ISSUED BY
BENTLEY MOTORS (1931) LTD.



BM/V1.

SB/GS.1/IP.

Subject : HUBS, REMOVAL, FRONT AND REAR.
3½ AND 4¼ LITRE.

Date of Issue 14th Jan, 1946.

I. General Description.

The front hubs are carried on ball or roller bearings on the stub axles, the side thrust being taken by the outer ball bearing, which controls the location of the hub. The inner or larger bearing is a roller race and carries journal load only.

The rear axle is of the fully floating type, the hubs being mounted on extensions of the axle tubes, thus driving torque is the only load taken by the axle shafts. Torque is transmitted from the axle shafts to the hubs by means of detachable dogs. Axial load is taken by the inner ball bearing.

IMPORTANT

THE CONTENTS
OF THIS
DOCUMENT ARE
STRICTLY
CONFIDENTIAL
AND ARE NOT
TO BE
TRANSMITTED
TO ANY
UNAUTHORIZED
PERSON.

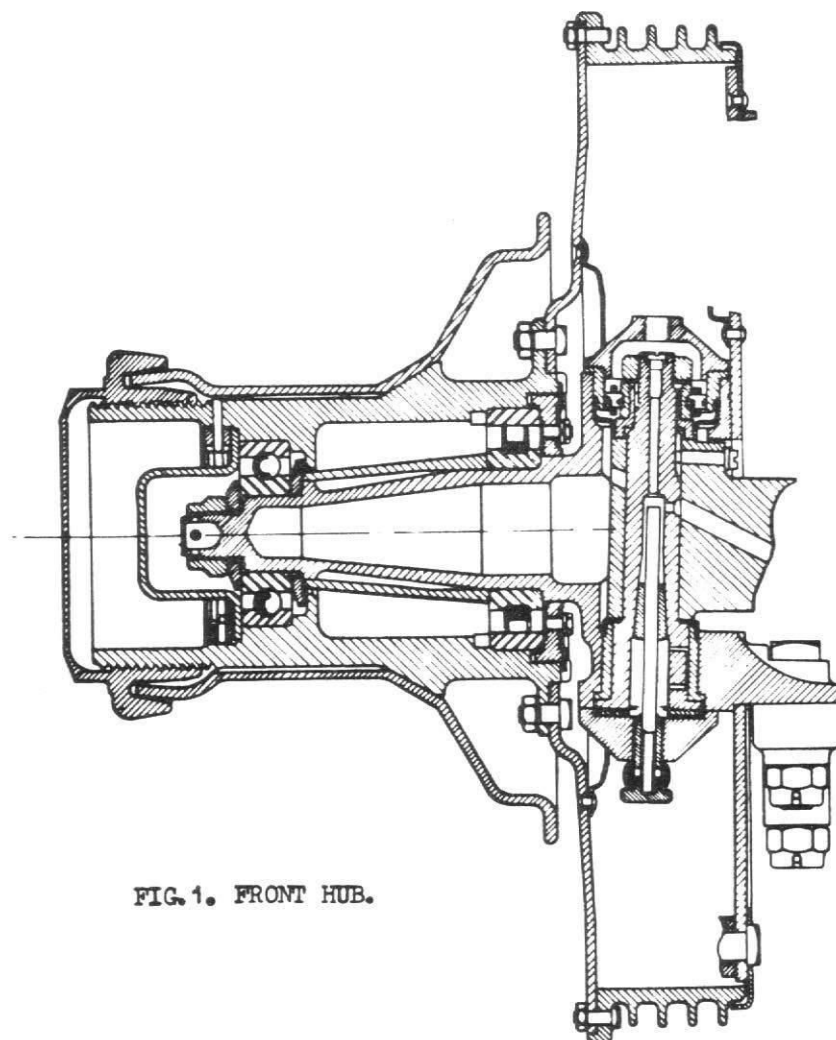


FIG. 1. FRONT HUB.

ALL COMMUNICATIONS SHOULD BE ADDRESSED TO

BENTLEY MOTORS (1931) LTD., SERVICE STATION, HYTHE ROAD, WILLESDEN, LONDON, N.W.10

continued:

For the purpose of making clear the general construction of the hubs, sectional views of the front and rear hubs are shown in Figs. 1 and 2.

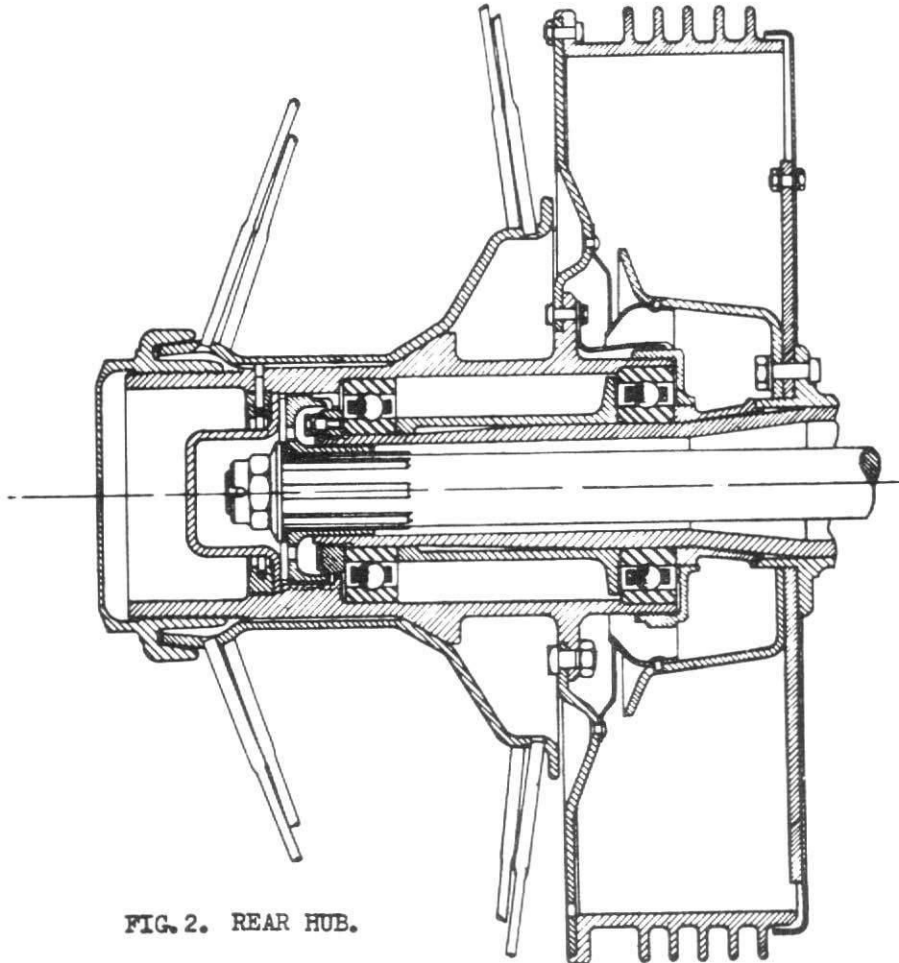


FIG. 2. REAR HUB.

With the exception of the nut securing the rear wheel driving dogs, all the various hub retaining nuts are provided with right and left hand threads according to the direction of rotation. To avoid damage, it is important to note the correct handing of the thread, also it is most important to ensure that the hubs are not transposed after removal.

II. Special Tools.

Special tools are necessary to unscrew or extract the various hub retaining parts. A chart of the hub removal tools is shown in Fig. 3, and it is recommended that one or more sets of tools be made available in each Service Station.

continued:

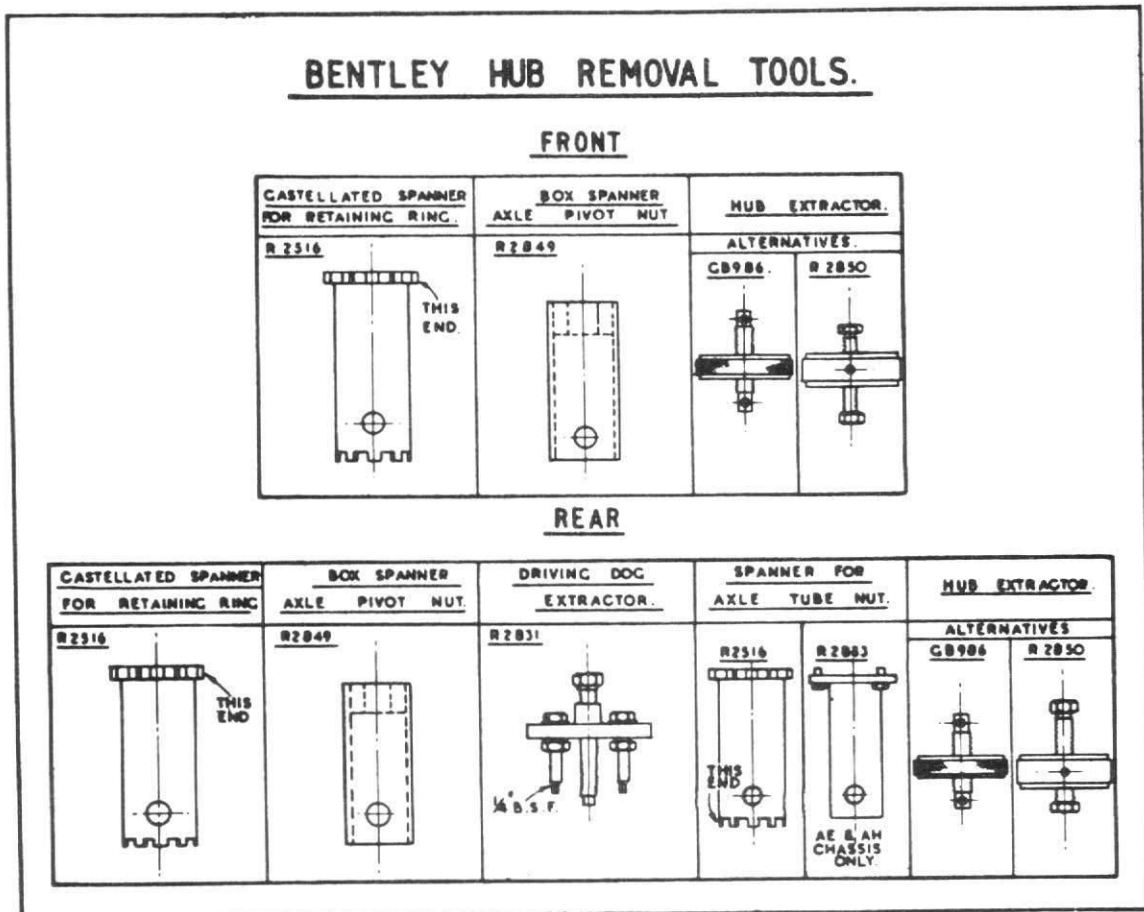


FIG. 3.

III. Method of Hub Removal.**(A) Front Hubs.**

Refer to Fig. 4.

- ★ 1. By means of a screwdriver remove the wire locking ring (G) from inside the grease cap retaining nut (H) and unscrew the nut with the special spanner. Remove the grease cap (J). Note:- The nut is left hand thread on the off side and right hand on the near side.
 2. Remove the split pin and unscrew the stub axle nut (K). Note:- Left hand thread on the near side and right hand on the off side.
 3. Withdraw the hub with the special extractor.
- ★ On the MR and MX series of the $4\frac{1}{4}$ Litre models the grease retaining cap screws into the hub. It has no locking piece and can be removed with a box spanner on its hexagon head. Note:- The thread is left hand on the off side and right hand on the near side.

- 4 -

continued:

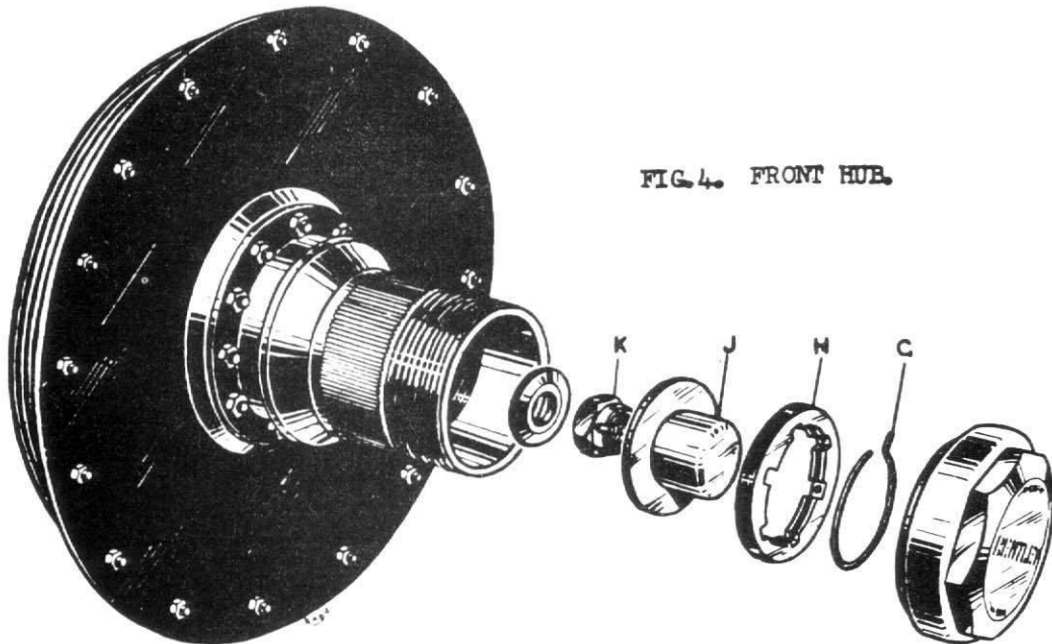


FIG. 4. FRONT HUB.

(A) Rear Hubs.

Refer. to Fig. 5.

- ★ 1. By means of a screwdriver remove the wire locking ring (L) from inside the grease cap retaining nut (M) and unscrew the nut with the special spanner. Remove the grease cap (N). Note:- The thread is right hand on both off side and near side.
 2. Remove the split pin and unscrew the axle shaft nut (O). In addition to the plain washer (P) there may be a packing washer (P₁) fitted behind the nut and special note must be made of this in order that it is not forgotten when reassembling. Note:- The nut is right hand thread on both off side and near side.
 3. Withdraw the driving dog (Q) with the special extractor.
 4. Remove the three ZBA nuts and spring washers that hold the locking plate (R) to the axle tube nut (S) and remove the locking plate. Note:- On the MR and MX series of the 4 $\frac{1}{4}$ Litre models the locking plate is secured by three ZBA setscrews in place of the nuts.
 5. Unscrew the axle tube nut with the special spanner. Note:- The thread is left hand on the near side and right hand on the off side.
 6. Withdraw the hub with the special extractor.
- ★ On the MR and MX series of the 4 $\frac{1}{4}$ Litre models the grease retaining cap screws into the hub. It has no locking piece and may be unscrewed with a box spanner on its hexagon head. Note:- The thread is right hand on both sides.

- 5 -

continued:

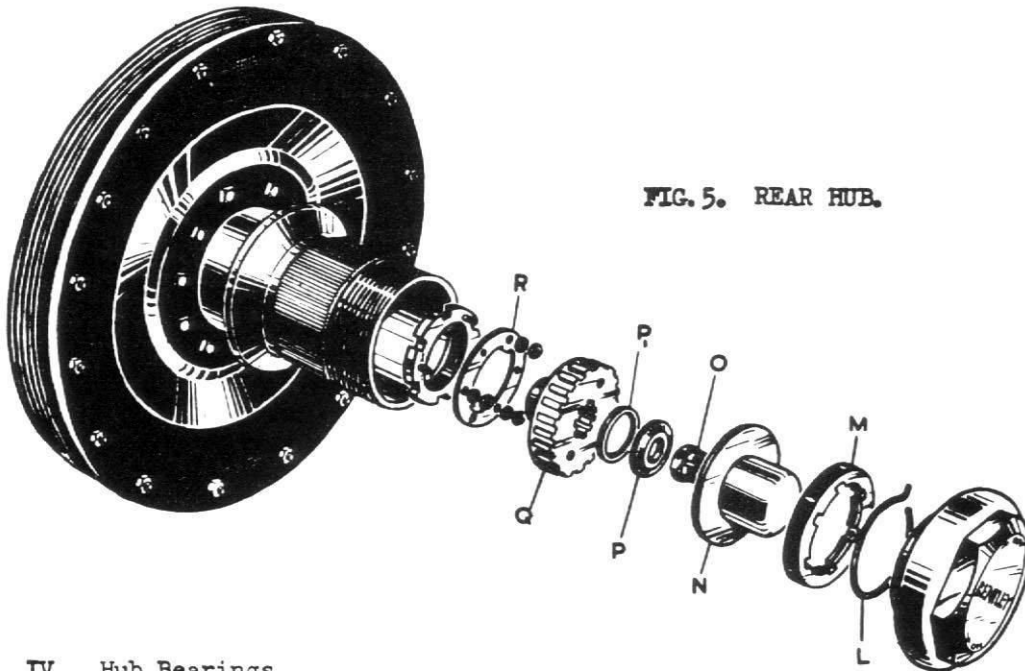


FIG. 5. REAR HUB.

IV. Hub Bearings.

(A) Removal of Bearings.

If necessary the hub bearings may be removed from the hub shells in the following manner:-

Front Hubs.

Pass a hardwood drift through the inner bearing and knock out the outer race. Remove the locking plate and unscrew the retaining nut* of the inner race, which can now be knocked out.

Rear Hubs.

Remove the locking plate and unscrew the retaining nut* of the inner race, which can then be knocked out. Remove the distance piece between the bearings and knock out the outer race.

* Note:- The retaining nut thread is left hand on both front and rear hubs.

- (B) Ball bearings may require replacement or inspection due to noise or wear. The only method of inspection, apart from obvious damage, is to test for side play and noise. In regard to side play, it must be borne in mind that as the ball bearings have to take considerable side thrust, special Hoffman bearings are used, having greater diametric clearance for the balls than is normal in order that the resolved line of force is brought round to a more favourable angle. For this reason, bearings should not be condemned merely because the side play appears to be excessive, judge for noise as well, and if O.K. pass the bearings unless the side play denotes obvious wear.

continued:

In testing for noise, wash the bearing out in paraffin to remove old grease and foreign matter, and oil with good quality engine oil. Then spin the bearing by hand, when it should be possible to feel any roughness caused by worn or damaged balls and tracks. Replace the bearing if lumpy or excessively rough.

(C) Greasing the Bearings.

The recommended grease is Duckham's Adcol HBB. Ball Bearing Grease. In addition to packing the bearings, the hubs should be packed inside between the bearings to a thickness of approximately $\frac{1}{8}$ ". This quantity should not be exceeded otherwise the surplus will leak out. In order to minimise leakage of grease into the brake drums, it is advisable to face the inner bearing with a layer of high melting point grease before replacing the retaining nut.

ALL COMMUNICATIONS SHOULD BE ADDRESSED TO

BENTLEY MOTORS (1931) LTD., SERVICE STATION, HYTHE ROAD, WILLESDEN, LONDON, N.W.10

Sr. - F.B.A. Ltd.	Mr. Reid. - Glasgow.
NRC. - Allied Motors, Ltd.	Instruction School.
Ry. - Madrid.	✓ Br. - N.
Mr. de Boeck. - Nice.	D.O. - Mr. Walker.
Bentley Repair Depot. - London.	Hs.
Sg.	Mr. Hancock.
C.	D/BP.
H.	EWT.
Tr.	Mk.
Bn.	BY.
Ck.	EP.
Mr. Evans. - Lillie Hall.	Mr. Robinson. - Germany.
Mr. Crawford. - Lillie Hall.	Repair Department.

24th January 1935.

Depot Sheet No: Hd.274.

S.U. PETROL PUMP.

BENTLEY CHASSIS.

Origin of information:-
Hs/Bwg.6/KW.15.1.35.

It is possible that only one unit of the S.U. petrol pump may be working, due to shrinkage of the diaphragm after a certain amount of use, which causes the pump to operate sluggishly, prolonging the make and break of the contacts and so setting up oxidisation of the points.

It is important that whenever a car is at a Depot for other work, the pump units should be checked to ascertain whether they are both functioning, and in the event of one unit appearing to be sluggish or out of action, the whole unit should be changed.

Hd.

PRIVATE AND CONFIDENTIAL
FOR THE USE OF OFFICIALS ONLY.

Er.	FBA. Ltd.	Bentley Repair Depot, London.
MRC.	- Allied Motors.	Mr. Reid, Glasgow.
Ev.	- Madrid.	Instruction School.
Mr. de Boeck.	- Nice.	D.O., Mr. Walker.
Es.		Es.
C.		Mr. Hancock.
H.		D/BP.
Tr.		BWT.
Cx.		Mx.
Mr. Evans.	- Lillie Hall.	BY.
Mr. Crawford.	- Lillie Hall.	EP.
Br.	- N.	Mr. Robinson - Holland.
Bentley Repair Depot,	Glasgow.	Repair Department.

PRIVATE AND CONFIDENTIAL
FOR THE USE OF OFFICIALS ONLY.

15th July 1935.

DEPOT SHEET NO. Hd.286.

Carburetter Filter.
Bentley Chassis.

Origin of Information:-
Hs/Bwgl1/KW.7.6.35.

In order to minimise the likelihood of carburetter flooding troubles due to foreign matter becoming lodged between the needle and seating, it has been decided to fit a filter to the float chambers on all Bentley cars in service.

The filter to be fitted is the standard No. 139 S.U. Filter and it is fitted as shown in the attached sketch, the only operation necessary being to unscrew the union from each float chamber lead and fit the filter in the manner shown.

When fitted, the letter "O" should be stamped on the petrol inlet boss.

All chassis modified should be reported to W. in the usual way.

- 2 -

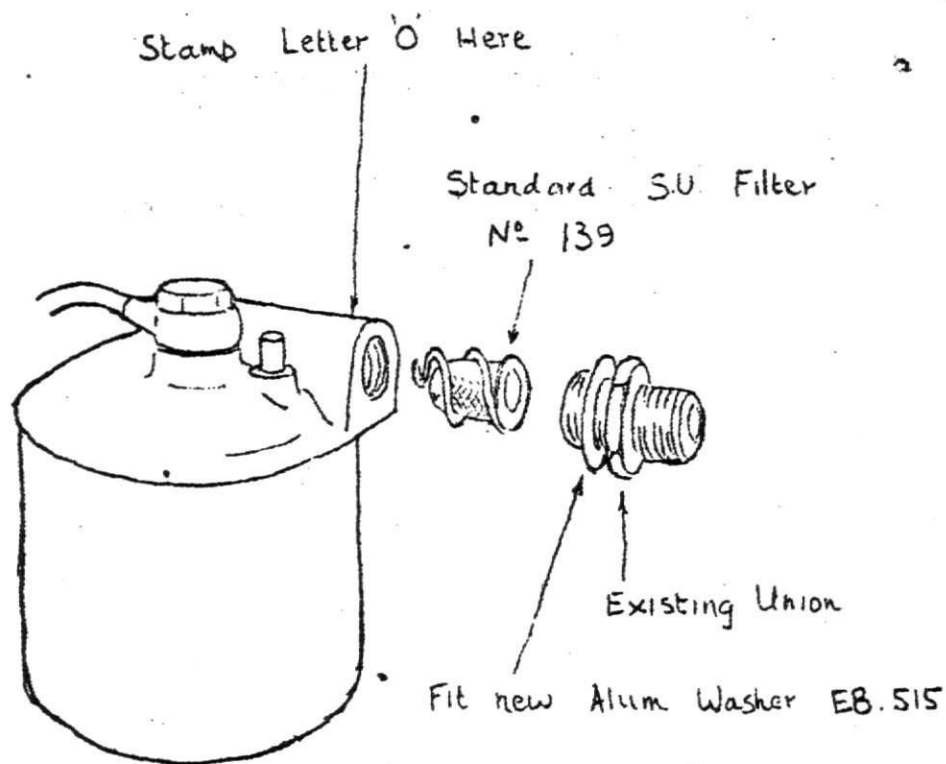
Depot Sheet Hd. 2861

Continued:-

Supplies of filters will be forwarded to Depots as soon as available.

Every convenient opportunity should be taken to fit these filters to cars in service.

Hd.



SKETCH SHOWING FITTING OF
FILTER TO FLOAT CHAMBER. BENTLEY

Sg.
C.
Sr. - FBA. Ltd.
Mln. - Bombay.
Rv. - Madrid.
Mr. de Boeck - Nice.
H.
Tr.
Cx.
Mr. Evans. - Lillie Hall.
Mr. Crawford. - Lillie Hall.
- Br. - N.
PH. - c/o Clyde Auto. Co.Ltd.
Bentley Repair Depot, London.
Mr. Reid. - Glasgow.
Instruction School.
D.O. - Mr. Walker.

Hs.
Mr. Hancock.
D/BP.
EWT.
Mx.
BY.
E.
EP.
Sit.
Mr. Robinson - Holland.
Repair Department.
Kellow Falkiner Pty. Ltd.
Dalgety & Co.
Perrot Duval & Cie, Geneva.
Baumberger & Forster, Zurich.
R. P. Collyer, Ltd., Canada.

PRIVATE AND CONFIDENTIAL
FOR THE USE OF OFFICIALS ONLY.

22nd June 1936.

DEPOT SHEET NO. Hd.303.

ENOTS PETROL FILTER BOWLS.
20/25 HP., Ph.II and Bentley
Chassis.

Origin of information:-
BY/HML/J.10.6.36.

One or two instances have occurred where corrosion of the aluminium bowl on the Enots petrol filter has occurred. This corrosion has been due to the action of tetra-ethyl lead which is present in Ethyl fuels now available. The process is accelerated if any moisture is present in the fuel.

In order to prevent this corrosion the aluminium bowls are now being anodically treated, which produces a hard oxidised film which is impervious to the effects of T.E.L. and water.

When any cars come into Depots the aluminium bowl should be inspected for signs of corrosion due to T.E.L., and in cases where corrosion is evident the bowl should be replaced by one of the latest anodically treated bowls.

-continued-

Continued:-

A small supply of these bowls is being prepared and will be forwarded to Depots in due course.

Hd.

Sg.
C.
Sr. - FBA. Ltd.
Mln. - Bombay.
Rv. - Madrid.
Mr. de Boeck. - Nice.
H.
Tr.
Cx.
Mr. Evans. - Lillie Hall.
Mr. Crawford. - Lillie Hall.
Br. - N.
PH. C/o Clyde Auto. Co. Ltd.
Bentley Repair Depot, London.
Mr. Reid, Glasgow.
Instruction School.
D.O. - Mr. Walker.

Hs.
Mr. Hancock.
D/BP.
BWT.
Mx.
BY.
E.
EP.
Sft.
Mr. Robinson. - Holland.
Repair Department.
Kellow Falkiner Pty. Ltd.
Dalgety & Co.
Perrot Duval & Cie, Geneva.
Baumberger & Forster, Zurich.
R. P. Collyer, Ltd., Canada.

10th July 1936.

PRIVATE AND CONFIDENTIAL
FOR THE USE OF OFFICIALS ONLY.

DEPOT SHEET NO. Hd.306.

USE OF ETHYL PETROL.

Origin of information:-
Hs/Rml5/KW.3.7.36.

Since its inception the Bentley has been designed to run on Ethyl petrol. This year the other Rolls-Royce models have been brought into line with the Bentley, and now the 25/30 HP. and the Phantom III can be run on leaded fuels without harmful effects to the engine.

The compression ratio of the Phantom III and the 25/30 HP. is such that they will give satisfactory results on almost any touring car spirit available. The main advantage to be gained from the use of Ethyl in these cars, therefore, is a prolongation of the period required between one de-carbonisation and another. In every case where an Owner complains of pinking he can be recommended to run on Ethyl.

-continued-

Continued:-

As we have already pointed out in Depot Sheet No. Hd.294, the Bentley - being a high performance chassis - is essentially designed to run on the best anti-knock fuel widely distributed, and this is Ethyl petrol.

Hd.

9

6th November 1936.

DEPOT SHEET NO. Hd. 316.

S.U. PETROL PUMPS.
4 $\frac{1}{2}$ Litre Bentley.

Origin of information.
Sg7/E.3.11.36.

It has been decided to fit new diaphragms to the S.U. Petrol Pumps on all 4 $\frac{1}{2}$ litre Bentley cars in service.

The new diaphragm is known as the G-3 type, and all pumps so modified will be stamped G5 on the front of the base. A few pumps have already been stamped G45 after this modification. The G5 mark will over-ride all other stamps on the pumps already existing.

This type of pump will also be used to replace any defective pumps on 3 $\frac{1}{2}$ litre cars in service.

A further modification to be carried out when changing any pump is to fit a new form of fixing to avoid difficulty at present experienced by Owners when having to change a pump.

The pump will in future be fitted with an aluminium base plate so arranged that the complete assembly can easily be detached from the dashboard after unscrewing two nuts and disconnecting the pipes.

The sketch attached on Depot Sheet No. Hd 316. 3 $\frac{1}{2}$ Litre Bentley. makes this clear.

The aluminium plate is secured to the pump by two countersunk screws and nuts. The assembly is then secured to the dashboard by two studs. The existing forward hole A in the dashboard should be tapped out 1/4" x 26 T.P.I. to take the special stud shown. An additional hole in the dashboard at B must now be drilled .201" diameter and also tapped 1/4" x 26 T.P.I. for the 1/4" stud.

Cont'd.

9
13th November 1936.

AMENDMENT TO
DEPOT SHEET NO. Hd. 316.

S.U. PETROL PUMPS.
 $4\frac{1}{2}$ Litre Bentley.

Further to the above Depot Sheet, it should have been made clear that the complete petrol pump must be changed on all $4\frac{1}{2}$ litre cars in service and on any $3\frac{1}{2}$ litre cars where trouble with the pumps is experienced.

Will Depots also please note that the modified fixing of the petrol pump should be applied on all $3\frac{1}{2}$ litre and $4\frac{1}{2}$ litre cars, as and when they are available at Depots. This will facilitate changing the pump should the Owner ever have occasion subsequently to fit a new one.

Hd.

To secure the pump it is only necessary to slide the base plate under the two petrol pipes running along the dashboard, and drop the forward boss of the pump over the front stud, when the nuts can be fitted and tightened.

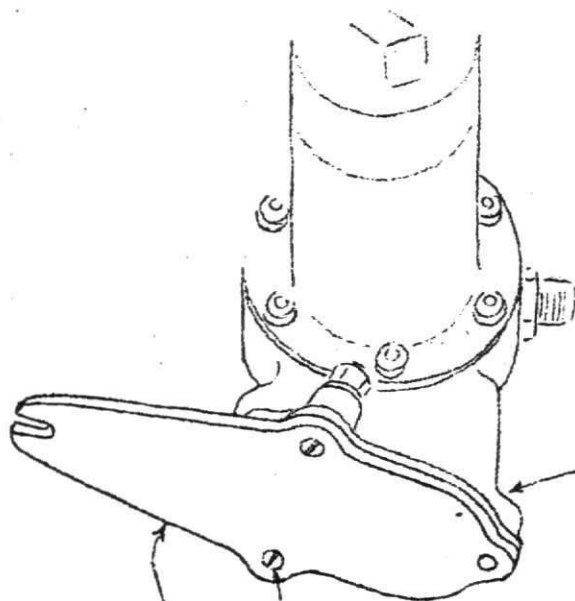
The existing pipe clips behind the pump are dispensed with.

The foregoing scheme applies to all cars up to B.1-GP, after which the reserve tap and double pipes do not exist. The fixing is therefore modified inasmuch as the base plate is not slotted since it can be lifted straight off the studs.

The new fixing must be applied on all cars whenever the pump has to be changed.

All cars modified must be reported to us as usual for record purposes.

Hd.

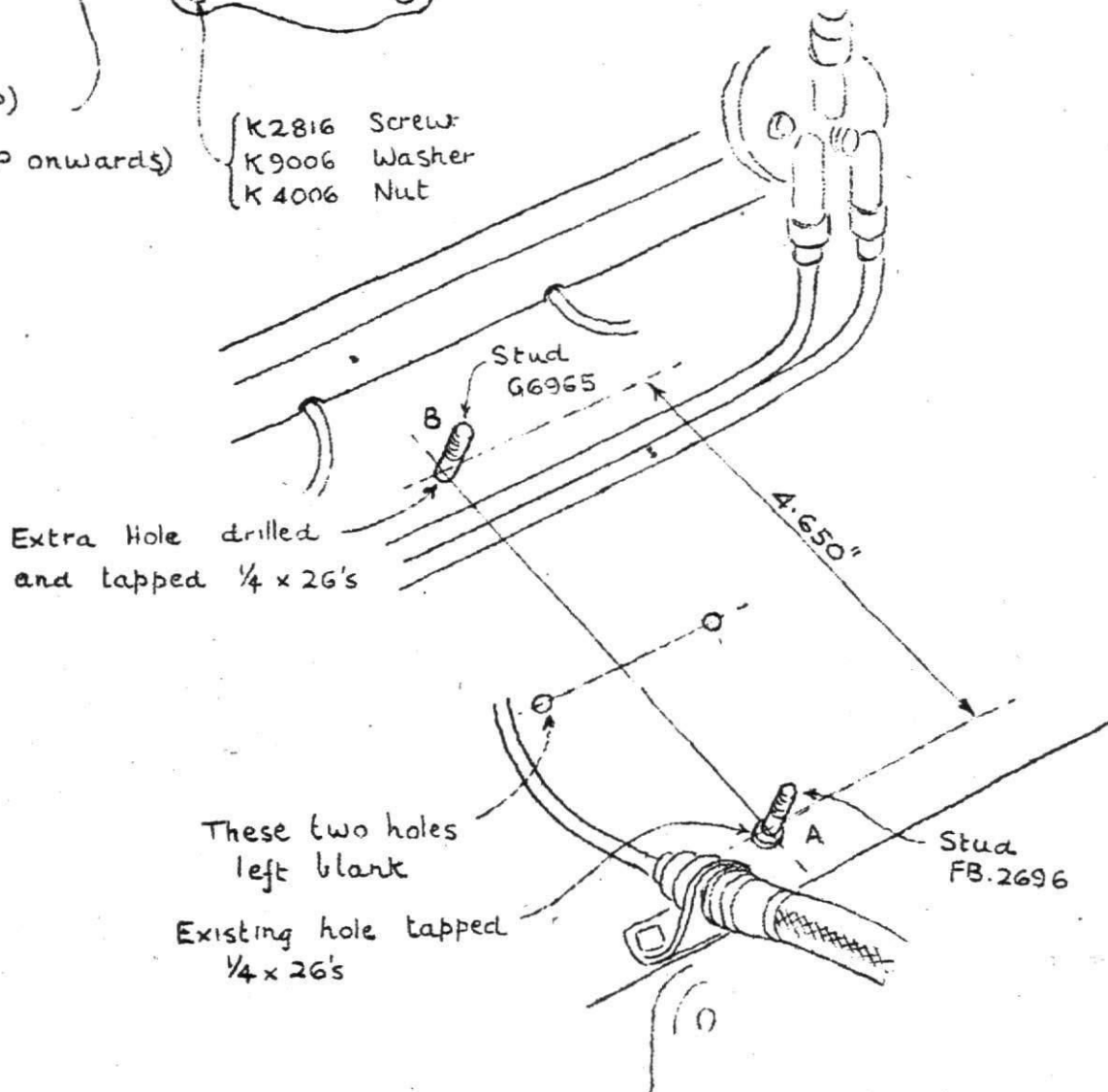


File boss to give clearance for nut

Plate DB1313
(Prior to B.I-GP)

DB.1314 (B.I-GP onwards)

{ K2816 Screw
K9006 Washer
K4006 Nut



Extra Hole drilled
and tapped $\frac{1}{4} \times 26$'s

These two holes
left blank

Existing hole tapped
 $\frac{1}{4} \times 26$'s

SKETCH OF MODIFIED FIXING FOR
BENTLEY PETROL PUMP.

Sg.
O.
Sr. - FBA. LTD.
Mln. - Bombay.
Fv. - Madrid.
Mr. de Boeck. - Nice.
H.
Tr.
Cz.
Mr. Evans. - Lillie Hall.
Mr. Crawford. - Lillie Hall.
Br. - N.
Ph. C/o Clyde Auto Co. Ltd.
Bentley Repair Depot, London.

Mr. Reid. - Glasgow.
Instruction School.
Hs.
BY.
E.
Rm.
RHC.
Mx.
Mr. Hancock.
BY/NW.
D/BP.
Mr. Robinson. - Holland.
Repair Department.

29th May 1937.

DEPOT SHEET NO. Hd.346.

ACCELERATOR PEDAL.
Bentley Chassis.

Hd/SB3/HR.29.5.37.

A case has occurred where the accelerator pedal has stuck down, and as this may cause damage to the engine due to over-revving it has been decided to inspect the accelerator pedals on all Bentley chassis.

The bronze bearing in the dash bracket can be removed with the shaft after unscrewing the nut which secures the pedal to the shaft.

The present nominal clearance between shaft and bearing is .002". This is to be increased to .005". The shaft is nominally .623" diameter and the bearing .625" diameter. The bearing should be opened to .628" diameter by means of a 5/8" expanding reamer.

It is also important to see that the end clearance of the shaft when the pedal is tightened up on the taper is at least .025" with a plus limit of .015".

-continued-

Continued:-

When re-assembling the shaft care should be taken to see that the oil hole is at the bottom, otherwise the lubricator will not be of much value. Also the annulus in the bearing should be filled with oil.

The letter C. should be stamped on the dash board adjacent to the lower stud of the steering column bracket, to denote that this modification has been carried out.

Hd.

Sg.	Instruction School.
C.	Bentley Repair Depot - London.
Sr. - FBA. Ltd.	Hs.
Min. - Bombay.	BY.
Mr. Birkett - New Delhi.	Rm.
Ry.	RHC.
Mr. de Boeck. - Nice.	Mr.
H.	LA.
T.	Mr. Hancock.
C.	BY/NW.
Mr. Evans - Lillie Hall.	D/BP.
Mr. Crawford. - Lillie Hall.	Mr. Robinson - Holland.
Br. - N.	Repair Department.
PH. C/c Clyde Auto Co. Ltd.	
Mr. Reid. - Glasgow.	

PRIVATE AND CONFIDENTIAL
FOR THE USE OF OFFICIALS ONLY.

2nd May 1938.

DEPOT SHEET NO. Hd.383.

STICKING THROTTLE.
4½ Litre Bentley.

Origin of information:-
Rm/GR.23/JH.22.4.38.

When dealing with complaints of sticking throttles on 4½ litre cars, the following modification should be carried out.

This consists of anchoring the pull-off spring so that it opposes the induction pipe depression, thus reducing the frictional load on the spindles instead of adding to it as at present.

This will mean fitting a new front throttle spindle EB.3641a having the spring fixing pin below the spindle instead of above, and fitting a new spring anchorage bracket EB.3640a beneath the rear boss on the carburettor body which secures the air valve cylinder.

This boss will require filling underneath to a thickness of .225 so as to provide a location for the bracket. A longer bolt E.23778 and split washer K.9006 will then be required.

-continued-

Continued:-

The following parts will be required to complete:-

- | | | |
|---|-----------|--|
| 1 | EB, 3429. | Throttle spring. |
| 1 | E. 51877. | Link (making one at each end of the spring). |
| 1 | E. 50658. | Collar. |

The existing spring anchorage bracket on the induction pipe should be removed, but the nuts and washers can be re-fitted to the studs for the sake of appearance.

Hd.

Derby Bentley Society – technical paper compilation

P

Fuel & Carburetion

RREC, RROC & Misc Articles

Unleaded Petrol

WHEN this vexed subject first became a bone of real contention some six years ago, we asked Ken Lea, then a technical director of Rolls-Royce Motor Cars, Crewe, for definitive company guidance. This was published as an article (see page 22 of this manual) in Bulletin 154, January/February 1986. It was comprehensive and indicated that in most Rolls-Royce and Bentley cars all that was required was minor adjustment to ignition settings - offered free by the Rolls-Royce dealer network. You then filled up with unleaded and drove happily away with a bevy of humming birds chirping their gratitude.

However, a maelstrom of technical turmoil followed. Experts galore made learned pronouncements boding dreadful damage to our engines if we used this dreaded potion - so we turned back to leaded.

Ken Lea kindly responded to a request for an update to clear the air.

Just so you know something about him, a brief CV precedes his article.

Ken is a Chartered Engineer, who is a Fellow of the Institution of Mechanical Engineers, among his engineering qualifications. He has spent much of his working life concerned with many aspects and developments of internal combustion engines. He has to his credit a record of making a major contribution to the design and development of many commercial and automotive engines. He has held senior posts and directorships in both power train engineering and manufacturing in the motor industry.

During his period starting in the mid-1980s at Rolls-Royce Motor Cars Ltd., he was responsible for a major revision to the venerable V8 designed by Jack Philips in order to fit it for the future. This led to a radical reappraisal, culminating in the release of the rationalised injected version introduced in 1986/87. He is particularly to be associated with the later turbocharged development of the Turbo R engine and power train, which is now so highly regarded.

He has more recently entered general management but still retains strong links with his engineering background. He is a keen owner of the Company's products and therefore speaks with first-hand knowledge of the older cars. Currently in the stable are B99CW, a 3 1/2 Bentley; a 4 1/4, B119JY, which he has had for twenty years; and a recent addition a Mk. VI, B401LH.

He was awarded the Evernden Trophy by the RREC for the original article.

A review of operation on unleaded fuel

by K. E. Lea

C.Eng., B.Sc. (Hons.), F.I.Mech.E., M.I.Mar.E

IN 1986 I wrote an article for the Bulletin concerning the use of unleaded fuel in engines that the Company had produced, many of which are still in service. For those who would like to refresh their memory, this can be found in Bulletin 154. The article sought to inform as to the differences between leaded and unleaded fuel and the likely effects on engine operation specifically for the Company's designs.

Subsequent to that, the Company confirmed its position by making it clear that Rolls-Royce and Bentley engines designed and manufactured by them could safely be operated on the standard unleaded fuel then available in the market, provided those engines that were developed to run on high octane leaded fuels had their static ignition setting adjusted to take account of the lower octane ratings associated with unleaded fuel. This was the only proviso that was required and although I am no longer associated with them, as I understand it this still remains the official position.

Since that time I have read with interest the differing views propounded by various people who in general have been reporting on the work of others. Many of these statements published in the Bulletin can be taken to have substance and, taken generally, are a fair assessment of problems across a whole range of designs and application. However, I am concerned that, however well meaning, they are now misleading the members of the Club who do not have the engineering knowledge to make their own judgement of the situation.

The original article quite clearly stated that the most sensitive characteristic of operation on unleaded fuel was the risk of valve seat wear. Indeed, it concerned itself with an analysis of which engines could be most at risk from this but then concluded that risk was minimal and that the only precaution was to regularly check inlet valve tappet clearance. Obviously, during compilation of the article I carefully considered the highest risk, which was for those designs incorporating inlet valves seating directly on to the parent metal, this being cast iron.

In spite of all the counter positions put forward, specifically for Rolls-Royce and Bentley engines fitted with cast iron cylinder heads, my personal views remain unchanged. Perhaps, therefore, it would be useful to review the reasons behind my stance and, in particular, to explain why the risks of valve seat wear on those engines fitted with cast ironheads is minimal.

Valve seat wear for engine design and development engineers is a well-known feature which over the years has beset many an engine programme, usually but not always before release to production. It is not just a petrol engine characteristic but also appears on diesel engines. Indeed, much of the detail research and development was done for diesels and the findings transferred to petrol engine designs. It is the inlet valve which is most prone to valve seat wear.

During the design and development evolution of any production specification, engines are subjected to extraordinary tests that set out to explore the engine's performance against a set of criteria in a short period of time and which should deliver to the customer an engine that will meet the service life envisaged. This was particularly a feature of the Company's philosophies emanating from the attitudes of Sir Henry Royce himself. Thus, members should be confident that, as released for production, engines met the criteria determined. Only if such external factors such as fuel, oil or service factors were outside those under which testing was conducted is there a risk of failure, save of course for abuse.

Thus let us examine the design factors that affect inlet valve seat wear. Some of these are:

1. The choice of both cylinder head seat material and the valve material. As far as the valve is concerned its material specification is also a function of many other demands for its strength and working environment.
2. The geometry of the seat and valve are particularly important. These include the seat width and angle.
3. The stiffness of the valve head is critical as the deformation of the valve head under the influence of cylinder pressure is a known parameter that affects seat wear in addition to the fatigue criteria that can ensue if the head is too flexible.
4. The closing velocities of the valve on to its seat and the stability of the valve train during the open and closed cycle can also be important.
5. The wear characteristic of cast iron in this particular case is affected by lubrication of the contacting surfaces and the mean operating temperatures of the metal. Lubrication is always minimal unless the valve stem seal allows oil down the guide. The waxed asbestos string seal of the era is not particularly effective and tests have shown it to be a significant part of total oil consumption. This is somewhat advantageous to the case. It is this sphere that leaded fuels improved the lubrication of the two faces and hence if removed can lead to wear. However, it is not all the story.
6. The operating load of the engine in service over its working speed range.

The mechanism of wear is thought to be due to the

minute relative movement of the two faces while in contact and hence can be affected by changing this action and the unit thermal and mechanical loads that are present. Although much of the understanding of this wear characteristic was attained much later it remains true that the basic engine designs and their further uprating were passed to production meeting the development standards of the day and that the origins of all the cast iron heads and the original 40/50 engine were well before the advent of leaded fuels. Therefore the original development running was completed on the available unleaded fuels of the period.

The improvements of fuel and lubrication oil technology over the years have led in themselves to cleaner combustion and fewer cylinder deposits and are a significant improvement.

The use of valve seats with better wear characteristics and the adoption of 30 degree valve seat angles for inlet valves were typical of the changes that had to be adopted over the years. On some engine designs they were mandatory even with leaded fuels.

When the development of the small horse power engine was in its later phases covering the Bentley 4 1/4 and the 25/30 it is fair to say that leaded fuel was available but the specific ratings (i.e. hp/sq.inch of piston area) over their predecessors were not increased, the extra power over the speed range being obtained by increasing the bore dimension. On the 4 1/4 the maximum power was not increased in proportion to swept volume increase and hence the specific rating was marginally reduced. It is significant that there was no increase in maximum engine speed for example between the 3 1/2 Bentley and the 4 1/4, this being precluded by considerations of torsional vibration characteristics. Similarly, when leaded fuels became more widely available and also provided an increase in octane rating (RON) during the thirties there was no adoption of increasing the compression ratio over that which suited the earlier low octane fuels available. This was in spite of considerable testing and the support of Hall in B35AE.

Hence, in comparison with other makes of the time, the approach to increasing performance by the Rolls-Royce engineers was conservative, probably coloured by the impact of continental road systems and their attention to increasing the overall vehicle gearing and hence lower engine operating speeds per given road speed.

It is therefore my contention that the reliability of the later engines was enhanced by the advent of higher octane leaded fuels only insofar as they took no advantage of the undoubted capacity of the fuel to increase rating. If this is accepted then reliability even on unleaded fuels cannot be worse than the early variants, especially as there were some detail improvements in valve material specifications.

engine is that of in-service load on the engine over its speed range. It is this factor which differentiates the engine's service experience from others. It is well known that within certain limitations of good design and material selection that inlet valve seat wear only occurs at high load, coupled with high engine speed. On a petrol engine this occurs on wide open throttle (accelerator hard down for most of the time) with the engine working in the upper speed range consistently. Many other engines not manufactured by the company were forced to work in this more onerous regime because to have any sort of reasonable performance, being of smaller capacity and lower horsepower, they operated at a significantly higher proportion of both their design speed and load. This assumes all other design characteristics are comparable.

It is this aspect that sets the Company's products apart from the rest in that the larger swept volume of the engines keeps the engine in lower stress and wear regimes than its contemporaries, especially when seen against the detailed and extensive development that were and still are a part of the legend of Sir Henry Royce.

I am an enthusiastic owner of Derby Bentleys and my cars are driven briskly to enjoy their latent performance but I can say without fear of contradiction that it is very rare indeed that I have to operate in the high load/high speed regime. This is not true of many contemporary or even later vehicles.

It therefore remains my position that for engines in sound order, properly maintained and driven without abuse, that all the Company's products can be safely operated on unleaded fuel with only the proviso that, for those designs which utilised the octane range of leaded fuels, they should have the correct ignition timing. For older designs the significant improvements of both fuel and lubricating oil specifications, with reference to additives, has given a much wider safety margin over those upon which the original development programmes were conducted. My only additional recommendation for comfort's sake is to regularly check the valve tappet clearance for engines with cast iron heads and the valve seating directly in the head, this being consistent with my previous advice.

My case is simple. It is that generalities have to be specifically considered; what is true for one or even the majority need not apply to all.

(B191/40)

Due to frequent questions asked about unleaded fuel, we reproduce part of an article by Ken Lea which first appeared in Bulletin 154.

"It is said by many that the deletion of Tetra Ethyl Lead from fuels will cause serious valve seat/valve wear and hence as tappet clearances close will lead to valve burning. Many engines may well so suffer but two aspects need clarification:

First, engines fitted with aluminium heads which have valve inserts in high grade steel or iron will not suffer from this problem as this is the method by which cast iron heads are improved in terms of valve life if they suffer from valve breakage.

Second, valve seat wear of non-inserted cast iron heads is extremely sensitive to combustion and operating metal temperatures and hence on large swept volume engines such as ours if such a sensitivity were present at all on older designs it will only occur at high speed and load running. Load factors on large engines are generally lower than those on medium size and small family cars.

If we review the situation specifically, we have:

1. Ghost engine: Low rated low compression. No problems envisaged as it was developed to run on unleaded fuels in the first place.
2. Phantom I, post-AL series; Phantom II; Phantom III: All aluminium headed with seat inserts. No problems envisaged.
3. Phantom I, pre-AL series: Rolls-Royce 20, 20/25, 25/30; Bentley 3 1/2 and 4 1/4 litre; Wraith and Bentley Mk. V engines: An iron head developed as a combustion system on unleaded fuels with the Rolls-Royce 20 and Phantom I. No problems are envisaged but when using unleaded fuel check inlet valve clearances more frequently if the vehicle is driven hard.
4. All 4 1/4 litre and 4 1/2 litre postwar six-cylinder overhead inlet and side exhaust engines up to S1 series cars and any eight-cylinder engine built in this period: Aluminium head seat inserted. No problems envisaged.
5. All V8 engines from S2 onwards, to current day: Developed for operation on both leaded and unleaded fuels with aluminium heads with seat inserts. Absolutely no problems.

It can be seen therefore that all our engines' sensitivity to running on unleaded fuel only varies from minor to nil, and frankly apart from keeping a watch on tappet clearances on iron headed engines if driven very hard, very frequently, no other action is required."

(B219/53)

The Unleaded Fuel Saga

by Ken Lea

The withdrawal of leaded petrol clearly cannot be prevented as it will be ruled by market forces and will be determined by the reducing vehicle 'park' of vehicles that must use leaded fuel. When the demand falls to a level where a garage finds it uneconomic to invest in stocking leaded fuel, then it will be gradually discontinued until the demand for its supply from the petrol companies is in itself uneconomic. The end may well be hastened by national legislation, as I believe it has been, for example, in Austria.

However, the article that was published in part in Bulletin 219 was published in full in Bulletin 154 and I revisited the subject in Bulletin 173. The article deals with both changes in octane rating and the removal of lead from fuels and its effect on the automotive engines made over the years by Rolls-Royce. When I originally wrote the article I was Chief Engineer for Rolls-Royce Motor Cars Ltd. and particularly responsible, among other things, for all engines. The article was quickly transformed into a Service Bulletin and thus its recommendations became company policy and I am informed that this remains the position today. Hence, for the reasons provided in the article, owners of the product should be content to use unleaded fuel as directed in the article and I really cannot see what better advice can be provided to Mr Wrapson. (See item from B190/32, on page 19 of this Technical Manual). The only exception to the general clearance was the carburetted turbo-charged V8 fitted to Bentley Mulsanne Turbos and early Turbo Rs prior to mid-1986. However, the restriction was only concerned with the lower octane limit of the 'Premium Unleaded' fuel which increased the risk of detonation damage. The advent of the 'Super Unleaded' grade should eliminate this particular restriction.

Let us review if any problems arose. I know of only one which was said to be caused by the change, which was that of vaporisation and the inevitable result of failing to proceed, or at best an 'asthmatic like' progression. However, this problem was not related to the use of unleaded fuel but rather a problem of too low a Volatility Index specification for summer grade fuels in British Standards and conformance to it by the oil companies. The standard has since been revised in line with the European Standards that cope with higher ambient temperatures than are usually seen in the UK and the supply is now to a better standard. I remember well one member telephoning me to say that unleaded fuel was 'NBG' for his car. Upon ascertaining that, on suffering vaporisation, he had filled the tank with leaded fuel and the problem had disappeared, it took some persuading to have him accept that the improvement was not due to the change in fuel type but rather that a tank full of cold fuel from the underground storage had suppressed the tendency to vaporise! In fact, both fuels have to conform to the same Volatility Index. However, this was not to say that fuel system improvements, to guard against vapour lock, would

not be beneficial.

I was concerned to see that the part of the article concerning octane rating was not covered in Bulletin 219, as on high compression engines, that is around more than about 8.5:1, there are detonation damage risks associated with the lower octane rating of premium unleaded fuel. The article predates the advent of 'Super Unleaded' and the important advice missing is that, for high compression engines, the static ignition timing should be retarded by one degree for each octane numerical unit reduction from that declared in the handbook.

I think I must try and clear up in owners' minds why some articles appear to conflict with mine. This is because the design of engines and the materials utilised vary widely and will react differently to a change in fuel from that upon which they were designed to operate. Some engines will see no effect at all, while others will suffer serious damage. Articles from bodies such as the VSCC or the Historic Vehicle Federation must necessarily provide advice to cover this broad spectrum, and hence the advice to convert to hardened valve seats is sound when viewed in this context. However, large swept volume engines do not see the same load factors as a small engine such as an Austin Seven and they rarely run continuously on wide open throttle at high revolutions. The problem of valve sinkage is not only design and material dependent but also is very sensitive to the combined load and speed factor. My advice was for engines supplied only by Rolls-Royce Ltd., Bentley Motors (1931) Ltd. and Rolls-Royce Motor Cars Ltd. and readers will, I hope, appreciate that it is a case of 'horses for courses'. The advice provided, therefore, is not necessarily transferable to other makes and models.

I trust this assuages for once and for all the doubt felt by members, but for those who wish to play even safer you must do one of the following:

1. Buy some worry beads, which is less expensive than converting to hardened seats. (A new line for the Club Shop?)
2. Convert cast iron heads to hardened seats, which in itself is not entirely risk free due to the sensitivity of the head to interference fit between the seat and the parent head.
3. Mix one of the new but costly additives into the fuel. In this regard I have discussed with Peter Baines reviewing for the Club, as required, the evidence of testing provided by the additive suppliers. A poor additive could do more harm than doing nothing as recommended!

Finally, I was talking recently to a very good friend of mine who has a well known franchise for new cars where early failure of engines through heavy carbon build up had been experienced on a few cars at very low mileage. This was traced to the use of a particularly cheap but widely available petrol where there was a dearth of the clean combustion enhancing additives normally to be found in the fuels from the traditionally established company brands. I think the lesson here is to use these well established brands in our cars irrespective of whether they are leaded or unleaded.

(B220/63)

Autovac

by Peter Baines

The article on Autovac problems in B208 (see this manual page 128) still simmers. Richard Hipkiss says that he has seen hairline cracks in petrol pipe union nuts and old and cracked solder where the end of the petrol pipe is soldered to the 'bell mouth'. He says that he has seen three cases of 20/25 Autovac taps leaking from the outside face — the engine side — of the cylindrical valve body. The problem is in the circular plate, which is silver-soldered into the end of the cylindrical valve prior to plating. Sometimes a crack appears, which opens up as the engine warms, the engine is starved and fuel can be seen running down the petrol pipes, bulkhead conduit, starter solenoid and exhaust. As these cracks are almost invisible, the cork gasket is usually suspected or the castellated nut is tightened too much. He also mentions another obscure problem caused by the float chamber bleed nut becoming blocked. In this case the car will run perfectly, but when the engine is switched off the fuel in the float chamber evaporates and the gas pressure pushes fuel back up the fuel line, making the next start almost impossible. Parts for Autovacs are still available: correct cork gaskets, aluminium washers, new bell mouths and union nuts — even reconditioned complete Autovacs. (B210/14)

Autovac source

There appeared to be a shortage of Autovac square tanks earlier in the year. I received three requests over a very short period. While there are a few around, many are rusting through the base, so Derby Road Garage in Northampton is having a batch made up. They also hold full spares for all Autovacs. They can rebuild them, repair them, and are always delightful people to deal with. Keith Jay, Registrar, 20hp (B225/69)

Fuel Pump Diaphragms

The petrol pump on my 25/30 Wraith has recently suffered leakage from the pump bodies due to the degrading of the diaphragm material and I have since heard of similar cases in another marque.

On enquiry, Messrs. Burtel Fuel Services have kindly explained that fuel left standing for long periods of time undergoes chemical changes, producing substances which attack this material and, consequently, that replacement diaphragms have 'for many years' incorporated a plastic membrane to combat this effect.

The diaphragms in my pump had seen long service and did not have this membrane but, having particular regard to the location of the pump directly under the driver's seat this has now been rectified!

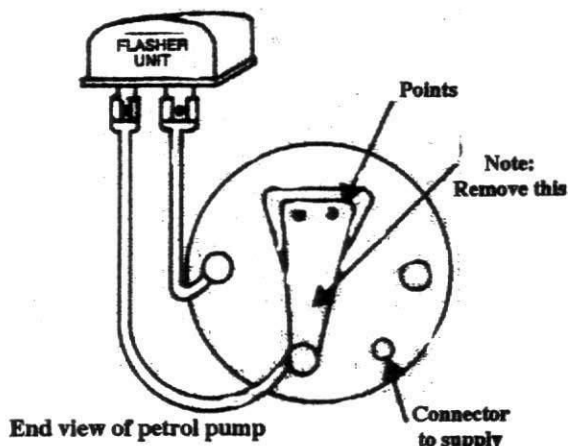
Garnet W. Wrapson, East Yorkshire (B198/76)

Fuel Pumps

by Tony James

From Derby Bentley to Shadows, 'back to back' SU fuel pumps are used. If one half of the pump has failed the other will continue to supply fuel. When the remaining half fails, an embarrassing 'failure to proceed' occurs. Failure usually occurs after a period of inactivity. To check that both halves of the pump are working, unscrew the knurled bakelite nuts and disconnect the wire joining them and connect the supply wire to each end in turn. Do not run the engine but listen for the reassuring 'clicks' from the pump, which are an indication that it is working. Switch off the ignition while changing the wiring.

Sticking after storage: The SU electric petrol pumps fitted to Bentley 3 1/2 to T and Rolls-Royce 25/30 to Shadow II are all basically the same. Therefore, the following applies to all models. After a long period of inactivity the points can stick. A judicious tap with a rubber mallet can set them ticking, as they should be. Make sure you hit the metal parts of the pump to avoid cracking the plastic end caps.



Emergency pump repair: If both sides of your pump fail, your car will no longer proceed. If cleaning and freeing the points is unsuccessful, you can get home with a flasher. Remove an end cap and use a two connector flashing indicator unit and connect it across the points. The pump will now operate slowly and steadily, delivering sufficient petrol for normal motoring. Use a broken cap or adhesive tape to keep the pivot of the moving points in place..

(B192/40)

Repairing a prewar petrol hose

by Roger Sumner, Vancouver, BC.

After a recent run in my 1939 MX series Bentley I noticed some wetness around one end of the flexible fuel pipe which goes from the pumps on the engine bulkhead to the pipes feeding the carburetors. After checking the unions it had to be accepted that the rubber hose under the woven metal protective cover had deteriorated and caused the seepage, sad but not surprising after possibly forty-eight years.

The next step was to find a replacement. A few local telephone calls quickly determined that there were no spares available nearby, so I tried my excellent UK contacts. Again no known source, they were in need of the same item. I also asked if it was possible to dismantle the hose, replace the rubber pipe and reassemble it with the metal covering and end ferrules to give the same original appearance, but that didn't seem to be possible. Simply use a new neoprene rubber pipe and some hose clips and wait till the original type becomes available (if ever) was the best advice from all sides.

I'm not interested in concours events. I enjoy driving and tinkering with my car, not displaying it (hope I am not blackballed from the Club for this), but even so that old, dull, metal-covered and ferruled hose pipe looked nice and I had got used to it and didn't fancy a shiny new rubber pipe and a couple of modern clamps, so I decided to take the old hose unit apart and see if anything could be done. Here was my only real piece of luck. I needed a fine high speed drill to remove the ferrules which clamp the hose ends and I have a sympathetic dentist at hand (myself). The outcome was that, as advised, I used a new piece of neoprene hose and two small hose clamps but was able to replace the metal hose cover and put the ferrules back in place over the new parts. Although the ferrules are now

strictly decorative rather than functional, the whole thing looks exactly the same as before.

Here is the method:

1. With the hose from the car I made a thin cut along the length of the two ferrules (see diagram), then prised them off.

2. With much effort and some cutting of the old rubber, I then removed the metal unions from each end of the hose.

3. With similar effort, easing, pulling and encouragement, the woven metal cover can be removed from the rubber hose, like a snake shedding a tight skin. Well, at least I had everything apart. The metal hose cover had become slightly frayed at the ends but that was all right because it needs to be trimmed back at least the width of the new hose clamps.

4. With new hose of the same diameter, which was readily obtainable, I was able to cover it by easing on the metal cover quite easily. Having checked that, I pushed it a little further off one end of the pipe and trimmed it back about $\frac{3}{4}$ in (see above), then did the same with the other end, using sharp wire cutters.

5. Then the metal unions were pushed back into the ends of the new hose.

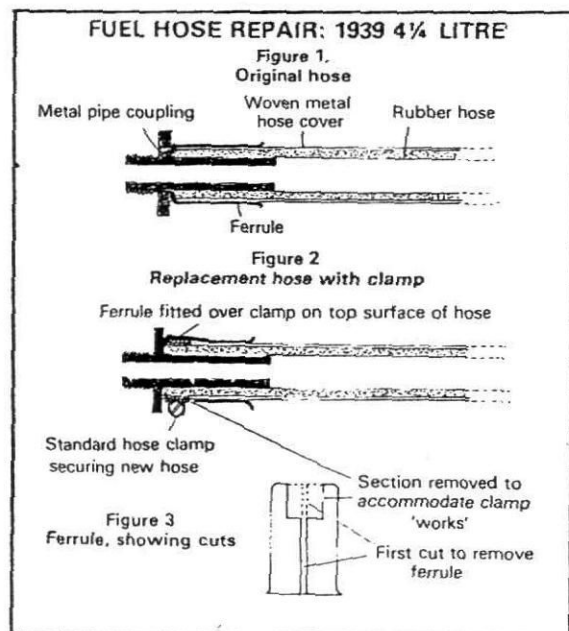
6. The smallest possible size of hose clamp was fitted, one each end.

7. The two ferrules were cut further, as shown in the diagram, to leave an open section just big enough to fit around the new screw housing of the clamps. This part should be on the underside of the hose when it is replaced on the car.

8. The cut ferrules were opened widely again to place them back in their original position over the ends of the hose and then bent back to shape to fit tightly.

As one can see, it is simple routine, apart from cutting the ferrules, and it would seem that a fine, high speed drill would be the only way of doing this, a hack-saw could not get at the neck of the ferrule. I'm sure that most dentists would be happy to help perform a small job to preserve an interesting old car. They are inventive by nature and many of them spend a lot of time repairing fifty-year-old teeth, so a bit of drilling on an inanimate fifty-year-old fuel pipe is child's play. So don't be afraid to ask. The recommended drill bit or burr as it is correctly termed is a special metal cutting design, No. 1931 FG (friction grip) made by Midwest. You could offer to buy a couple of these to use for the job as many dentists will not normally have them, or probably he/she will suggest using their regular old discarded burrs, which are often kept. As an alternative to a dentist, a dental mechanic, a jewellery, or anybody with a small drill, air or belt driven, could assist with the cutting.

A further note on annealing leaking copper washers may be of interest on the subject of fuel pipes. After reassembling all the pipes connecting the fuel pumps to the carburetors there was some seepage around the various copper washers. The explanation seems to be that the copper has hardened over the years and it is difficult to get them to reseal at the junctions concerned. Copper or aluminium or teflon replacements may be found, but a racing car driver



friend (they constantly take down or rebuild their engines) suggested annealing the old washers. This proved to be simple and effective; by holding each washer from a piece of wire I heated it to a dull red hot glow with a propane torch then quenched it in a can of engine oil. This softens the copper miraculously and the washers sealed the pipe unions with no further leaks.

Adjustment of the mixture control for Rolls-Royce 20 models

by Kevin Walton

For the past thirty-three years I have owned and loved my very original Barker bodied Rolls-Royce 20, GRJ68.

For at least half of that time soon, after completing a major refit, I have had problems with my mixture control adjustment and have had advice from all directions, expert and otherwise, and achieved very little. This year I have given the engine a top overhaul and, acting on the assumption that Royce was a very

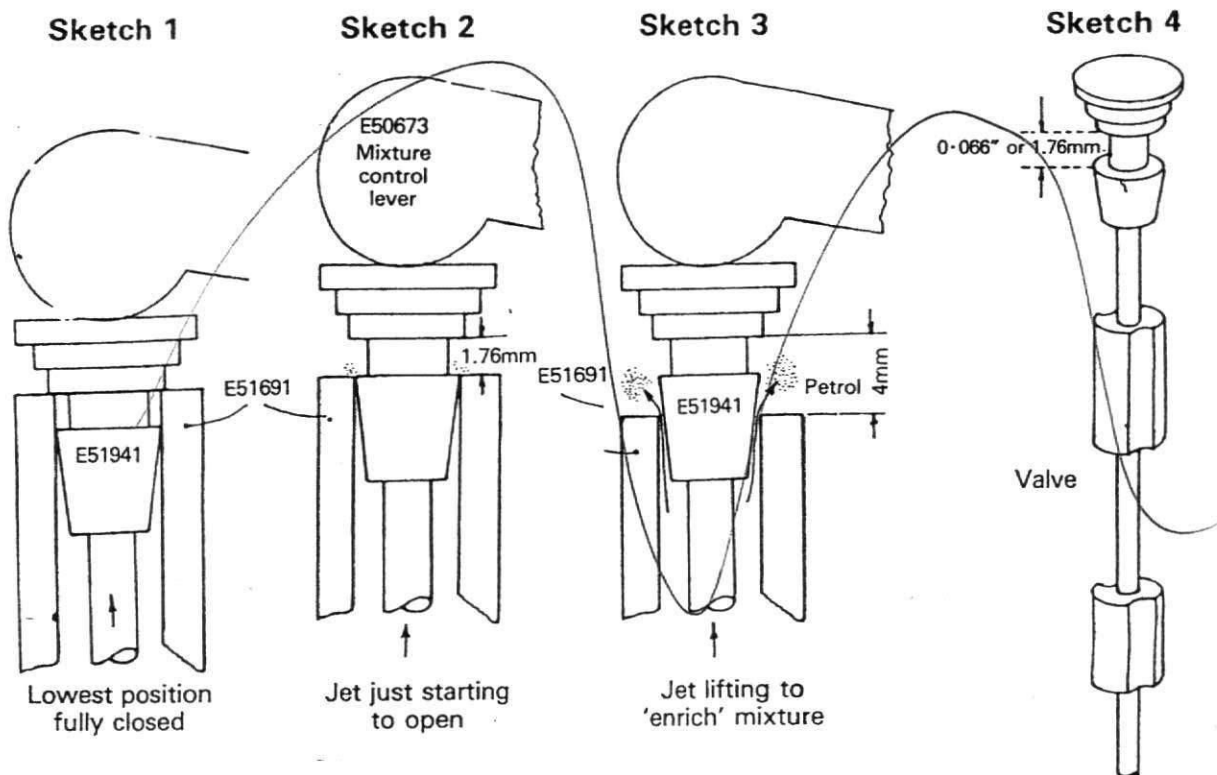
good engineer and not a magician, I went back to first principles to see if I could sort my petrol problems out and at long last I have a car that is back to being the pleasure that it must have been when new.

As far as I know, apart from the rather discouraging remarks in the Rolls-Royce owner's handbook, there have not been any notes under 'technical matters' about mixture control and this article explains how I tackled things.

I recently put the exhaust on to a CO analyser and found to my horror that on main jet I was 'off the gauge' in excess of 8% and no mixture adjustment would bring me back on to scale. The mixture adjustment was just not working. On slow running jet all was fine.

I removed the drain plug, part No. E53150 ($\frac{1}{8}$ " in Whitworth socket). The spring loaded plunger in this plug was removed and checked for full movement. (I had trouble with this when I first bought the car, when it was found to be solid with sludge.) I removed the jet and valve, parts No. E51691 and E51941, and checked that they were sliding freely and made a dimensioned sketch of the valve (sketch 4).

I replaced the jet and with my finger as a spring and using a steel rule marked in millimetres I checked the full movement of the valve from the position of top



The SU Fuel Pump

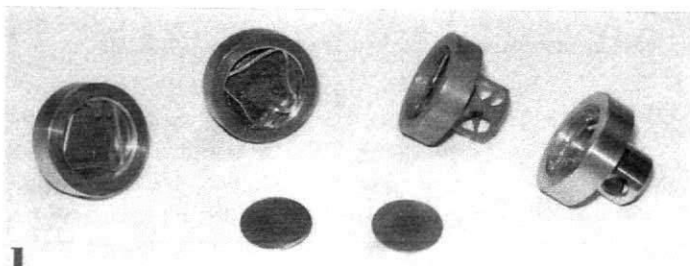
Part II: How To Test It

Gary Phipps (NM) © 2009

In Part I, we developed a firm foundation in operating theory for the entire range of SU fuel pumps from initial Rolls-Royce applications in the 1930s to the Silver Shadow in the 1970s. Part II concludes the series with specific methods for testing and repair.

during June of 2008 the pumps on my prewar Wraith WMB16 were intermittently going into a rapid tick mode and the car would randomly fail to proceed from fuel starvation. The diaphragms were fine so I tried adjusting the pumps per *FL* p. 485 which was no help. What was I to do? Examination showed that the "B" pump contacts were burned much more than were the "A" contacts, for unknown reasons. While the pumps were out I replaced both contact sets for the first time in 40 years although contacts were not the direct problem since the pumps were still ticking.

Once a source for the valve hardware was located (same parts as an MGA twin-cam pump) the suction and pressure valves on both pumps were replaced **1**. The photo shows some minor differences in the old (inner) and new (outer) pair of cage valves. These differences mostly concern the holes drilled in the bottom of the cage (right side of **1**). The truly important dimensions, such as the overall diameter and length of the body were identical and the new valves were a direct replacement for the old. The old, flat discs had odd patterns worn on them from many years of service. Not easily seen in the photo is that the old disc surfaces also had a leather-

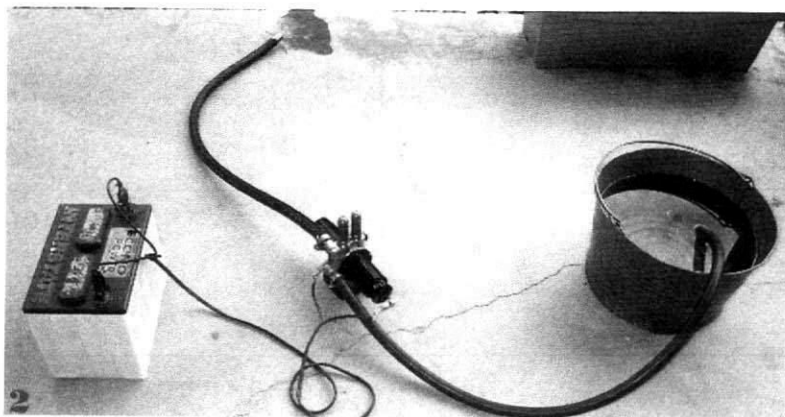


1 Old (center) and new (outer) cage and suction valve hardware for an SU fuel pump.

like grain pattern from corrosion of some kind. No wonder they might not have been sealing well. After both reassembled pumps ticked in air they were re-installed and taken for a test drive. Pump "A" wasn't too bad with an NFTR (No Flow Tick Rate) of about one per minute. "B" was one per second: not good. Out came the pumps, more adjustments per *FL* p. 485—with the same result! After about four rounds of this, another approach was needed.

Fortunately the pipe connections on the Wraith pump are a size that fits a $\frac{3}{8}$ " garden or dishwasher hose very nicely. A test setup was assembled with hoses, Jubilee clips, a bucket of water, and a spare 12V battery with cabling and clips so that either pump could be selectively energized and made to pump water **2**. The shank of a short, $\frac{1}{2}$ " drive socket extension fit perfectly in the end of the $\frac{3}{8}$ " outlet hose with no need for a clamp. This allowed the outlet hose to be easily stoppered after the trapped air was bled from the line.

Before disassembling the pumps again, a water pumping test gave the same results: "A" one per minute, "B" one per second, same as with fuel. Either liquid works similarly and water is considerably cheaper and nonflammable. Several diaphragm adjustments and other worthless changes convinced me that the *FL* p. 485 adjustments were not going to work. The pump bodies were then swapped end for end; the front pump was now at the rear and the rear at the front. The problem stayed with the front pump. The problem was in the center section valve hardware not the magnets, diaphragms, or anything in the



2 Simple pump test using water as the pumping fluid.

pump bodies. It became clear why the "B" contacts had been more scorched than the "A". The "B" valves had probably been bad for a long time causing the "B" pump contacts to tick much more often than "A".

The output from each pump feeds a common chamber, i.e. the line to the carburetor, through independent pressure check valves. Since pump "A" was working reasonably well, both of the outlet pressure check valves had to be working reasonably well. They are in parallel; if either was leaking it should affect both pumps. The problem had to be the "B" inlet suction check valve leaking pressurized fluid backwards into the common supply chamber at the bottom.

To verify this, the outlet hose was filled, bled, and stoppered. Then the inlet hose was raised out of the water supply while still full of water. With the good "A" pump the water

level in the inlet hose barely moved since nothing was being pumped. With the "B" pump the water level dropped $\frac{1}{2}$ " with every tick but immediately started to rise indicating the pump was pumping liquid but it was immediately leaking backwards through the suction valve. But all the valve hardware was new! What else could possibly be done?

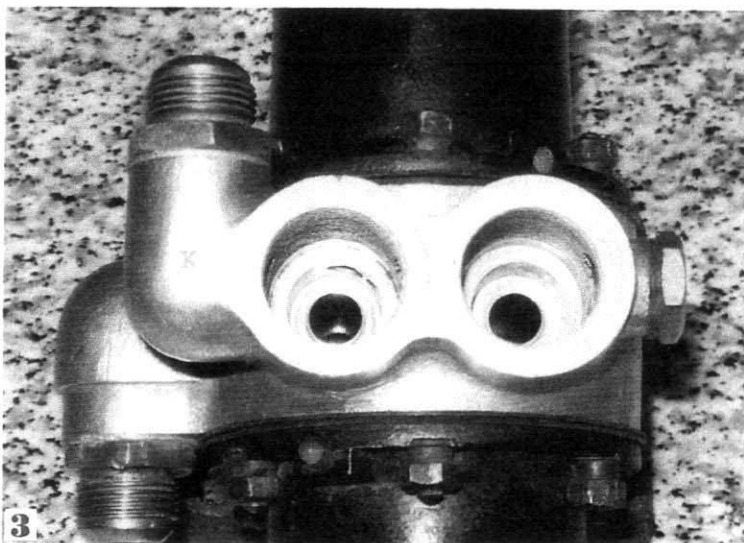
The brass circles in the bottom of each valve chamber are the inlet suction valve seats against which the 0.5" diameter brass discs rest **3**. The 0.8" diameter cage valves of **1** fit on the intermediate ledge above the lower discs. (The inlet to the valves from the upper pump can be seen on the upper side of the left chamber.) There had to be something wrong with the lower "B" seat but they were barely visible. If I had to visually choose one of the seats to be bad I would have picked the wrong one. Various means were tried to polish the "B" seat using Scotch-brite, polish on a fingertip, etc. After working for hours another water test proved that nothing had been accomplished. Eventually, I decided to produce the tool shown in **4**. Some may recognize it as a slightly modified step plug that every local community college student must make in Lathe 101 class; there was finally a use for it. A "proper" tool could be turned, but there was no certainty that such a tool would be a true solution. The bottom plug diameter was turned to just fit the 0.60" surrounding the suction valve seat. Then the bottom of the tool was turned back until its flat diameter was just over 0.5". Black electrical tape was used to shim the upper ID to fit the 0.80" diameter of the cage valve thread. The idea was to generate a tool which would not wobble in the valve bore while turning against the seat.

Half inch diameter circles were punched from a sheet of 1500 grit sandpaper and attached to the tool bottom with tacky adhesive meant to hold similar, although much larger sanding discs to an air sander. Two such "sheets" of sandpaper were lightly turned against the seat for about 30 seconds each. The only thing visible on the sandpaper was a brass-colored circle. As a final touch the bare bottom of the tool was coated with Mother's Mag Wheel (metal) polish and used to gently polish the seat. As a preliminary test the "A" suction valve seat was stoppered with a tapered rubber plug, a brass valve disc was placed on the "B" side seat and mouth suction was applied to the inlet connection of the pump body. Surprisingly a small vacuum could be pulled against the valve. A similar attempt before lapping the seat failed to achieve any vacuum by this crude method.

The pump was reassembled and taken back to the water test shown in **2**. After each pump independently filled and pressurized the output line, four consecutive pump cycles were timed, i.e. five ticks. The "A" NFTR averaged 56 seconds as it had previously. At first it seemed that the "B" pump had quit working. No, it was just ticking so slowly that it seemed to have quit. The valve which had produced an NFTR of 1 per second now averaged five minutes: a 300% improvement. By Jove, I think we've fixed this thing!

As I was somewhat anxious about water remaining inside the pump being pushed into the carburetor, the pumps were flushed with isopropyl alcohol before installing them on the car for the final time. WMB16 is again on the road with no fuel delivery problems.

A good health test for an SU fuel pump is to measure its NFTR. If the number is low, repairs are in order. Testing with a liquid is the only way to be certain that repairs have been successful and testing off the car



3 View into valve chambers atop a dual SU pump. The (pressure) cage valve and (suction) valve disc have been removed and only the brass suction valve seats are visible at the bottom.



4 Valve seat lapping tool generated from a left over project from lathe school.

is less frustrating than on the car. The check valves are an important and often neglected part of any pump overhaul and the fixed valve seats inside the older pump bodies may be difficult to assess or correct. However, valves as well as diaphragms and points are all important for a pump to operate correctly. Only after the NFTR is acceptable is it worthwhile to even consider a flow or pressure test.

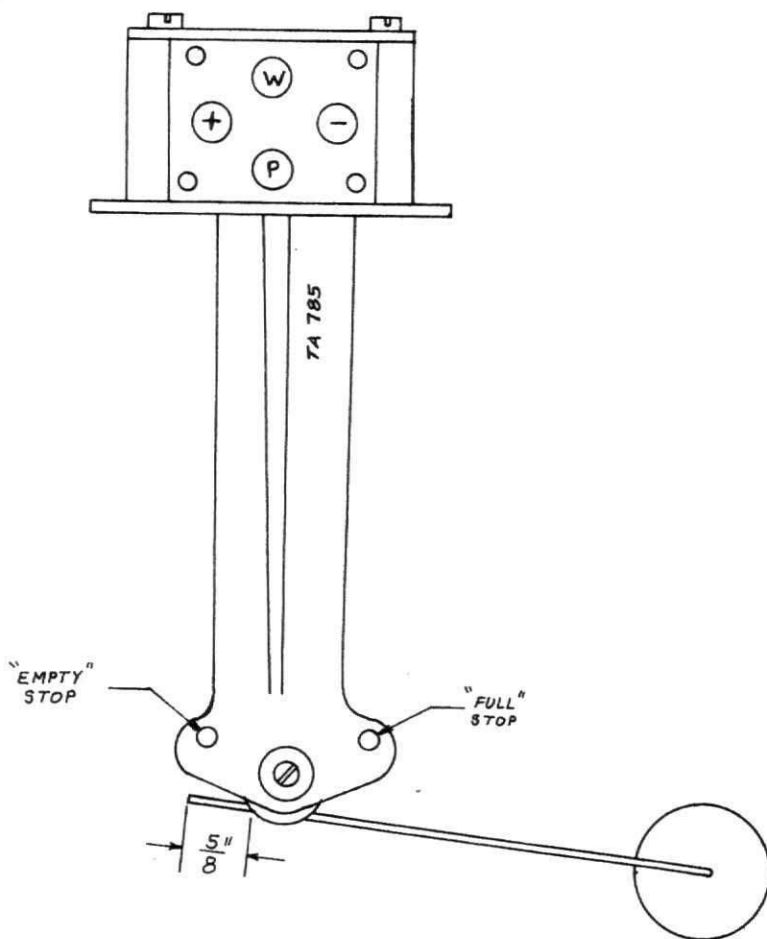


FIG. 1 SENDING UNIT

1642

THE SMITH ELECTRIC PETROL GAUGE

By Robert A. York, Penn.

The Smith electric petrol gauge as used on Rolls-Royce and Bentley cars is a remarkable device capable of a high degree of accuracy and dependability when properly adjusted. The modern electric petrol gauge has replaced older methods which involved mechanical linkages, spiral float rods, sight glasses and even measuring sticks. All electric gauges consist of two major components: the tank or "sending" unit and the dashboard indicator. Basically, the indicator unit simply shows the position of a float in the tank and is calibrated to read directly in Imperial gallons. This article deals with the more common faults of the petrol gauge system and presents a technique for troubleshooting and adjustment that should be useful to the owner or mechanic. The system shown is from the Phantom III chassis; however, the information will be found to apply to other models.

Principle of Operation

Common to all electric petrol gauges is a sending unit in the tank that translates the position of a float into a voltage that varies in magnitude with the quantity of the petrol. In the Smith gauge, a thin brass float is attached to an arm and is so arranged that it is made to rotate a vertical shaft by means of a right-angle gear drive (see Figures 1 and 2). The gear ratio is such that as the arm moves through an arc of approximately 90 degrees, the shaft moves through an arc of approximately 300 degrees. At the top of the vertical shaft, external to the tank, is located a potentiometer. The potentiometer resistance element is circular

in form and has its slider fixed to the top of the vertical shaft. The battery voltage is applied across the resistance element so that as the slider moves, it "picks off" a voltage that is indicative of the level of the petrol in the tank.

In conjunction with the slider is a set of electrical contacts that are arranged so that they close when the petrol level falls below a pre-determined point (3 to 4 gallons). These contacts are utilized to operate a "low petrol" warning light on the instrument board.

The indicator unit on the instrument board is so constructed that the voltage from the sending unit determines the position of a needle on a dial. The dial is calibrated to read in Imperial gallons (3 to 33 gallons). The indicator unit works on a magnetic principle and is best understood if compared to a pocket compass. Just as the needle of the compass aligns itself with the earth's magnetic field, the needle of the indicator likewise aligns itself with an artificially-created field within the indicator. The needle is free to pivot and has no return spring. The magnetic field that determines the position of the needle is the resultant of two fields that surround coils set at right angles to each other (see Figures 3 and 4).

The horizontal coil is connected across the battery supply and is tapped at its mid-point. This is referred to as the control coil. The vertical coil is connected between the above-mentioned tap and the potentiometer slider in the sending unit, and is referred to as the deflecting coil. The strength of the field created by the control coil is relatively constant and varies only with the battery (or dynamo) voltage. On the other hand, the field created by the deflecting coil changes in strength and polarity depending on the voltage from the sending unit. Since one end of the deflecting coil is always maintained at a reference voltage equal to half of the battery voltage (the control coil acts as a voltage divider), the current through the coil can flow either toward or away from the tap connection, or even be zero, depending on whether the potentiometer voltage is greater than, less than, or equal to half of the battery voltage, respectively. If the potentiometer voltage is equal to exactly half of the battery voltage, the needle will remain at its center position.

It can now be appreciated how the interaction of the two magnetic fields determines the position of the indicator needle. It should be further appreciated that the beauty of this system lies in the fact that the indications of petrol quantity are practically independent of variations in battery voltage or temperature, since the system operates on the differential principle and these errors tend to cancel each other.

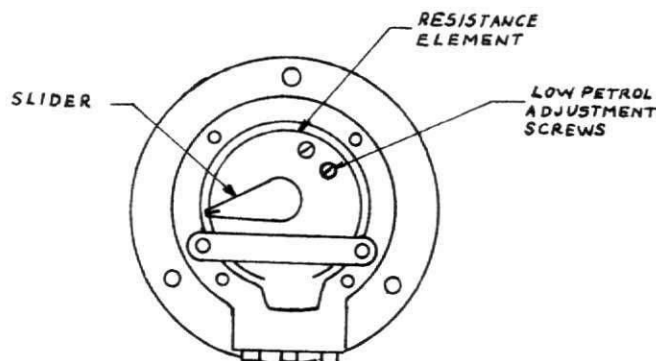
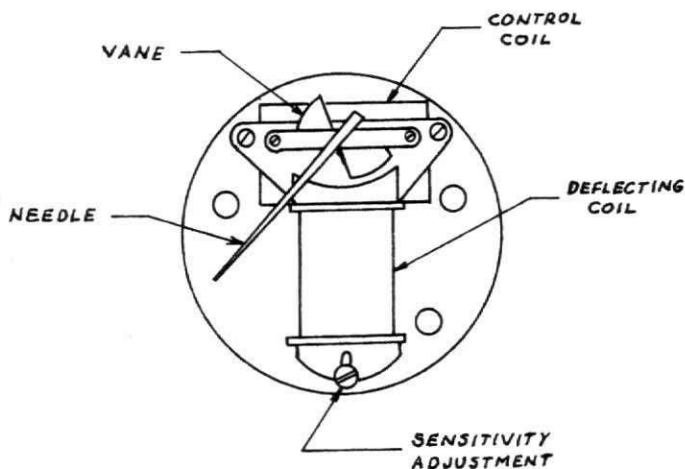


FIG. 2 SENDING UNIT, TOP VIEW



**FIG. 3 INDICATOR UNIT,
DIAL REMOVED**

Troubleshooting

Despite the fact that the Smith gauge is very well made, and that most have lasted for several decades without any attention, some do require service or restoration. The common faults may be divided as being mechanical or electrical in nature. Common mechanical faults are: leaking or missing floats, bent or maladjusted float mechanism, frozen potentiometer unit, etc. Most mechanical faults involve the sending unit, referred to by Smith as the "tank attachment". Common electrical faults are: broken or improperly connected wires, blown fuse, potentiometer slider not making contact, damaged potentiometer element due to shorts, open-circuited indicator coils, etc. A troubleshooting chart, Figure 5, is included to aid in relating the symptom to the cause and thereby expedite the repair procedure. It should cover the majority of cases.

Checking the Indicator Unit

The indicator unit, as previously explained, contains two sets of coils of relatively fine wire wound on a special low hysteresis iron core (see Figures 3 and 4). Checking these coils is an easy task using an ordinary ohmmeter. The gauge should be removed from the dash but this is not absolutely necessary so long as all wires have been disconnected first, care being taken to re-connect these properly after taking the resistance readings. Connect one lead to the "P" terminal of the gauge while touching the other lead to the first "-" terminal and then the "+" terminal. A reading of 165 to 170 ohms should be obtained in each case. Readings which differ greatly from these, either higher or lower, indicate a defective coil. The coils can be re-wound, however, this is a very difficult procedure in the field without special equipment.

Another test which does not require the use of an ohmmeter is as follows: (1) Apply 12 volts DC to the "+" and "-" terminals of the gauge. The needle should center at about 16 gallons. (This tests the control coil); (2) Short the "P" terminal to the "+" terminal. The needle should point to "3" or "empty"; (3) Short the "P" terminal to the "-" terminal. The needle should point to "32" or "full". (This tests the deflecting coil.)

During these tests, make certain that the needle is free to move over the entire scale. Should it become necessary to open the gauge, it will be noticed that there is a small adjustment screw located at the bottom edge of the rear of the case. This is used to set the clearance between the deflecting coil pole piece and the moveable vane. A clearance of .020 to .030 should give satisfactory results. This adjustment will have an effect on the sensitivity and linearity of the gauge. Errors will be most pronounced at the scale

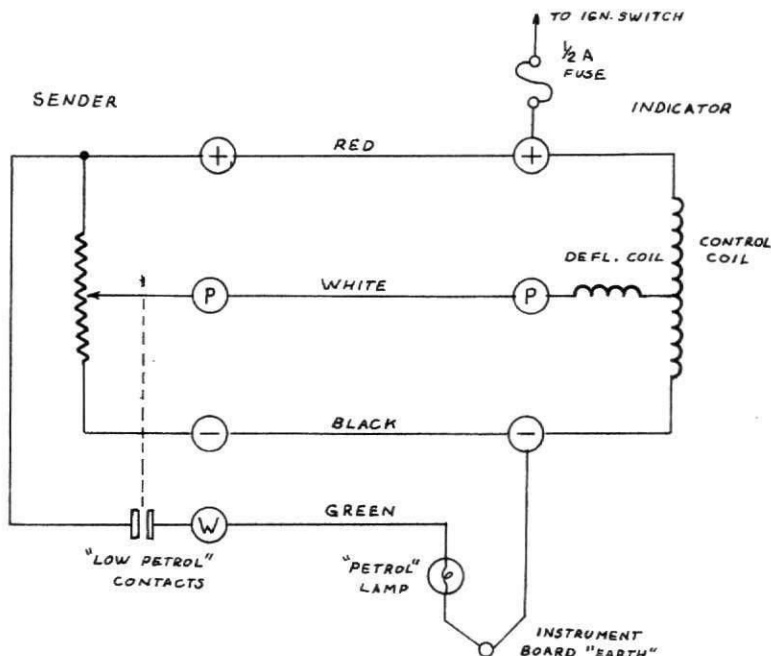


FIG. 4 WIRING DIAGRAM

ends.

The pointer is made of light-gauge aluminum and is very fragile. Should any refinishing or straightening be required, it must be carried out with the utmost caution. A scratched or broken cover glass can be repaired or replaced by consulting Bausch and Lomb Optical Company.

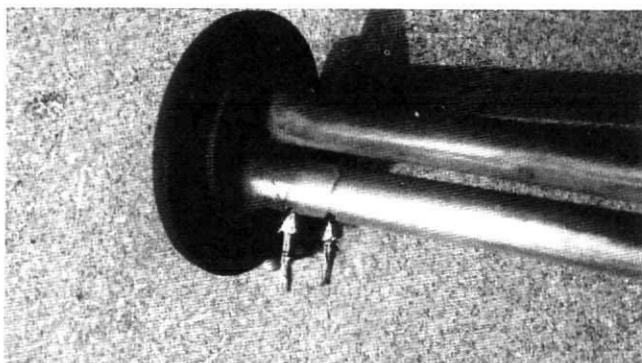
1643

Checking the Sending Unit

The sending unit is referred to by Smith as the "tank attachment" and is usually mounted at the top center position on the tank. Access to this unit can be gained through the floor of the boot or under the rear seat, depending on body style. Some quick checks can be performed without

FIGURE 5 - TROUBLESHOOTERS' CHART

Symptom - Probable Cause	
Always reads "Empty"	
Defective float	
Sending unit stuck	
"P" wire (white) shorted to pos.	
Blown fuse on gauge	
Positive feed disconnected	
Ground (black) disconnected at gauge	
Always reads "Half-Full"	
"P" wire (white) open circuit	
Slider in sending unit not making contact at all	
Open deflecting coil in gauge	
Sending unit stuck	
Always reads "Full"	
Pos. wire (red) disconnected at gauge	
"P" Wire (white) shorted to ground	
Sending unit stuck	
Reads O.K. on part of scale, then returns to "Half" (16 gallons)	
Slider making contact with only part of resistance wire in sender	
Intermittent operation	
Weak slider spring, corroded or loose connections, broken wires, loose fuse	
Reads backwards	
Red and black wires interchanged at gauge	



Arrows point to cracks in reserve tube. It is longer in order to dip deeper into tank when level falls below bottom of main feed tube.



Sleeve in place after application of epoxy.

Reserve Fuel System Repair on a Derby Bentley

2116

Recently, while replacing the tachometer in B27FC after repair, my eye was caught by the lever of the reserve fuel tap on the engine bulkhead. Having never had to use it, I wondered if it worked OK. Flipping to the "reserve" position while cruising at 40 mph caused coughs and sputters from the engine, indicating lack of fuel. Returning the lever to "main" cured the trouble. Diagnosis: an air leak somewhere in the reserve pipeline.

In deciding to attack the problem from the rear, I was lucky. Removing the floor of the trunk (secured by latches operated by a coach key) gave access to the top of the fuel tank. Disconnecting two pipe union nuts and removing four mounting screws freed the dip-tube assembly so it could be lifted out of the tank. Suction applied by mouth (Yecch!) showed that the longer (reserve) tube would not sustain a vacuum for even a second. Cleaning the full length of the tube disclosed the culprits — two fine cracks at the upper end.

Soldering seemed the immediate answer, but I was afraid of disturbing the soldered joint where the tube joins the cap. A neat solution turned out to be the use of an epoxy glue incorporating a filler, plus a piece of 1/2" copper water-pipe as a sleeve. The pipe was cut slightly longer than the cracked area and slit length-wise. Slitting it permitted it to be squeezed down to a sliding fit over the damaged tube. Then I mixed a small amount of epoxy (about an inch squeezed from each of the basic epoxy and hardener tubes) and buttered the cracked area of the tube and the inside of the sleeve with it. Sliding the sleeve over the cracked area sealed the cracks and reinforced the weakened section of the tube. The epoxy was allowed to harden about an hour before re-assembly of the dip-tubes to the tank.

John R. Utz (NY)

The SU Fuel Pump

Part I: How It Operates

Gary Phipps (NM) © 2009

During June of 2008 the pumps on my pre-war Wraith WMB16 were intermittently going into a rapid tick mode and the car would randomly fail to proceed from fuel starvation. The diaphragms were fine so I tried adjusting the pumps per FL60-6 p. 485 which was no help. What was I to do?

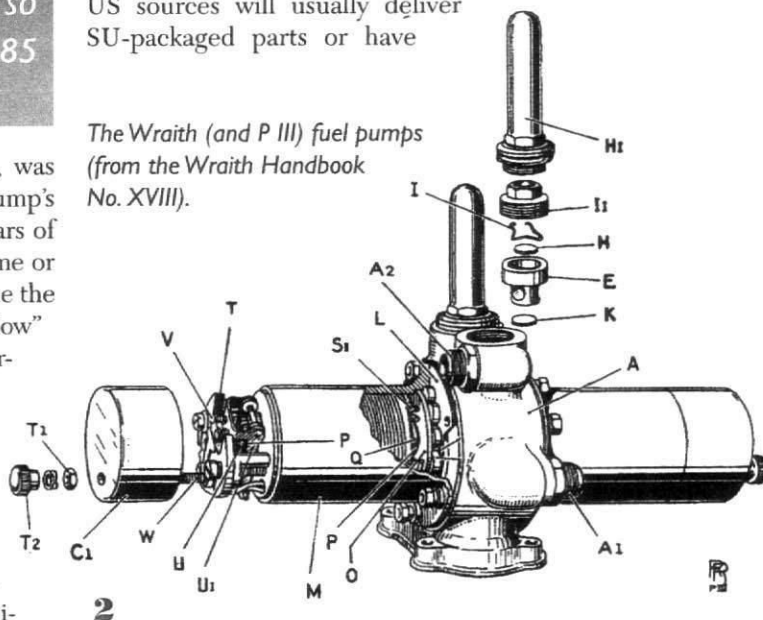
The SU electric fuel pump, mostly in dual form, was used by Rolls-Royce in many models from the pump's introduction in 1934 through the Silver Shadow cars of the 1970s. Many other English makes used the same or similar pumps on their cars of the same era. In all that time the pumps were unchanged in their basic design. There were "low" pressure and "high" pressure models and other small differences but the basic pump and most of its internal parts remained the same. The simplicity of its design rivals that of the Kettering points and condenser ignition of 1912. Such simplicity had much to do with the longevity of both designs in the automotive marketplace.

Over the decades several articles have appeared in both *TFL* and the *RREC Bulletin* concerning the maintenance and overhaul of SU electric fuel pumps. These typically deal with replacement of diaphragms and contact points, and those topics have been well covered. What has not been

discussed is the *why* and *how* of pump operation which helps explain the often conflicting adjustment instructions, nor have there been many words about what to do if parts replacement fails to cure an ailing pump. My recent attempt to overhaul the pumps on Wraith WMB16 using the prior written words resulted in a pump that operated nearly as badly as it did before I started! Not being one to accept defeat, I did some research and testing that not only solved the problem but generated information that could be useful to other owners. Any details given in the following are likely those taken from the twin SU pumps on WMB16 which should be similar to, although not exactly the same as, those from other models. Although these pumps have mechanical switching contacts and flat brass valve hardware, much of the information is common to the newer, electronically switched pumps.

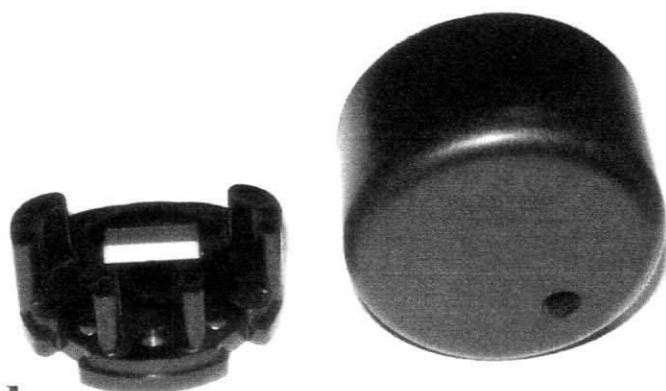
The current source for nearly all SU parts is Burlen Fuel Systems in Salisbury, UK, who manufacture both SU pumps and spares. I have listed Burlen in the sidebar along with other sources which all offer spare parts for these pumps. The US sources will usually deliver SU-packaged parts or have

The Wraith (and P III) fuel pumps (from the Wraith Handbook No. XVIII).



Burlen part numbers on their own packages. Depending upon where you live it may or not may not be more convenient to go directly to Burlen. In most instances, but not always, Burlen will be considerably cheaper until you factor in international shipping and handling. Because of the limited numbers produced none of the sources may be familiar with your particular Rolls-Royce and Bentley needs, especially for the older models. You need to conduct a parts search for a particular *type of pump* instead of a particular *car*. B88/14 (*Bulletin* January 1975) provides information on various pump and spare parts numbers. Although written 34 years ago many of the part numbers listed are still the current ones used by Burlen.

The pumps are so similar that with a few exceptions, you can almost assume that if an SU part you find *looks* like what you need, then it probably *is* what you need. That, of course, might not apply to diaphragm springs since it would be difficult to judge a spring's stiffness by looks alone. However, the B88 article states that there were only three different springs used in all the various pumps at least up to 1975.



I
A modern-day flat cap (r) and pedestal (l) for SU fuel pumps.

The pump bodies all have an ID of approximately 2" so the end caps are nearly all interchangeable. The later pumps had vents built into the caps but the nearly identical earlier pumps operated without such a vent so it is unclear why vents were deemed necessary. A "correct," modern replacement cap for a Wraith would be the flat-topped one **1** which is as the original except that the pump type, "HP" and "12V" are not molded into the cap. The new pedestal shown with the cap is slightly sturdier than the original but otherwise also interchangeable.

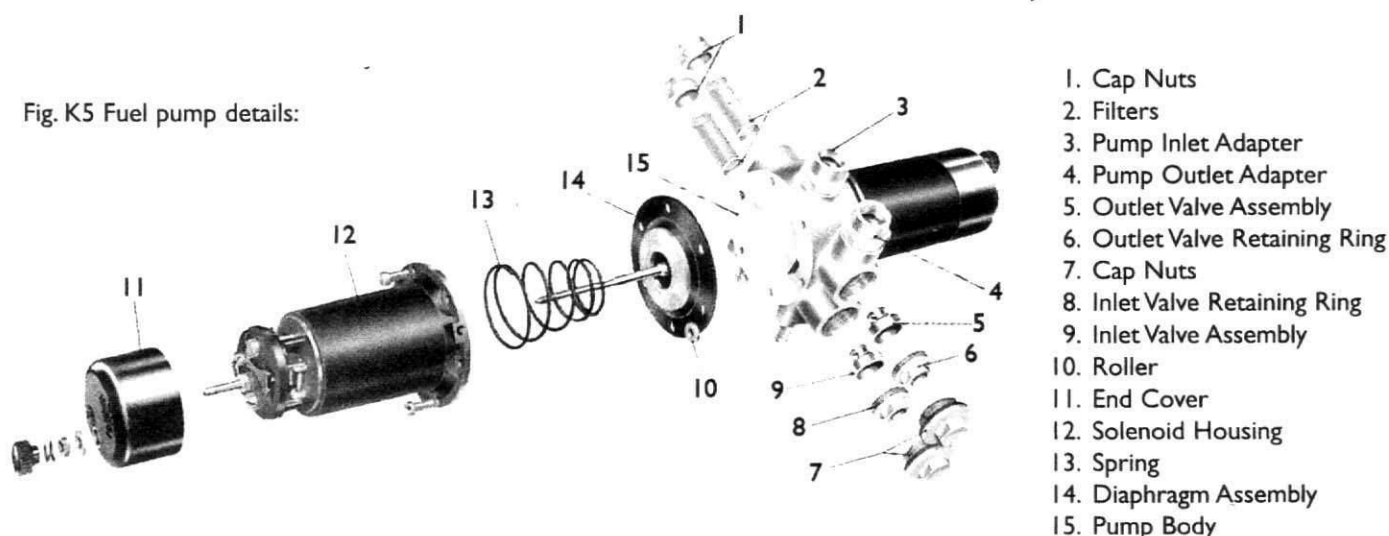
Later pump models added a somewhat bulky capacitor alongside the points so a stepped cap was needed. Originality aside, except for details such

A type HP dual fuel pump is shown in the Wraith handbook **2**. The letters in the lower right hint that the same pump was also used on some P III cars. Figure K5 in the Silver Cloud workshop manual **3**, shows how similar the pre-Shadow postwar pumps were to the pre-war ones. The obvious differences for the Cloud are the filter screens on the inlet and the lack of brass air chambers on top. Those chambers were similar to the anti-air-hammer stubs on household plumbing situated near water faucets or valves. For an SU pump the chambers are not so much to quiet the plumbing but, as the Wraith handbook states, "to smooth out the pulsation of the delivery." Liquid that the carburetor float won't accept immediately is pushed into these

discs (17) with a simpler nylon guide plate (18) was a more subtle change that could be retrofitted to any of the pumps. Atop the SS outlet pressure chamber there is now an air bottle (1) which revives the prewar air chamber function but with a diaphragm (not shown) separating the air from the fuel. Thus, the possibility of the air dissolving into the fuel is eliminated.

As on the Silver Cloud pump **3**, all of the pumps use a nearly 3"-diameter flexible diaphragm (14) clamped inside a clamshell-like cavity (left, open side of 15) with fuel on the #15 side only. The coiled spring (13) is on the non-fuel side of the diaphragm which forces the diaphragm, and fuel, forward (to the right) towards the engine. Just before the diaphragm

Fig. K5 Fuel pump details:



3

The Silver Cloud fuel pumps (from Workshop Manual TSD 729).

as the capacitor, a cap-mounted fuse, or a vented cap, any of the caps will fit any of the pumps.

It is a similar situation for the neoprene pump covers, DW544. As the part number indicates, these covers were first used prewar on the Wraith. (The Mk V is the only other prewar model to use the covers.) But the same identical cover with the same part number is found on cars through at least the Silver Cloud series. There was a Silver Cloud Service Bulletin in 1959 saying that the rubber covers weren't all that effective and instead suggested using a wide rubber band, UD 4901. For this and other updated items, exactly which should be used on a particular car is often an owner decision.

chambers, compressing the air above. The resulting air pressure will then help push the fuel forward until the pump can tick again. A problem with such chambers in household plumbing is that over a few months the air is absorbed into the water and the system must be drained to recharge the chambers with air. This likely happens with fuel as well although at an unknown rate.

Figure K7 from the Silver Shadow workshop manual **4** shows the first significant update of the pump hardware. The magnet, diaphragm, and contact switches stay essentially the same but the flat brass valve discs have been replaced by newer hardware (items 19, 20, 21, 22). The replacement of the eleven brass locating

touches the forward end of the clamshell a set of electrical contacts (unnumbered) on the rear of #12 close causing the electromagnet (12) to pull the diaphragm to the rear which draws in more fuel for a repeat of the process. The pressure from the pump is determined solely by the force from the coiled spring (13). There are no adjustments that can measurably affect pressure and as long as the original spring is in good condition and there are no physical blockages the pump output pressure should be proper.

The pumping area of the diaphragm is roughly 2" in diameter or 3.14 in². A compressed spring force of 6.28 pounds will provide an output pressure of 2 psi. The difference between a high- (type HP) and a low-pressure (type L) pump is

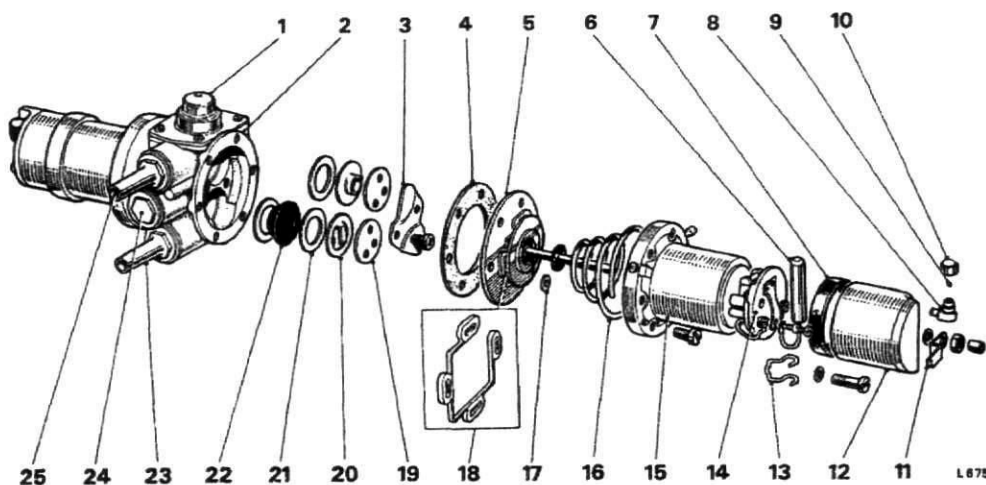


FIG. K7 EXPLODED VIEW OF FUEL PUMPS

- | | | |
|--------------------------|------------------------------|-------------------------------|
| 1 Air bottle cover | 9 Valve ball | 18 Nylon armature guide plate |
| 2 Pump body | 10 Ventilator cap | 19 Valve cover |
| 3 Clamping plate | 11 Lucar connection | 20 Valve assembly |
| 4 Joint washer | 12 End cover | 21 Sealing washer |
| 5 Diaphragm | 13 Condenser clip | 22 Filter |
| 6 Condenser | 14 Rocker and blade assembly | 23 Inlet connection |
| 7 End cover sealing ring | 15 Solenoid housing | 24 Plug |
| 8 Ventilator valve | 16 Armature spring | 25 Outlet connection |
| | 17 Roller (eleven off) | |

4

The Silver Shadow fuel pumps (from Workshop Manual TSD 2476).

essentially the spring stiffness. For these SU pumps "low" pressure meant 1.5 psi and "high" pressure 2.7 psi. While some of the later pumps developed 3.8 psi there is little need for a pressure reducer/regulator on any car using these pumps. What will be needed is the proper internal spring for a particular car since some fuel delivery systems require the extra 1 or 2 psi from the higher-pressure pumps. As with any pump the maximum pressure is generated with no flow and the maximum flow rate is generated with no pressure.

The literature for the early cars had no flow specifications while the later literature tended to be more specific. For the six-cylinder Silver Cloud/S1 cars the dual pump was to lift fuel 3 feet into the pump and discharge it at a rate of 1 pint (Imp.) in 32 seconds. For the V8 Silver Cloud II/S2 cars, that same volume was delivered in 22 seconds. Each of the Silver Shadow pumps was to lift fuel 10" to the pump and deliver 0.758 liters in 28 seconds at a 4-ft head, i.e. 1 pint in 21 seconds. Each Silver Shadow pump was to deliver the same fuel volume as *both* S2 pumps. Since the diaphragm, electromagnet and contact hardware were essentially unchanged, this increased volume is likely attributable to the updated valve hardware on the Silver Shadow

pumps. Unfortunately, the newer valves are nearly twice the diameter of the older disc type and cannot be retrofitted to the earlier pumps. Incidentally, delivering fuel at a 4-ft head requires the SS pump to generate approximately 1.5 psi at the specified delivery rate.

A slender shaft on the diaphragm passes through the electromagnet body to oper-

shut. Their opening action is similarly rapid. The differences between the two sets are shown in the foreground in 5. The original had a fiber disc at each end of the wider pivot shaft (supposedly to quiet the operation) and the new style has two small protruding arms on the front end that can be bent for adjustment if necessary.

"On modern SU pumps (type SP onwards) the diaphragm should not be flexed when tightening the six securing screws" which suggests that flexing or stretching the diaphragm is no longer applicable.

ate the electrical contacts on the rear of the pump. The original design contacts (right) and the current-style contacts (left) are shown in 5. The old and new contact blades shown at the extreme left and right appear unchanged. The inner and outer arms of either contact set are pivoted together at the rear using a hardened hinge pin (not shown) mounted in the pedestal. Both old and new sets have a nearly identical arrangement of springs that allows the pivoted contacts to maintain a fairly large open gap before they nearly instantly snap

There are differences for these contact sets when installed onto a pump 6. Again, on the right is the old design, left is the new design. The pivot pin ends are barely visible at the right rear as are the contact blades on top of the pedestal; both of these items are essentially identical. For either style, as the contacts close against one another the upper blade contacts move back which produces a wiping motion across the lower mating contacts. This tends to clean the contacts but also makes precise alignment somewhat of a guess. The best one can do is to adjust

them so that the total wiping stroke of the contact arm is centered with respect to the approaching contact. For the earlier Wraith pumps the handbook states "the [open contact] gap at the points is not of vital importance." The lack of anything to adjust is probably one reason for this instruction.

As with the flow data, the earlier literature says essentially nothing about contact adjustment. The later the car, the more detailed the instructions on setting the contacts become.

- **Wraith:** the gap at the points is not of vital importance
- **Mk VI, R Type, Silver Cloud:** 0.030" gap at the contacts and also to the pump body
- **Silver Shadow:** 0.030–0.040" contact gap/blade lift, 0.065–0.075" to the pump body

My measurements indicate that the contact adjustments are rather unimportant unless there is something grossly incorrect. The contacts, diaphragms, and magnet bodies are essentially the same for all these pumps and their operation is not greatly affected no matter which of the adjustment specifications you wish to use.

Since Wraith contacts have no adjustment procedure I simply installed new contact sets as they came from the bag. After reading the detailed Silver Shadow instructions I measured the contact gaps on my already installed pumps. They were essentially correct and no changes

were required. Looking at **5**, the metal of the earlier contacts extends further in front of the contact buttons to form a fixed stop for the outer pivot arm. The metal of the newer contacts is somewhat shorter and these contacts rely upon a metal finger extending forward to perform the same stop function. When the contacts close, the upper contact blade should lift to ensure a positive electrical contact.

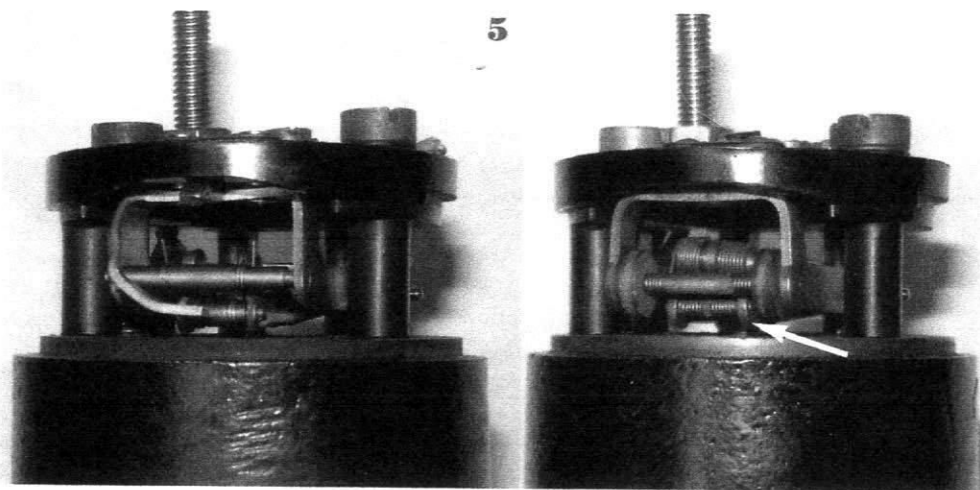
The Shadow manual instructs to "check the lift" of the contact blade but the corrective action indicated is to adjust the contact gap to 0.030–0.040". *Lift* and *gap* are related but not the same thing, making it difficult to know what was intended. From the bag, without adjustments, the installed contact gap measured 0.060" and provided a lift of 0.035". These values seemed reasonable since they have little effect upon operation. As long as the contacts touch, the actual value of the lift is rather unimportant and more is likely better.

Continuing with **5**: Motion of the outer arm in the direction of the magnet body (down) was originally stopped by the fiber wheels at either end of the pivot axis. Those fiber parts are missing from new contact sets and the motion is now stopped by a second metal finger extending forward and down. The exact adjustment of this finger does have a small influence upon the pump operation. The **smaller** the lower gap the **less** distance the outer pivot arm can move downward when the pump ticks. The distance the outer arm moves determines how far the inner arm, i.e. diaphragm, must move before the contacts snap closed. Because

of the geometry involved each additional millimeter of outer arm motion translates to about ½ millimeter more diaphragm movement. A **larger** lower gap **lengthens** the diaphragm stroke and pumps slightly more fuel with each tick. The lower gap is also a measure of the outer arm's total motion which is the sum of contact gap and blade lift from the previous paragraph. Although the effect is negligible, a reduced lower gap must also reduce the upper contact gap and/or lift. The Silver Shadow specification for the lower gap is 0.065–0.075". For a new contact with no adjustment this gap was 0.095" agreeing with the sum of the 0.060" contact gap and 0.035" lift. I saw no reason to change the adjustment since it would slightly reduce the pump's output.

In an attempt to electrically limit erosion of the contact points some early SU pumps connected a resistor across the contacts. Many of the pumps may have been fitted with nothing at all across the contacts. There was a time when a capacitor (condenser 6 in **4**) was fitted and new replacement capacitors are available today. This was possibly better than the earlier resistor but neither was a correct solution. Once the semiconductor diode was invented all the other options were decidedly obsolete. A 1N4001 diode, see insert on *FL* page 8519, provides the best protection for any of the pumps using contacts. A diode is so small that it will fit inside even the flat pump caps and is incredibly inexpensive if purchased at Radio Shack (\$0.50 ea.) or other electronics suppliers.

There is a limited space within the clamshell for the diaphragm to move fore and aft. The heads on old and new diaphragms were 0.43" and 0.50" thick, respectively. At first thought the thicker one would seem to be a problem since it would limit the ultimate stroke of the pump. Taken to the extreme this would be true, however, as mentioned above, the stroke is determined almost entirely by the snap-over action of the contacts and not by the internal space available for movement. Looking at the right half of **5**, one side of the inner pivot arm, attached directly to the diaphragm, is seen nearly resting on the pump body (see arrow). This position



Pump contact set removed from WMB16 (r) compared to current replacement parts (l).

corresponds to the fully relaxed position with the diaphragm pushed fully forward by the internal spring.

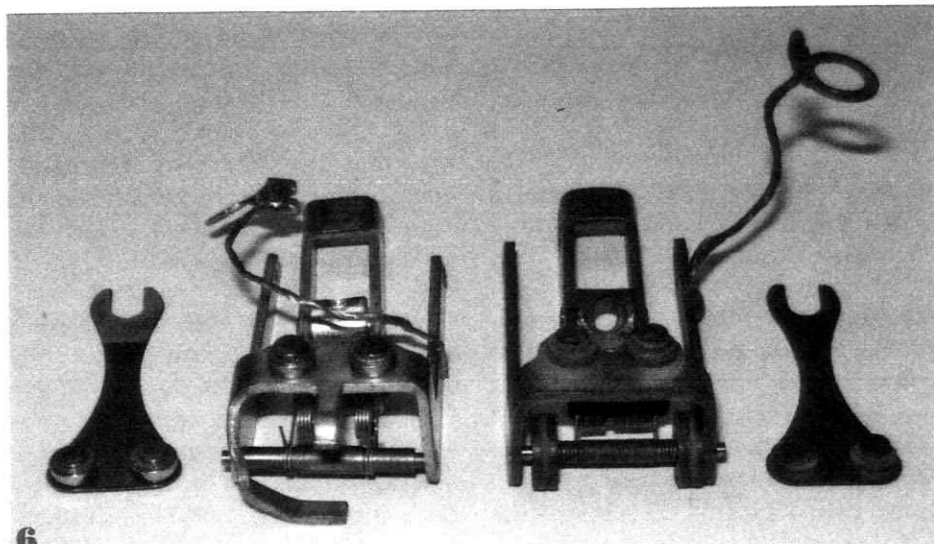
When the electromagnet actuates, the diaphragm pulls this inner arm rearward (up) and the outer arm snaps downward. The result is that the inner arm will stand a few mm above the wider pivot bar. This position corresponds to the diaphragm pulled fully to the rear as it was when the diaphragm was adjusted. As the pump discharges fuel the inner arm moves forward (down) as fuel moves out of the clamshell cavity. When the pump is powered the inner arm will never reach its rest position. Instead, when it reaches about the height of the wider pivot bar the contacts snap closed and the pump ticks. By examining the clamshell dimensions one would expect a maximum stroke of as much as 5 mm. In reality, the contact springs limit the stroke to about 2 mm or less.

What does this mean for fuel flow rate? Using a 2" effective pump diameter and a 2 mm stroke, each stroke of the pump could supply approximately 40 cc of liquid. The earlier pumps are rated at up to 10 gallons (Imp.) per hour. That would be 45,461 cc per hour or 12.63 cc per second. Even recognizing the crude assumptions in the calculations, this tells us that one pump stroke per second should more than supply the *maximum* fuel flow. In other words, although they might tick faster when initially filling empty lines etc., the maximum sustained tick rate of an SU pump is intended to be less than once a second.

If your pump, refurbished or not, ticks once per second when feeding a non-running engine, as those on WMB16 did, you do not have a useful pump even though it ticks. I would also disregard the words saying that one of the two plies of the pump diaphragm should have a hole through it. None of the ones examined have, or ever did have such a hole, and why should they? Manufacturing cost cutters would have eliminated that second layer if it did not serve a purpose. The purpose of a double-layer diaphragm is to provide some extra lifetime if one layer happens to develop a perforation. Neither layer should originally have a hole. In fact, don't be surprised if a modern diaphragm is made with only a single ply.

Many older documents instruct that the diaphragm should be stretched while the six bolts of the body are tightened. The instructions are confusing and contradictory on this aspect with neither "stretching" nor the direction of stretch being clearly defined. Some texts instruct to pull the pivot pin to stretch the diaphragm. Others instruct to insert a matchstick under the outer pivot arm to force the contacts closed to energize the magnet. The Mk VI manual instructs to do either of these as alternatives. A third method uses a screwdriver under the inner pivot arm. The latter two pull the diaphragm to the rear while the first does the opposite, allow-

There are two styles of diaphragms which differ in the length of their shaft: one is 2 3/8" the other 3". In the correct housings the operation and adjustment of either is identical. If the shaft is screwed in too far the contacts can never snap open when the shaft moves. Starting from such a non-opening contact condition the adjustment procedure is to push the diaphragm rearward to its stop and screw the diaphragm out until the contacts barely open. The "standard" adjustment is then to back the shaft out an additional four bolt holes which is 3/4 turn of a 4BA thread or 0.017". However, this is not a magic number. It is intended only to



6

Old- (r) and new-style (l) contacts installed on an SU pump.

ing it to move further forward, although only slightly. In some instances the first method may do nothing at all. The inner pivot arm on the left in 6 is not resting on the pump body. Pulling this pivot pin will do nothing. Experimentation has shown this step to be unnecessary and potentially detrimental since it can alter the rest position of the inner pivot arm. It is believed to be an outdated instruction for old-design diaphragms. The Shadow manual from 1971 does not mention anything except to tighten the six screws. An *Auto-car* SU pump article reprinted in 1972 on *FL* pages 1436-8 states: "On modern SU pumps (type SP onwards) the diaphragm should not be flexed when tightening the six securing screws" which suggests that flexing or stretching the diaphragm is no longer applicable. By the way, it will be easier for you to understand the above *FL* reprint if you realize that pages 1437 and 1438 should be read in *reverse* order.

ensure that the contacts will snap open when the pump is being operated cold, hot or however. In fact, the various RR manuals specify this adjustment to be anywhere from four to eight bolt holes. Within obvious limits this adjustment is unimportant as long as the pump ticks. The exact positioning of the diaphragm within its cavity will be slightly changed but the length of the stroke, which does the pumping, and which is determined by the contact springs will be unchanged.

Although *FL* page 485 suggests that the pump tick rate can be changed by altering this diaphragm adjustment, my experiments prove otherwise. As long as the contacts snap open, the tick rate is determined by the springs in the electrical contacts and the flow rate inside the pump (from both leakage and engine demand). If the pump clicks once and then stops **completely** then the dia-

phragm is likely adjusted too far **in** and should be backed **out** which is opposite to the advice of FL p. 485. An additional correction to note in that article is that its *Figure 1* is incorrect in showing the contacts on the battery side of the magnet coil; the contacts are always on the earth side of the circuit.

The characteristic "tick" when a pump operates is mostly the sound of the contact points and springs clicking as they switch the electromagnet on and off. After the first few ticks pressurize the lines with the engine off, the pumps should theoretically *not* tick, indicating there is no fuel demand. The more fuel demand, the faster the pumps should tick. Contrary to the suggestion that these pumps work nearly as well pumping air as they do fuel, it is nearly impossible to judge pump health by using only air. If powered in air the pump will tick rapidly which tells you only that the electrical bits are operating. By blocking the output with your thumb the pump might slow

a bit but it will be impossible to build enough air pressure to make the pump quit ticking. You will not be able to tell if the "no flow tick rate" (NFTR) is acceptable. For that you need to pump a liquid.

From the Wraith handbook: "If the pump struggles in its work and becomes very hot, it is an indication that there is an obstruction somewhere in the pipeline." If the inlet line is blocked the magnet may not be powerful enough to move the diaphragm. In this case the contacts will not open and the magnet current will be continuous and quickly heat the coil. However, since the pumps are meant to tick less than once per second, anything that causes them to tick rapidly can cause them to heat although not as much or as rapidly as a blocked inlet pipe. The pump inlet (suction) and outlet (pressure) valves which tend to be ignored in most literature must be in good working order or any pumped liquid will leak backwards causing the pump to tick rapidly. In the Shadow pumps these valves became a plastic flapper but the originals were a plain, flat, 0.018" thick brass disc of 1/2" diameter. Some of the earlier brass valve discs had a cross-hatch pattern on one side for unknown reasons. If this pattern is placed against the valve seat the valve can never seal effectively. They may not seal correctly even if properly oriented. With the pump sitting upright both fluid flow and gravity have a part in opening and closing these valve discs which must seal against a plain brass seat. In the assembly shown in **2**, the upper pressure valve and seat (E, H, I) are completely removable and replaceable if needed. The lower suction valve seat is permanently pressed into the body and only its brass disc (K) can be replaced.

The non-replaceable nature of the lower seat in the earlier pumps can cause problems and may well be the reason for occasional admonitions against attempting to rebuild pumps that use the flat brass valves. Roy Bertsch was trying to give us hints with his words on FL p. 1295: "Check valves in the pump body and lap them if necessary." With no further explanation it was not immediately obvious what Roy was saying. The valve discs each move very little vertically: H is stopped by the spring clip I, and K bumps against the bottom of the valve cage E. For both discs the total motion is about 0.025" which is determined by the dimensional accuracy of the various valve and pump body parts. Thinking that the lack of a sealing washer under the valve cage E was allowing fuel to leak around the cage, I placed a red fiber washer under E to better seal that path. Unfortunately, this allowed the suction valve disc to move vertically almost twice its normal distance which proved self defeating. The valve disc moved further, it took longer for fluid backflow to seal the plate onto the seat, and the resultant leak rate through the valve was greatly *increased*, not decreased. The washer was quickly removed. Although such washers are used in other models of SU pumps they weren't helpful for this one. What might work in a similar pump may not work particularly well as a retrofit to others.

Part II will conclude this series with specific methods for testing and repair of SU fuel pumps.

ALPHABETICAL LISTING OF SUPPLIERS FOR SU PUMP SPARES

Burlen Fuel Systems Ltd.
Spitfire House, Castle Road, Salisbury
Wiltshire, SP1 3SB, UK
44 (0)1722 412 500
<http://www.burlen.co.uk/>

Fiennes Restoration Ltd.
Clanfield Mill, Little Clanfield
Bampton, Oxon OX18 2RX, UK
44 (0)1367 810438
<http://www.fiennes.co.uk/>

Little British Car Company
29311 Aranel
Farmington Hills, MI 48334
800-637-9640
<http://www.lbcarco.com/>

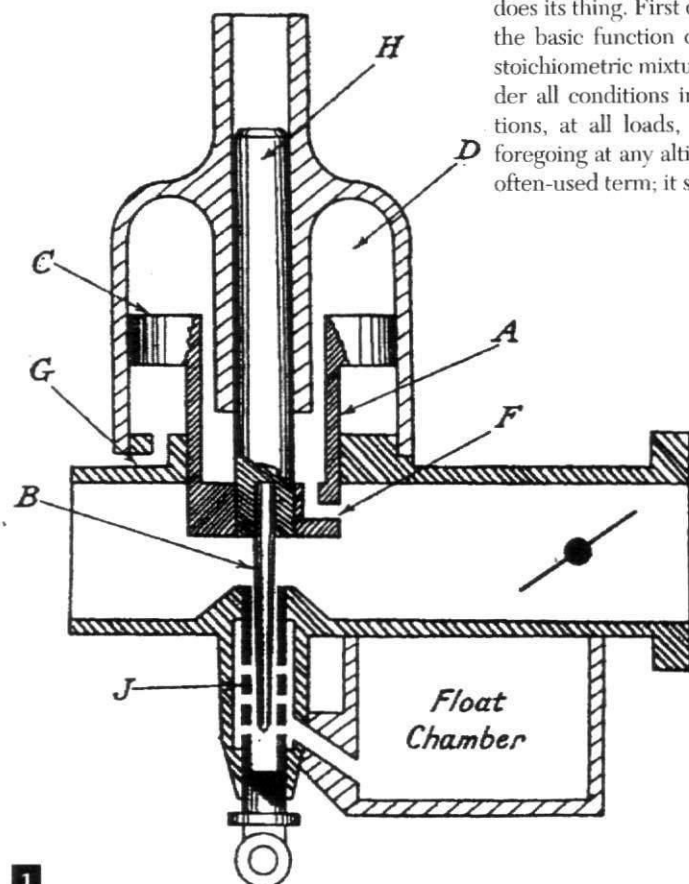
Moss Motors Ltd.
440 Rutherford Street
Goleta, CA 93117
800-667-7872
<http://www.mossmotors.com/>

Victoria British Ltd.
14600 W. 107th Street
Lenexa, KS 66215
800-255-0088
<http://www.victoriabritish.com/>

XKs Unlimited
850 Fiero Lane
San Luis Obispo, CA 93401
800-444-5247
<http://www.xks.com/>

It's probably a safe bet to say that 50% or more of British cars built between the end of World War II and the early '70s were fitted with the fascinating but idiosyncratic S.U. carburetor. This includes everything from high-end luxury cars such as Rolls-Royce, Bentley and Aston Martin to low-end grocery getters such as Austin, Morris and MG. A few holdouts chose not to use S.U. carburetors. These included the Rootes Group (Sunbeam and Hillman) and Vauxhall. Many prewar cars were also fitted with S.U. carbs. A good example being the pre-Derby Blower Bentleys with their huge supercharger protruding through the radiator with an S.U. bolted to it.

The most commonly asked question is: what does S.U. stand for? It stands for Skippers Union. Invented by the three Skinner brothers at the turn of the 20th century it originally used leather sealing washers instead of the aluminum piston. The Skinners were in the leather business at the time and therefore needed another outlet for their production facilities.



1 This simplified cross section shows the key components that make up the S.U. carburetor. Note that in this view a partial throttle opening is depicted, i.e., the throttle butterfly is open approximately 50% and consequently the piston has risen to a similar 50% of its stroke, provided the engine is under load. If the engine was not under load, the piston would not rise as high.
A. Choke piston; B. Needle; C. Suction piston; D. Suction chamber; F. Manifold pressure duct that communicates with top of suction piston; G. Ambient pressure duct that communicates with underside of suction piston; H. Guide rod J. Main jet showing fuel feed holes

S.U. Carburetors

Theory and Practicalities

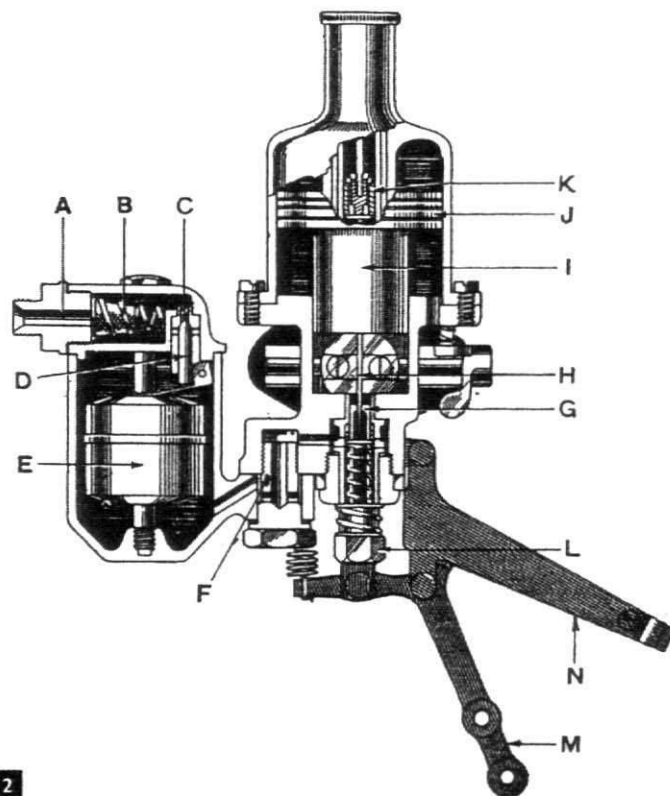
By Graham White (NC)

S.U. carburetors work on the so-called "constant vacuum" or "constant velocity" principle. With this in mind, forget about anything you ever learned about conventional carburetors, these things (S.U. carbs) are a very different animal. However, regardless of the type of carburetor employed, the final outcome is the same: meter the correct amount of gasoline at all throttle positions, engine speeds and power settings. The engine doesn't care how this function is performed just as long as the appropriate amount of fuel/air mixture gets into the cylinder.

Let's take a look at how an S.U. carburetor does its thing. First off we need to understand the basic function of a carburetor. Ideally, a stoichiometric mixture is fed to the engine under all conditions including all throttle positions, at all loads, any rpm and do all the foregoing at any altitude. *Stoichiometric* is an often-used term; it simply means a chemically

perfect mixture. If the exhaust of an engine running a stoichiometric fuel/air mixture is analyzed, no unburned fuel will be detected and there will be no unused oxygen. If the mixture was rich, that exhaust analysis would reveal unburned fuel. Likewise, if the mixture was lean, the presence of oxygen would be evident in the exhaust. Even the so-called chemically perfect stoichiometric mixture isn't always the ideal mixture. For maximum *power*, a mixture slightly *rich* of stoichiometric is preferable. And for maximum *economy* a mixture slightly *lean* of stoichiometric is preferable.

Most carburetors are a compromise to the extent that they do not supply a perfect mixture throughout all operating ranges. Under some conditions a rich mixture occurs and in other operating conditions a lean mixture exists. This is especially true with fixed-jet carburetors. However, an S.U. can overcome some of these compromises. Measuring mass air flow through the intake man-



2 A cross section through the carburetor. A. Banjo fitting for fuel supply from pump; B. Fuel filter and spring; C. Float chamber needle valve seat; D. Float chamber needle; E. Float; F. Float chamber securing union bolt; G. Main jet; H. Tapered needle; I. Choke piston; J. Suction piston; K. Oil damped damper; L. Main jet adjusting nut; M. Choke lever; N. Outer cable clamp



ifold is the key. S.U. carburetors perform this function by comparing the MAP (manifold absolute pressure) against ambient pressure. On a "standard" day, at sea level and 59° Fahrenheit, the atmospheric pressure is 29.92 inches of mercury. In other words, if a perfect vacuum were pulled at sea level under standard day conditions a column of mercury 29.92 inches tall could be supported. At higher elevations, the atmospheric pressure drops roughly in the proportion of one inch of mercury for every 1,000 feet. As an example, at an elevation of 5,000 feet, the atmospheric pressure would be approximately 24.92 inches of mercury. The figures quoted are for a standard day and of course in the real world nothing is standard; that's one reason why we have weather variations. The fact that S.U. carbs have the capability of measuring mass air flow means that they are not affected by altitude. With conventional fixed-jet carburetors, the mixture richens with altitude. In other words, if a fixed-jet carburetor has its mixture correctly set for sea level conditions, at higher elevations the mixture will be rich.

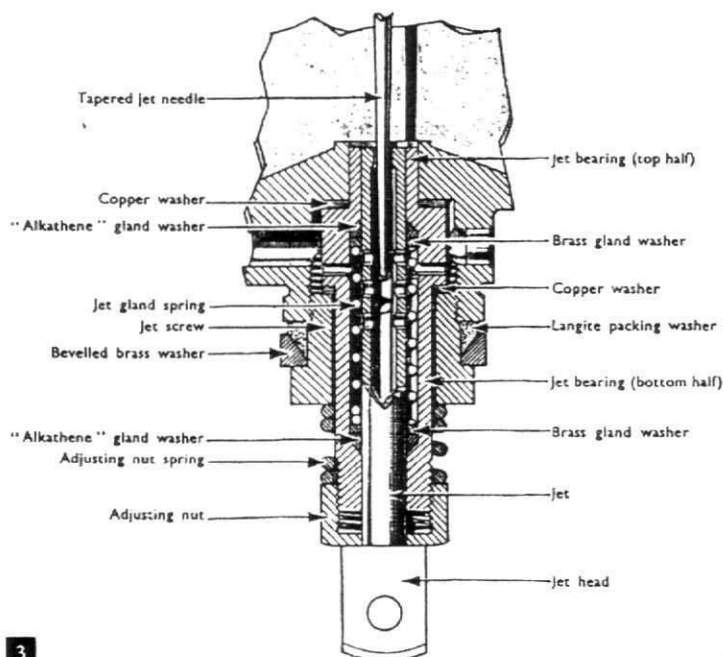
So now the question is, how does the S.U. measure mass air flow? The answer is disarmingly simple. If we refer to **1**, a floating suction piston, item **C**, rides in a cylinder which also gives the S.U. its characteristic shape. Integral with this piston is a smaller-diameter choke piston, item **A**, which governs the effective choke area of the carburetor. Duct **F** is open to chamber **D** above the piston. In other words, suction chamber **D** is exposed to manifold pressure

in front of the throttle butterfly or something less than ambient. The bottom side of piston **C** is exposed to ambient pressure via duct **G**. In this way, the piston **C** will rise and fall depending on manifold pressure in front of the throttle butterfly. To keep things in alignment, an accurately ground guide rod, item **H**, runs in the suction chamber casing. To assist the suction piston drop to its lowest position when the engine is shut down a light coil spring is used to augment the piston's weight. A long, tapered needle valve, item **B**, attached to choke piston **A**, also rises and falls in unison with the piston assembly. Tapered needle **B** rises and falls in a fuel jet. As the piston assembly (and consequently the needle) rises, the tapered needle exposes a larger annular gap in the main jet which allows more fuel to flow into the intake manifold. The main fuel jet communicates with the float chamber via a number of holes drilled in its periphery. When the engine is shut down, the pressure above and below the piston is the same, i.e., ambient, therefore the piston will drop to its lowest position under the influence of gravity and the light coil spring.

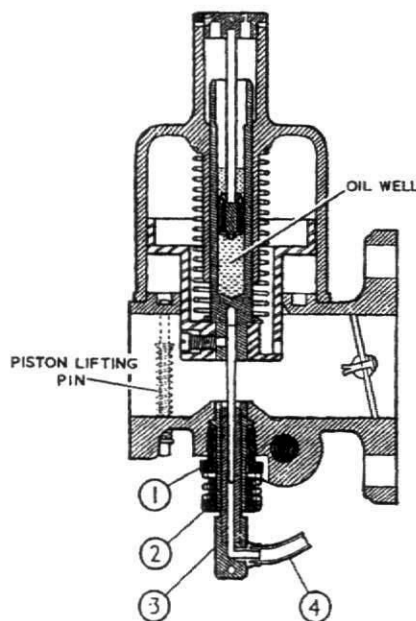
The foregoing is a very basic—perhaps oversimplified—explanation of how the S.U. operates. Now we need to look at other operating conditions such as cold start and accelerating. For cold start operations a richer than normal mixture is required. The S.U. accomplishes this by the simple means of dropping the main jet, item **J** in **1**. By doing this a larger annular gap is exposed to

fuel. When the throttle is quickly opened, a momentary rich mixture is required, otherwise the engine will suffer a lean stumble until things get stabilized. Conventional carburetors just use a small-diameter rubber piston running in a cylinder that squirts the appropriate amount of raw gas into the intake manifold. S.U. carbs accomplish this task by restricting or slowing down the rate of ascent of the piston assembly, consequently choking off the intake and forcing a richer mixture into the intake manifold until the piston rises. Although not shown in Fig. 1, a small-diameter piston runs inside guide rod **H**. Item **K** in **2** shows the damper. Attached to this piston is a rod with a thumb screw at its end which screws into the top of the suction chamber casing. Guide rod **H** is filled with a light oil. Therefore, if the piston assembly tries to rise rapidly, its progress is retarded by the dashpot piston running in the oil. As many S.U. owners know only too well, keeping the dashpot filled with oil is an ongoing chore.

One feature of the S.U. that is unique in the world of carburetors is the ability to change mixture strength without changing jets. As we've already seen, the amount of fuel allowed to flow into the engine is determined by the annular gap created by the needle and main jet. If the main jet is lowered then the mixture will be enriched throughout the operating range. Likewise if the main jet is raised the mixture will be leaned throughout the operating range. Raising and lowering the main jet is an easy (too easy?) task performed by simply screwing in the main jet adjusting



3 A close-up of the all-important main jet assembly located at the bottom of the carburetor. Various needles and main jets can be installed for an almost infinite degree of adjustability.



4 The piston lifting pin. If this is not fitted then the piston can be raised with a screwdriver. (1. Lock screw, 2. Jet adjusting nut, 3. Jet head, 4. Fuel supply from the float chamber.) Note the oil well inside the guide rod. This is the infamous dashpot that needs to be replenished with oil on a regular basis.

