SECTION 2 SUSPENSION AND STEERING

GAZETTE No 1 AUGUST 1969

(Revised May 1991)

1 THE REAR AXLE

The saddest thing that one can read in a report on an interesting and historical motor vehicle is a phrase such as "No example of this make is now in existence". Yet many people who currently own such vehicles do not recognise their responsibility to preserve them. Post World War 2 cars seem to suffer greatly from this, the coachbuilt Healey being far more neglected than the 'Silverstone‘ (bearing in mind the fact that Silverstones represent less than 10% of the output from Warwick.)

This is probably because the Silverstone is an extremely simple all metal structure, whereas the coach built variety are a nightmare of small pieces of wood (decayed) screwed together from the outside and then covered with aluminium so that no one dare try to remove it.

Having decided that something must be done, you must now decide who is going to do it. If you are disgustingly rich, you might persuade a member of the motor repair trade to take an intelligent interest in your car , but if you are that rich you will probably be in the Lamborghini or Bugatti Owners Club. It is therefore inevitable that you will need to do most of the work yourself. It will help to own, or have access to, a decent set of tools, a spray plant, welding plant (gas and M.I.G), a workshop manual and a workshop. This last requirement is by far the most difficult to obtain. In the past I have done as much work as possible in my rented 'Lock-up‘ and then hired a corner of someone’s workshop for the final spray session. Odd bits and pieces were sprayed upstairs in the spare room, together with the walls, the windows, and anyone standing outside on the pavement (As I wrote this in 1969, it was to be 1985 before I had saved enough to buy a house with double garage),

All this may seem somewhat daunting, but the "Association of Healey Owners" has been formed so that the collective knowledge gained by those who have solved (or failed to solve) various problems shall be available to those who require it.

For this year (It was to be ten years, I was conned!) I have the task of handling technical queries and trying to find reasonable answers. I regret that I am not in a position to accept work, and can only offer moral support and advice. However, if a subject is somewhat involved for correspondence, I may be willing to make a personal visit, time and distance permitting, providing I get a cup of tea. Meanwhile, let us consider the problem of that curious artefact — the Riley torque tube type rear axle.

I once wrote an article for the Healey Register (A.H.C) to encourage owners to attempt the replacement of worn bearings immediately ominous noises become apparent, in order to preserve the 3.5 to 1 crown wheel and pinion, which is unobtainable. I shall now enlarge upon this subject and include comment on some modifications to the torque tube and propeller shaft.

This type of axle is fitted to chassis types A,B,C,D & E. Remove the seats and universal joint cover. With the car in its normal (not jacked up attitude, check the wear on the joints by using two spanners to rotate the two yokes of each joint in opposite directions. It is not easy to detect slight wear once the joint is removed, since the needle rollers cause indentation in their natural position.
Check also that the angle between the axes of the engine and the propeller shaft is equally shared between the two joints, when the car is carrying it normal load.

The axle must weigh about 2 cwt at least, so a trolley jack is desirable, but I have used lengths of timber as rails and run it out on its brake drums. The timber must be thick enough to keep the lowest points of the spring nuts clear of the ground when the trunnion is lowered to the ground. The car must now be safely blocked up high enough to allow the axle to roll under the fuel tank (or bodywork on the Silverstone), and the oil drained.

Jack up the axle slightly to take the weight off the retaining cables. Remove wheels, shock absorbers, the top end of the flexible hydraulic brake pipe, the lower ends of the retaining cables, hand brake cables and Panhard Rod.

I have also found it helpful to remove the stay rods which brace the axle to the torque tube as this facilitates the forward movement of the assembly necessary to enable the trunnion to be unscrewed.

Remove the universal joints and check the coupling drive flange on the propeller shaft for excessive free play. Remove the flange, and note whether the boss of the flange shows any sign of contact with the inside of the trunnion; bright rub mark or heavy scoring.

Unscrew the trunnion pinch bolt, taking care to retrieve the spacing piece from the slot. Remove the trunnion rubbers and cups. Move the axle forward as far as it will go and unscrew the trunnion from its housing. To wheel the axle out from the propeller shaft tunnel is fairly difficult, since one needs to start with the diff end fairly high, lowering it just as much as is necessary to pass under the fuel tank, since the pinch bolt lugs foul the top of the tunnel, whilst the stay rod lug fouls the chassis cross member. It is because of this, that the trolley jack is the preferable method of support, while the whole proceedings will be facilitated if two or three people are involved. Once the assembly is on the floor, one may consider the external condition of it. It may be like mine, totally free from rust or oil leaks, and coated with a nice thickness of black gloss paint. On the other hand it may be filthy, rusty and/or oily. The source of any oil leakage is best ascertained at this point. There is a tendency for the domed pressing which covers the differential to crack adjacent to weld which fixes it to the axle case. There is also a breather hole on one side of the casing which can be improved by the addition of a vent pipe.

The whole assembly should be thoroughly cleaned and any rust removed. the surface can then be treated with a rust neutralizer such as Jenolite, ready for painting after reassembly. On the "C" type etc. the spring mountings are a composite arrangement of mag alloy casting with steel side plates, which can get badly corroded. Dismantle, clean and paint.

The assembly is now ready for dismantling.

It is desirable that all parts be marked in some way to ensure that they return to their original location, for instance, the brake back plates are left and right handed, the rectangular holes into which the slave cylinders are fitted being off—set toward the trailing shoe (opposite end to the snail cam adjuster).

Some were probably assembled at Warwick the wrong way round, since mine, and at least one other were found to be so at a very early age, so check this point, or the trailing shoe will barely touch the drum. One simple method is to fully apply the brake, carefully remove the drum, then see if the cylinder will move any further toward the trailing shoe.

The bearing housing and back plate are fixed to the axle with eight 3/8" B.S.F. nuts and bolts.. There are also two 5/16" set bolts fixing the back plate to the bearing housing. Remove these, and using two longer (about 1"-1/4") bolts, jack the bearing housing out of the axle casing.

To inspect the bearing and oil seal it is necessary to remove the half shaft from its bearing. Flatten the locking washer and remove the nut with a 1/8" tube spanner (I made a hair pin type toggle for mine). The housing can normally be bumped off quite easily, if not, a long puller must be made up.

The Riley half shaft is a classic case of "If it looks wrong, it is!" A shaft of massive dimensions, suddenly reduced to a very small splined section. It will break with monotonous regularity unless machined to a more normal tapered profile. This will also reduce the weight by about 3lb each!

(By 1978 the scarcity of 2 1/2 litre shafts made it expedient to convert 1 1/2 litre shafts to fit. This involves either fitting a pair of sleeves over the bearing and oil seal areas, or machining the shaft down and fitting a stepped sleeve at this point. My machinist used the latter method, but unfortunately, one shaft had a grease nipple hole at this point. In 1990 this shaft fractured, allowing the wheel to come off:- Beware!).

Next, we will consider the torque tube. This is a natural disaster area. Commencing with the trunnion assembly, and referring to Fig.2, it can be seen that the suspension coil springs of the Healey, by applying the weight of the car in front of the rear axle, cause a downforce at the trunnion in proportion to the ratio of the two measurements involved, (in contrast to the Riley, where the leaf springs work directly on the axle). This causes the thread to wear on the top front, and lower rear areas, allowing the front to tilt upwards, and impinge on boss of the drive flange.

This puts a lateral load on the spline, and causes a noise exactly like an epicyclic gearbox. It was many years before I solved this one. At a mileage of 220,000 I measured 0.007" of wear on the trunnion below the pinch bolt, no doubt there was similar wear inside the sleeve.

I visited my local Riley breaker, and four trunnions were examined. To my surprise, the original thread diameter varied 0.015" in varying increments} I do not know whether selective fitting occurred originally, or whether oversize trunnions were obtainable as aftermarket spares. I selected a good low mileage sleeve, and mated it to the largest trunnion. The Riley manual suggest a stiffness torque of 35-55 ft.lbs with the pinch bolt tight.

The sleeve is fitted to the torque tube and located by six dowels. These are positioned at random, so the original holes were welded up and filed smooth. The sleeves do not seem to be a very tight fit, so I used 'Loctite' to fit the new sleeve before drilling the new dowel holes, I used a tapered reamer and dowels for a nice secure job.

The pinch bolt lugs are fairly rigid, and cannot be expected to take up anything but the minutest amount of wear.

The trunnion ball race fits into an adaptor (Part 105, Fig.1). This sometimes slips round in the torque tube with a hideous screech. I have an opinion that this may be caused by the fact that two row races have a ball feed track at right angles to the running track which might cause snatch. I therefore use a two row self aligning race which can be assembled without feed tracks. Use 'Loctite' for reassembly.

In the unlikely event that the above ball race/adaptor is a tight fit in the torque tube, it may be necessary to make a clamp to fit on the shaft, so that it can be jacked out using the trunnion.[*JJ 2023 If you don't have access to a machine shop an easier solution is to buy a Double Split 1" Shaft Collar from eBay or a bearing supplier.*]

From a noise abatement point of view, the propeller shaft has great potential for trouble.

At the trunnion end I have found one 0.007" slack in the ball race. This was cured by metal spraying and regrinding between the two circlip grooves.

The shaft is long and whippy, so that any play in the centre bearing bush will allow vibration which is no doubt amplified by the torque tube. The bush has no provision for serious lubrication, and with a maximum speed of 5000 r.p.m. excess clearance may well develop. A new bush should be manufactured from 'Oilite' porous bronze. It should be soaked in oil for at least 24 hours before fitting. The fit should be tight in the housing, while still having a reasonable fit on the shaft, since it would be difficult (impossible?) to reamer the bush in position.

Some years ago I examined a Ford E93 type torque tube, which has an even longer propeller shaft, but it is tubular, and has a better weight/stiffness ratio and does not require a centre bearing. I therefore fabricated a tubular propeller shaft for the Healey. This was made from the good ends of two damaged shafts, a piece of 2" outside diameter tube and two turned adaptor pieces. The most difficult part was removing the centre bush housing (Item 45, Fig 1) since it is dowelled and welded. It would have been easier to fit a new torque tube! The modification is an improvement on the original equipment.

The propeller shaft is connected to the pinion by means of a muff coupling (Item 40. Fig.1) It may be found that the coupling is going rusty, due to the aforementioned lack of lubrication arrangements in the torque tube. The drive surface area of the spline is too small for the stress involved, even under ideal conditions, but dry rust causes rapid wear. I have therefore welded a 1/4" bore steel pipe (which is spoon shaped at the end, to collect oil thrown forward from the top of the crown wheel) through a hole in the front casing flange (where this mates up with the top recess on the axle casing flange) and down through a hole above the front end of the coupling.

This pipe must run very close to the differential casing, as there is not much space between the torque tube and the rear end of the chassis tunnel. To prevent the entire contents of the differential casing from being pumped into the torque tube a 3/8" bore steel pipe was then welded through a hole half way up the side of the differential casing near the coupling, and running down to the bottom of the case, to act as an overflow.
This has been a total success.

A muff coupling has two important dimensions, the fit of the sides of the spline control torsional forces only, whilst the alignment and tightness of the shafts are controlled by the base diameter (the smaller diameter) of the spline.

The fit of the coupling on the pinion should be very tight, (it may well need some sudden heat from an acetylene flame to remove one}. The fit on the propeller shaft should be a push fit, with no clearance on the base circle, otherwise when the sides of the splines wear, the shaft will rattle up and down under light load conditions.

If the propeller shaft has proved too tight to remove, one can drive it out from the pinion end, once the pinion assembly has been removed.

The next stage is to remove the differential casing from casing from the axle casing and thoroughly clean all the internal parts.

The setting of the crown wheel and pinion will be lost bearing caps are removed, so mark the differential bearing housings and caps (I use white Tippex) so that one can reassemble in a similar location, and remove the differential assembly.

The Riley Workshop Manual shows a tool for engaging the slots in the pinion sleeve, but even if you had one, it would not pass over the twelve tooth pinion of the Healey, as it is of larger diameter. If you have machine shop facilities you could make a similar tool. I fabricated mine from scrap metal as indicated in Fig.5. I cut the tube to form two prongs, which were then bent inward to fit the pinion sleeve. A piece of 1/2" square was bent into a circle, and welded into the opposite end of the tube to form a landing for a thrust race.

The tool is held in place with a fabricated three leg spider fixed to the differential casing by means of three lengths of stud iron.

Fig.4 shows a simple tool for holding the differential casing and torque tube during the coming struggle, since the assembly is impossible to secure in a vice without it.

Remove the locking screw (Item 102, Fig 1) and unscrew the pinion assembly, making note of any shim washers which may be under its shoulder.

A ballrace may have no apparent wear when assembled, yet when cleaned, and inspected closely, have pitting on the balls or tracks and even broken cages, especially if they are of the modern cheap and nasty type! Therefore I strongly recommend that you remove and thoroughly inspect all bearings.

Remove the wire circlip and grub screw from the muff coupling, and remove the coupling. Note that when reassembling, the grub screw locates in a cut away in one spline on the pinion.

Straighten the pinion tab washer (Item 23) and remove the two lock rings (Items 21 & 22), The removal and replacement of these rings will greatly facilitated if you make two thin spanners to fit. Reassembly requires these to be set to give a slight preload on the pinion thrust bearings.

The removal of all bearings will be self evident. Take note of any bearing which has fretted itself loose on any of its mating surfaces, and use 'Loctite’ during its replacement

When refitting the larger component of the main pinion thrust race, take extreme care not to pick up metal from the bore of the pinion sleeve, as this will remain trapped, and cant the race out of true. It is probably a good idea to grind a slight chamfer on the back of this race to prevent this happening.

Assemble the smaller thrust race, the thick lock ring next to the race, the lock washer and the thin lock ring. Adjust the lock rings so that a slight resistance is felt when the pinion is rotated by hand when both rings are tight then bend the lock washer into a slot in each ring.

Fit the front pinion bearing, followed by the muff coupling. This should be a very tight fit, so access to a press will be an advantage. Press the coupling on until the grub screw hole is centralised on the spline cut-out. Replace grub screw and spring ring.

The pinion assembly is now ready for refitting into the differential housing, together with any shims which were previously fitted. As the front pinion bearing may have fretted the housing, I suggest application of some Loctite to its outer surface, just in case.

Assemble the differential, and fit this carefully into its threads, with the near side bearing housing in its original position. Tighten the bearing cap bolts, then slacken them off enough to allow movement of the bearing housing. From this point I have a difference of opinion Riley Service Manual on the position of the diff. bearings when checking the backlash of the teeth.

The differential assembly is located only by one thrust bearing and relies on the reaction from tooth pressure to push the assembly against this thrust bearing. The two main bearings carry purely radial loads, the final running position being determined by screwing the off-side bearing in until the diff assembly is 'nipped‘, and then backing off two notches, (1/3 of a turn), then checking the backlash. My opinion is that the location of the diff will be random with no tooth loading, and that the backlash will be similarly random under this condition. I therefore prefer to measure the backlash while the off side main bearing is pushing the assembly toward the thrust bearing, releasing the pressure afterward.

Fig 9 shows a special dial gauge pedestal fitted to the differential case flange, which is very good if you can make one, but if you have secured the casing to your vice with the tool shown in Fig.4, a normal magnetic base stand can be located on the vice.

Backlash figure given in the manual is 0.005-0.008. However, in the case of C.1902 there was a variation of 0.003" per half revolution!

Mysteriously, there was not a corresponding run out on the back face of the crown wheel. It was therefore necessary to grind the back of the crown wheel by hand where it locates on Item 3, until the backlash was reasonably even. Failure to correct this problem causes a rhythmic hum at road wheel speed.

The manual also says that the teeth are marked and should be matched up. There were no marks on the teeth of C.1902!

The location of the pinion relative to the crown wheel can now be checked in the traditional way, as indicated in Fig.7. It is probable that if the only replacement parts were the bearings, and if the assembly was properly set up in the first place, then it may well be correct first time. If not, correct as indicated.

When satisfied, replace all locking plates (Items 28/29/30) and locking screw (Item 102). It may be necessary to redrill its location in the pinion sleeve.

Reassembly of everything is straight forward, a new gasket will be required for the torque tube/axle case joint. The rear hub housing/axle case joint does not have a gasket, I use red 'Hermetite'.

The whole assembly can finally be cleaned and painted prior to relocation into the car. However, whilst the axle is out of the way, one has a good opportunity thoroughly inspect, clean, and paint the rear of the chassis. Pay special attention to the sides of the chassis directly above the axle, adjacent to the apex of the bottom plate, since this is a very weak area. Method of repair of problems in this area are the subject of a later article on body alignment.

The brakes will, of course, need to be bled and adjusted in the normal way.

The Panhard Rod should be carefully inspected, It is made of an aluminium alloy, and frequently suffers terminal corrosion in the vicinity of the steel lock nut due to electrolytic reaction. I suggest a thorough clean and paint, plus a smear of underseal in the thread, and up to the nut. Fill the axle with S.A.E. 140 oil, and you are back on the road.

THE RILEY 2½ LITRE REAR AXLE COMPONENTS (Later Type)
(SHOWING HEALEY MODIFICATIONS)

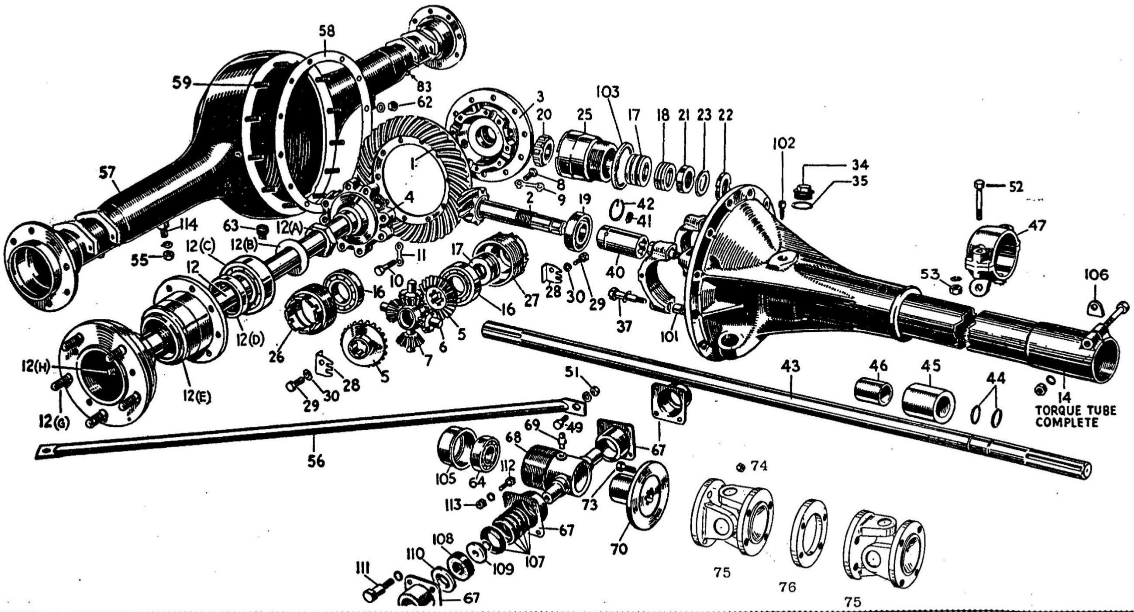
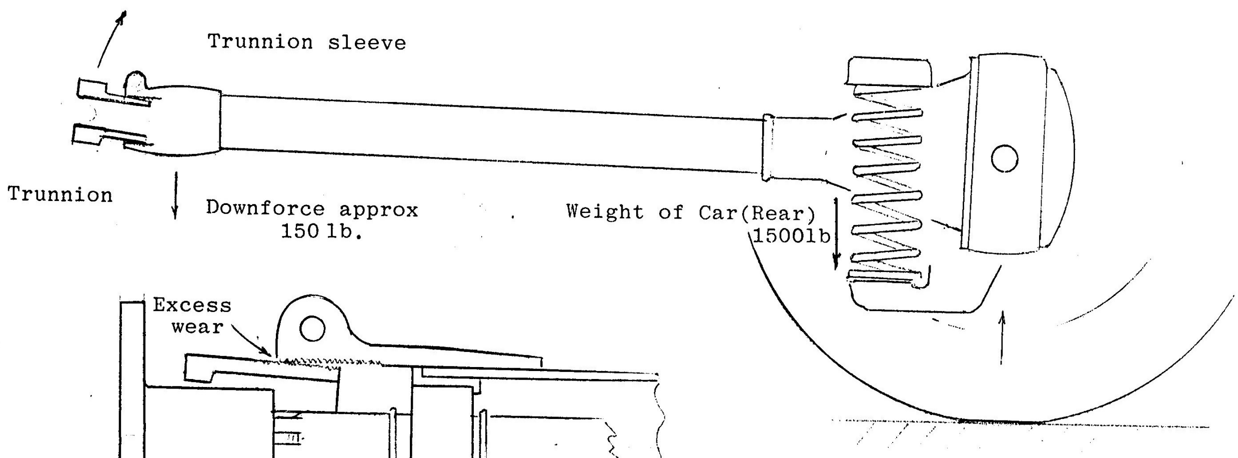


Fig.1

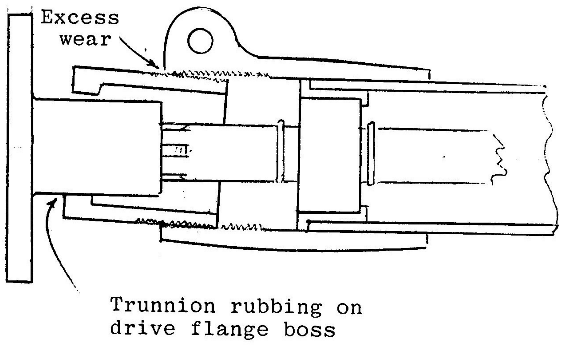
KEY TO REAR AXLE COMPONENTS (2½ LITRE, LATER TYPE)

No.	Description
1.	Crown wheel and
2.	Pinion.
3.	Case—differential (left-hand).
4.	Case—differential (right-hand).
5.	Gear—differential.
6.	Spider—differential.
7.	Pinion—differential.
8.	Bolt—crown wheel to differential case.
9.	Lock plate—crown wheel to differential case bolt.
10.	Bolt—differential case.
11.	Lock plate—differential case bolt.
12.	Axle shaft.
12 (A).	Locknut—axle shaft.
12 (B).	Washer—axle shaft locknut.
12 (C).	Bearing—rear hub.
12 (D).	Oil seal—rear hub.
12 (E).	Housing—rear hub bearing.
12 (G).	Stud—wheel—rear.
12 (H).	Plug—axle shaft.
14.	Torque tube assembly.
16.	Bearing—differential.
17.	Bearing—pinion thrust (rear) and crown wheel thrust.
18.	Bearing—pinion thrust (front).
19.	Bearing—pinion journal (front).
20.	Bearing—pinion journal (rear).
21	Lock ring—pinion (thick).
22.	Lock ring—pinion (thin).
23.	Tab washer—pinion.
25.	Housing—pinion sleeve.
26.	Housing—differential bearing R/H.
27.	Housing—differential bearing L/H.
28.	Lock plate—differential bearing.
29.	Bolt—differential bearing lock plate.
30.	Washer—differential bearing lock plate bolt.
34.	Plug assembly—oil filler.
35.	Gasket—oil filler plug.
37.	Set screw—differential bearing cap.
40.	Coupling—muff.
41.	Grub screw—muff coupling.
42.	Spring ring—muff coupling.
43.	Propeller shaft.
44.	Spring ring—propeller shaft.
45.	Bearing—propeller shaft centre.
46.	Bush—propeller shaft centre bearing.
47.	Bracket—torque tube stay.
49.	Bolt—torque tube stay.
51.	Nut—for bolt.
52.	Bolt—torque tube stay.
53.	Nut—torque tube stay bolt.
55.	Nut—rear axle (torque tube stay).
56.	Stay—torque tube.
57.	Casing—rear axle.
58.	Gasket—rear axle casing.
59.	Set screw—rear axle casing.
62.	Nut—rear axle casing set screw.
63.	Plug—rear axle drain.
64.	Bearing—torque tube trunnion.
67.	Cover—trunnion mounting rubber.
68.	Trunnion (std.)—torque tube.
69.	Greaser—trunnion.
70.	Flange—torque tube coupling.
73.	Bolt—torque tube coupling flange.
74.	Nut—torque tube coupling flange bolt.
75	Universal joint
76	Spacing ring
101.	Bush—differential bearing cap dowel.
102.	Locking screw—pinion sleeve housing.
103.	Thrust ring—pinion sleeve housing.
105.	Adaptor—torque tube bearing.
106.	Spacer washer—torque tube trunnion sleeve.
107.	Rubber ring—trunnion.
108.	Rubber ring—trunnion (side).
109.	Washer (inner)—trunnion mounting.
110.	Washer (outer)—trunnion mounting.
111.	Set screw—trunnion mounting.
112.	Bolt—trunnion mounting cover.
113.	Nut—trunnion mounting cover bolt.
114.	Stud—rear axle—torque tube stay.

Fig 2.



Trunnion sleeve
Trunnion
Downforce approx
150 lb.
Weight of Car(Rear)
1500lb



Excess
wear
Trunnion rubbing on
drive flange boss

Fig.3

SOME HOME-MADE TOOLS.

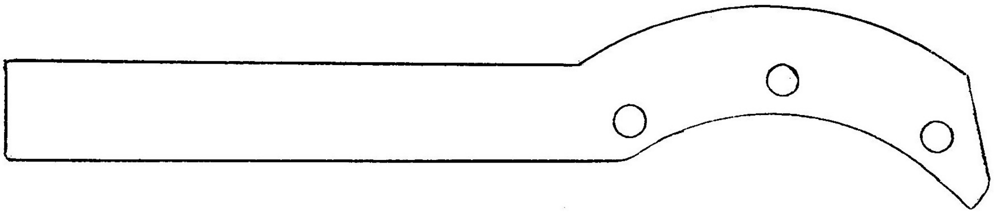


Fig.4. Tool for steadying torque tube adjacent to vice:- Bent from 1" x ½" mild steel, drilled ⅜" clear to match three holes on the differential flange.

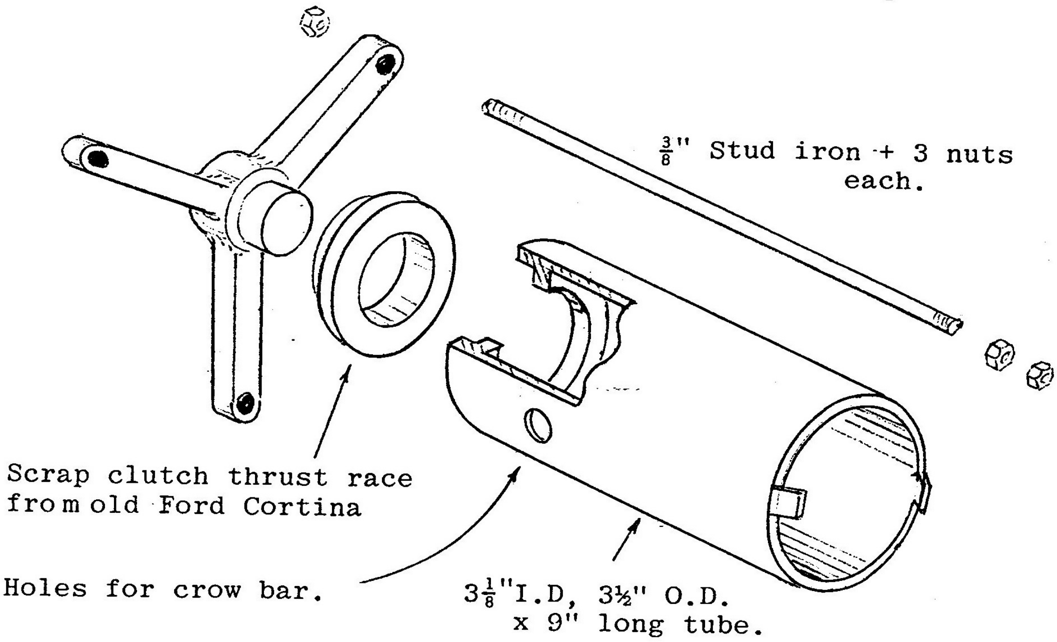


Fig.5. Tool for unscrewing/screwing pinion sleeve.

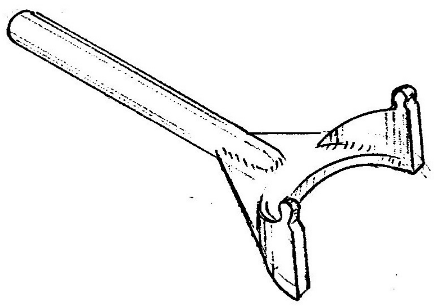
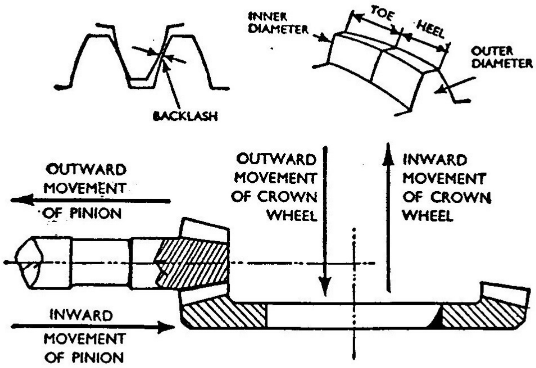
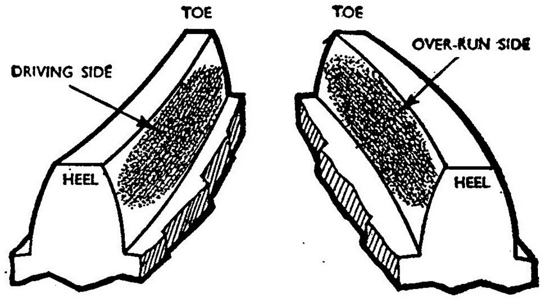


Fig.6 Tool for adjusting crown wheel bearing location.

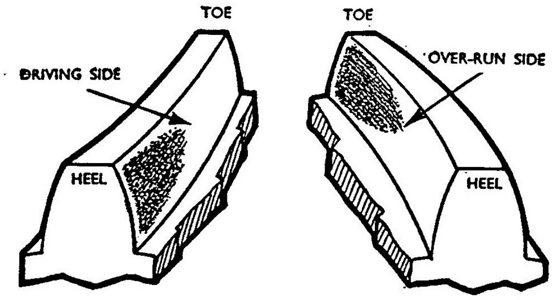
CROWN WHEEL TOOTH MARKINGS



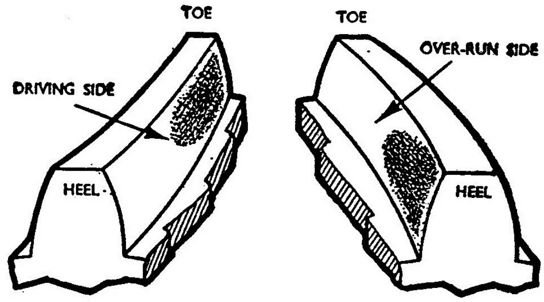
THE NOMENCLATURE USED IN CONNECTION WITH THE GEARS IS HERE CLEARLY SHOWN. OPERATORS SHOULD BE FAMILIAR WITH THE CORRECT MOVEMENTS OF THE GEARS IN PARTICULAR



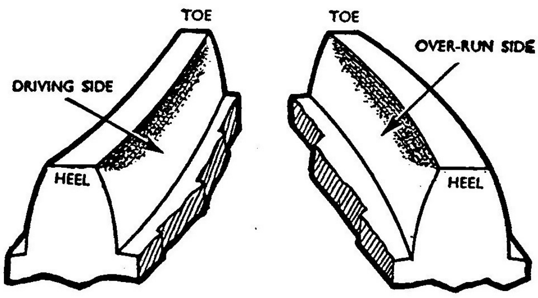
CORRECT GEAR TOOTH MARKINGS WHICH GIVE QUIET OPERATION AND MAXIMUM LIFE. NOTE THAT THESE MARKINGS ARE GIVEN WHEN THE CROWN WHEEL IS ROTATED



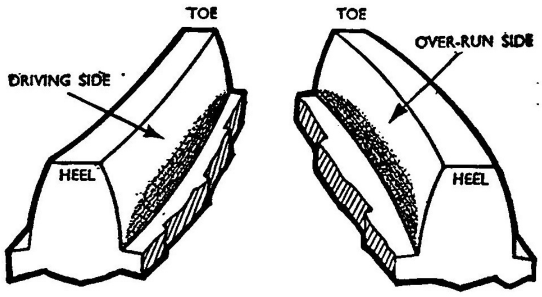
DRIVE TAKING PLACE AT HEEL AND TOE AS SHOWN BY THE ABOVE MARKINGS IS INCORRECT. RECTIFY BY MOVING CROWN WHEEL INWARDS AND PINION OUTWARDS TO MAINTAIN CORRECT BACKLASH



DRIVE TAKING PLACE AT TOE AND HEEL AS SHOWN BY THE ABOVE MARKINGS IS INCORRECT. RECTIFY BY MOVING CROWN WHEEL OUTWARDS AND PINION INWARDS TO MAINTAIN CORRECT BACKLASH



HEAVY CONTACT AT NOSE OF TEETH INDICATES THAT PINION IS TOO FAR OUT OF MESH. MOVE INWARDS TOWARDS CROWN WHEEL AND MOVE CROWN WHEEL OUTWARDS TO MAINTAIN BACKLASH IF NECESSARY



HEAVY CONTACT AT ROOT OF TEETH INDICATES THAT PINION IS TOO FAR IN MESH. MOVE OUTWARDS AWAY FROM CROWN WHEEL AND MOVE CROWN WHEEL INWARDS TO MAINTAIN BACKLASH IF NECESSARY

The references to moving the pinion apply only to the older type 1½ litre cars, and not to the later models where the pinion position is set by gauge. These models should be finally adjusted by movement of the crown wheel only.

Note.—These markings are only produced when the pinion is rotated from the crown wheel and not when the drive is applied from the pinion drive flange. A different set of markings is produced in the latter case, and care must therefore be taken of this point when interpreting from the markings.

Fig 7

Section H.14

FITTING THE TRUNNION BEARINGS

It is of importance that the trunnion bearing assemblies should be correctly fitted when the axle is fitted to the chassis. (See Fig. H.17.)

When the trunnion is correctly positioned in the brackets on the chassis the inner mounting rubber covers A.1737 should be fitted in position, followed by the five rubber bearing rings and stepped washer with its boss facing inwards towards the trunnion. The outer rubber bearing ring A.1901 and the thrust washer A.1910 are then located on the end of the trunnion by the retaining bolt A.1909.

The outer mounting rubber cover is then placed in position, and the complete assembly of covers and mounting is bolted to the frame brackets.

The same process is repeated on the other trunnion.

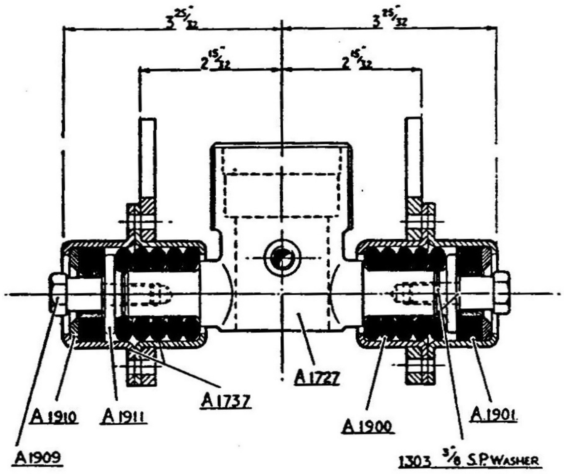


Fig. H.17.
The correct method of assembling the torque tube trunnion bearings.

Fig.8.

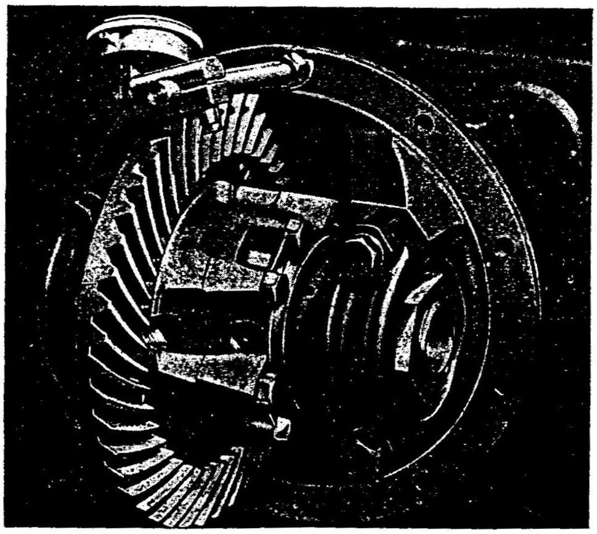


Fig. H.14.
The method of mounting a dial gauge on the axle casing flange with its indicator in contact with the outer end of one tooth of the crown wheel to check the backlash.

Fig 9

2 STEERING

C.1902 has, up to the time of these words being written (Christmas day 1975) enjoyed a miraculous two year run of near reliability, which may give cheer to those of our faithful old members who have never actually got around to driving their car, and who may have wondered what they have let themselves in for, *(By 1991 some of them still have not got around to driving them!)* but has left me without inspiration for Technical Notes.

However, during the last summer it was brought to my notice that a members Tickford had failed its MOT test five times on the rather vague indictment of heavy steering. Unfortunately, by the time I had made contact the car had been sold, and the new owner had not joined the club, so I never heard the end of that tale.

After my debut in Gazette No.1, in 1969 I received a number of enquiries on the subject, and conversation since then suggests that a large number of owners are suffering in silence. *(In l990 I 'drove an 'F' type which was absolutely lethal!)*, It would therefore seem that the time has come to repeat, and enlarge upon the words written in Gazette No.2. before the MOT ban all Healeys from the road.

With regard to my own car, with an unladen weight of over 27 cwt. and the normal Healey steering ratio, it is inevitable that the torque required at the steering wheel must always be twice that of a similar weight car with a steering ratio of four to one, nevertheless, the steering is tolerable at parking speeds and remarkably light at normal speeds. As an engineer I consider it is immoral to turn the steering wheel of any car when it is stationary!

In conjunction with the achievement of light steering, it is desirable that free play be reduced to a minimum, so that castor angle may also be set to a minimum.

3 SURVEY OF STEERING BOX

It may be as well to consider the historic problem of steering the four wheeled vehicle, commencing with the horse drawn variety, which had the elementary live front axle pivoted at its centre and attached to a more or less steerable power unit by two shafts of great lateral rigidity. The system suffers greatly from 'kick back' when either wheel meets an obstruction, but this is absorbed by the excessive weight of the power unit and the considerable leverage it has over the axle.

The next stage in the line of development is seen on the steam traction engine where the same type of axle must be controlled by the human hand. A worm wheel at the lower end of the steering column drives a pinion on a transverse chain shaft which controls the axle. It will be apparent that the worm drive both reduces steering effort and prevents any kick back being fed back to the steering wheel.

With the advent of the fixed axle with stub axles pivoted on 'King Pins', kick back could be eliminated by having the axis of the pin through the centre of the tyre inclined to pass contact patch, nevertheless, the principle of the worm wheel and pinion persisted as a means of converting the rotary motion of the steering wheel into the linear motion required to move a steering arm on a stub axle. As the pinion now drove a drop arm shaft , which rarely moves more than 60° it could be reduced to a sector of suitable size, the tooth displacement being equal to the number of turns from lock to lock, whilst the worm wheel would be developed to an 'hour glass' shape to increase the tooth contact area. The final development as seen on the Healey involves the use of a tooth profiled roller in place of the pinion teeth to reduce wear and friction. The whole assembly being enclosed in a steel casing.

A parallel development was the worm and nut, later refined into the recirculation ball type of steering box.

All the above types have suffered from the post vintage plague of miniaturisation which causes the parts of the mechanism to work through small distances and therefore very high loadings, while the introduction of ball bearings, with their almost infinitely small contact areas, ensures that the mechanism will destroy itself at the slightest provocation, or at best, suffer accumulated free play throughout the complex train of linkage.

With the coming of the double wishbone independent front suspension, with its mandatory three piece track rod, some bright individual realised that all that was needed was a row of teeth on the centre section of the track rod, meshed with a pinion on the steering column, so that a low stress, direct acting system would be achieved.

Unfortunately, the ‘Rack and pinion‘ steering assembly, now so universally accepted on performance and mini cars alike (In spite of the fact that it offers no resistance to ‘kick back‘) is ill-suited to the geometry of the trailing arm suspension used on the Healey, since the track rods must sweep forward to match the length of the trailing arm, to avoid ‘bump steer‘ effects, and this angularity would subject the rack to intolerable side thrust. For this reason the Healey, like its similarly suspended rival, the early DB Aston Martin, would have to be fitted with a well developed example of the worm and pinion principle, known as the ‘Marles cam and double roller steering box‘ linked to a central swivel plate forward of the front axle line. (bell crank on the Aston). The word worm refers to the Marles development of the worm into the shape shown in Fig.10.

There are three main adjustments provided on this box:-
1. Adjustment of bearings between which the cam revolves.
2. Adjustment of end play of drop arm shaft.
3. In conjunction with '2', adjustment of mesh between roller and cam.

The geometry of the assembly is such that there is, at the optimum setting no free play in the central position, whilst the clearance will increase progressively on each side of this point to a maxima at each full lock, to allow for adjustment of wear at the point where it will naturally be greatest, in the ‘ahead’ position.

Unfortunately, there is no provision for adjustment of end play of the although XXX no roller between the jaws of the drop arm shaft, doubt oversize thrust washers could be made if this was the only fault in the box. The axis of the roller is so close to the axis of the drop arm shaft, that any clearance at this point is greatly magnified at the end of the drop arm, and is sometimes apparent even on a new reconditioned box. It will also be seen that the roller spindle is heavily 'nobbled' over at its ends, to retain it in position, so that it is unlikely that one can removed it without damage, I have, however, managed to close the gap by pinching the eyes of the drop arm shaft between two socket spanners in a vice, and warming the reverse side of the forging with the oxy/acetylene flame.

To check the total free play in the steering box, lift and support the chassis so that the front wheels are clear of the ground and in the ahead position.

Persuade assistant with clean hands to hold the steering wheel firmly, and rock the off-side road wheel about its vertical axis, while observing any movement of the drop arm.
Ideally, there should be no play, but in the real world there always is. A maximum tolerance of 1/32” is quoted in one data source.

Another very common malfunction to afflict the steering of a Healey is caused by the failure of the alloy mounting bracket to grip the steering box tightly enough on those occasions when maximum torque is being applied to the steering wheel. The tendency of the box to rotate in the opposite direction to the drop arm is resisted primarily by the tightness of the mounting bracket, and secondarily by the tightness of the steering column outer tube where it fits into the box. This is the weakness of the plot, since the tube fits into a rather short recess in the box, and will frequently be found to have fretted slack, while the three minute dowels do nothing other than prevent the tube falling out when the assembly is removed.

When both the above faults occur together, all the stress is transferred upon the steering shaft, which rapidly destroys the cam bearings, including the ends of the cam itself.

The first symptoms of this problem, where the box will just about move when subjected to maximum stress, will be detected as a stiffening of the steering when entering a tight corner, and a reluctance to centralise itself at the exit from the corner, although it may free up if aided manually, thus winding the box back to its natural position.

As the box becomes more loose, the steering will become spongy as the shaft ‘bows' throughout its length. To diagnose this malady, the car should be standing on its wheels. The assistant may then rotate the steering wheel forcefully to and fro, while the despondent owner observes the restlessness of the box.

Should the diagnosis of any of the above problems prove positive, the owner must now remove the steering box from the car.

The survey of track rod and drag link ends, and swivel plate bearings are discussed under a later heading and will be carried out with the steering box in place, however, for the purpose of continuity, I shall continue with the box. The owner may arrange his work as convenient.

4 REMOVAL OF STEERING BOX FROM CAR.

Disconnect the earth lead from the battery, since during the coming struggle, the column may be waving about behind the dash-board.

Jack up and firmly support the chassis so that the wheels are well clear of the ground, and remove the front off side wheel.

Disconnect the horn button wire from the snap connector near the steering box.

Prise the horn button assembly out of the steering wheel hub and remove the small screw which holds the horn wire to the assembly, taking care not to lose the horn button and spring which will also be released. (I have not been able to familiarise myself with the more complex arrangement on the 'F' type chassis, but I suspect that its removal is controlled by a clamp at the lower end of the box.)

Slacken the steering wheel adjustment nut, and slide the wheel down the column. Remove the wire circlip, steering wheel, spiral spline cover and cups.

Remove the pinch bolt and fixing bolt from the chrome clip which attaches the top of the column to the cross tube behind the dash-board.

With regard to the removal of the box, I would assume that in the in the case of all coach built models, the assembly will be removed forward and downward, whereas, in the case of the 'Silverstone' I am told that the toe board has to be removed and the assembly moved backward and upward into the cockpit.

I shall therefore proceed as per personal experience.

Remove the drag link from the lower end of the drop arm. (I use the Sykes Pickavant Universal extractor, which will fit all the ball joints on a Healey, Halfords also stock a similar model).
The speedometer cable may be clipped to the engine side of the box by one of the bolts securing its cover, if so, remove this bolt.

Remove the three 7/16" B.S.F. bolts which secure the alloy I mounting bracket to the chassis, and note that the lower one is shorter than the top pair.

Jack up the off side front hub assembly. It should then be just possible to pass the assembly forward and downward under the track rod, while the assistant prevents the top of the column from doing mayhem behind the dashboard.

The drop arm is attached to its shaft by means of a tapered spline and secured by a large nut. Slacken the nut and apply a very robust two jaw puller to the two lugs on the arm. (I made a puller from a piece of 1" plate). Remove the arm.

It will be observed that on the back plate of the steering box, in line with the drop arm shaft, there is a slotted adjusting screw fitted with a lock nut. Slacken this nut and remove the four 5/16" bolts. The adjusting screw can then be used to jack the cover off its dowels, being prepared to catch the oil.

The drop arm shaft may now be withdrawn. The shape of the casting is such that it will only allow the roller to exit in one position. This is best achieved by careful manipulation of the steering shaft as the drop arm shaft is lifted out.

Remove the four 1/4" bolts from the end cover, and tap the top of the steering shaft, so that it comes out, together with both ballraces. Clean the whole assembly thoroughly.

The ball bearings are of the angular contact type, and, unfortunately, run directly on the radiused ends of the cam, instead of on a removable inner race. Therefore, any damage which occurs at this point requires a replacement cam.

The next point to look at is the aforesaid endplay between the roller and its housing in the end of the drop arm shaft.

When coming to a decision about how much imperfection one is prepared to tolerate in these, or for that matter, any part of the box, one should take into account the fact that at the time of writing, reconditioned (all new wearing parts) boxes are available through A.J.Bowers from the original makers, and this supply could be cut off at any time at a stroke of a cost accountants pen. *(How prophetic this was, in 1990 production ceased. In 1991 it is still not clear whether design and production rights have been sold to anyone else:- You were warned!)*

I have mentioned two possibilities for dealing with excess end play earlier on, however, there may also be lateral play, since the roller rotates on needle rollers with all the problems that can imply. One really must have new parts if there is trouble in this area.

If, however, the survey indicates that the internal parts are in reasonable condition and fit for further service, attention can now be turned to the external problem of loose column outer tubes and mounting brackets, where applicable.

Now that the steering shaft has been removed, any slackness of the tube in the box will be easily assessed. If any movement can be detected, then the tube must be removed, thoroughly cleaned, and fixed back in with a low temperature brazing or silver soldering process, taking care to achieve good penetration of the joint. It will be apparent that, since heat would damage the working parts, ball race outers etc., all of these must be removed. Therefore, some form of jig must be arranged to maintain correct alignment during this process.

This could be made of wood or metal, to be bolted to the mounting bracket at its lower end, and supporting the shaft at the steering wheel end, or it could be a dummy shaft, with a short fitting at its lower end to mimic the cam and bearing assembly. In the case of

C.I902, the box was of slightly different design, the tube being fitted into a detachable four bolt flanged boss. which simplified the process, four long bolts with spacing pieces were used to reduce the transfer of heat.

A possible alternative method would be to fill the joint with 'Loctite', which would have the advantage of being a cold process, and can therefore be done with the mechanism in place, thus ensuring correct alignment. It must be noted (see instructions) the amount of clearance that 'Loctite' can cope with.,

It is most unfortunate that the original manufacturers thought it unnecessary to braze this joint, and it is even more unfortunate that their successors still consider it unnecessary.

If, having carefully inspected all the working surfaces, one has decided that they are in fit condition for further use, all that remains to be done is reassembly. This is, of course, the reversal of the dismantling procedure with attention to the adjustments which are outlined below, hopefully to eliminate most of the free play previously present.

(1) Adjustment of steering column cam bearings.
(2) Varying the thickness of the drop arm shaft thrust washer (and shims if present) in conjunction with -
(3) Adjustment of thrust screw.

Item 1 is quite simply a matter of selecting the correct thickness of shim and joint between the end cover and the body of the box. As the end cover is quite flimsy, I feel that a slight preload is permissible, the shaft should, however, rotate smoothly and freely.

Items 2 and 3 require rather more dexterity, since the object of the exercise is to achieve a situation where there is no end play in the drop arm shaft, while its position will be such that there will be a very slight interference between the roller and the cam in the central position.

Assemble the drop arm shaft in the box, note that the thrust washer has an internal chamfer which aligns with the radius on the shaft.

Rotate the steering shaft, so that the drop arm shaft is moved toward the end of its travel.

Replace the cover, and adjust the thrust screw so that the drop arm shaft end play is zero. With the drop arm loosely fitted it should be possible to detect some free play between the cam and roller in this position.

Rotate the steering column shaft until the drop arm shaft is in the position which gives minimum free play. This should be mid travel, and will be the position of the drop arm shaft when the road wheels are in the straight ahead position. If new parts have been introduced, the roller may bind against the cam, in which case shims will need to be added between the thrust washer and the body to achieve the objective. With existing parts one would expect to see free play, unless the assembly was wrong in the first place.

The next step is to reduce this clearance to a slight interference, bearing in mind the fact that even when this is achieved, it may still be possible to rock the drop arm shaft slightly if there is any end play in the roller itself.

If present, shims must be removed, if not, the thickness of the thrust washer must be reduced progressively until this objective is achieved, the metal being filed from the unchamfered face of the washer so the chamfer is left intact. Access to a magnetic bed face grinding machine would, of course be an advantage. My original box had shims, but the removal of these was insufficient and the washer still had to be reduced.

Great care must be taken not to remove too much metal from the washer since this would allow the roller to jam under the cam with much detriment to all parts. However, if the work is progressed by small increments, with the full test carried out each time, all should be well.

The soft bearing at the steering wheel end of the column may be found to be slack, which may upset an M.O.T. tester. If the correct part is not available, it is probable that many modern cars will yield a similar material.

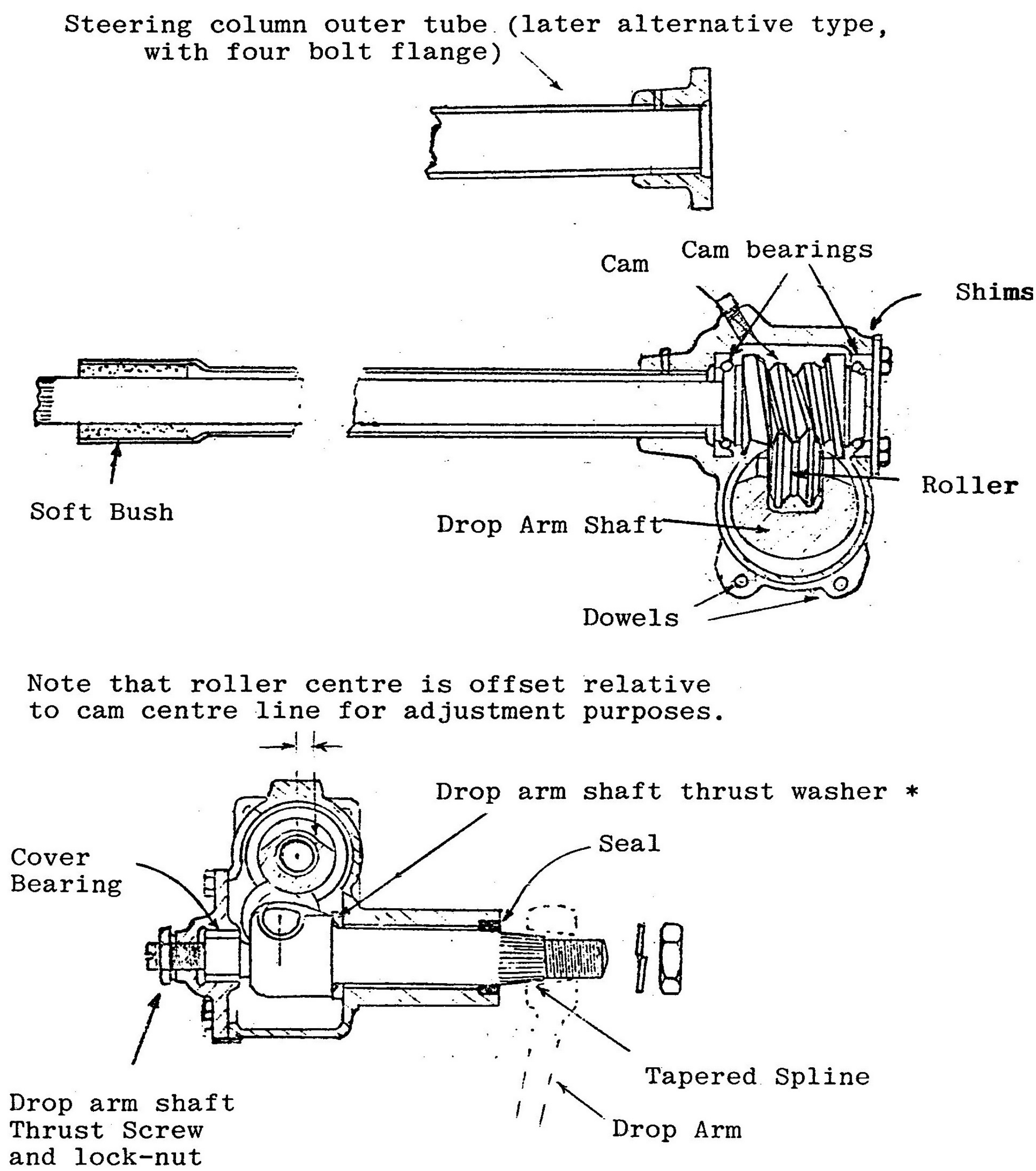
The box can now be filled with S.A.E. 140 oil, and refitted to the chassis.

If the alloy mounting bracket had previously allowed the box to move, or if an exchange box is to be fitted, the fit of the clamp must be checked, and if necessary adjusted by filing carefully that part of the butts which is holding the clamp apart, so that the box is firmly held as the butts meet with the full tightness of the nuts.

Ascertain finally the position of maximum interference between the roller and cam, connect the lower end of the drop arm to the drag link, and with the road wheels in the straight ahead position, fix the drop arm tightly on its shaft. (Note that the wheels may be excessively 'toed in‘ if the suspension is hanging at full droop).

Positioning of the steering wheel to one's taste is best finalised between road tests.

THE MARLES DOUBLE ROLLER AND CAM STEERING BOX.



* In original boxes, there may be shims between the thrust washer and body,

Fig.10.

5 SURVEY OF TRACK ROD ENDS ETC

This is most easily done over a pit or on a car lift since the weight must remain on the wheels while the observer must be able to see the joints and swivel plate clearly. An assistant should rotate the steering wheel to and fro so that the road wheels just begin to deflect from the straight ahead position. The observer should now be able to detect by sight or feel, any free play in any of the six track rod or drag link ends.

Some of the more brutal M.O.T. testers may call for excessive torque to be applied to the steering wheel, so that the part spherical surfaces of the joints are displaced against their springs. I do not consider that a joint is necessarily unservicable when this can be done, and would use my own discretion where possible. However, one rarely wins an argument with an M.O.T. tester on such matters.

A finger placed between the back edge of the swivel plate and its bearing housing will help to detect play in this assembly.

The swivel plate is made of hard aluminium alloy plate, and the holes into which the three ball joints and the main bearing shaft fit, are each fitted with a flanged steel insert which is a pressed fit in the plate and is riveted through its flange. I have heard of these becoming loose, in which case the plate should be reamed oversize, and an oversize insert fitted. Re-riveting a slack insert is not likely to be successful. I have also suffered a plate which was cracked between the central insert and the edge, possibly due to some garage mechanic putting a trolley jack under it! The plate had to be replaced.

The pin of each joint is a normal tapered fit, with castellated nut and split pin. The Sykes-Pickavant Universal Ball Joint Remover No.817, will remove all six joints without damage.

The removal of the plate from its spindle if this should need attention, is rather more difficult. I made a puller from two pieces of 1” plate which cannot fail to remove the plate without damage. (Fig.11). It consists of a top plate, which is 1" thick 9" diameter 'horseshoed' out so that it can be slid on to the swivel plate from the front. It is drilled and tapped 7/8” B.S.W. (or whatever you can lay hands on), so that three lengths of stud can be screwed into it. A similar plate (not 'horseshoed') suitably drilled with clearance holes is then passed up the studs, and the three nuts evenly tightened. The spindle nut should, of course, be slackened until it is flush with the end of the thread to retain the weight of the assembly as it comes free.

The casting which carries this bearing assembly is fixed into the chassis by six bolts. The radiator must be removed on all chassis except 'D' and ‘E’ types to allow these bolts to come out.

John Bowers prefers to receive the complete assembly for reconditioning as there , are variations in the internal dimensions.

On C.1902, I have fitted a grease nipple to this casting, as there is little movement to circulate the grease which may tend to be displaced from the bearings, especially when it hardens with age.

The track rod and drag link ends are screwed into the tubes with the usua arrangement of left and right handed threads, but what is rather unusual is the use of a hexagonal taper bored collar which squeezes the end of the tube onto the shank of the joint as the lock nut is tightened against it. To remove the joint simply unscrew the lock nut and tap the collar free, the joint will then unscrew easily,

It is not a bad idea to measure the average length of the complete track rod assemblies before dismantling so that the ‘toe-in’ will be somewhere near correct when the parts are reassembled.

The original specifications stated toe in 3/16” which seems rather a lot, even with cross ply tyres of those days, however in the case of radial tyres, I have seen a manufacturers manual which suggested no toe in at all! Therefore I run C1902 with wheels parallel, This must be, of course, be measured with the car standing in its natural position.

6 THE FRONT SUSPENSION (Gazette Nos 3 & 21)

Having now dealt with the steering box, ball joints and centre swivel plate, we may now pass on to the subject of the front suspension. As I said at the beginning, this, with a few additions will be a repeat of the notes in Gazette No.3, but please note that once the wheel post 'B' (Fig 12) has been removed, one may divert ones effort to king pins and bushes before the reassembly of the suspension bearings etc. although in the interest of minimum confusion I shall comment on this as a separate item.

Many years ago I received a letter from the owner of a 'B' type who was worried by the negative camber angle (top of the front wheels closer together than the bottom) of his front wheels. He thought that some part of the front suspension might have been bent by ‘pot hole‘ impact.

'A' and 'B' type chassis have a fabricated steel mounting box joining the front suspension to the cross tube of the chassis in place of the later alloy casting with steel side plates used from the ‘C’ type onward, and it has been known for these early types to crack. However, the usual cause of negative camber (the wheels should be vertical) is wear, corrosion and indentation of the needle roller and ball bearing at each end of the trailing A arm. This cannot be detected simply by taking hold of the road wheel and shaking it, because when the weight of the car is on the front wheels the suspension spring is so far inboard of the line between the front trailing arm bearing assembly and the centre of the contact patch of the tyre, that the wheel leans inward very heavily.

It is due to this unfortunate twisting force to which the trailing arm is subjected that its bearings, which only rotate through a very small angle, suffer indentation from the almost stationary balls and rollers.

TOOL FOR REMOVING SWIVEL PLATE FROM SHAFT

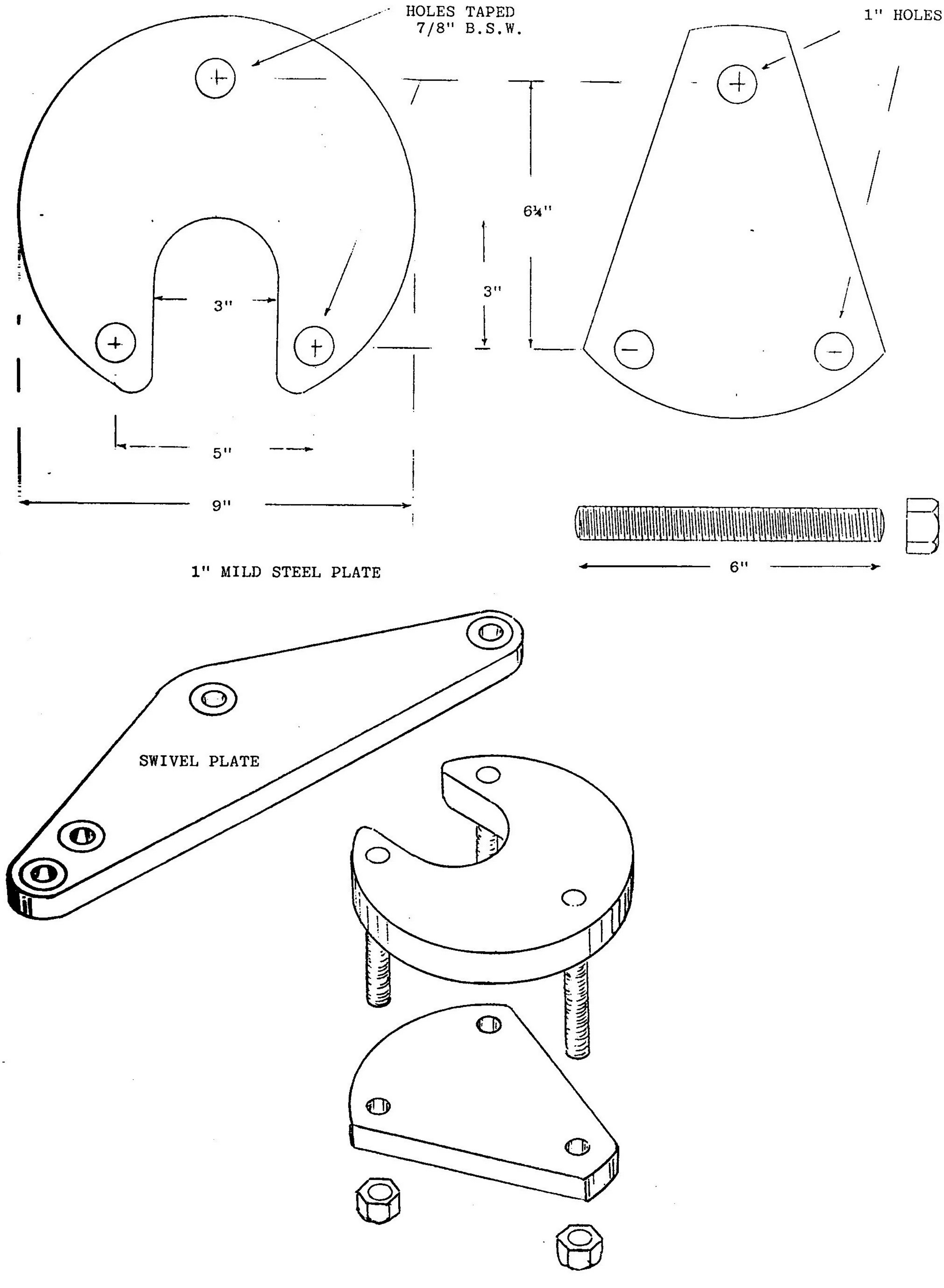


Fig.11.

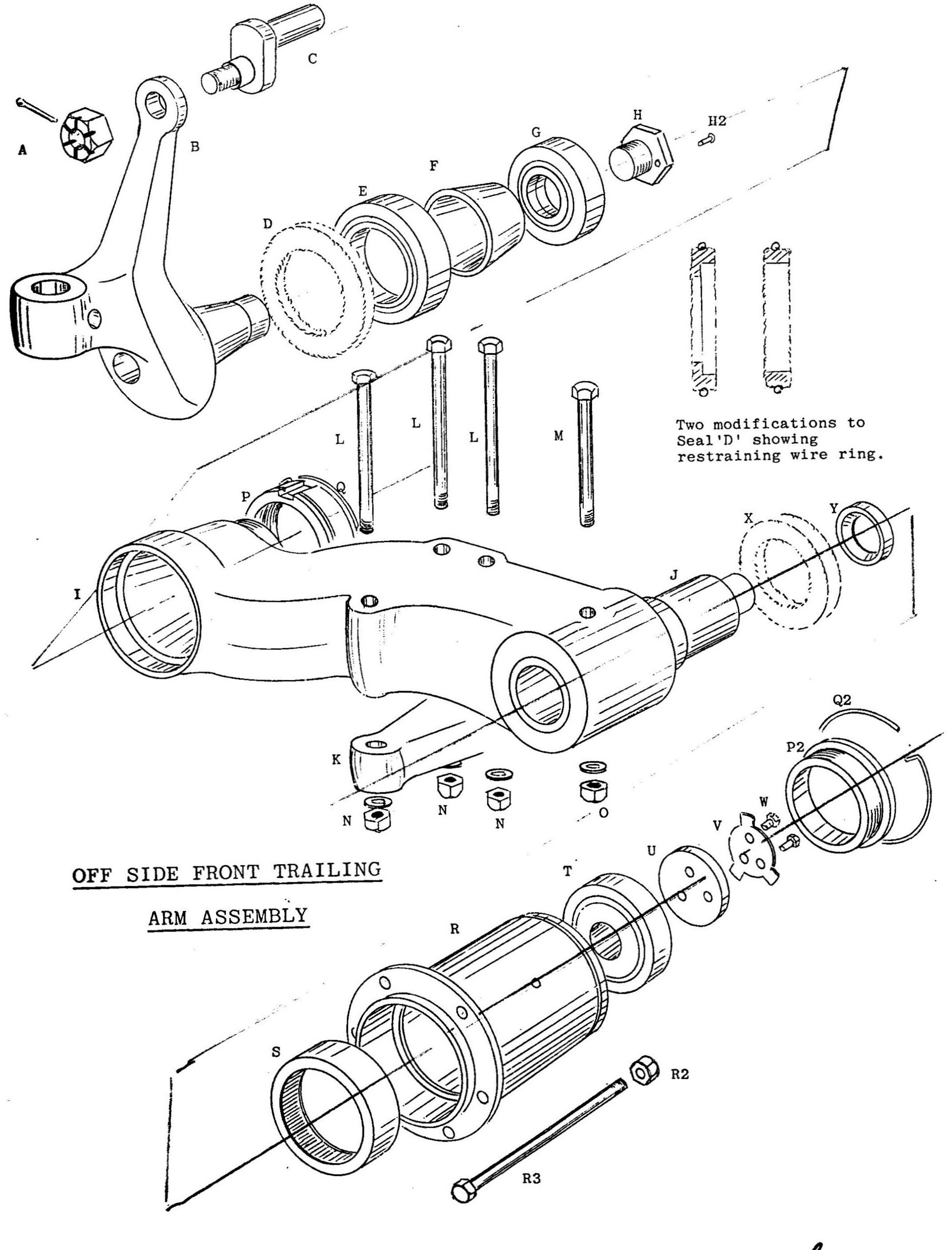


Fig 12. R K Sugg

Wear measured on the horizontal diameter of the front bearings does not have to be very great to allow considerable lateral movement of the wheel, and this will cause the wheel to change its direction of travel because it is obvious that if the wheel assembly moves, for instance 1/16" toward the near side while the track rod remains stationary, the wheel will also steer itself toward the near side, just as if the wheel assembly was fixed and the track rod moved 1/16" to the off side.

Similarly, wear measured on the vertical diameter of all the bearings will cause uncontrolled camber angle, producing unpredictable movement at the front of the car, wear on the inboard edge of the front tyres, (as with toe-out) and heavy side thrust at the ends of the of the shock absorber arms, which tears up the main bearing surface of the shock absorber.

To test for wear, jack up the front of the car, remove the front wheels. With the front of the car firmly supported on blocks, if, for example, it is decided that one will survey the off side assembly, put the steering on full left lock, and arrange a jack under the brake drum so as to just take the weight of the suspension limit cable.

Remove the three nuts and washers (N) and remove the alloy bracket (K) together with the bottom spring cup and the spring (The purpose of putting the steering on left lock was to allow maximum clearance between the track rod and the trailing arm, the converse applies to the other side).

Remove the split pin and nut (A) at the top of the wheel post (B), and ensure that the eccentric pin (C) is free from the post. Support the hub assembly so that the trailing arm assembly is at the attitude in which it normally runs. It should then be possible to observe the amount of free play in the bearings at each end of the trailing arm, although it may be necessary to s1acken or remove the shock absorber if this restricts movement.

It will be as well to check the wheel bearings and king pins while operating in this area. Inevitably one now comes to:—

<u>7 REPLACEMENT OF TRAILING ARM BEARINGS.</u>

It is desirable to reduce the weight at the wheel end of the trailing arm, for this reason I remove the hub and brake back plate as follows:- Unscrew the hub cap (Preferably with a suitable tool) (Fig.15), remove the Brake drum, the stub axle split pin, nut and washer (Note that on most cars this nut has a left hand thread on the near side). The hub can now be prised off quite easily with a pair of tyre levers.
Note the loose collar which mates with the oil seal, its internal chamfer fits over the radius on the stub axle. Unscrew the four bolts which secure the brake back plate to the stub axle, the plate can then be removed and tied up under the wheel arch without disturbing the hydraulic system, unless it needs cleaning and painting. (I find that it is worth filing the sharp edges off of the back plates, since this is where the paint starts to peel away from). One may now either remove the steering arm from the stub axle, or the track end from the arm.

Remove the wire circlip (Q2) from the end of the bearing housing (R). Ensure that the visible part of the housing is clean, and free of rust, old paint or burrs. The screwed plug type of cap (P2) shown in the illustration is the type fitted to chassis from 'C' type onward. It is sometimes very tight in the housing, therefore, it is advisable to loosen it at this stage with a thin ring spanner made for the purpose. On ‘A’ and 'B' type chassis I understand that the housing is covered by a plate which is secured by a number of small screws.

One must now decide whether to remove the trailing arm assembly complete with the bearing housing (R) which will enable you to grapple with it on the bench, or remove the shaft from the housing, which is a short cut, but makes the job of removing and refitting the bearings rather tricky, especially the thrust race (T). I prefer to remove the housing.

To remove the housing, unscrew the six nuts (R2) and withdraw as many of the bolts (R3) as possible, (One or two of these may have to be withdrawn and replaced with the housing, as the arm obstructs the heads of the bolts if the shock absorber is still in situ.

The aluminium box responds quickly to the gentle heat from a paraffin blow lamp, allowing the bearing housing to be withdrawn easily by hand. I understand that the steel boxes of the 'A' and 'B' types also benefit from a warm up, although I have no personal experience of these. The aluminium boxes are, I believe, Magnesium alloy. I was once grinding away the corroded surface of one of these, a small pile of the grindings was forming under the stone, suddenly there was a vivid blue flash. In its powdered form this metal is highly inflammable. Anyone who remembers the persistent combustion of a WW2 Magnesium Bomb will forgive me for not experimenting with a mag alloy casting and an oxy-acetylene flame, but a paraffin lamp should be safe enough.

The trailing arm assembly can now be placed in a vice with the bearing housing facing upward. Remove the cap (P2) and the three set bolts (W), the locking washer (V) and the bearing retaining disc (U). The housing will then lift off, taking care to catch all the needle rollers, because otherwise the floor will be covered with rollers and when you drop a new one, you will never find it!

The thrust bearing is a split centre ball race and is easily inspected. The shaft has a radius just behind this race to prevent stress concentration and so there is an internally chamfered spacing collar (Y).

The roller bearing is used at this end without its centre, the needle rollers thus run directly on the shaft (J). If the shaft is indented, it should be renewed, although if the wear is hardly measurable it may be expedient to remove the bolt (M), heat the trailing arm, and rotate the shaft 180°, so that when fitting new bearings, load may be applied to the perfect side of the shaft.

The seal (X) is made of 3/8" thick felt.

The bearing can be tapped out with a drift, taking care that you are tapping the bearing and not its landing.

At the wheel post end, remove the wire circlip (Q) and unscrew the cap (P). Find, and remove the small socket headed screw (H2) with an Allen key, and unscrew the bearing retaining screw (H).

IMPORTANT! This screw has a very thin head which is sometimes strained by excessive tightening and should be checked for deformation across its head. I know of at least three cases where the shank has pulled right out of the head.

The wheel post (B) can now be pushed down through its bearings, again taking care to catch any falling needles.

The layout at this end is similar to the front end, the thrust now used is a smaller split centre ball race, *(Recent study of an R & M manual states that this type of bearing should not be subjected to high radial loads, and as there is quite a high radial load in this application, one wonders whether a normal ball race might not serve just as well, they have been used on some of our cars)*, although one may find either a normal ball race which is tolerable or a single angular contact bearing which is either less effective or totally lethal depending on which way round it is fitted! I have heard that some of these were supplied by a certain motor manufacturer in Warwick many years ago!

A further problem arises due to availability of the split centre bearing. An expensive alternative would be to make a split outer double thrust race by surface grinding to half width two outer parts of an angular contact bearing and using them in conjunction with one centre part. Inevitably the resultant bearing would cost more than twice as much as an AC bearing.

The roller bearing (E) is similar to that at the front end and is used complete with its centre. Check these for indentation, and renew as necessary. The centre of this bearing is sometimes difficult to remove. If it cannot be removed with a sharp wedge or knife, it may be necessary to apply a sudden touch of oxy-acetylene flame. Alternatively, grind two diametrically opposite flats and split it off.

The seal (D) is made from 1/4" thick felt, and is trapped between the outer ring of the race (E) and the wheel post (B) Since there is not much space here, it is necessary to carefully reduce the thickness of the felt to about 1/8" up to the external diameter of the race, otherwise the races (E) and (G) may not be drawn fully on. As considerable force is required to locate the bearings against this reaction from the felt and the possible tightness of the inner needle roller part, and with regard to the frailty of the screw (H), I would suggest that a bolt with a head of normal proportions be used to draw the assembly together *(I seem to remember this was a 5/8" B.S.F Bolt)* whereafter the original screw will be substituted and pulled up hand tight. *(Since this was originally written, I have used a restraining ring made from a length of 1/8" welding wire. This positively prevents the felt from being displaced by grease pressure in which case one might as well cut the felt to fit the outer diameter of the needle roller bearing (E) as in the sketch showing the second modification of seal (D), Fig12).* Both felt seals should be soaked in oil or some such water repellent as WD40, but in the long term it is more important there is grease on the way out, rather than water on its way in!

In general, re-assembly is simply the reverse of the dismantling procedure, and as always absolute cleanliness is essential (one member found a two inch nail inside a bearing assembly!)

Both housings should be filled with grease via the grease nipples before the end caps are replaced so that no air is trapped, since unlike a wheel bearing, there is little rotation to circulate the grease and no risk of overheating. Once the caps are tight, a few more shots of grease may be applied.

The front seal is completely captive and will stand considerable pressure, and one can see the oil being squeezed out as the pressure rises. At the wheel post end, if a restraining ring is not fitted, then the seal is only held in by the pinch of the roller race, so it can easily be displaced by gun pressure, and must be carefully watched during servicing throughout its life.

The lower spring cups have a drain hole which should face forward. If it does not, it is probably safer to drill a fresh hole rather than to expect the bonded rubber to adopt a new position so late in its life. I would suggest that it is necessary to file notch in the fibre washer which is interposed between the spring and the cup, so that the water can find its way to the drain hole. Neglected cups have been known to collapse due to rust, so ensure that they are well cleaned and painted.

The setting of the eccentric pin (C) is empiric. When its position is such that the wheel post leans back, the castor effect is at its maximum, the car will run straight on level road, but be strongly deflected by road camber, and generally be heavy to deviate from its own desires. At the half way setting things will feel more normal, but if, in the search for lighter steering one sets the wheel post progressively farther forward, one may come to a point where, although the car is still stable in a straight line, on sharp corners taken near the limit, tyre distortion seems to alter the geometry of the plot and the front wheels suddenly 'tuck in. A most unpleasant sensation. The best setting in my opinion, must therefore be just before this happens.

8 FRONT WHEEL BEARINGS

There is not much to say about this subject. As usual the bearings should be removed and cleaned for examination, I have found a broken cage in a bearing which showed no other sign of wear. The large castellated bearing retainer is locked by a steel pin. If the pin cannot be easily removed, cut it off, and punch it out once the retainer has been unscrewed. The large race controls all lateral thrust. If the end play in the large race is greater than the play in the small race, then the small race will be forced to move to and fro in the nose of the hub, where it soon becomes slack and wears the nose, a very common fault. For this reason one should always renew the races as a pair. 'Loctite' will solve the problem in the hub.

Renewal of the oil seal will also need to be considered, of course.

9 THE KING PIN ASSEMBLY

In historic terms, the king pin and bushes assembly is as old as the earliest motor cars. It is on the one hand, robust and reliable, and on the other hand primitive and not very efficient.

Most manufacturers have, by now, found alternative ways of pivoting the front road wheel about its vertical axis, for instance, the Chapman Strut transmits its load via a thrust ball race to the structure of the car, thus minimising friction.

Morris Minors, Triumph Herald/Spitfire etc. pivot on a square; section screw thread, which has the advantage of concentrating all its friction on a small effective diameter, thus minimising the torque required. However, it is not ‘fail safe‘, and when the thread strips, the wheel assembly falls off!

The pre-war Austin 7 has a king pin diameter of only 1/2", which, combined with its light weight, keeps friction torque to a minimum. However, once one increases the weight to the 1 1/2 tons of Healey Tickford, with two occupants, then there is inevitably great scope for problems, since not only is the weight increased, but the diameter of the pin and its thrust surface must also be increased, thus increasing the frictional torque out of all proportion.

The following points must therefore be considered:-

l. The surface of the pin must be mirror smooth,
2. The surface of thrust faces must be smooth and true,
3. There must at all times be lubricant between all working surfaces.

I have long pondered on the difference between C.l902, which in spite of being one of the heaviest Healeys is existence has relatively light steering, and the large number of other Healeys which are incredibly heavy in their steering. One obvious difference is that C.1902 has been used all its life, apart from its three year rebuild in 1964/67. It is also frequently greased, especially after wet journeys.

It must be remembered that since the pin is made of steel, and the bushes of bronze, if water is allowed into the interface, electrolytic reaction will take place. This will etch away the surface of the pin. As some of our cars have been laid up for twenty or thirty years, the pins may well be in a very bad way.

The top and bottom bushes are lubricated by one grease nipple ('D' — Fig.13) in the top cap, there being a hole drilled through the centre of the pin. If, after a long lay-up, grease has hardened in the bottom bush, then it may be impossible to penetrate the interface of both bushes with grease. It may be worth trying a long drill down the centre of the pin, a grease gun full of oil, and a warm up with a blow lamp. The top cap ('E' Fig.l3) can be removed, and the grease nipple screwed directly into the king pin, which has a 5/16" B.S.F. thread in its top end.

Another possibility is that replacement bushes have been fitted with insufficient or no clearance.

It was interesting to hear that when one Tickford had its M.O.T. test, with the front of the car jacked up, the steering was perfectly free, and the car passed its test. On the road it is almost impossible to turn the steering and there is grave danger of damaging the steering box! (What price the M.O.T. test?). At this moment in time these pins have not been inspected.

10 REPLACEMENT OF KING PIN AND BUSHES

If all the preceding operations have failed to improve the stiffness of the steering on the road, or, of course if the pins and bushes are obviously worn out, then one will have to remove, and inspect the pins

Returning to the point where the car is securely jacked up, and the hubs and brake back plates removed, or better still, the king post is on the bench, proceed as follows:-

Drive out the cotter pin (Item 'K', Fig.l3) with a pin punch
Unscrew the top cap (Item 'E').
Screw length of 5/16" screwed rod into the top of the pin.
Assemble jacking tube and nut (Item 'M').

Tighten nut, and observe whether the pin is moving or not, whilst taking care not to break the stud. It is most unlikely to withdraw this easily.

Apply sudden heat to the eye of the king post with a large oxy-acetylene flame, taking care not to overheat it. One could well get lucky at this point. The problem is sometimes caused by a ridge of rust in the vicinity of the thrust washers.

Since my own pins have come out easily enough, I have never had to manufacture the merciless looking tool I have designed in Fig 14. The dimensions shown are for general guidance, the reader may use his discretion with regard to such metal as is available. The method of operation of this press is obvious, but since the bottom of the lower bush is blind, the bottom of the bush will have to be cut out to allow the ram (Item 'O') to gain access to the base of the pin. This is probably best done by drilling a ring of small holes around the base of the bush, and then chiselling it out. An Oxy-acetylene flame will still be desirable to facilitate movement, and reduce possible damage to the eye of the king post.

Many years ago one young member purchased a Silverstone which had very evil steering. It had probably had a fairly serious accident in its previous life, since the king post eye had been stretched slack, and then hammered into a triangular sort of shape to prevent the pin wobbling about. The steering column shaft was also seriously bent adjacent to the cam! Needless to say, the pin fell out quite easily!

Once the pin is out, the bushes can be pressed out of the stub axle. You have now done the easy bit!

As indicated at the beginning the fitment of the new parts must be perfect. For a plain bearing to function, there must be a layer of lubricant between the working surfaces. It therefore follows that there must be a clearance between those surfaces. Since the diameter of a 1" reamer is exactly 1", and since a standard king pin is 0.999" diameter, we may assume that the makers require a clearance of 0.001"

As supplied, the new bushes slide on the new pin, and the clearance is probably not more than 0.001". However if the outside diameter is greater than the outside diameter of the old bushes, and if these are forced in, then a corresponding reduction of the internal diameter will occur. If the resultant internal diameter is a shade over 0.999" the owner may still be able to insert the pin into the stub axle, but there will not be enough clearance to sustain a lubricating film.

It is therefore, in my opinion, necessary to compare the outside diameter of the new bush to that of the old bush with a 1"- 2" Micrometer. If the difference is more than 0.0005", then I would suggest the difference should be machined off. This should be done on a piece of metal turned to such size that the bush can be pushed on to it for machining, to ensure perfect concentricity.

At the same time the thickness of the bush flange needs to be considered. Extra thickness is generally found on these to allow for differences in original stub axles and king post eyes. It is traditional to file the surplus metal away, but this must be done with perfect accuracy. The owner must seriously assess his own capability with a file, and may prefer to machine this difference away at the same time as dealing with the diameter. The difference can be measured by clamping the new bushes and thrust washers to the king post eye and measuring the total thickness, then measuring the gap in the stub axle.

Before assembly, the king post and stub axle eyes should be carefully checked for smoothness, freedom from burrs and sharp edges and general cleanliness. There must be no possibility of particles of bronze being scraped from the sides of a bush and trapped under the flange.

The bushes may now be pressed in, excessive force should not be required. One owner complained that he had bent a stub axle during this operation: the mind boggles!

Wipe the preserving oil off of a new pin and try it in to the bush assembly, it should fall easily to the bottom. If not, reamers must be used. A normal 1" hand reamer, which has a slightly tapered leading end can be used as far as it will go. However, this will not cut 1" diameter right up to the blind end of the bottom bush. For this purpose a machine reamer must be used, since this is parallel throughout its length. (In this final clean up mode it could be used by hand) One may now be certain that one has a clearance of 0.001".

I have been told that in the past, king pins have been inserted too far, so that thrust was taken on the end of the pin. Quite how this tied up with the position of the cotter pin flat is not clear, but as a simple precaution, drop the pin into the bush assembly, and measure the distance between the top of the bush and the top of the pin. When the pin is finally assembled, this distance should obviously be less.

For final assembly screw a 5/16” nut and bolt into the top of the king pin, this will give some rotational control over the pin during assembly, to facilitate the alignment of the cotter pin flat as it comes into view.

Note that both thrust washers are fitted between the underside of the king post eye and the bottom bush. The one with the dowel hole locates on the dowel under the eye, to prevent the eye from wearing, while the second one is free floating.

It may also be a good idea to warm the eye to some extent to facilitate the entry and positioning of the pin. Insert the cotter pin immediately, so that the king pin can align itself. The top cap and grease nipple can now be refitted and the assembly greased. I use Castrols' MS3 Moly grease.

Reassemble all related parts in the reverse order of dismantling, and you are all set to go.

THE KING PIN ASSEMBLY.

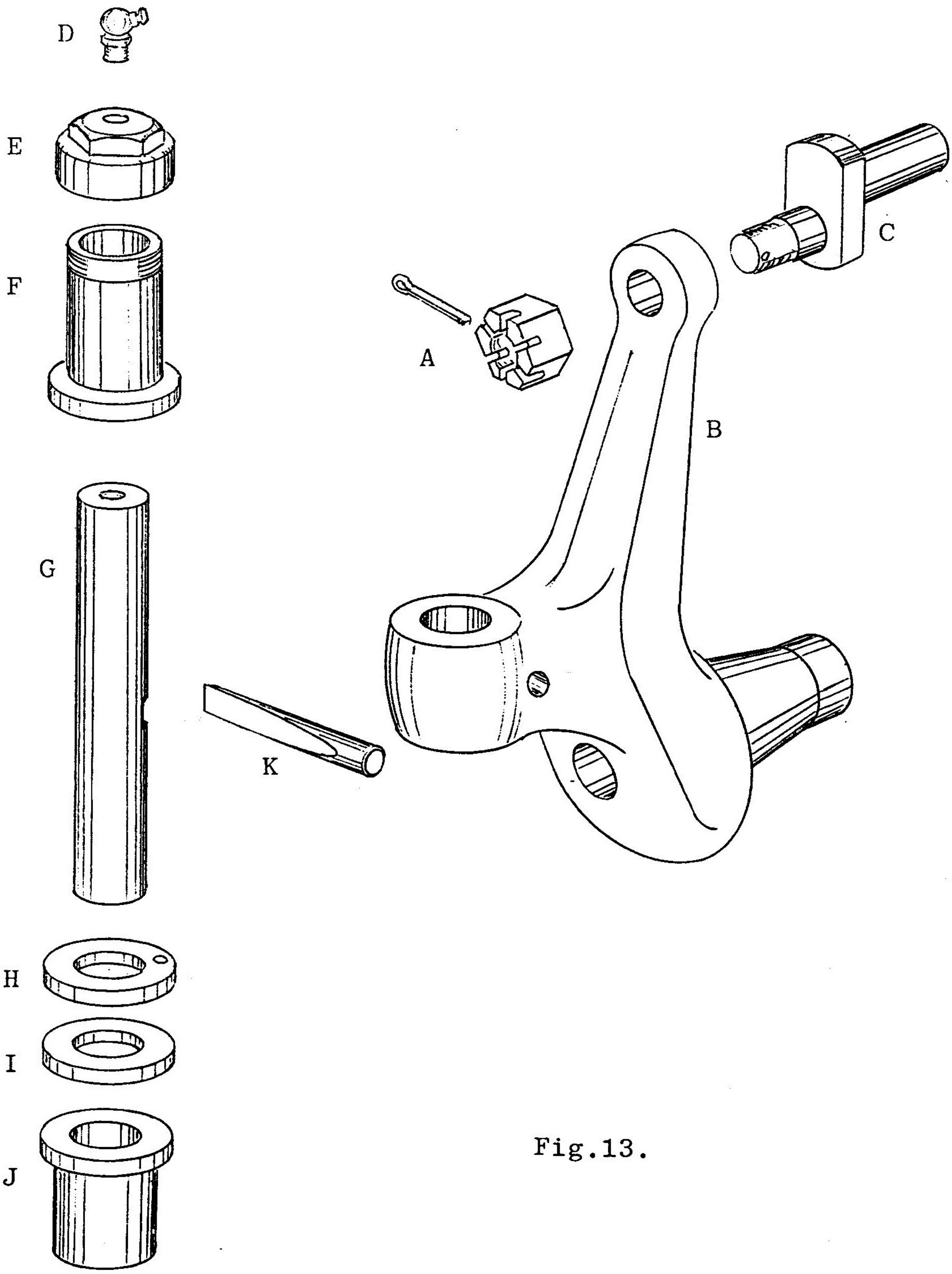
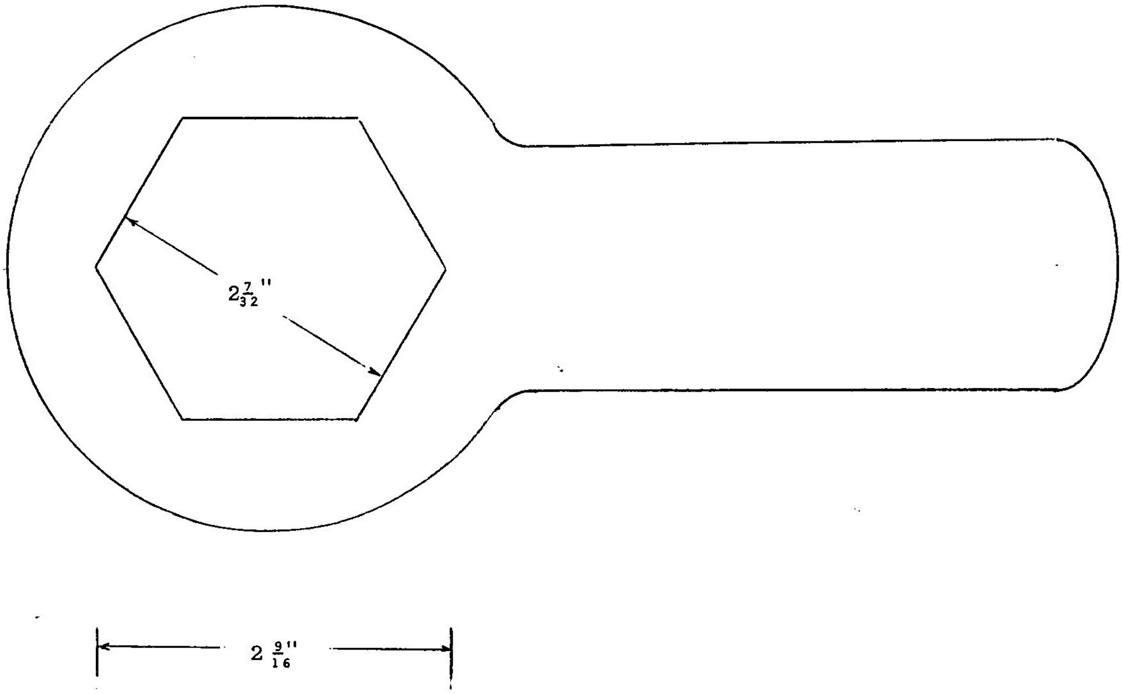


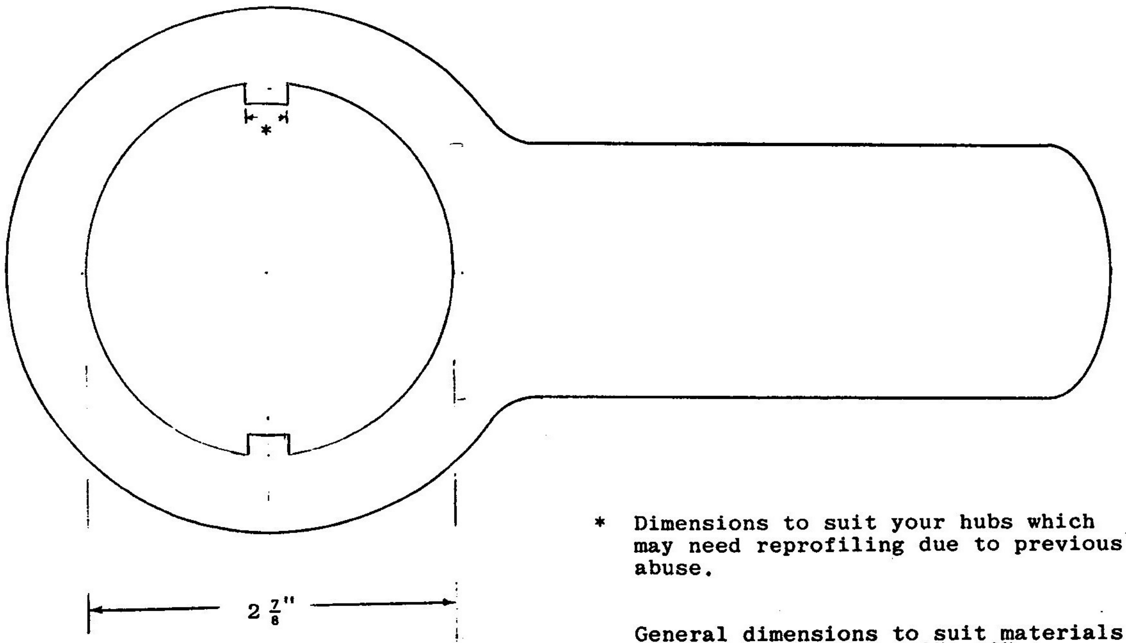
Fig.13.

SPANNER FOR TRAILING ARM FRONT BEARING CAP

ITEM P2: FIG.12



SPANNER FOR FRONT HUB CAP



* Dimensions to suit your hubs which may need reprofiling due to previous abuse.

General dimensions to suit materials available. Thickness $\frac{1}{8}$" or $\frac{3}{16}$" Steel Plate.

Fig.15.

<u>11 SOME THOUGHTS ON THE PROBLEM OF TYRES</u> (Gazette No.2 1969)

Having minimized friction in the mechanical parts, one is left with the grip of the tyre on the road. Everyone knows that if one takes hold of the front wheel of a heavy car which is standing on a firm, dry surface and tries to swivel it, it will only move as ‘ far as the flexibility of the carcass and tread of the tyre will allow. The area of rubber in contact with the ground is roughly elliptical and is called the contact patch. The distortion of the tread will range from nothing in the centre to a maximum at the ends of the major axis of the patch. It is the sum total of this strain which has decided how far one has moved the wheel. i From this one can see that the following factors are involved:-

1. The thickness of the tread - The thicker the tread, the more easily it will deform.

2. The design of the tread - The more cuts and grooves the more easily it will deform.

3. The characteristics of the rubber - the softer the rubber the more easily it will deform

4. The tyre pressure - The higher the pressure, the smaller the contact patch will be, and the greater the angle the wheel can be swivelled to produce an equivalent amount of strain.

Unfortunately, if taken to extremes, these factors would lead to some rather nasty side effects, so the best a tyre manufacturer can do is a compromise.

If one now starts the wheel rolling, strained rubber is lifted off of the road at the rear of the contact patch, while unstrained rubber meets the road at the front, ready to be strained by the application of further lock. This is why one must move the car when trying to turn the steering otherwise damage may result. It is also why the steering gets lighter with increasing speed.

I cannot remember the make of tyres which were fitted to C.1902 when I bought it, they were, of course, cross ply, and the steering was rather heavy. I then fitted Avons which were a bit better. The next set were Mk.1 Avon Turbospeed, which was their first attempt at a high speed Nylon cross ply tyre using the new ‘High Hysteresis‘ rubber for the tread only. This was all very well, but on the most gentle of bends there was a terrible smell of burning rubber! By the time I had progressed to Mk.4 Turbospeeds, this problem had been solved, and they performed very well, especially in the wet.

However, with all these tyres I had never been able to cure a vibration period at about 70-75 m.p.h. When the Mk.4 production ceased, I had to consider an alternative.

It had always been said that the radial ply tyres would make the steering heavier, but John Bowers insisted that his Silverstone was lighter on Pirelli 165 SRl5's. I went to the local Pirelli depot, where they agreed that 165HR15's would be a very suitable choice, but said that there were none in the country! I then went to my usual tyre agent who suggested Dunlop 165HR15 Super Sport radials.

I have only done about 1000 miles on these, but I have been amazed at the lightness of the steering, the reduction of twitching on longitudinal grooves and ridges etc., the total elimination of the vibration in the speed range 70-75 m.p.h. and the general progress which has been made, *(I continued to use the Dunlops for many years, but after having returned six of them under guarantee due to lack of accuracy in the required circular form, which caused the return of the vibration problem, I have tried Pirelli, which were good on circularity and balance, but poor on wet grip, and am now trying Michelin XZX, which is a steel braced tyre)*.

The Healey Handbook gives a tyre pressure recommendation of 22 lb/in^2 on all wheels. This is far too low in my opinion. As Healeys have long since been forgotten in the tyre makers charts, one can only look at other models of similar size and weight distribution. The Austin Healey (six cylinder) has the same size tyre with 26 lb/in^2 at the front. I run the Tickford with a pressure of 27 lb/in^2 front, 32 lb/in^2 rear, which gives a reasonable handling balance.

I was worried about lowering the ground clearance, as most radials have a slightly lower profile, and are more deformed at the bottom, but the Dunlop was only 1/4" lower than the Avon, the centre of the wheel being 11 3/4" from the ground. (The Pirelli is probably lower)

It is, of course, preferable to have the same tyres on all the wheels, because although it is safe to have, for instance, cross ply on the front and radial on the rear wheels, there may as a result be a state of understeer, which means that for a given radius of turning circle, a greater steering angle must be applied to the front wheels, and therefore a greater castoring force must be overcome, and this causes heavier steering at all speeds. From this it can be seen that even rear tyres are a factor to be considered,

The Tickford is an oversteering car, but improved balance can achieved by the addition of a front anti-roll bar, as fitted as standard on the Silverstone. (I can now get all the tyres squealing together!)