SECTION 5 SPRINGS AND DAMPERS

GAZETTE NO_16

By Dr. Ian Picton Robinson

One of the most outstanding aspects of all Healey cars is the excellent compromise that is achieved between a comfortable ride and safe predictable handling. Many prewar cars had excellent handling, but achieved this by using such hard springing that only smooth roads could be covered quickly. British roads, especially the quiet back roads, are far from smooth and such hard sprung cars had at times to be driven relatively slowly in order to avoid them leaping about alarmingly. The Morgans perpetuate this philosophy to the present day. On the other hand, soft springing, such as is used by most American cars, and copied on most mass produced British cars in the 1950's, gave a generally comfortable ride at the expense of sloppy steering, excessive roll and sometimes uncomfortable wallowing and float. Healeys were almost the first British car to achieve a comfortable degree of firmness with good control under all circumstances. How was this done?

Essentially, Healeys were given soft springs, as on the best American cars, and firm dampers, as on the best sportscars.
Spring strengths front and back were related in such a way as to reduce the violent pitching motions which some cars even today (small Vauxhalls, Ford Granadas) are subject to.

I shall attempt to show in this and following articles, why this approach works, and in so doing, will point to ways in which small adjustments can be made to suit individual preferences.

The perpetual headache of suspension designers and development engineers is lack of agreement on what is ideal or even acceptable. No car yet achieves the perfect balance or compromise which suits everybody. I believe that the preferences of drivers and passengers spread quite widely along the axis between the limousine with its soft boulevard ride and the harsh firmly sprung sports/racing car. It is not true that any achievable middle position is entirely satisfactory. More specifically, I have observed that many people tolerate slow frequency vertical movements, which others find uncomfortable, even sickmaking.

By accepting this sort of motion, a remarkable degree of insulation from sharp bumps, jiggling motions and harshness can be achieved. The Jaguar XJ6 is one of the best of this type. With it come the disadvantages of a certain slackness in the steering, indecisive response, and if cornering near the limit of adhesion, an unsettling loss of precision.

The other half of the population seems to put precision and quick response in the top priority, dislikes large, slow body movements, and can accept a certain degree of firmness and sharp movement to achieve these objectives. There are a few who do not mind either type of vehicle;- unhappy are the men who.....

Before going into details about springs and dampers, the suspension geometry merits discussion, since it forms the almost unalterable basis of all that follows. The geometry is not of the best by modern standards, but has great consistency, and individual suspension components are secured precisely and rigidly with the minimum of rubber. Trailing links at the front ensure that the wheels always remain parallel to the vertical axis of the car. Bumps do not alter this relationship.
If the car rolls in a corner at an angle to the road, then so do the wheels. This results in some loss of maximum potential adhesion, since a wheel tilting into a corner degrades the

grip of the tyre, (less so with radial tyres than with cross ply tyres), but this tilt is maintained however bumpy the road, and the adhesion qualities remain relatively constant. At the back the solid axle keeps the wheels upright, maintaining a better potential adhesion, while again being little affected by bumps. Unfortunately, some adhesion is lost by the impossibility of keeping such a heavy axle (less heavy on the ‘F’ types with Salisbury axles) under complete control on rough roads, the lighter front suspension is better in this respect since its weight, unsprung in the technical sense, is less. The rear axle is, however, well located even by modern standards with either a long torque tube and Panhard rod, (A,B,C,D & E chassis) or by four trailing links and Panhard rod (F type). Advantages and disadvantages affecting the potential maximum adhesion at each end of the car cancel out fairly well; both suspensions act in a consistent manner so that predictable behaviour results, allowing a balance which can be played with by the driver using acceleration, braking and steering.

Further points of interest are, the heavier nose weight (except Silverstones) and front anti-roll bars on some, leading to more work for the front tyres to do in corners, balanced by the high roll centre (prescribed by the high mounted Panhard rod) and rather stiffer springing at the rear, both tending to load the rear tyres.

The springs contribute to this balance of handling, as well as to ride and comfort, in two ways, firstly by their relative strengths front and back, and secondly by their 'softness' or ‘low rate‘. To understand this it is best to consider a car at rest. Its weight is supported by the springs which are compressed to the point where they exert, directly at the back, and through linkage at the front, a force exactly equal to the car weight. The height of the car represents a position of balance. Now consider a different example perhaps try it out as an experiment Hang a weight from your hand by a throttle spring (or similar light spring) in such a way that its coils open out a little. Move the hand up and down, slowly at first, then gradually more quickly observe that with the slow hand movement the weight follows fairly accurately at roughly the same speed and through the same amplitude

As the hand moves up and down more quickly, so the weight tends to move more than the hand until at a resonant frequency, the weight moves up and down so much it flies off the spring. Start again, but now move the hand very quickly, at least twice the rate of the resonant frequency. The weight now moves up and down less than the hand, more strikingly so as the hand movement becomes very rapid. (I have also tried this with a jelly in a bowl without disaster). We can see that this is analogous to a car resting on its springs with the wheels moving up and down over bumps (ignoring the action of the dampers). A car so sprung will tend to absorb bumps coming through at high frequency, will move gently up and down with very low frequency bumps, and indeed would not be uncomfortable so doing, but will tend to bounce violently if it hits a pattern of bumps which come at a rate somewhere near the resonant frequency. Such a car would have the classic, but quite horrifying, boulevard ride. This matter of response is illustrated in fig.41.

The graph shows the size of car body movement as a multiple of the size of wheel movement, in response to the range of bump frequencies low to high. At about √2 x resonant frequency, response equals input, but at the higher frequencies the response drops to less than half the size of wheel movements. If we could find resonant frequencies which were so low as hardly ever to occur, and indeed be slow enough not to be uncomfortable to the human body, we would have somewhere near perfect ride, without the need for dampers. The Citroen DS series is close to this ideal with resonant frequencies of about 30 cycles per minute once up and down every two seconds! Roll angles, of course, have to be controlled by other means. The importance of low resonant frequencies is related to the human requirements of the human frame. It does not like being accelerated up and down by large forces. Resonance at high frequency implies rapid movement through large amplitudes and this requires high forces.
Resonance at low frequencies involves lower forces. It is and unfortunate fact that resonant frequencies cannot be entirely damped out, and this will be illustrated later. The

limit to how low frequencies can go, i.e. how soft springs are, is set by the available wheel movement. Clearly a very soft spring could compress completely under the weight of the passengers, and there would be nothing left to cope with the bumps. Healeys are quite well endowed with available wheel movement, and this was quite a pioneering feature amongst British cars in October 1946, when they were first shown.

Part 2 GAZETTE NO.17

Another way of looking at the same problem is to consider again the analogy of the weight on the throttle spring. If the hand is moved up and down quickly, the weight moves as a result of a change of force acting on it. As the spring extends, it exerts more force upwards, pulling the weight up; spring compression lessens the upward force and gravity pulls the weight down. For a given amplitude of hand movement, a soft spring will change its force less, so the movement of the weight will be less. A given size of bump will, through a soft spring, cause less change of upward force on the car, disturbing it less from its position of balance, in effect, not disturbing its level ride.

Using our analogy a stage further, the rate at which the weight moves will depend on the size of the change of force, and the heaviness of the weight. The suspension rate (cycles per minute depends on spring rate (= strength - lbs. weight per inch of deflection), and the weight to be carried by the spring, corrected for any leverage effects that may be present.

For the springs to be pressing upward on the car, they must equally be pressing the car's weight down through the tyres on to the road. By preventing much upward change of force over bumps, soft springs prevent much downward change to the tyres. Downward force or load through the res affects maximum available adhesion, and the amount of side slip from tyre distortion. Soft springs therefore minimise changes in these, allowing more consistent handling, most vitally near the limits of adhesion. In this way, Healeys gain almost all they lose by not having the ultimate in suspension geometry. They can be driven up, and through the limit with complete confidence; many a car with excellent grip has been so unpredictable that its limits can rarely be approached.

In the old days it used to be said that any designer who needed to use an antiroll bar to control the handling of his car was, in effect, admitting his errors. This is no longer an acceptable view, partly because relative strengths of front and back springs must primarily be adjusted to control uncomfortable pitching movements, using roll bars to fine tune the handling. It is found in practice that the effective rear spring rate must be some 10% above that of the front. This is necessary to avoid uncomfortable pitching movements. It will be seen later that it is not possible to damp out completely the primary resonant frequency of each suspension. This frequency of movement remains the most significant one to control. When bumps are taken at speed, there is a significant delay in the time between the front and the rear wheels passing over the bump. If the spring rates are equal back and front, and the time delay is about half the time for a full oscillation, up and down, the back will be going upwards, just as the front is going downwards. If, though, the rear spring rate is higher than the front, it oscillates more quickly and soon gets into phase with the front. Further oscillations are normally damped out. Also if a series of bumps, or more likely waves, in the road surface should occur at the resonant frequency, only one end of the car will be affected; the other end will be slightly out of phase, and the resulting body movement will not be too violent.

The full explanation is very technical, and relates to the relationship between the centre of gravity, the inertia of rotation about that point, the relative position of the suspension units. Those who are interested can find it in an article in the ‘Motor’ week ending December 12, 1970.

We have now reached the stage where we have a comfortable car with periodic uncontrolled movements. We now need to consider the dampers (or shock absorbers) which should transform it into something precise and controllable.

Dampers are so called because they damp out the oscillations of the suspension system. The term shock absorber is not entirely incorrect, as they do absorb finally the energy temporarily stored in the springs compressed by bumps. Hydraulic shock absorbers work by causing oil to be squirted through small holes, a process which heats the oil up, the energy of the heat being dissipated into the atmosphere. The Girling piston type used on the front of all Healeys, and on the rear of most is illustrated (Fig.41).

Anyone who has pushed a child on a swing knows that it takes very little push at any one time, but several correctly timed small pushes to build the swinging up to a very large amplitude. This is analogous to bouncing a car at its resonant frequency, or bouncing the weight on the end of its spring. The key to damping, therefore, is to provide a small force at the very earliest stage before the oscillations build up. Indeed, the forces exerted by dampers are surprisingly small; Healey dampers at very high rates of movement are resisting with some 200 lbs.force, and at normal slow bouncing rates of movement only some 60lbs.

Our original analogy can be used to illustrate this - if the weight suspended from the throttle spring is flat in the horizontal plane, and is hung in water, it will be impossible to produce a resonant movement of the weight.

The detailed construction of Healey dampers is shown in the diagram. The external lever acts through a spindle on an internal lever which sits between two pistons, which are held in contact with this lever by a pair of piston coupling springs. Movement of the lever pushes one or other of the pistons (on bump or rebound) towards the end of its cylinder, displacing oil up narrow passages into the valve block area. In this block are two small spring loaded valves, each in the shape of a hollow piston with holes in their sides. One has a hole in its end, partially obstructed by a tapered screw. The fluid is guided to the valve blocks in such a way that it passes the screw on both bump and rebound movements. At high velocities one or other valves lifts, the arrangement being such that movement of oil in one direction presses one valve against its spring, but also gets to the back of the other valve, pressing it even more firmly shut. The point at which the valves lift is different for bump or rebound, the bump valve lifting at approximately half the pressure of the rebound valve. After passing through the valve block, the oil is free to pass into the space behind the piston which is not being pushed by the internal lever, thereby forcing that piston along and maintaining its contact with the lever. As the valves lift against their springs, the holes in their sides are uncovered, giving an easier passage to the oil, and so offering less resistance to the suspension movement.

The dampers, therefore, give a fairly strong resistance to small movements, a resistance which is then held steady for higher rates of bump movement by the valve spring, but is allowed to increase for the more rapid rates of rebound movement. The screw controlling the slow movement is called a ‘bleed’ screw. Without the valves allowing wider orifices to open up, the increase of resistance with the increase of speed of damper movement would rise exponentially, i.e. very rapidly, and would reach almost infinite levels.

PART 3. GAZETTE NO.I8

I believe that sophisticated dampers, such as those used by Peugeot, have a series of valves arranged to lift one after the other to give a very precise control of damper characteristics. It is possible to do the reverse, that is to have valves that blow shut. I have observed this on at least one model of Rolls-Royce where small movements were virtually undamped, but rapid large movements were tightly controlled.

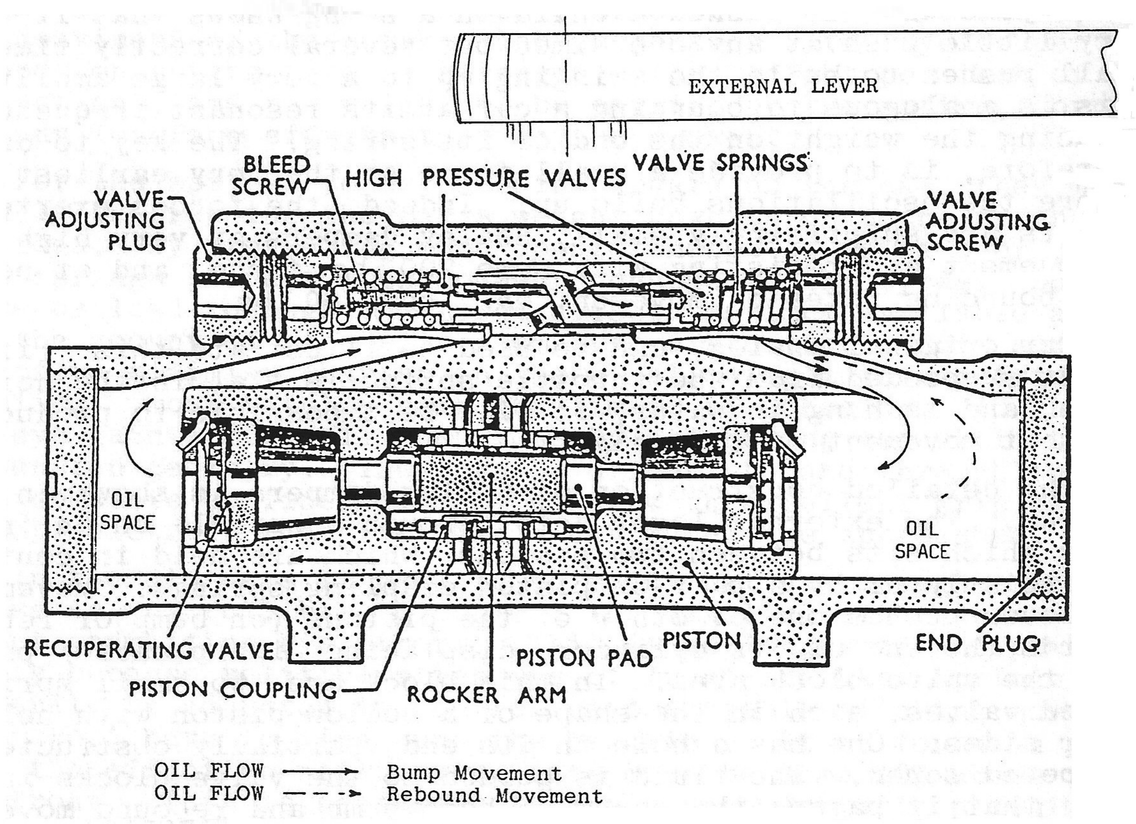


Fig.41. GIRLING PV TYPE DAMPER

The significance of these damping mechanisms is best understood by considering the spring characteristics discussed earlier. The great need is to damp out the resonant movements of the car on its springs. Higher frequency movements are absorbed by the springs alone, and require no damping. Slower frequency movements are allowable as they are not objectionable to driver and passengers. However, there is one high frequency movement that must be controlled - the phenomenon called ‘wheel hop‘.

The wheels rest on tyres which are flexible, i.e. they act as springs. Their resonant frequency is about ten times the car suspension resonance, i.e. 700 cycles per minute. The force that needs to be exerted to control this is related to the weight that bounces, i.e. the weight of the wheels, brakes, suspension links and axle. The force exerted on these will be reacted against the car, so it is clear that the less the unsprung weight, the less the disturbance in the car. At these frequencies the disturbance is felt as harshness. Secondly, damping these frequencies tends to increase the car‘s response to suspension inputs over and above that which would be felt with undamped springs.

Fig.43 illustrates this. It shows a series of graphs, the heaviest line being identical to Fig.40. representing the magnitude of the car body movement in response to various frequencies of wheel movement, i.e. half as much, the same (times 1), twice as much etc. The other lines show the effect of various levels of damping; very little for a boulevard ride, a great deal for a competition car. It shows that as the resonant frequency is progressively controlled, there is less and less absorption of high frequency input. Indeed, elimination of all resonant magnification of wheel movement results in the graph lying along the ‘times 1' line, i.e. the car follows the wheels exactly (vertically, as well as horizontally along the road!) and the springs and dampers do nothing. From which it can be argued that no energy is absorbed, the dampers are too hard and there must be a calculable setting of the dampers for maximum energy absorption.

This diagram seems to me to be fundamental to any spring/damper system, however and wherever it occurs. Water slopping in the bath, voltage oscillations in an electronic set—up, let alone motor cars all obey the rules. But the graphs do apply only to simple damping, where damping force is a function of movement velocity. Real dampers, we have seen, can vary the controlling force more subtly, allowing various settings at critical points. Much of the art of suspension development lies in determining these settings. There seems to be precious little theory of value and what there is, takes the form of mathematically derived computer simulations. It is still very much a 'seat of the pants' business, plus experience; here is the sea of rocks that has ruined many a potentially sophisticated design, or allowed a good navigator to produce good results from archaic basics. A few elementary facts do tend to be clear.

Damping upward (bump) movements can be precious little. Bumps need to be absorbed, the subsequent rebound needing firm control. A ratio of 1:2 has been suggested, though some manufacturers still believe symmetrical settings to be the best. I believe that this ratio can be higher, say 1:3,or 4 etc. Healeys have as high velocity settings a ratio of 6 :11 for the front and 11 :15 at the back.

The lowest limit for bump settings is determined by the need to control the unsprung weight bouncing upward off the tyres, the upper limit by harshness. The upper limit of rebound settings is set by the hollows without losing contact with the road.
The graphs show that body movement needs to be controlled around the fundamental frequency, which should, in any case, be low.

There is also a need to control roll movements and give a feeling of precision to the car and prevent it lurching too far. This requires quite firm damping; the inherent friction between leaf springs of pre-war cars provided this initial damping, and is in part responsible for their rapid steering responses. Healeys have no such friction, and the suspension linkage design is likewise unusually free from stickiness or friction, so that the dampers must be set to provide this response. The practice, therefore, is to give very firm initial damping, bump and rebound, to have light valve spring settings in bump so as to afford little resistance to rapid movements, but retain strong rebound valve spring settings to give firm rebound control, but nevertheless to blow that valve off so as to limit resistance when the wheels fall into hollows. Fig.44 gives a graphical representation of these settings. It shows a plot of force exerted by the damper at increasing velocities of movement. The diagram shows a typical lever arm damper of the Girling or Luvax type fitted to Healeys, or indeed, of the later Armstrong type fitted to Austin Healeys and many other cars up to the present day.

The graph shows an initial rise on the bleed setting, the solid line shows a flattening at a point determined by the length and strength of the bump valve spring. The slope of the next part of the curve is determined by the strength of the spring, allowing the valve to uncover an increasing area of passage for oil to pass through. The rise at the end of the curve is determined by the size of this passage. The dotted curve shows the settings for the rebound valve. The whole diagram will be referred to again in talking about the adjustments that can be made. More sophisticated dampers fitted to modern cars with good ride qualities (Peugeot, NSU R080, Mercedes Benz) can be represented by a graph with a series of rises and flat portions, as a series of springs release a series of valves.

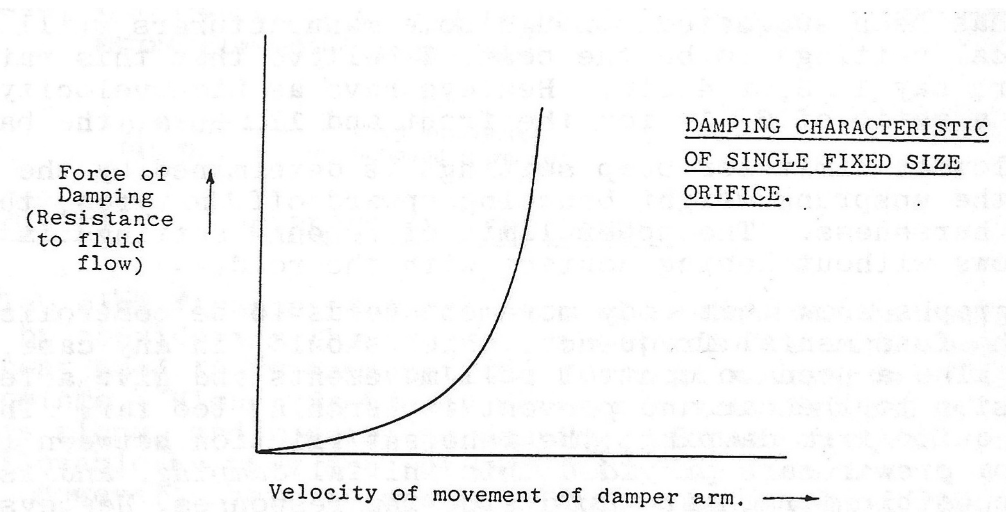
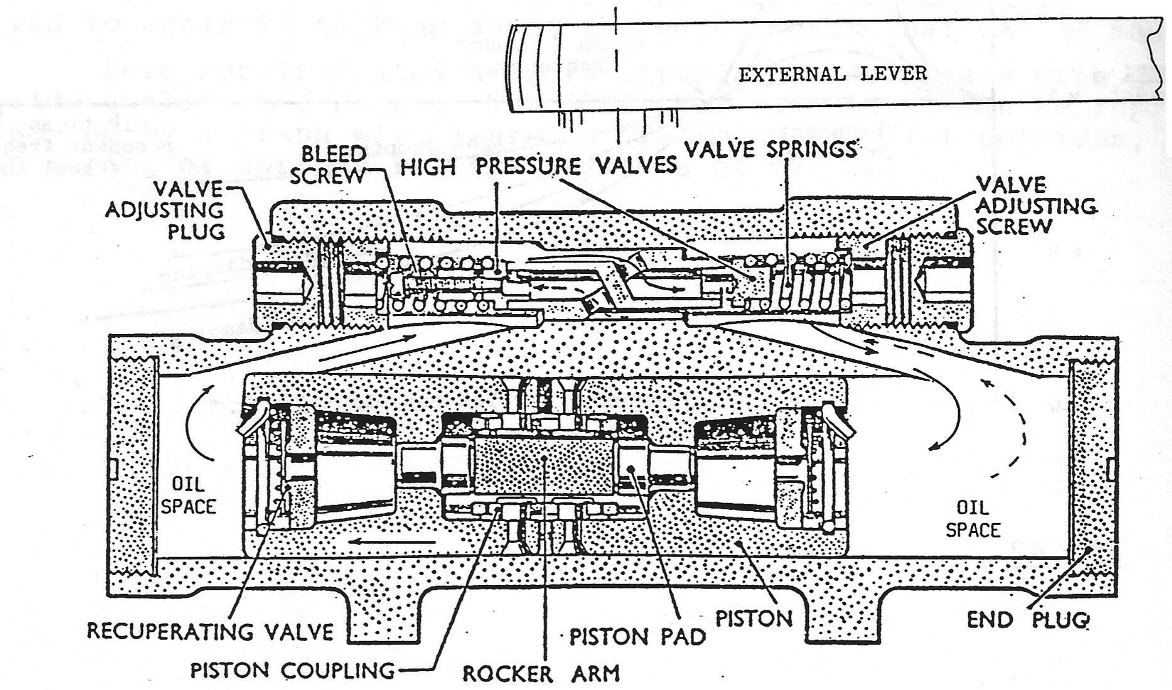


Fig.42.



GIRLING PV TYPE DAMPER.

Fig. 41a (As Fig 41, but including exploded view of valve)

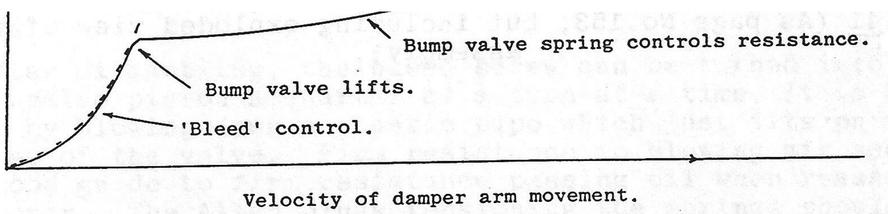


Fig.44

Part 4. GAZETTE NO.19

I now propose to discuss adjustments that can be made to the valve springs and bleed screw. Fig.4l has an exploded diagram of the valve block assemblies. There are two assemblies to each Girling type damper, each situated under a sunken Allen screw at the side of the damper, just under the lever. Beneath the Allen screw is a further brass Allen plug whose position determines the compression of the spring beneath it, which in turn bears on the piston valve. One of these valves has a small screw set into it, whose setting adjusts the low velocity bleed. It seems not to matter whether this screw is in the bump or rebound valve; oil is going to pass through it both ways; the pair of dampers that I have taken apart both had the screw on the rebound side. The bump valve is under the Allen plug which is furthest away from the lever.

The need for alteration of any of these settings may justifiably be disputed, as they are pretty good in the first place.
According to information that I have received, and whose accuracy I cannot be sure of, the original settings are given below. They are expressed as the force exerted by the damper at two angular velocities of the levers. The forces are expressed as in-lbs.

Velocity 100°/sec. 20°/sec.

	Rebound	Bump	Rebound and Bump.
Front	1100	600	450
Rear	1500	1100	450

I have already discussed individual preferences. Alterations of the settings in no way preclude reversion to standard settings. I wonder in fact how many cars in the club do have anything like the correct settings. A brief survey at an AGM some two years ago revealed widely differing settings, some cars being stiff at the front and soft at the back, some vice versa, some with different settings on each side of the car. So perhaps some work needs to be done to bring some cars into line, (At the 1990 Classic & Sportscar photo session, the Beaulieu Elliott had dampers completely inoperative!).

A word of warning, however. Adjustments, if not made a little at a time and tested on the road, can lead to instability, and could be dangerous! Be careful to keep the front dampers working harder than the back, at least until you are confident of the results.

After dismantling, the bleed screw can be turned into or out of its valve piston a quarter of a turn at a time. It is best tested by blowing down a plastic pipe which just fits on to the shoulder of the valve. Firm resistance to blowing air seems to be a good guide to firm resistance passing oil when reassembled in the damper. The Allen plugs tensioning the springs should be set about eight turns below the point where they are flush with the damper surface, the closing Allen plugs inserted, and the damper mounted on a slave bracket firmly secured to the bench. Two dampers mounted back to back and resting on the floor will serve as a crude alternative. The lever should be pulled upward with a fairly firm force, and there should be resistance to the movement, similarly downwards. Much firmer upward force should result in a definite 'yielding‘ of the lever and a squelching from inside the damper as the bump valve lifts. Downward force should be resisted to somewhere near the maximum that can be exerted, with the rebound valve perhaps just letting the lever yield.

Adjustments should now be made to the plugs tensioning the valve springs, turning them about half a turn at a time, until a suitable setting is achieved. If you can find a measuring rig, you are indeed lucky. The target to aim for, in my opinion, is very tight control of slow movement, easy relaxation of resistance against more rapid bump movements, but no relaxation of rebound control until very great force is exerted. There is now no alternative to fitting the dampers to the car and trying it on the road. It is vitally important to avoid too firm a bleed setting on the rear dampers. When the car rolls, the force exerted by the dampers will tend to load the rear tyres, increasing their slip angles, even at quite small deviations from the straight. The car will tend to swing about at the back and may even break adhesion in the wet and slide. Firmer settings at the front promote a much more stable transient understeer. It is likely that the subjective impression of better handling when the trailing link bearings are broken or seized is probably due to the stiffness mimicking such a firm front setting.

There are other causes of tail swings, which seem to be very noticeable in the longer tailed cars, such as the Tickfords and Abbotts. Ray Sugg has found that extra baffling of the petrol tank, reducing the tendency of the petrol to slop from side to side brings great benefit.

Harshness is to be avoided by keeping the bump valve spring pressure not too high. Firmness, steering response and roll control can be achieved by screwing up the bleed valve (not too tight, otherwise nothing will get through at all).

There is a limit to the amount of damping that can be done. This limit is set by the size of the dampers and their ability to lose heat. Telescopics are better than lever arm dampers in the latter respect, as they work with bigger volumes of oil moving at lower pressure through larger valves, and the dampers are usually direct acting, not working through eight inch long levers. Dare I suggest that certain Armstrong van sized lever dampers will fit? DAS 10 type will fit at the back with a suitably shaped lever (Eight inches long with the last three inches inset towards the damper mounting plane by 2 1/2") and DAS 12 with long straight levers may be persuaded to fit the front. Unfortunately these dampers have a short life, since their cylinders are formed directly in the soft alloy body, and their valve block arrangements, though different in detail from Girlings, are no more sophisticated.

Fitting telescopics to the back has been tried quite often, but it is difficult to specify valve settings, and adjustable dampers such as Koni and Spax, only adjust some of the settings discussed above. At least with lever types one can find a combination of settings to suit one's taste.

Be warned though, it is very easy to get a dangerous result, so never drive quickly on new settings until you know their effect; remember also that wet road handling is very different, and much more delicate than dry road holding.

Alterations to spring rates can be used to tune the handling - to load the front more to produce ‘understeer’, or the rear to produce ‘oversteer’, or to alter the basic ride characteristics, perhaps improve the phasing to diminish pitch, or stiffening to avoid hitting the bump stop when carrying heavy loads. Small alterations may possibly be beneficial, but large changes seem generally unwise. Hard springs will become uncomfortable, though quite appropriate for competition. However, the geometrical limitations of the front suspension could be greatly diminished by stiff springing reducing roll angles. Softer springs run a very real risk of allowing too much wheel movement, especially when the car is tilted over in corners - they roll enough as it is. So what can be done? The use of anti-roll bars front and back seems the most sensible; front ones were often fitted as an optional extra, and were standard on the later cars. Limiting roll thus, while leaving spring rates alone, has every potential merit. The difficulty may be to obtain good balance in all road and weather conditions, wet or dry, for tight slow corners and fast open ones. It may prove difficult to avoid lifting an inside rear wheel on corners, with the consequent loss of forward drive. Over stiff roll bars can produce an uncomfortable lateral rock, and tend to reduce the independence of each front suspension from its companion. My guess is that there may be a case for doubling the stiffness of front anti-roll bars, and adding a very light rear anti-roll bar as well.

The target to aim for, again in my opinion only, is a stable, but very slight degree of understeer for conditions near the straight, and for very fast open corners - tail swinging at 70 m.p.h. (and the rest) is likely to add to the number of grey hairs. At no time should the car be very far from neutral handling. Strenuous medium speed (40/50 m.p.h.) corners seem to need similar conditions, but it is desirable to be able to swing the car to milk oversteer - tail out - attitude by some means - i.e. hard acceleration. For very tight hairpin corners, taken near the limit of adhesion, it seems best to be able to get the tail out, so as to be able to keep a more tight line into the corner. The loss of adhesion characteristics need to be gradual, perhaps the most important characteristic of all. Sudden breakaway, without warning, a characteristic of some radial ply tyres, will not only cause anxiety when it happens, but will always leave a nagging doubt whenever the road surface conditions are uncertain, i.e. patchy wet or greasy conditions.
There would seem to be some scope for development. I am sure that many cars in the Club need attention to bring them up to the high standard originally developed into them. If any further doubts or queries arise from the above, I should be very pleased to expand on this basically theoretical exposition.

Dr. Ian Picton Robinson.

DAMPERS ETC

Ray Sugg

As I am no expert on the subject of shock absorbers, or dampers, as they are more correctly known. I have never written on the subject.

However, for the purpose of the book, I have cleaned up, and reprinted some rather scruffy photostats of an original Girling Handbook which I obtained some time ago. The Fig. numbers therefore relate to the Girling text, and not to the numbering system I have used for this book. In addition to this I have also reprinted a rather learned dissertation on the subject by one time member, Dr. Ian Picton Robinson. In this I have again taken the liberty of re-drawing the diagrams and graphs to improve their clarity, and re-numbered them to provide continuity. It must, However, now be accepted, that many of the dampers now in circulation are very old, and increased clearances between pistons and cylinder bores will not be as perfect as they once were. This will, inevitably, make the discussion of the fine tuning of bleed screws and valves largely academic. Many of the firms professing to overhaul dampers, do no more than fit a new rubber seal and ' repaint the body, and few know what a test rig looks like, let alone own one!

If you happen to own dampers of known low mileage, beware of part exchange systems, always insist on the return of your own dampers.

GIRLING

THE BEST BRAKES IN THE WORLD

SIZES AND TYPES OF GIRLING PISTON DAMPERS

Each of the foregoing Piston Type Dampers is made in a range of sizes suitable for all classes of vehicles.

The type is denoted by the prefix letters :—

P PR PV etc.

and the size by the number :—

thus P5, PR6, PVA7, etc.

These cyphers are then followed by a number indicating the valve and bleed settings, and it should be noted that these latter are purely reference numbers, and do not in any way indicate the actual pressures or timing employed.

thus P5/1, PR6/27, PVA7/102, etc.

DESCRIPTION	RANGE OF TYPES AND SIZES			
	8-10 H.P. Cars	Medium Powered Cars	Heavy Cars, Commercial and Passenger Vehicles	Passenger Vehicles
Original Piston Type.	P.5.	P.6.	P.7.	P.9.
Ditto with High Tensile Shaft and Rocker Arm.	P.P.5.	—	—	—
Pressure Recuperation Type.	P.R.5.	P.R.6.	P.R.7.	—
Ditto with High Tensile Shaft and Rocker Arm.	P.P.R.5	—	—	—
Double Ended Rotor Type for Independent Suspension.	P.R.5.X.	P.R.6.X.	P.R.7.X.	—
New Girling Type.	P.V.5.	P.V.6.	P.V.7.	—
Ditto with High Tensile Shaft and Rocker Arm.	P.P.V.5.	P.P.V.6.	—	—
New type for Independent Suspension.	P.V.5.X.	P.V.6.X.	P.V.7.X.	—
Latest type with larger bore and working parts but retaining same fixings.	P.V.A.6.	P.V.A.7.	P.V.A.8.	—
Ditto for Independent Suspension.	P.V.A.6.X.	P.V.A.7.X.	—	—

GIRLING

THE BEST BRAKES IN THE WORLD

THE DEVELOPMENT OF THE MODERN DAMPER

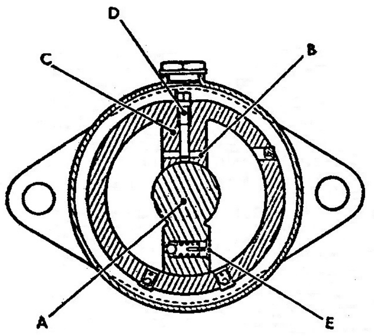


Fig 4 Section view of typical Vane Type Damper

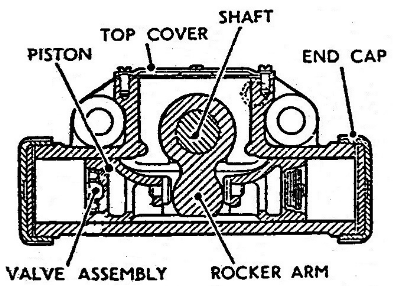


Fig. 5. Section View of Piston Type P. Damper.

When it was first realised that some form of control over the road springs was desirable, a frictional type of unit was fitted, and continued in use for many years. The most popular types consisted of two discs of suitable friction material held face to face by spring pressure and some form of adjusting nut. One disc being connected to the chassis and the other to the axle by suitable arms, oscillations of the road spring were reduced by the drag between the disc faces, as they rotated over each other. This method had many disadvantages, the principal of which, was the complete lack of any variation in the amount of control to meet immediate conditions, and the absence of any means to adapt the unit to suit the particular type of suspension, weight of vehicle, and other inherent conditions in the design of the car.

Manufacturers and designers soon realised that the solution to the problem of riding comfort lay in a hydraulic unit, which alone could give the variations in control that are so necessary to accommodate all the changes in requirements that are needed to meet various road speeds and surfaces, as they are encountered.

The first Hydraulic Units were of the Vane Type, Fig. 4, in which a Vane or Paddle (A) on the rotor shaft, forced the hydraulic fluid through a small orifice (B) in a reacting block (C). This orifice could be restricted by an adjusting screw (D), and spring loaded relief valves (E) prevented the internal resistance building up beyond a pre-determined figure, at violent movement of the axle.

Whilst this was a considerable improvement on the friction type of unit, it still failed to give the full variety of control, so necessary to maintain a smooth ride under all conditions, and the PISTON TYPE of unit (Fig. 5.) came into being.

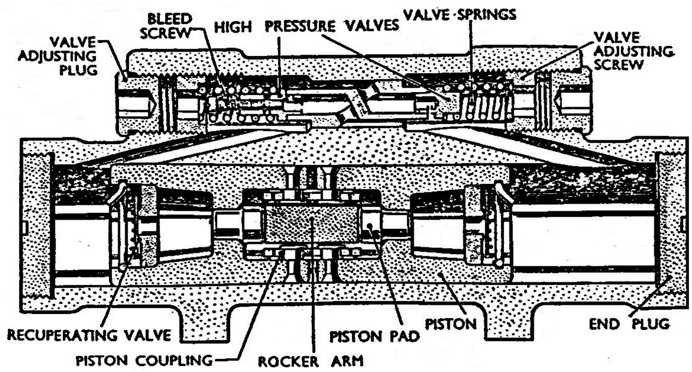


Fig. 6. Section View of the Girling P.V. Unit.

S

GIRLING

THE BEST BRAKES IN THE WORLD

THE DEVELOPMENT OF THE MODERN DAMPER

This type of Damper which with many improvements forms the basis of the latest types of GIRLING DAMPERS exercises a dual control over the road springs, a pre-set "bleed" taking care of small oscillations set up when travelling over normal road surfaces at moderate speeds, and high pressure relief valves to take care of the most violent movement at high speeds on bad road surfaces.

For the earlier Piston Types, these valves were of the shim types, set in the ends of the pistons, and whilst in the main satisfactory, they were prone to the effects of any dirt or foreign matter, which became embedded in the valve seat, and rendered the unit inoperative.

The latest type of GIRLING DAMPER the P.V.A. TYPE, Fig. 6, incorporates a sleeve type valve housed in a separate chamber, and permits a free end to end discharge in the pressure chamber. The only valves carried in the pistons are lightly loaded make-up valves to allow free movement of the piston in the reverse direction. The detailed descriptions elsewhere in this booklet will show immediately the considerable advantage of this P.V.A. unit over earlier types.

A further development of the post-war period has been the introduction of the GIRLING Direct Acting Telescopic Dampers, Fig. 7, which are especially suited for Independent Suspensions, and obviate the necessity for operating linkage of any kind.

With the previous forms of hydraulic damper short-stroke pistons, or perhaps vanes, move in chambers full of fluid against restrictions provided by valves, and are coupled to the axle ends by radial arms and links. In the new Girling direct-acting Damper the principles of the hydraulic system are similar ; that is to say, fluid is displaced by a moving piston, and the work done in forcing the fluid through the valve controlled restrictions and thereby raising the temperature of the fluid, is the measure of the damping provided.

Between the radial arm and the direct coupled types there is a basic difference. The radial arm type employs relatively short-stroke pistons and a system of mechanical leverage, whence the stresses are comparatively high. The direct-coupled type employs a long-stroke piston and no mechanical leverage is necessary ; hence the stresses are of a lesser order, and incidentally the hydraulic valve ports and restrictions may be larger and less sensitive. More fluid is in circulation and pressures are lower. The direct-coupled damper has therefore certain advantages in addition to the main feature of fitting in neatly on Independent Front Suspensions.

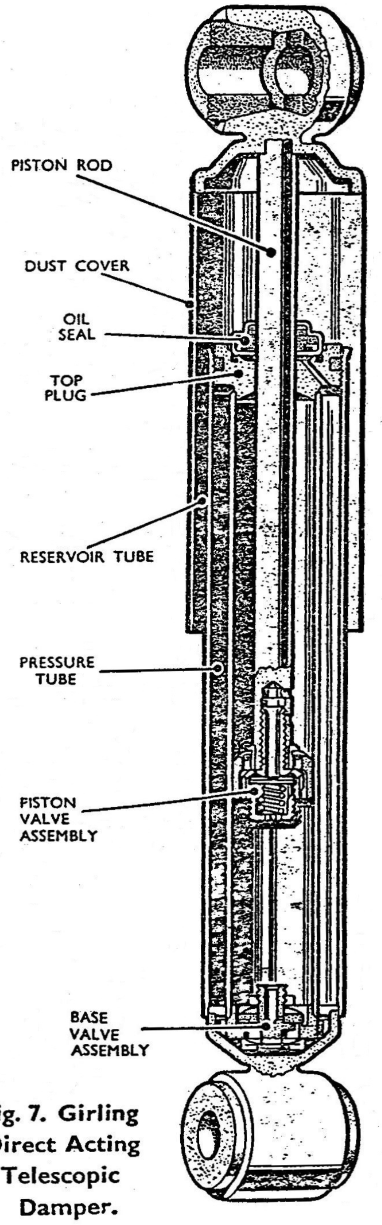


Fig. 7. Girling Direct Acting Telescopic Damper.

OPERATION OF THE P.V. TYPE HYDRAULIC DAMPER

The flexing of the vehicle suspension causes rotary movement of the rocker, which actuates the pistons in the working chamber.

Movement of the piston towards the end of the chamber forces the fluid through a channel into the

To control the bleed for slow movement of the rocker, a bleed valve is incorporated in the valve body. This valve is pre-set before leaving the factory, and operates in both directions.

GIRLING

THE BEST BRAKES IN THE WORLD

Service Instructions for the Maintenance of Girling Hydraulic Dampers

PISTON TYPES (All Models)

Maintenance

The only attention required on the chassis is the periodical examination of the anchorage to the chassis, the fixing bolts being tightened as required.

Connecting Link Bearings will last for very considerable periods but are normally renewed when complete overhauls are being carried out. Details of these operations are given later in the instructions.

Dampers should be topped-up with WAKEFIELD GIRLING Piston Type Damper Thin Oil occasionally.

Testing

When the question of vehicle suspension is under consideration, the chassis springs and tyre pressures should be checked.

If the Dampers do not appear to function satisfactorily, an indication of their resistance can be obtained by carrying out the following check :—

Remove the dampers from the chassis.

Bolt to a suitable plate, using fixing lugs, and hold plate in vice. (Holding the damper directly in the vice will distort the unit).

Move the lever arm up and down through its complete stroke, when an even resistance throughout should be felt.

If the resistance is erratic, and free movement of the lever arm is noted, it may indicate lack of fluid.

If the addition of fluid (added as described in the instructions) gives no improvement, a replacement damper should be fitted.

Too much resistance—when it is not possible to move the lever arm slowly by hand—possibly indicates a broken internal part, or a siezed piston, in which case the assembly should be renewed.

Topping-up with Fluid

Remove the complete assemblies from the chassis.

Place in a vice using suitable clamping plate.

BEFORE REMOVING THE FILLER PLUG, COMPLETELY CLEAN THE EXTERIOR OF THE DAMPER, AS IT IS MOST IMPORTANT THAT NO DIRT OR FOREIGN MATTER ENTERS THE MOVEMENT THROUGH THE FILLER PLUG HOLE.

Use only Girling Piston Type Damper Thin Oil. In this connection the correct oil is made up and distributed on our behalf by Messrs. C. C. Wakefield Ltd.

While adding the fluid, the lever arm must be worked throughout its full stroke to expel air from the pressure chamber.

Fill to the bottom of the filler plug hole. (The unit cannot be overfilled).

When refitting damper to the chassis, after bolting in position, but before reconnecting link, work the arm through the full stroke several times to make sure no air is present.

If for any reason it is not possible to remove the dampers from the chassis, these precautions are essential:—

(a) The unit must be thoroughly cleaned before the filler plug is moved.

(b) A shield should be placed over the unit before the plug is removed in order to protect the unit, and not removed until the filler plug is replaced.

(c) The filler can must be absolutely clean internally and externally (restrictions do not at present allow the supply of small cans with a special filler spout).

(d) Use only Girling Piston Type Damper Thin Oil, available from:—Messrs. C. C. Wakefield Ltd., 46, Grosvenor Gardens, London, W.1. or from all authorised GIRLING SERVICE AGENTS.

Investigating Noisy Dampers

This needs careful investigation. The bolts which secure the dampers to the chassis should be checked for tightness, and if the dampers are mounted on brackets, the bolts or rivets holding the brackets to the frame should also be examined. The anchorage of the lower end of the connecting links to the axles and the connecting link bearings are further points which should be looked at. If the various bolts or rivets are tight, the damper connecting links should be disconnected and each lever arm moved by hand. If there is free movement of the arm it denotes lack of fluid and/or air in the pressure chambers. If this condition exists, a noise may be caused by the piston or vane "slapping" against the fluid after passing through the air-gap. The remedy is to "top-up" with the recommended fluid and work the lever by hand to expel the air and recuperate the working chamber as already described. A case may be met with, however, where no free movement is present, or where "topping-up" with fluid has dispelled the free movement of the arm and the resistance is uniform throughout the stroke—but the noise continues. Obviously a further search must be made. It is well known how difficult it is to locate a noise whilst driving, and a simple method of determining if the noise is in the dampers, or not, is to take a short run on the road with each damper connecting link in turn disconnected. If a noise is present when one of the links is connected and absent when it is disconnected (and the fixing bolts are tight and the linkage correct) the noise is located as being in that particular unit. The noisy damper should be removed, and if it cannot be corrected by the usual maintenance methods it should be returned to the manufacturers, as some internal mechanical fault will have developed. A loose lever arm may also cause noise.

A word here of the importance of expelling the air from the pressure chambers of the piston-type units before refitting them to the car. It is imperative that all air is expelled by working the lever arm up and down through the full stroke, and, furthermore, after expelling the air, the unit must not be left lying on its side before fitting, otherwise air will re-enter. When all the air has been got rid of, the unit should straight away be bolted into its place or stood in its working position until it can be fitted.

"Rolling on Corners"

A further trouble which may be encountered is " rolling on corners." It should be clearly understood that the dampers are not intended to act as an anti-rolling device. A little thought will show why this is so. We have already explained that hydraulic resistance increases with speed ; now, rolling is a slow movement, and this causes the dampers to offer only a low resistance, if they are adjusted normally. Assuming that they could be adjusted to offer sufficient resistance to prevent slow speed roll, the amount of damping for normal straight ahead conditions would be excessive and the result of rolling does not come into the sphere of the dampers' duty. In fact, a large number of well-known car manufacturers fit hydraulic dampers to damp the road springs and anti-roll torsion bars to prevent " rolling on corners."

Bearing Replacement

Special tools as shown in these instructions are required for fitting bearings and a hand press should be available. These tools are available in sets to Girling agents only and a descriptive leaflet giving full details can be obtained on application to Girling Ltd., Service Department, Tyseley, Birmingham.

Dismantling Linkage

BEFORE DISMANTLING THE CONNECTING LINK FROM

FITTING TUBES (Where used)

To Assemble Pin to Connecting Link Rubber. Fig. 21.

Place the boss end, with the assembled rubber, in position on the base block.

Lightly smear tip of tapered guide tool only, with Wakefield's Rubber Grease No. 3.

Insert the tapered guide tool, together with the pin, into the bearing.

With a quick action, force the assembly complete with pin into the bearing.

Remove the tapered guide through the base tool.

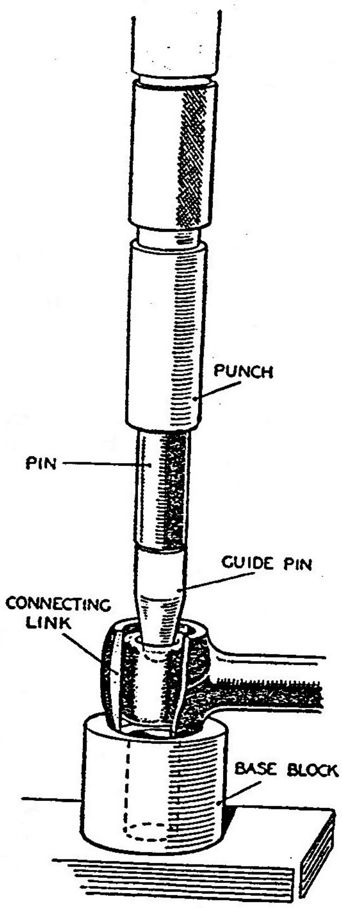


Fig. 21. Method of fitting pin.

To assemble pin to connecting link (rubber).

Fitting Connecting Link to Lever Arm, Fig. 22.

Place connecting link in clamping tool.
Fit the tapered tool on the end of the link as illustrated.
Lightly smear tip of tapered guide tool only, with Wakefield's Rubber Grease No. 3.
Place lever arm, with bush fitted, on to the guide pin.

Note. The bush is not central in the boss, and should be assembled exactly as shown in the illustration. When the link is assembled the bush will assume the central position.
With a quick action of the press, force the connecting link into the bearing.

N.B. A suitable clamping tool, as shown in the illustration, can be obtained, and greatly facilitates this operation.

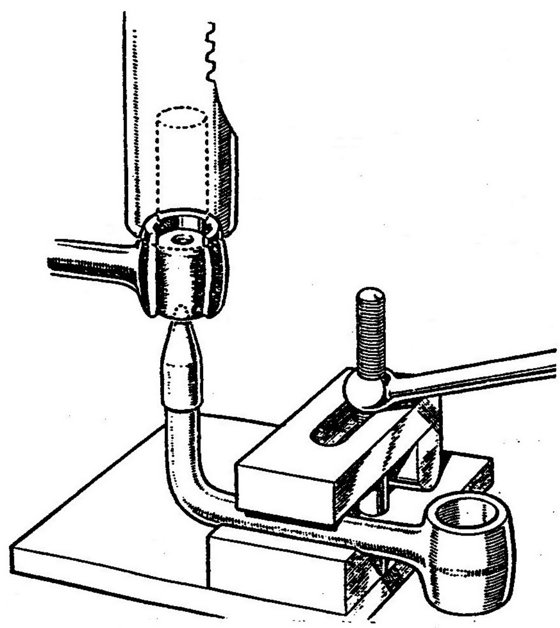


Fig. 22. Method of fitting

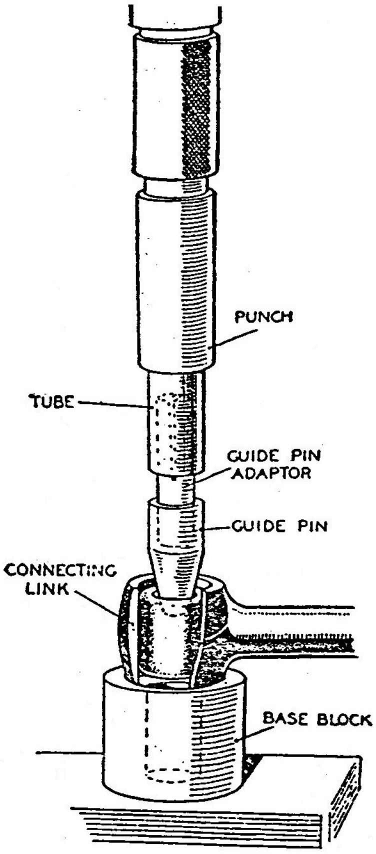


Fig. 23. Method of fitting Tube.

Fitting Tubes (where used) to Assembled Rubber (Fig. 23).

Place the boss end in position on base block.

Lightly smear tip of tapered guide tool only, with Wakefield's Rubber Grease No. 3.

Fit the guide pin adaptor into the guide pin.

Fit the tube over the split end of the adaptor.

Insert the tapered guide, with its assembled adaptor and tube, into the rubber, and with quick action force the guide pin adaptor and tube into the bearing.

The guide pin and adaptor can then be withdrawn through the base.

DAMPER FLUIDS

Two entirely different fluids are used for Vane and Piston types and under NO circumstances should these be mixed, or the functioning of the Damper will be seriously impaired.

Always insist on GENUINE WAKEFIELD-GIRLING DAMPER FLUID sold everywhere in sealed Green tins and marketed by:—

Messrs. C. C. Wakefield Ltd.
Grosvenor Gardens,
London, W.1.

FOR VANE TYPES

WAKEFIELD-GIRLING VANE TYPE **THICK** OIL.

FOR PISTON AND D.A. TYPES

WAKEFIELD-GIRLING PISTON TYPE **THIN** OIL.

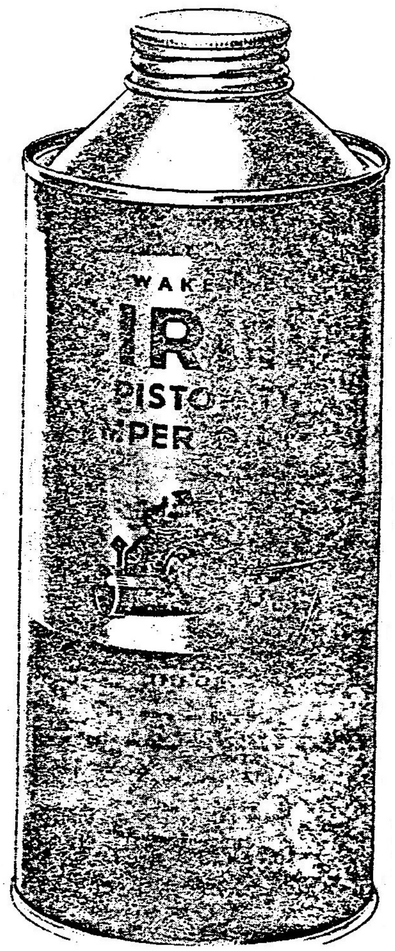


Fig. 24. Genuine Girling Damper Fluid in Sealed Tins.