TECHNICAL INFORMATION CONSTRUCTION OPERATION and SERVICE INSTRUCTION FOR

GIRLING

THE BEST BRAKES IN THE WORLD

HYDRAULIC DAMPERS

BOOKLET No. G94

HYDRAULIC DAMPERS FOR ALL PURPOSES

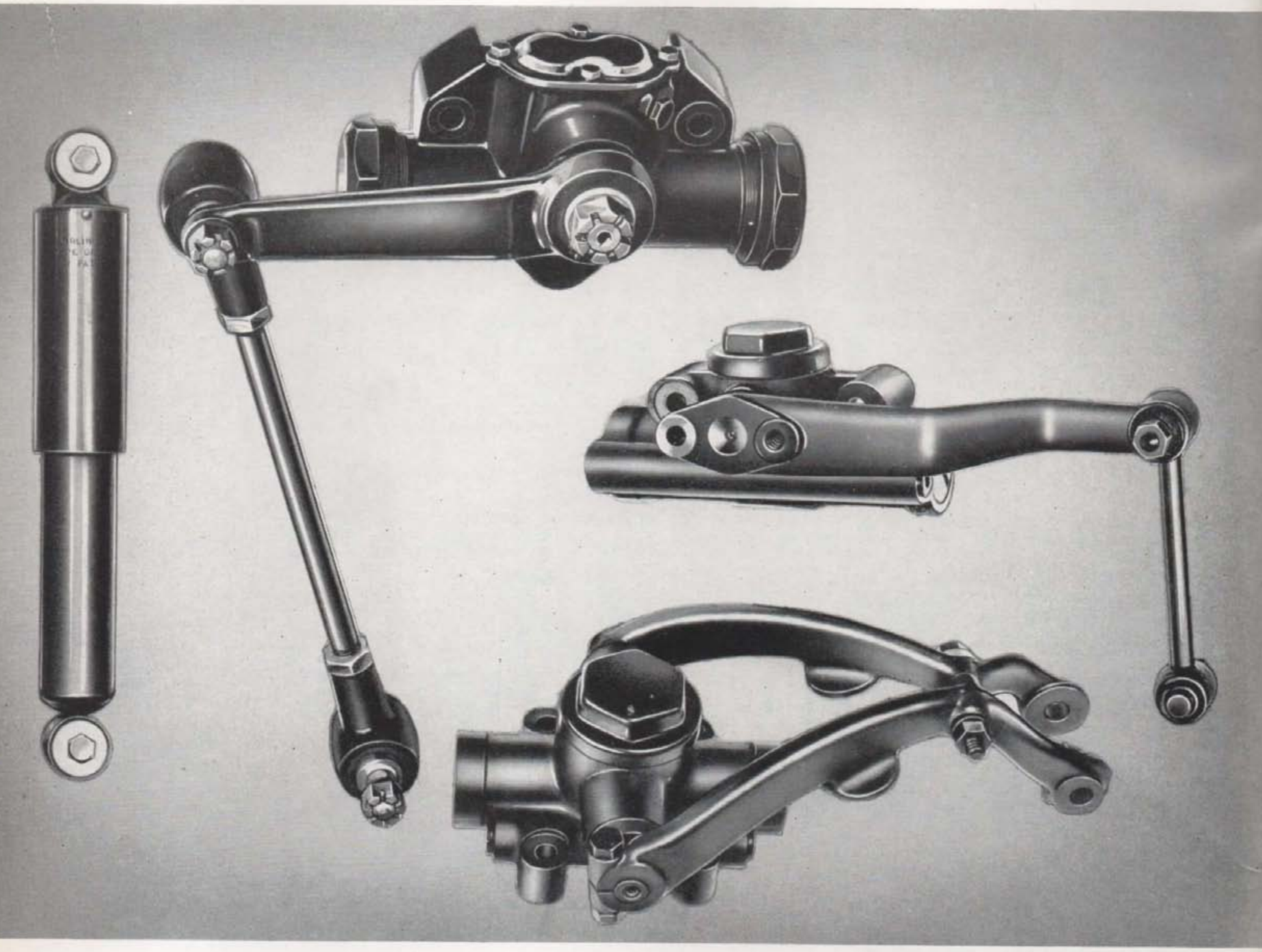

Fig. I. Some typical Girling Dampers.

GIRLING HYDRAULIC DAMPERS

The Damper forms an important part of the vehicle suspension and should accomplish far more than merely acting as a drag on the spring. The essential function is to control the movement of the spring, whether it is only a slight oscillation caused by normal road surfaces, or violent movement on impact with some depression or obstruction, and as shown in the following pages.

ONLY A HYDRAULIC UNIT CAN GIVE THIS MEASURE OF CONTROL.

The difference in riding quality between this type of damper and a friction type of any description is immediately apparent to the driver and passengers, and all the principal car manufacturers throughout the World specify Hydraulic Units exclusively.

GIRLING HYDRAULIC DAMPERS which are also the only standard replacement for the original LUVAX types, are specially designed to give the maximum riding comfort under all conditions. Various types and settings are specified for each model of vehicle and are carefully selected to suit the individual suspension employed.

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THE OBJECTS AND FUNCTIONS OF DAMPERS

Dampers, or "shock absorbers" as they have usually been somewhat misnamed in the past, are a very necessary part of the suspension systems of cars of to-day. Their main function is to check the rebound movements of the road springs after they have been compressed or extended, and so to reduce to a minimum the number, rapidity, and extent of oscillations which otherwise would occur. To put the matter into the most simple language, dampers stop the road springs from bouncing, as a tennis ball bounces in lessening beats on a hard surface.

On present-day cars the hydraulic dampers form a very important part of the suspension system. Before dealing with their construction and maintenance, we will consider their function, as it is most necessary that this is clearly understood.

Dampers are fitted in an endeavour to provide a means of absorbing and dissipating the forces produced by the wheels travelling over irregular surfaces, which tend to impart vertical movement to the body. The springs, which form resilient members between the wheels and body, are intended to deflect or compress and thus absorb the "shocks" or disturbing forces. The primary function of the damper is to dissipate these forces when thrown off by the springs in the form of "rebound."

It will, therefore, be seen that the duty performed by the so called "shock absorbers" is not that which was implied by the name. This was responsible for causing a great deal of misunderstanding, hence the more descriptive name "Dampers" is used to-day.

If a car is without springs, the shock occasioned by the wheels encountering bumps and depressions in the road would be transmitted direct to the chassis frame and body, therefore, all cars are fitted with some form of spring interposed between the wheels and body—the conditions then being that the wheels can move vertically in relation to the body. Wher the wheels receive impact from road irregularities, they are forced towards the body, and the force of energy or shock instead of being transmitted direct to the body is absorbed by the springs, which are compressed in the process. **It should be noted that the energy is stored in the compressed springs, but not dissipated.** In all springs the energy absorbed under these conditions must be thrown out again. The output of energy is responsible for what we term the "rebound," and this forces the wheels and body apart again. Subsequent to the rebound from the initial compression, the springs will continue to go up and down a number of times : these motions, or oscillations, we shall later refer to as "persistance." Without dampers fitted, although the road shocks are absorbed by the springs, there is the disadvantage of an uncontrolled rebound, and subsequent oscillations, which would produce what is commonly called "body bounce," as shown diagrammatically in Fig. 2.

THE OBJECTS AND FUNCTIONS OF DAMPERS

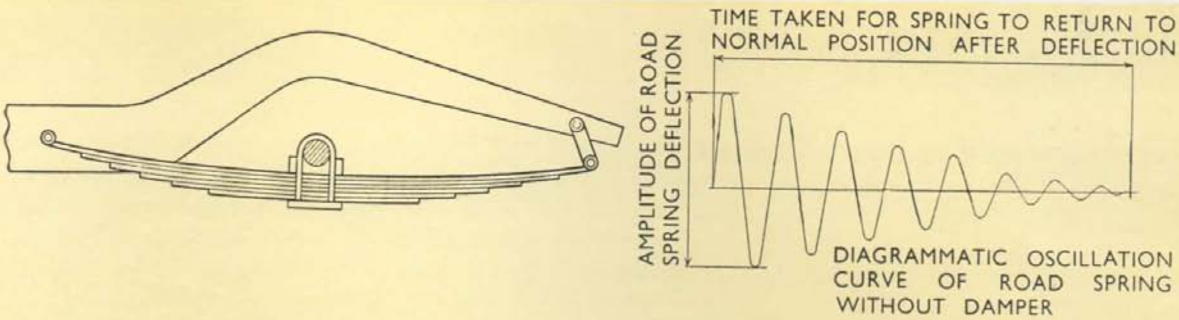

Fig. 2. Spring suspension system on rear of chassis without Damper.

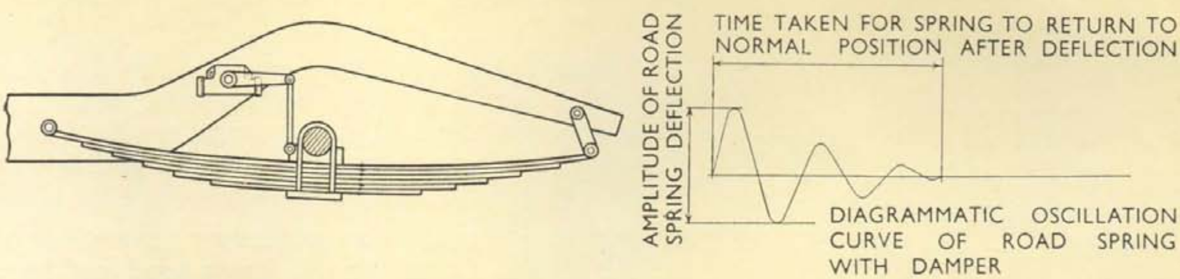

Fig. 3. Spring suspension system on rear of chassis with Damper.

When a car with a road spring is fitted with hydraulic dampers the impact of the wheels against the road irregularities produces a force which is absorbed by the springs, but the resultant output of energy in the form of "rebound" and "persistence" is dissipated or damped by the hydraulic damper. In other words, the surplus energy in the spring is expended in forcing a volume of fluid through a small hole or valve in the damper instead of by oscillating the body upwards and downwards. By setting these valves at predetermined pressures a controlled "ride" is obtained, the springs flexing to absorb impacts and the hydraulic damper controlling the subsequent rebound, as shown in Fig. 3.

Fig. 3. Spring Suspension System on Rear of Chassis with Dampers.

Diagrammatic Oscillation Curve of Road Spring with Dampers.

The above touches only on the elements of the theory of suspension, and is intended to serve as an illustration.

In actual practice there are many other considerations involved : for instance, the pneumatic tyres form a cushion between the wheels and road, and therefore play a part in the suspension system. Also, although the road springs are intended to absorb the shocks, in practice they only partly succeed, as no form of road spring has yet been found capable of absorbing all road irregularities without imparting some vertical movement of the body.

The perfect spring would deflect instantaneously the amount necessary to enable the wheels to follow the road contour, without disturbing the body, but this ideal has not yet been attained.

Yet again, it is not found desirable to retard the springs by the dampers to such an extent that they return from the compressed position to normal in one movement without subsequent oscillations. If this were done the rate of deceleration would be too high and would produce the effect of a harsh ride. The object at which to aim is to bring the springs to rest smoothly in the minimum time. The amount of damping necessary to achieve the best results requires very careful consideration. It is not the same for a given size of car, that is to say, one make of 10 h.p. car may require quite a different type and amount of damping to a similar h.p. car of a different design. One may require equal-acting dampers and the other differential, one way high-resistance and the other low. This is because the damping required is dependent upon the characteristics of the road springs, weight distribution, and other factors, each of which may vary widely.

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DAMPER REQUIREMENTS

Some suspensions, using leaf springs, variable rate springs, air legs, rubber suspensions, etc., need less damping than freely oscillating suspensions employing coil springs, or torsion bars with practically frictionless bearings owing to the inherent damping characteristics of the suspension, but as yet all need some form of damping.

Besides smoothing out road shocks; roll on corners, pitch when braking, and steering kicks can be alleviated to a remarkable degree by judicious setting of the dampers, which must continue to operate noiselessly and reliably for a long period under all extremes of temperature.

The damper must be capable of smoothing out oscillations, which in the case of 4 in. cobblestones are in the order of 30,000 reversals per mile, when the damper is working under tropical temperatures up to 120°F. at which temperature the piston type thin oil has a viscosity of 52 seconds Redwood, and yet still take care of the flow of oil and not allow pressures to rise dangerously high under arctic conditions down to – 40°F. with a corresponding oil viscosity of 30,000 seconds Redwood.

The highest recorded figure of axle velocity is in the region of 10 feet per second, and acceleration of 10.g. needs to be catered for, which presents a problem where recuperation valves must be lightly spring loaded in order not to interfere with recuperating flows of high viscosity oil under rapidly oscillating conditions.

After passing over a bump or depression, the damper should exert resistance to return the system to equilibrium in the shortest possible time. This means that in the case of a wheel passing over a bump, no resistance should be offered to the rise of the axle above the normal line, but resistance should be met when the axle starts to descend, the resistance increasing in degree with the extent the axle is moved from normal. The converse takes place when a wheel falls in a depression, the axle being allowed to fall freely, and follow the contour of the depression, but resistance again being applied immediately it starts to rise.

To meet these opposing requirements, a compromise must be found by setting the bleed flow, and relief valve pressures, at the settings best suited to the particular vehicle under consideration.

The most satisfactory ride comes from a balance of bump and rebound valve setting and their corresponding bleeds, when adjusted for slow and high speeds over both smooth and rough roads.

Personal opinion also enters very largely into the establishment of a "comfortable ride," and tests carried out with inertia instruments and accelerometers indicate that it is not so much the magnitude of the oscillation which makes a ride uncomfortable, as the frequency and type of oscillation. That is to say, fairly large displacements can be accepted if they are smooth and slow, but small, jagged oscillations are uncomfortable, although the car is moving up and down to a lesser degree.

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THE DEVELOPMENT OF

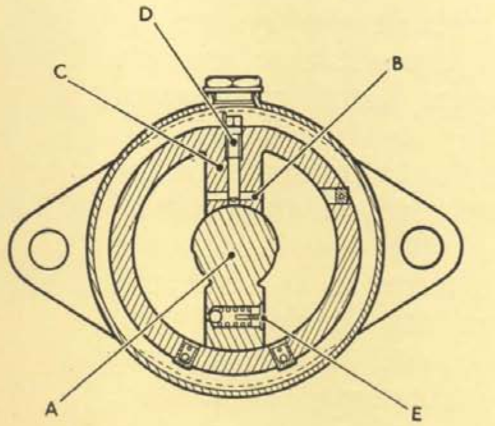


Fig. 4. Section view of typical Vane Type Damper.

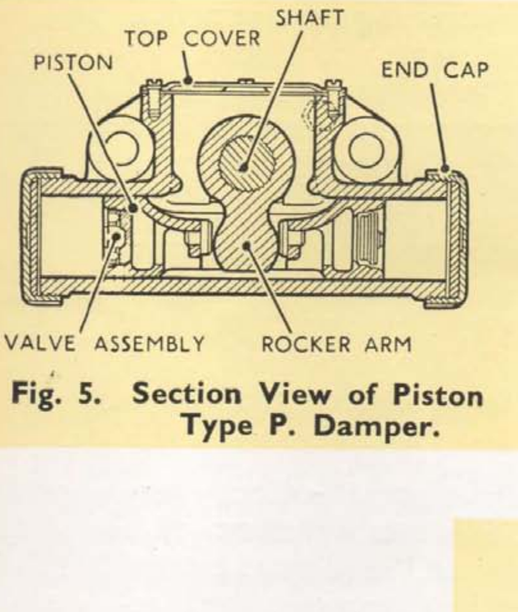


Fig. 5. Section View of Piston Type P. Damper.

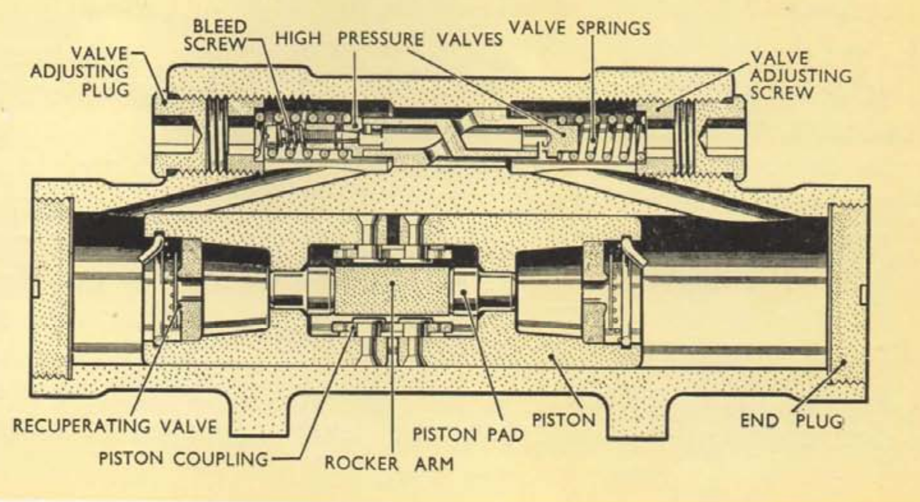
When it was first realised that some form of control over the road springs was desirable, a frictional type of unit was fitted, and continued in use for many years. The most popular types consisted of two discs of suitable friction material held face to face by spring pressure and some form of adjusting 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.



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 valve chamber, which is cast integral with the main body. On generation of sufficient pressure the fluid lifts the spring-loaded sleeve valve off its seating and escapes to the low pressure side of the main chamber.

While one piston is forcing the fluid at high pressure through the sleeve valve concerned, the pressure in the other cylinder falls, allowing the recuperating disc valve to open in order to recuperate the very small volume of fluid that has escaped past the piston, into the reserve chamber, thus maintaining the pressure chambers full of fluid ready for a change of direction of movement and reversal of the direction of flow of the fluid.

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.

The setting of the pressure and bleed valves is highly critical. This is carried out with extreme accuracy on special test rigs at our factory, and subsequently the adjustment is sealed with a screwed plug.

Under no circumstances should any attempt be made to interfere with these adjustments, as the riding qualities will be impaired and serious damage may be caused to the unit.

No responsibility can be accepted by GIRLING LIMITED for any units where this adjustment has been tampered with.

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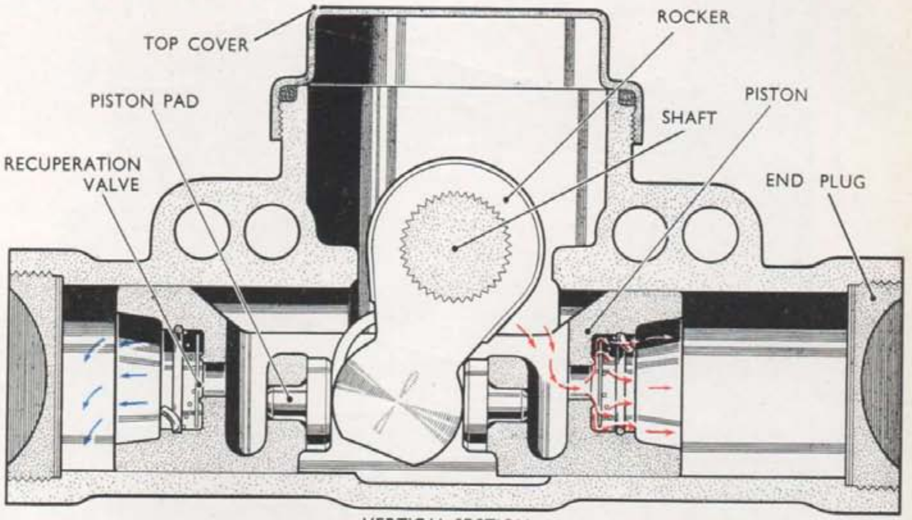
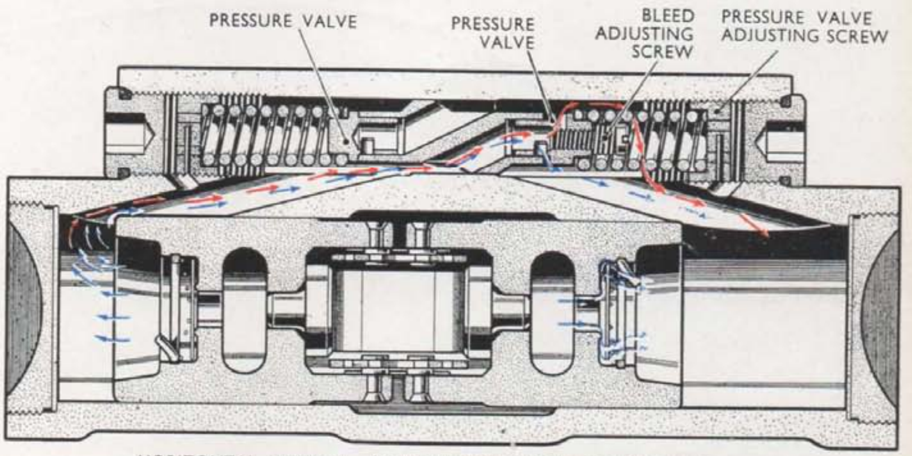
P.V.A. TYPE DAMPERS



VERTICAL SECTION
(PISTON MOVING TOWARDS THE LEFT)



HORIZONTAL SECTION (PISTON MOVING TOWARDS THE LEFT)
RED ARROW INDICATES FLOW OF FLUID THROUGH BLEED VALVE
BLUE ARROW INDICATES FLOW OF FLUID THROUGH MAIN VALVE

Fig. 11.

Changes which have taken place in British car design since the war have done a great deal to improve riding and handling qualities, but have imposed much more arduous duties on dampers.

Firstly, the leaf spring, with its own internal friction, has gone out of fashion for front suspension, and has largely been superseded by frictionless types — the torsion bar on 29 per cent. of to-day's models and the coil spring on a further 39 per cent. Secondly, spring flexibility has been increased greatly at the front and slightly at the rear, giving increased ranges of damper motion. Thirdly, improved riding qualities and increased emphasis on export sales have resulted in more cars being subject to fast driving over badly surfaced roads.

The new dampers, known as the P.V.A. type, Fig. 11, differ fundamentally from earlier P.V. types in having enlarged cylinder bores—the smallest size is now $1\frac{1}{4}$in. instead of 1in., a change which increases the fluid displacement by over 50 per cent., and so allows operating pressures to be lowered. There has been a corresponding increase in reservoir fluid and air spaces, the rocker shaft diameter has gone up from $\frac{5}{8}$ in. to $\frac{3}{4}$ in., and a wider rocker has allowed the contact line length on each piston end pad to be extended from $\frac{5}{16}$ in. to $\frac{9}{16}$ in.

With pre-war suspension systems, dampers were working with fluid pressures of the order of 550 lbs. per sq. in., but modern suspension systems and driving methods have roughly doubled peak fluid pressures. The new P.V.A. series of dampers, correctly applied, have lowered the operating pressures by means of increased displacements —for example, at 100 degrees per second rocker shaft movement, the rate of oil circulation is 30 gallons per hour, whereas previously it would have been 20 gallons per hour. Thus the working pressures are brought down to around 725 lbs. per sq. in., the reduced work input per specific volume of oil resulting in cooler operation. The new design changes have several beneficial effects: necessary operating clearances induce proportionally less leakage now that the cylinder bore is increased, and reduced operating pressures further minimise the importance of leakage past pistons and so make for more consistent damper performance.

As will be seen from the accompanying diagram, the principle of operation is the same as for the P.V. type previously described, and all the advantages of that damper have been retained in this new, more robust damper.

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P.V.A.X. AND P.V.X. TYPES

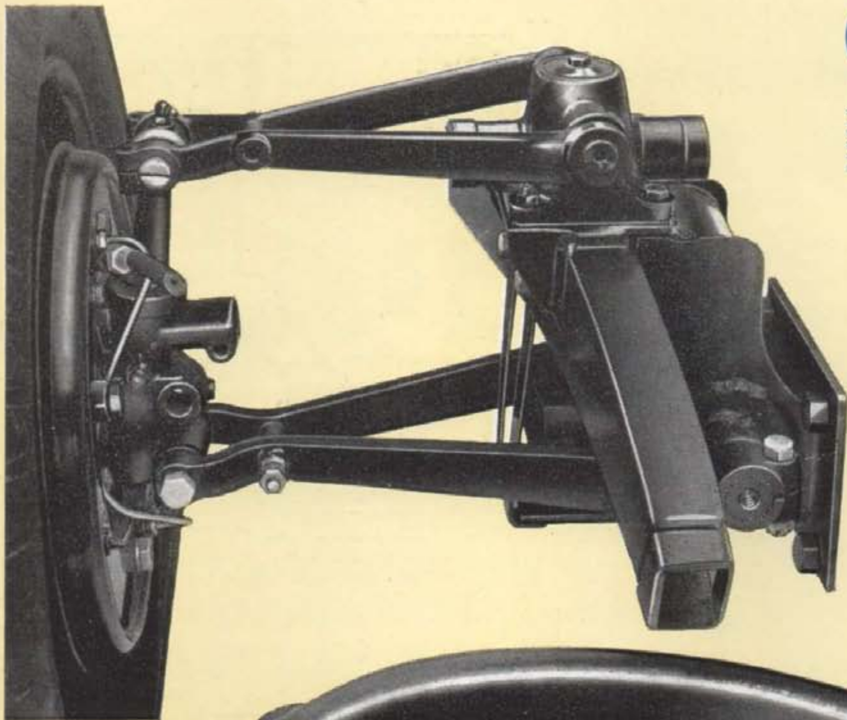

Fig. 12. The Girling P.V.X. Type in position on a front wheel suspension.

Fig. 13. Girling P.V.A.X. Type for Independent Suspensions.

This damper functions in a manner precisely similar to the foregoing P.V. and P.V.A. types, and the internal design is the same.

To provide damping action on Independent Suspensions these units Figs. 12 & 13, are fitted with a double-ended rocker shaft to accommodate wishbone type linkage.

In view of the greater stresses taken by the body casting, these are of sturdier construction and have four fixing holes.

No attempt should be made to dismantle the linkage on this type, the whole unit should be returned intact to an Authorised GIRLING SERVICE AGENT or to the manufacturers.

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GIRLING HYDRAULIC DAMPERS
(Pressure Recuperation Type)

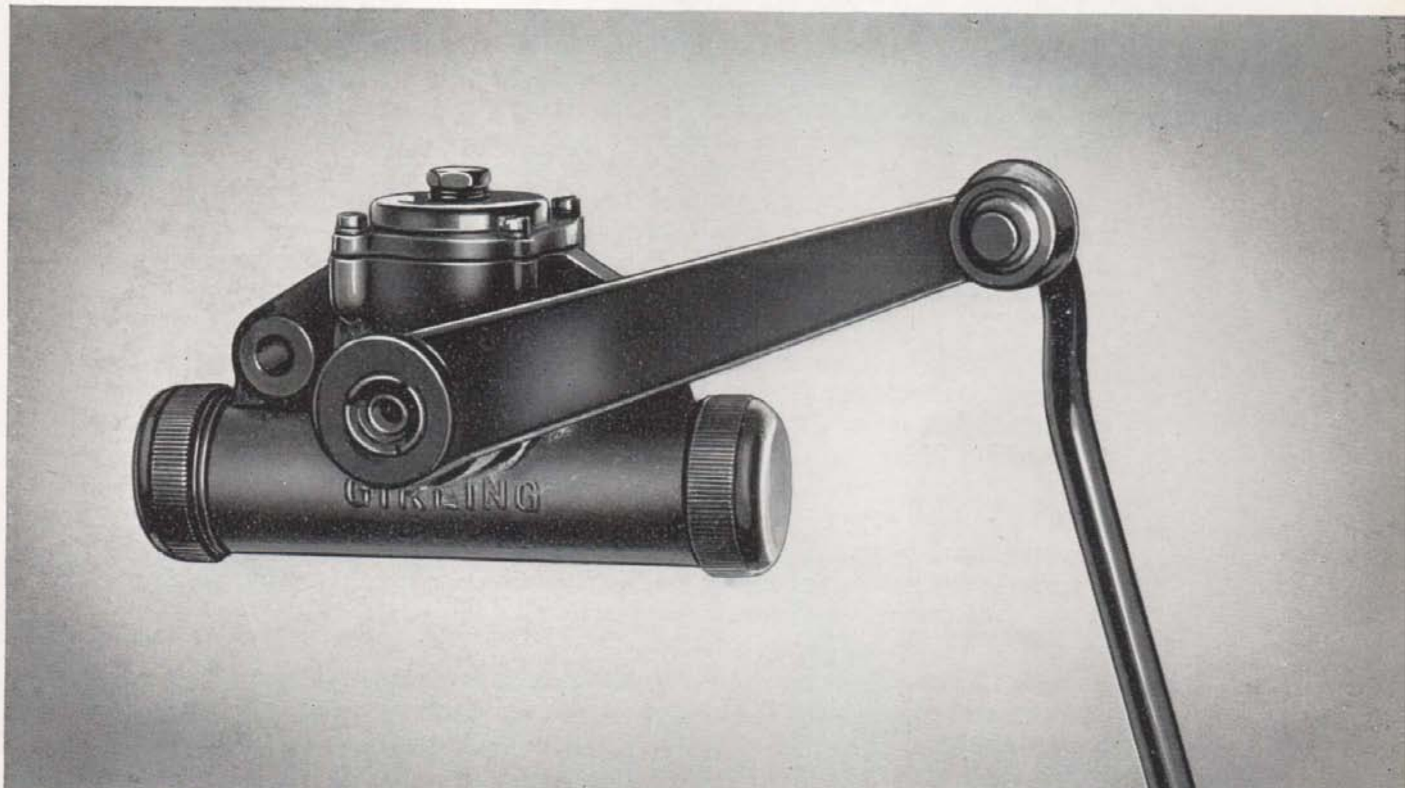

Fig. 14. Typical P.R. Type Assembly complete with Operating Linkage.

The Pressure Recuperation type of hydraulic damper, commonly known as the P.R. type, has a number of improved features over earlier piston types. The advantages may be summarised as follows : quick valve operation, absence of frothing and rapid recuperation at all temperatures and speeds.

It has, in addition to the recuperating chamber provided by the main body of the Unit, a deep cover at the top hermetically sealed by a gasket. The bottom of the cover is dished and a lip is formed through which an extension of the Filler Plug protrudes, practically restricting the lipped hole. The fluid percolates past this extension into the lower recuperating chamber keeping the Unit full of fluid at all temperatures and axle speeds, making in effect a sealed chamber. On a rise in temperature, fluid can pass the Filler Plug extension into the top cover, compressing air in the space provided by the screwed boss which extends into the cover for a certain distance.

Apart from the improved method of recuperation, the operation of both the Pressure Recuperation and the earlier Piston type is similar.

PRESSURE RECUPERATION TYPE

When the body and axle are forced towards each other (road springs compressing) motion is transmitted by the connecting link and lever arm to the rocker shaft, see Fig. 15, which rotates and causes lateral movement of the pistons, let us say, to the left. At the commencement of the stroke resistance is offered dependent on the pressure required to force the fluid in the left-hand pressure chamber, through the bleed in the piston, to the recuperation chamber. As the axle speed (and therefore piston speed) increases, the pressure of resistance builds up accordingly to the hydraulic law, the limit being reached when the pressure valve opens. During this stroke the recuperation valve in the right-hand piston opens and allows free flow of fluid from the recuperation chamber to the pressure chamber, thus ensuring that it is kept completely full of fluid. Movement to the right follows the same cycle.

The "bleed" and the tension of the pressure valve are accurately calibrated during manufacture, so as to be of the correct value for the car to which they are to be fitted. No further adjustment is required or provided for.

In the double-acting type, the "bleed," and pressure valve values, are the same in both pistons ; in the differential-acting type "bleed," and/or pressure-valve values are lower on the side which takes the compression of the road spring than on the recoil side.

As with all Piston Types the lever arm is a force-fit on the shaft serrations, and the end of the shaft is "staked" in three places to retain the lever longitudinally. The connecting link is bushed with special torsion rubbers which form silent, oil-less, flexible bearings.

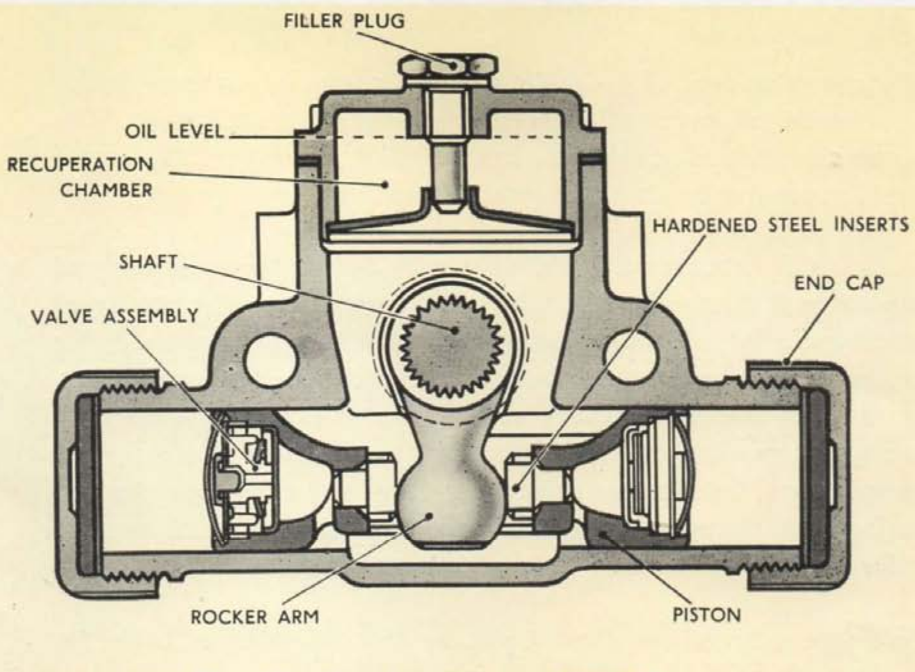

Fig. 15. Section View of P.R. Type.

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SIZES AND

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
Original Piston Type. Ditto with High Tensile Shaft and Rocker Arm.
Pressure Recuperation Type. Ditto with High Tensile Shaft and Rocker Arm. Double Ended Rotor Type for Independent Suspension.
New Girling Type. Ditto with High Tensile Shaft and Rocker Arm. New type for Independent Suspension.
Latest type with larger bore and working parts but retaining same fixings. Ditto for Independent Suspension.

TYPES OF GIRLING PISTON DAMPERS

RANGE OF TYPES AND SIZES			
8-10 H.P. Cars	Medium Powered Cars	Heavy Cars, Commercial and Passenger Vehicles	Passenger Vehicles
P.5.	P.6.	P.7.	P.9.
P.P.5.	—	—	—
P.R.5.	P.R.6.	P.R.7.	—
P.P.R.5	—	—	—
P.R.5.X.	P.R.6.X.	P.R.7.X.	—
P.V.5.	P.V.6.	P.V.7.	—
P.P.V.5.	P.P.V.6.	—	—
P.V.5.X.	P.V.6.X.	P.V.7.X.	—
P.V.A.6.	P.V.A.7.	P.V.A.8.	—
P.V.A.6.X.	P.V.A.7.X.	—	—