Report on Examination

OF

GERMAN

LIGHT AID DETACHMENT VEHICLE

Type V.W. 82

"VOLKSWAGEN"

Produced by
HUMBER
LIMITED

REPORT ON EXAMINATION

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Produced by

THE ROOTES GROUP

Engineering Dept., Humber Ltd.

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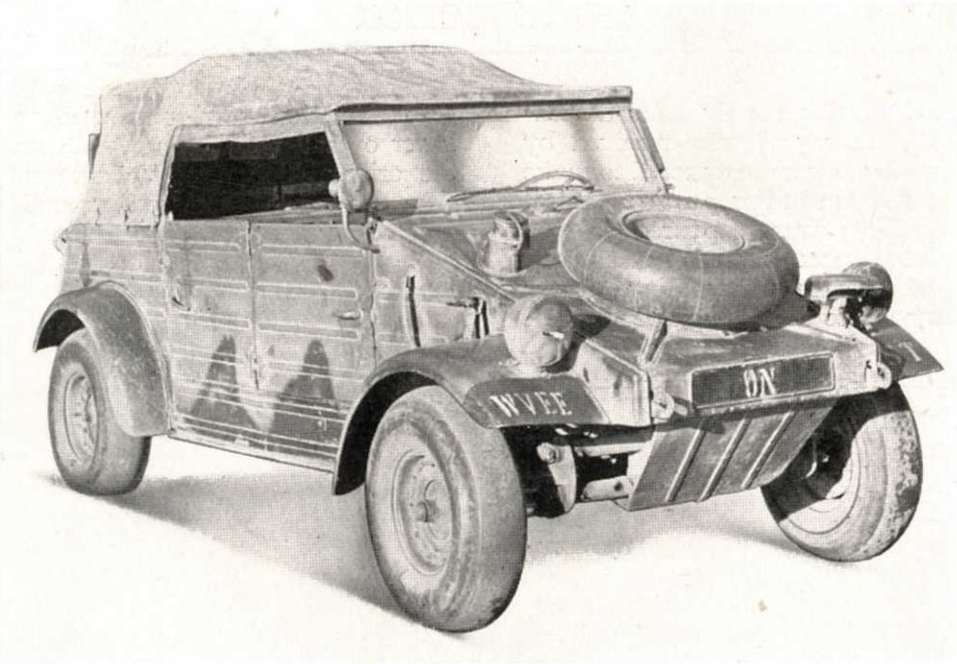


Plate 1.—Complete vehicle, threequarter front view

Plate 2.—Complete vehicle, side view

Plate 3.—Complete vehicle, threequarter rear view

INTRODUCTION

In January, 1943, a German light aid detachment vehicle (Volkswagen) was received by Humber Limited, who were instructed to make a complete examination and prepare a technical report. The vehicle was captured in the Middle East and it was ascertained that it was originally fitted with a gas welding kit for dealing with repairs to military vehicles.

Military Conversion of the Volkswagen Compared with the Original Design of People's Car

The vehicle under examination is based on the Volkswagen (German People's Car) and from the available descriptive matter the military version differs in the following respects.

The peacetime Saloon body is replaced by an entirely new open type tourer body which has obviously been designed to suit its military role.

Hub reduction gears have been added.

Special tyre equipment and wheels are also used.

Features of Noteworthy Interest

The engine is fitted at the rear of the vehicle, behind the axle.

A horizontally opposed, four-cylinder, air-cooled type of engine is employed.

The engine air cooling system incorporates a rotor and cowling arranged to circulate air to the cylinders and also to an oil cooler.

Independent wheel suspension is provided for all wheels, torsion bars being used. The front torsion bars are of unusual and ingenious design to obtain soft springing in a compact form. The front suspension, complete with the steering unit, shock absorbers and track rod system, forms a very compact assembly unit.

The speedometer drive is housed neatly within one of the stub axles.

Extensive use is made of aluminium and magnesium base alloys, and a very good finish imparted to the die castings.

Plain carbon steels are used in preference to alloy steels, except in special cases such as valves, etc. Nickel has not been used for the manufacture of any of the parts, and copper has been added to the cast iron components in order to produce a similar effect to nickel. The hardening elements used in the steels are manganese, chromium and molybdenum.

A special dog-type gear engagement is incorporated in the gearbox, using steel rods in grooves ; this is fully described in the text. The design of differential is ingenious, having only a partial slip, thus obviating wheel spin and therefore very suitable for cross country and muddy conditions. This is patented under German Pat. Spec. No. 639876, and British Pat. Spec. No. 431020, both patents taken out by Gottfried Weidmann.

Hub reduction gearing is used to obtain a lower overall ratio by a simple conversion of the original design of Volkswagen, and this also gives the increased ground clearance required for traversing across country.

Chassis consists of a light gauge pressed steel underframe ; this is arranged in a " back-bone " construction and also provides the floor. A comparatively strong chassis, especially torsionally.

The location of the rear suspension swing arms or struts above the axle enables a cheap and light form of strut to be used according to claims stated in Patent No. 544748 F. Porsche. Ground clearance is also increased by raising the torsion bar relatively.

The body was of open tourer type fitted with a collapsible fabric hood and provided with a steel trunk designed to carry the welding plant. It is thought that a study of the sections and methods of construction described in this report will be valuable.

In order to ascertain full particulars of the design, technical data, weights and dimensions, the vehicle was dismantled and assembly drawings, together with a detail description of the design and construction, prepared. Photographs (Plates 1, 2, 3 and 4) were taken on receipt of the vehicle and show its general appearance when it arrived at these works.

From the condition of the vehicle as received for examination it was apparent that it had covered a considerable mileage—unfortunately the speedometer was not functioning and the exact mileage could not therefore be verified.

The following identification plates were fitted inside the engine compartment at the rear of the body :—

Identification Plate relating to the Chassis.

Volkswagen Wks. Ltd. (People's Car Factory Ltd.)

Type VW.82.

Engine capacity 985 cu. cms.

Year of manufacture, 1941.

Weight of vehicle (unladen) 685 kilograms (1,510 lbs.).

Weight of vehicle (max. laden weight) 1,175 kilograms (2,590 lbs.).

Weight on Front Axle (max. laden weight) 450 kilograms (992 lbs.).

Weight on Rear Axle (max. laden weight) 724 kilograms (1,598 lbs.).

Chassis Number 001339.

Identification Plate relating to the Body.

Ambi Budd Presswords, Johannesthal, Berlin. No. 1777. Year 1941.

Identification Plate relating to the Electrical Equipment.

Screened, based on Group III Bosch.

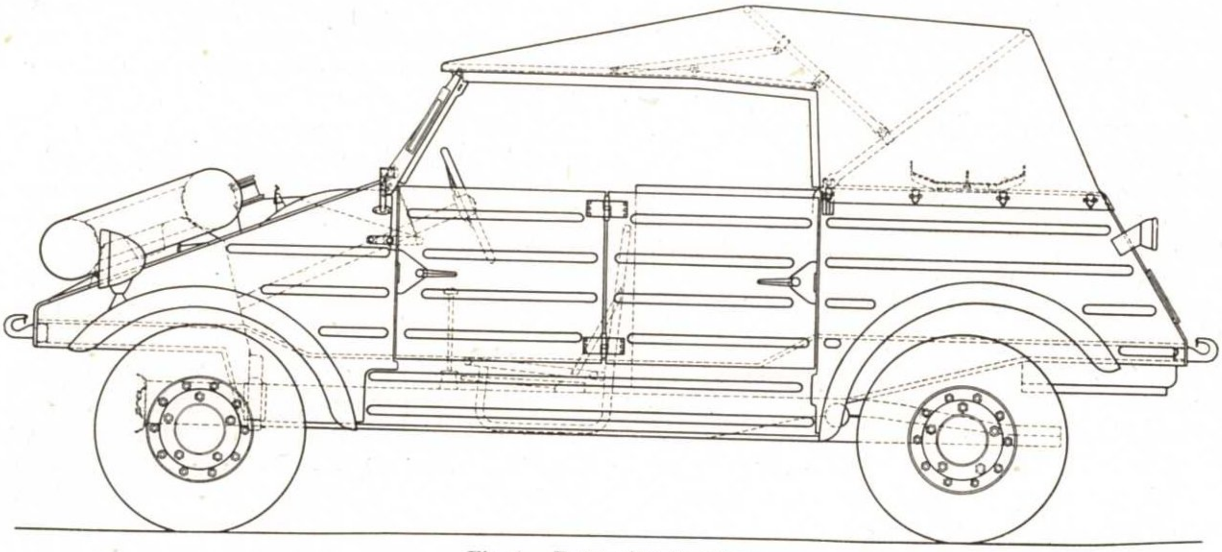


Fig. 1.—Body, side elevation

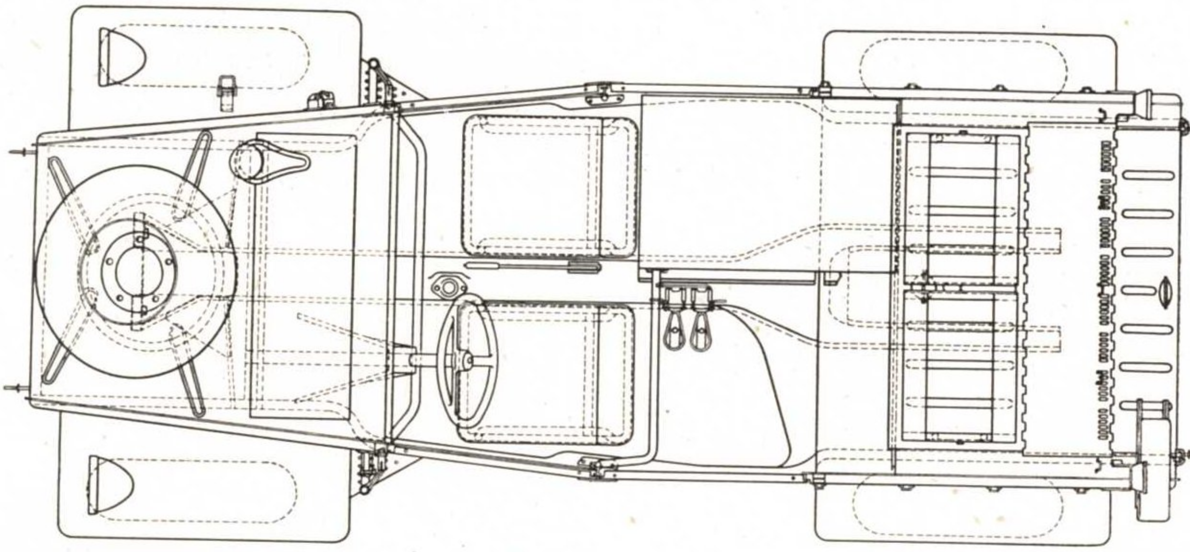


Fig. 2.—Body, plan

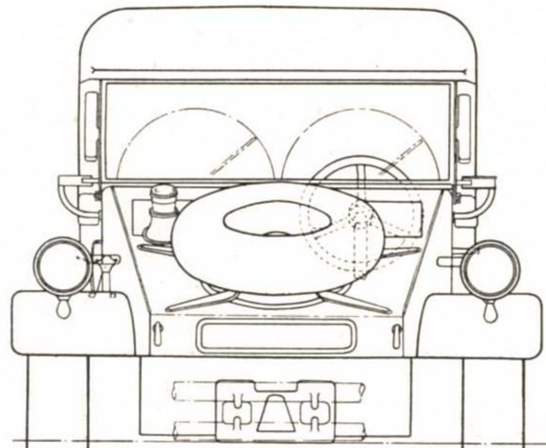


Fig. 3.—Body, front view

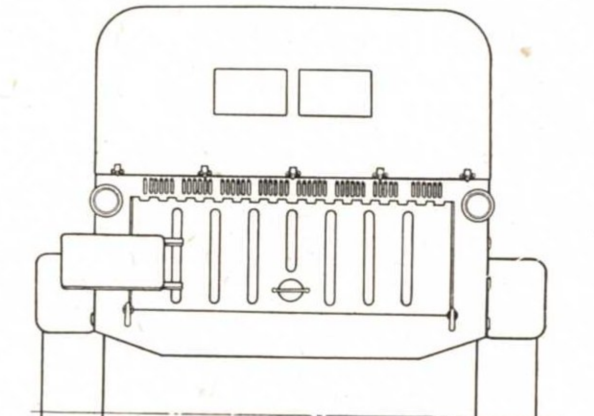
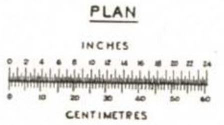


Fig. 4.—Body, rear view



The actual weights of the vehicle as received were as follows, which it will be noted are in excess of those given on the identification plate.

Actual weight of vehicle (unladen) 14 cwts. 3 qrs. (1,652 lbs.).

Actual weight on Front Axle (unladen) 5 cwts. 3 qrs. (644 lbs.).

Actual weight on Rear Axle (unladen) 9 cwts. 0 qrs. (1,008 lbs.)

General Observations

The following general observations are made by Humber Engineering and should be treated purely as their views.

The design is particularly interesting because it is quite uninfluenced by any previous traditions, and it is doubtful if the question of whether the public would or would not like a car with an air-cooled engine positioned at the rear was considered by the designer. This model has departed almost entirely from the conventional motor-car and features of interest have already been referred to above.

In spite of the assumed freedom of the designer and the unconventional vehicle produced, little or no special advantage has been obtained in production cost, neither does it appear that any improvement in performance or weight compared with the more conventional type of vehicle known in this country has been achieved.

So far as materials are concerned, no signs of the use of any ingeniously applied materials have been found, in other words the material specification is, with few exceptions, very parallel with what is already well known in this country. The use of plastics is not apparent. The tyres are, however, manufactured from synthetic rubber.

A study of the engine indicated that the unit was, in certain details, most inefficient. The design of the inlet manifold makes it clear that the designer did not intend the unit to produce power proportionate to its capacity, and from a study of both the design and condition of the crank bearings it is very doubtful whether it was even capable of giving reliable service had it produced a performance commensurate with its size.

Looking at the general picture, we do not consider that the design represents any special brilliance, apart from certain of the detail points, and it is suggested that it is not to be regarded as an example of first class modern design to be copied by the British industry.

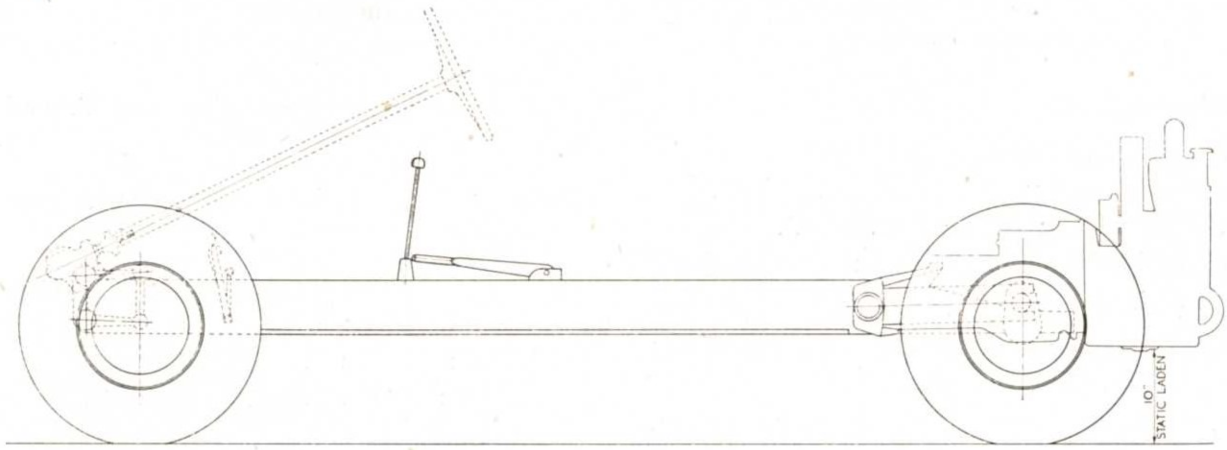


Fig. 5.—Chassis, side elevation

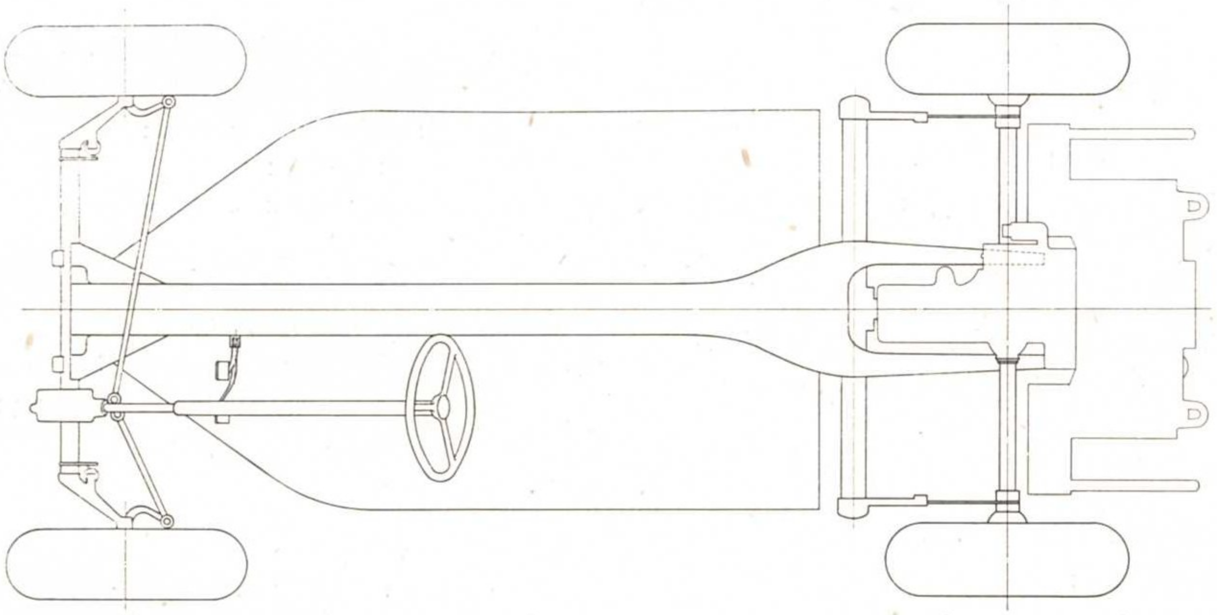


Fig. 6.—Chassis, plan

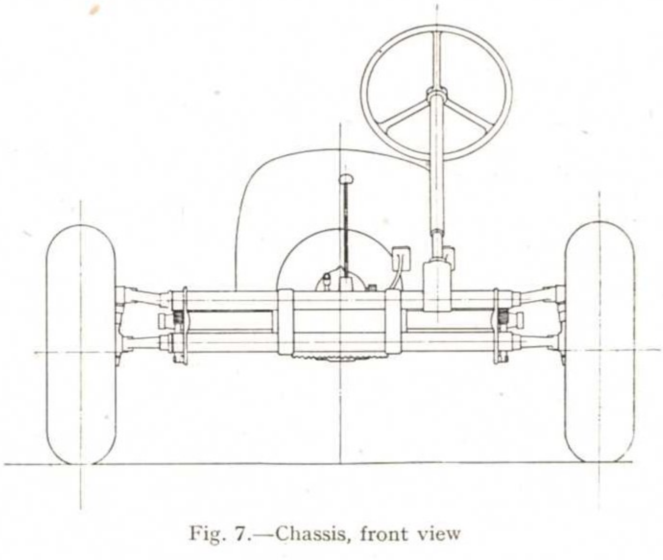


Fig. 7.—Chassis, front view

GENERAL DATA OF COMPLETE VEHICLE

Dimensions

Chassis No. 001339.

Overall length : 147·5 ins. (12 ft. 3½ ins.).

Overall width : 63 ins. (5 ft. 3 ins.).

Overall height (top of hood) : 63·5 ins. (5 ft. 3½ ins.)

Wheelbase, normal, static laden condition : 94 ins. (7 ft. 10 ins.).

Wheelbase variations under pitching conditions :—

(*a*) Front Wheel at full rebound position and Rear Wheel at full bump position : 95·40 ins., 5 ins. engine clearance.

(*b*) Front Wheel at full bump position and Rear Wheel at full rebound position : 93·40 ins.

Track : Front Wheels : 54·625 ins. (4 ft. 6⅝ ins.).

Rear Wheels : 55·125 ins. (4 ft. 7⅛ ins.) laden.

Turning circle. R.H. lock : 30 ft. 5 ins.

L.H. lock : 36 ft. 8 ins.

Weights

Chassis : 7 cwts. 0 qrs. 21 lbs.

Rear Axle : 4 cwts. 3 qrs. 21 lbs.

Front Axle : 2 cwts. 1 qr. 0 lbs.

Engine

Engine No. 001346.

Make : Volkswagen.

Type : Four-cylinder, air-cooled, horizontally opposed, overhead valves.

Capacity : 0·985 litres (60 cu. ins.).

R.A.C. Rating : 12·2 H.P.

Air Cleaner : Oil Bath type.

Clutch

Make : Fetchel & Sachs — Komet.

Type : K.10 Single Plate Dry Clutch.

Size : 180 mm. (7·09 ins.) O/Dia.

Gearbox

Type : Constant mesh helical—Top and third speeds. Straight Spur—First and Second Speeds. Special dog engagement on Top and Third Speeds.

Gear engagement on First and Second Speeds.

Control : Remote control. Ball change type gear lever.

Ratios. Four forward speeds and one reverse.

Top :	0·8	: 1.
Third :	1·25	: 1.
Second :	2·07	: 1.
First :	3·6	: 1.
Reverse :	6·6	: 1.

Rear Axle

Type : Enclosed swinging half axle. Spiral bevel drive and final hub reduction gear.

Axle ratios : Spiral Bevel : 4·43 : 1.

Hub gears : 1·40 : 1.

Overall ratio : 6·2 : 1.

Transmission Unit Weight

Gearbox, Clutch, Rear Axle, Reduction Gear and Starter less Brake Shoes and Drum : 147 lbs. weight.

Overall Ratios

Fourth speed :	4·96	: 1.
Third speed :	7·75	: 1.
Second speed :	12·83	: 1.
First speed :	22·32	: 1.
Reverse speed :	40·92	: 1.

Suspension

Type : Independent wheel springing on all wheels.

Longitudinal link type on front wheels. Swinging half axle and longitudinal arm on rear wheels.

Springs : Front torsion bar ; rectangular section ; multi-blades.

Rear torsion bar ; round section.

Shock Absorbers

Front : Hydraulic, direct, single-acting telescopic type.

Rear : Hydraulic, piston-operated, double-acting type and lever arm.

Wheels and Tyres

Make of Tyre : Continental.

Size of Tyre : 690 × 200 (8 × 12) smooth tread, aeroplane type.

Size of Wheel : 4·25 × 12, flat base rim.

Steering

Make : Volkswagen steering box.

Type : Worm and rocker shaft (segment nut interposed).

Number of turns of handwheel (lock to lock): 2·75

Connections : Divided track rod, directly coupled.

Brakes

Make : Volkswagen.

Type : Internal expanding ; two shoes ; floating operation.

Control : Cable operated, non-compensated type.

Petrol Tank

Capacity : 9 gallons.

Electrical Equipment

Dynamo : Bosch type, RED 130-6 2600 AL.89.
6 volt. Ventilated.
Speed : 1·75 times engine speed.

Starter : Bosch type, EEDD 4-6 L3P 6 volt. Screw push type.
Drive : Pinion, 9 teeth ; Ring, 109 teeth.

Ignition : Bosch ignition, coil type TL6. Bosch distributor, type VE4BS276. Screened.

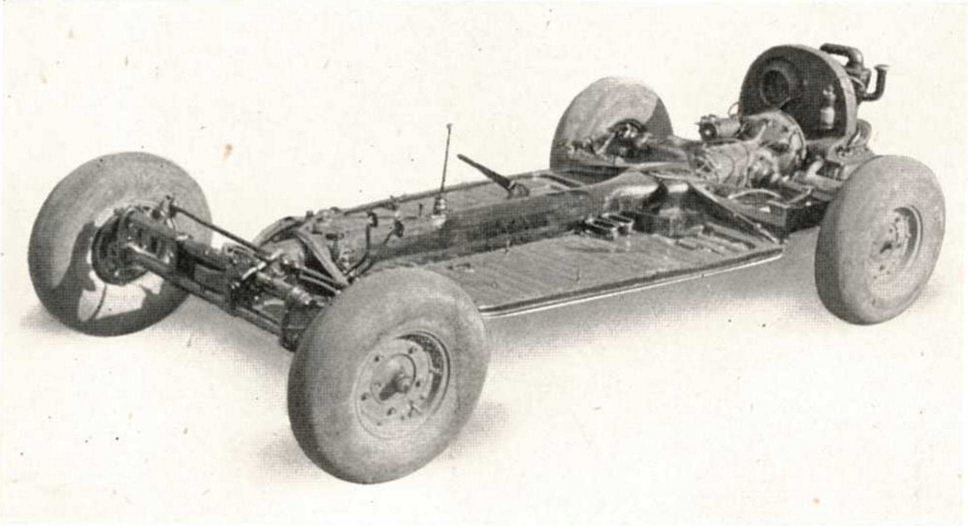


Plate 4.—Chassis

GENERAL DESCRIPTION

The engine was originally designed for the "Volkswagen," which was exhibited at the International Motor Show held in Berlin in 1939, the manufacturers being Volkswagen, Fallersleben, near Hanover, Germany.

Makers' identification marks: No. 001346 (stamped on the crankcase); No. 0402 (cast on each of the cylinder heads).

Other markings: Firing order, 1, 4, 3, 2 (cast on the crankcase), No. 1 Cylinder being nearest the flywheel.

The complete unit includes a sheet metal cowling mounted above the engine, and incorporating a blower: this circulates air for cooling the cylinders and the oiling system. The blower consists of a rotor, mounted on one end of the dynamo armature shaft, which is driven at the opposite end by a "V" belt drive from the crankshaft.

The engine is of the overhead valve, horizontally opposed four-cylinder type, consisting of two banks, each bank having two cylinders which are separately cast and interchangeable. Detachable cylinder heads of aluminium silicon alloy are fitted; these are cast in pairs and located in the cylinders by means of spigots formed on the latter. Both these are secured to the crankcase by long studs, screwed direct into the crankcase, the cylinder head joint being formed between the top face of the cylinder spigot and the head. Bronze alloy valve seat inserts, phosphor bronze valve guides, and steel sparking plug inserts are employed.

The crankshaft is supported by three main bearings, and an additional bearing which acts as a steady for the auxiliary drives; the thrust loads are taken by the bearing nearest to the flywheel. The crankshaft main journals consist of thick steel shells lined with lead bronze; all the bearings are exceptionally narrow, especially the centre one, which is split for assembly purposes.

The connecting rods are made from steel stampings, a relatively thick layer of bearing metal being run direct into the big end. The bolts securing the connecting rod caps have hexagon socket-type fittings on the heads.

The aluminium crankcase is made in two halves, and is split on the vertical centre line through the main bearings; the halves are secured together by means of bolts and studs. An oil sump is formed integral with the crankcase; the underside is generously finned. In addition, the casing serves as a mounting for the various accessories such as the dynamo, oil cooler, blower equipment, etc.

A single camshaft driven at half engine speed by single helical gears from the crankshaft runs direct in the aluminium crankcase, and actuates the overhead valves through push rods, each cam operating two rods. The whole of the valve gear is pressure lubricated.

The distributor is mounted on top of the crankcase, and is driven by spiral gears from the rear end of the crankshaft. The driven shaft consists of the spindle, and gear and cam for operating a petrol pump, and is made from a steel stamping, which is hardened and ground. It is supported at both ends and runs directly in the crankcase, the gear end thrust also acting against the crankcase facing.

The petrol pump is an AC diaphragm type, mechanically operated, mounted on the left-hand of the crankcase, on a neat moulding which also houses the operating rod.

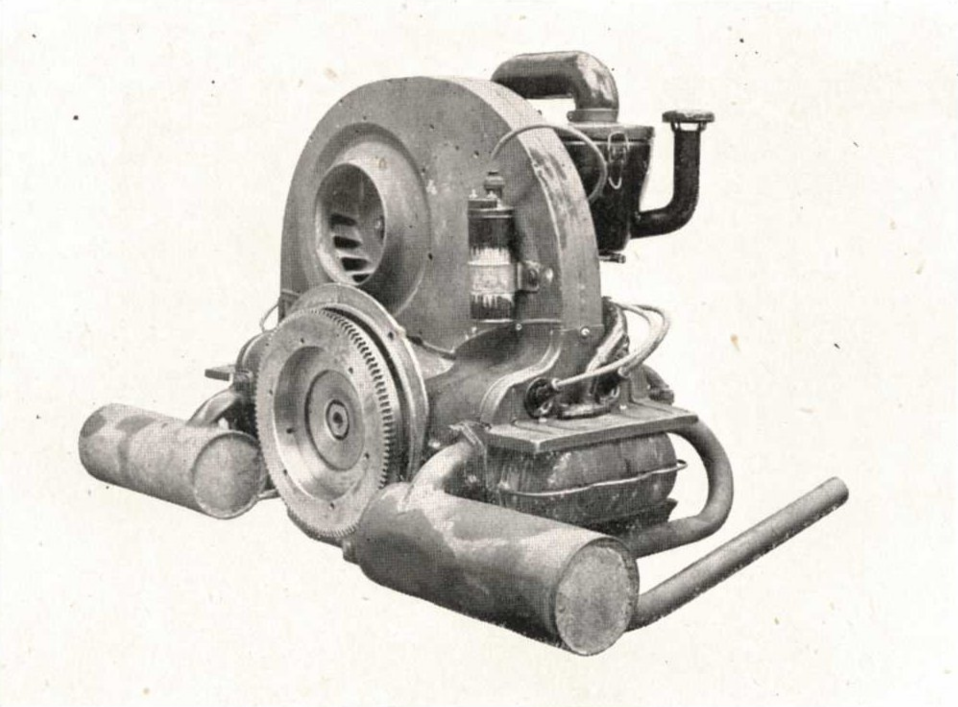


Plate 5.—Engine, threequarter rear view

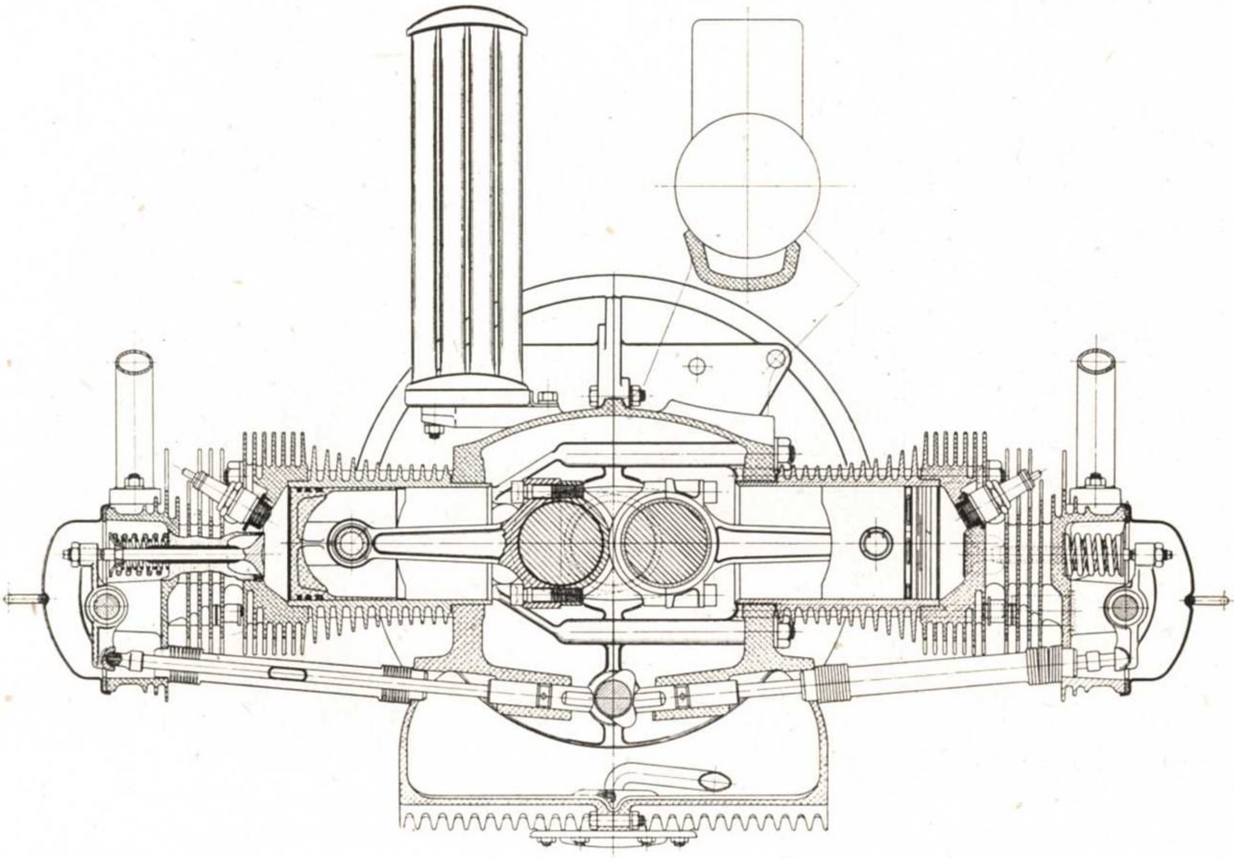


Fig. 8.—Engine cross section, end

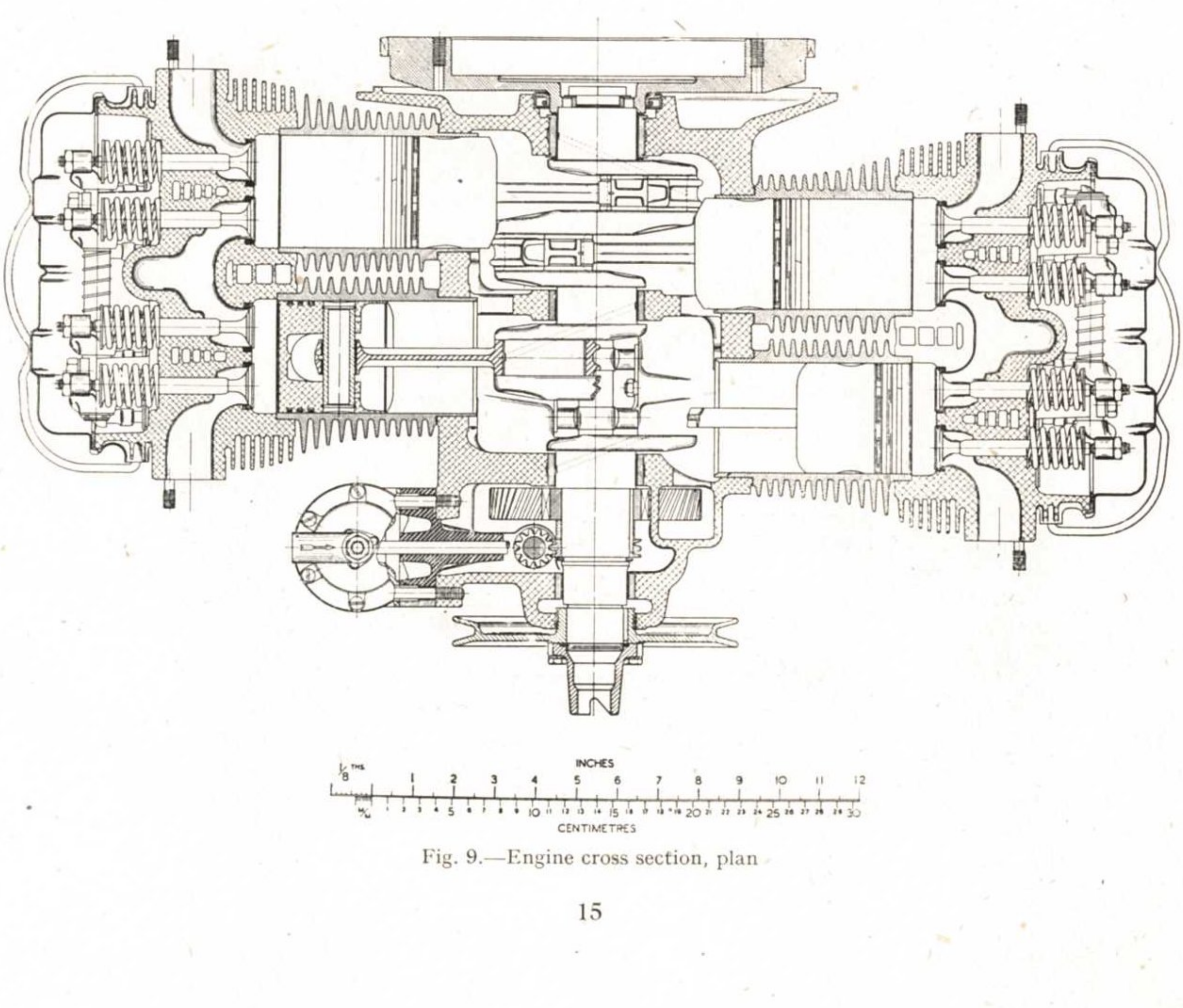


Fig. 9.—Engine cross section, plan

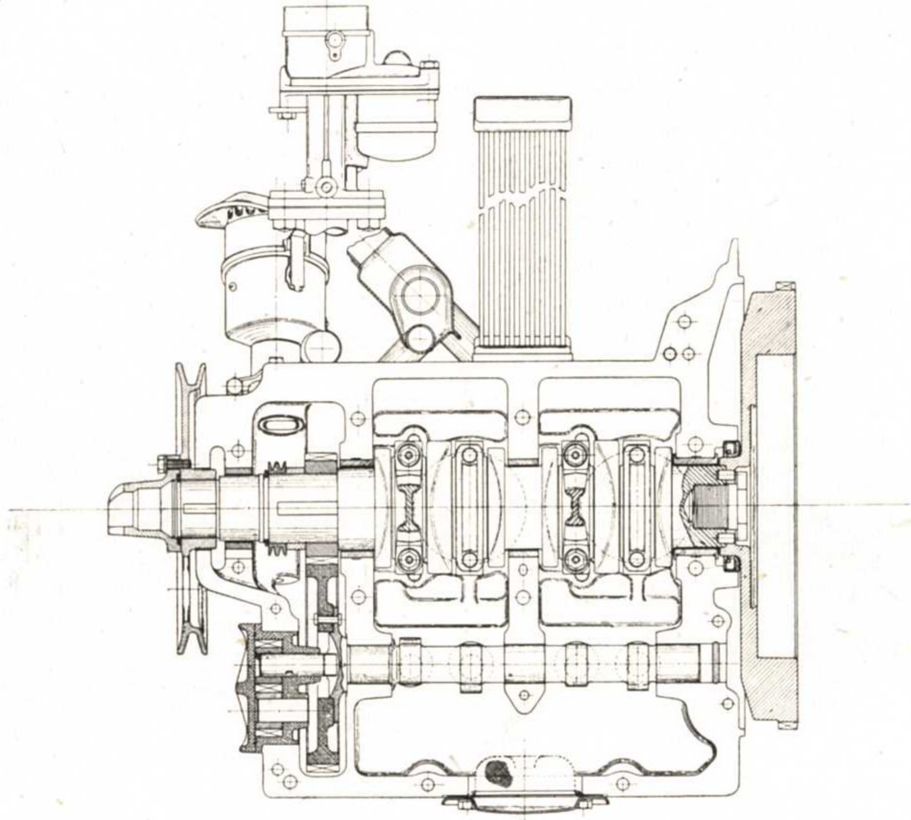


Fig. 10.—Engine, longitudinal section

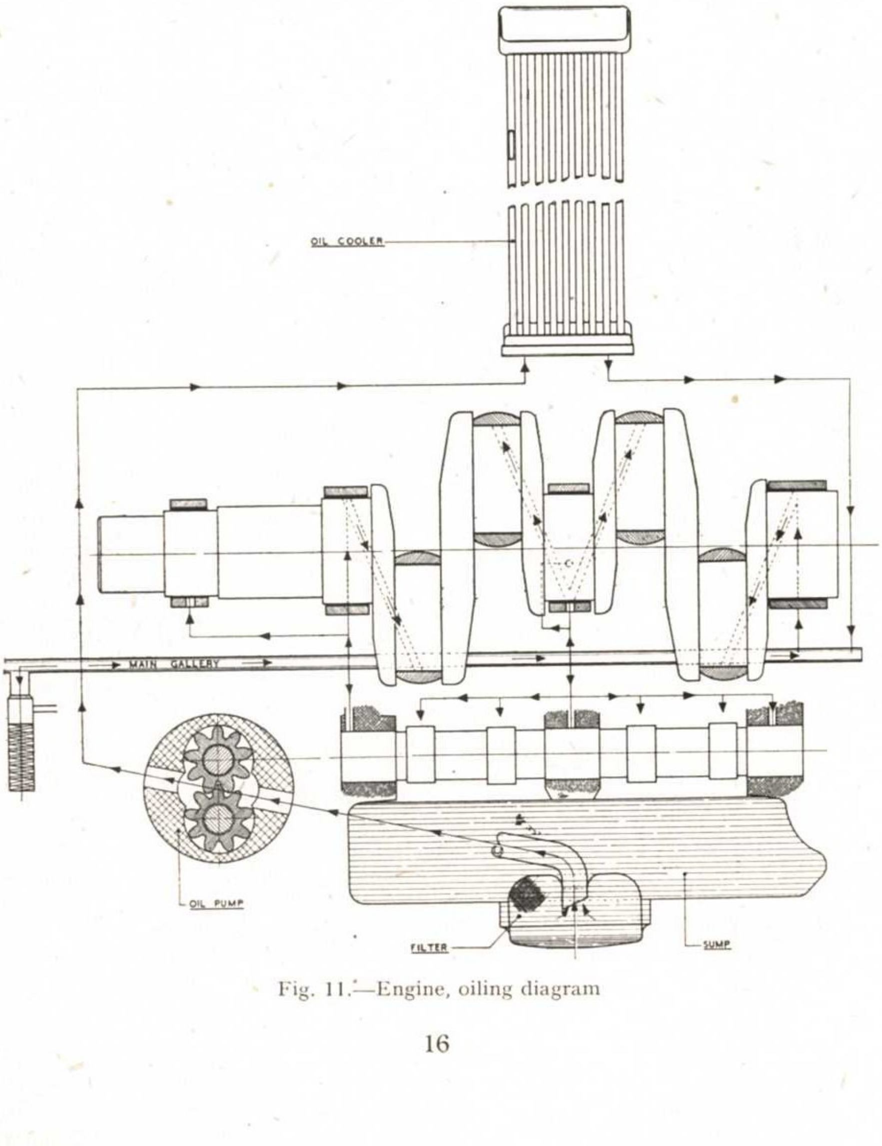


Fig. 11.—Engine, oiling diagram

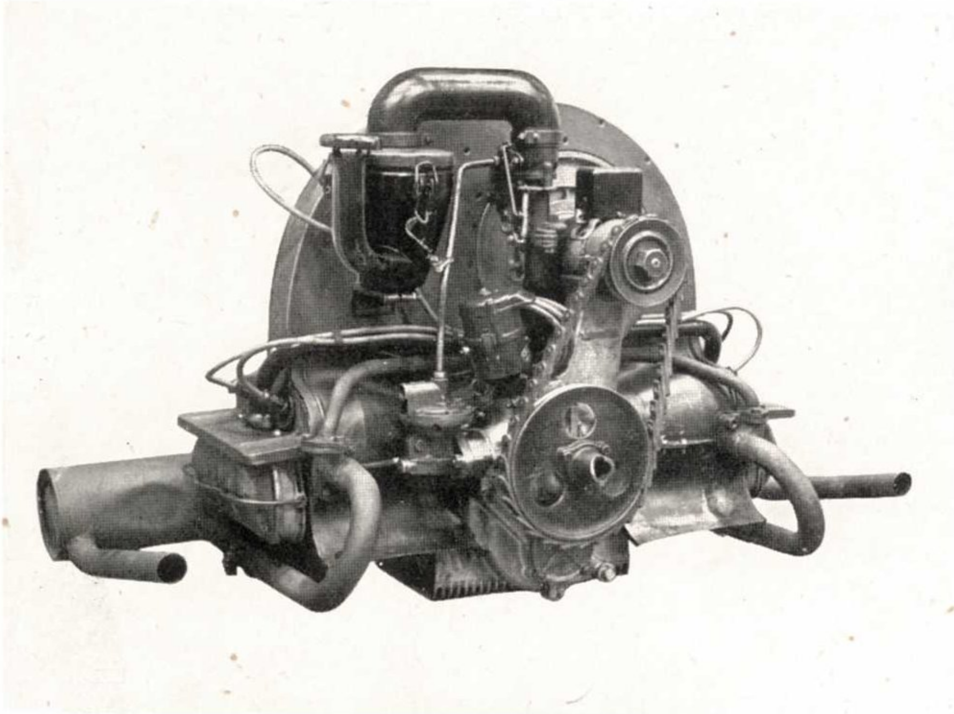


Plate 6.—Engine, threequarter front view

A single downdraught " Solex " carburettor is fitted. This is connected to the cylinder head by an extremely small bore inlet pipe, which has a central hot spot. The latter is obtained as the result of pressure pulsation which causes the exhaust gases to flow past the hot spot.

The crankcase has an extension which provides a saddle mounting for the dynamo and also forms a convenient oil filler orifice on account of its hollow construction. The dynamo is driven by means of a " V "-shape belt, adjustment being provided.

The flywheel is a steel stamping with integral starting gear teeth, and is spigoted to the end of the crankshaft and driven by four dowels. It is secured to the crankshaft by a single centre bolt, the latter being hollow so as to include a self-lubricating bush for the clutch shaft. No locking device is provided.

Condition

The main bearings were scored, badly worn and of oval shape. The connecting rod big ends were worn ovally, but the small ends were round. There was considerable end play in the crankshaft. Valves were quite a good fit in the guides. The camshaft and its bearings were in good condition. The tappet push rod guide holes were in good condition. The connecting rod in No. 3 cylinder was bent towards one end of the engine. The pistons were in good condition. The compression rings and one scraper ring had broken and these had been replaced with new rings.

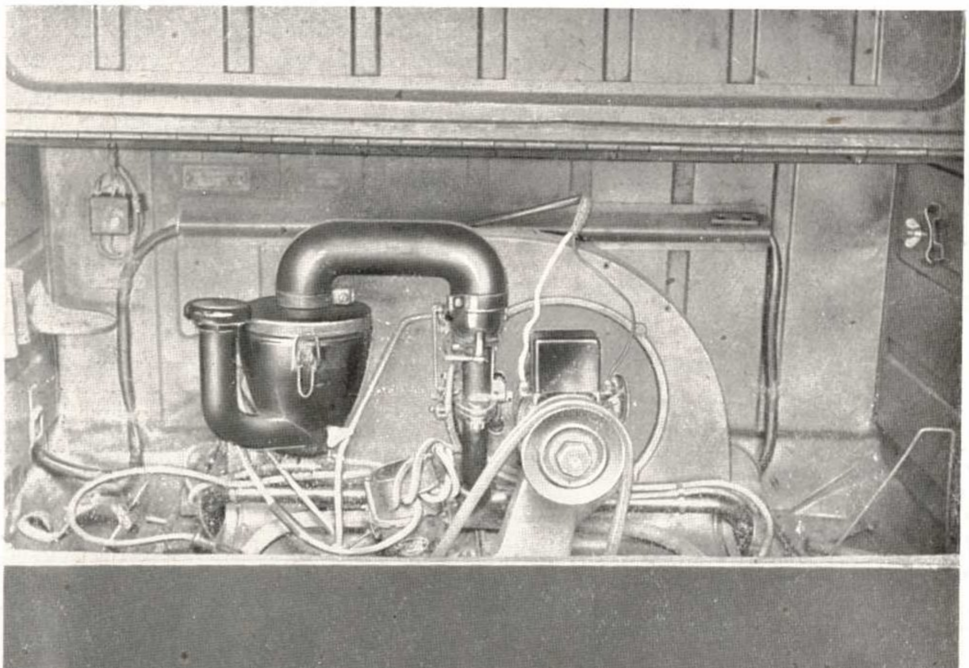


Plate 7.—Engine compartment

CRANKCASE

The crankcase is an aluminium alloy sand casting, built in two halves, the joint passing vertically through the centre lines of both the main bearings and the camshaft bearing—the camshaft itself running directly in the crankcase. An oil sump is formed integral with the crankcase, of fairly wide and shallow proportions so as to afford maximum ground clearance, fins being cast in a longitudinal direction on the underside. (Provision is made for a detachable gauze filter which is centrally mounted on the base of the sump.)

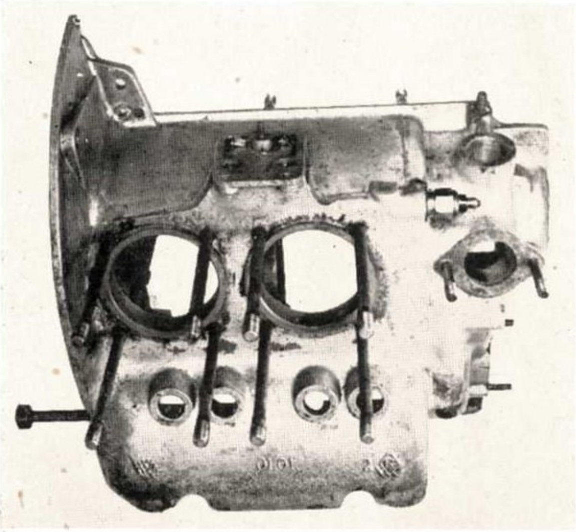


Plate 8.—Crankcase, L.H. half, exterior

A large diameter flange formed at the flywheel end is utilised as an engine mounting face with spigot fitting. Lubrication is through drilled oil ways in the crankcase. Platforms

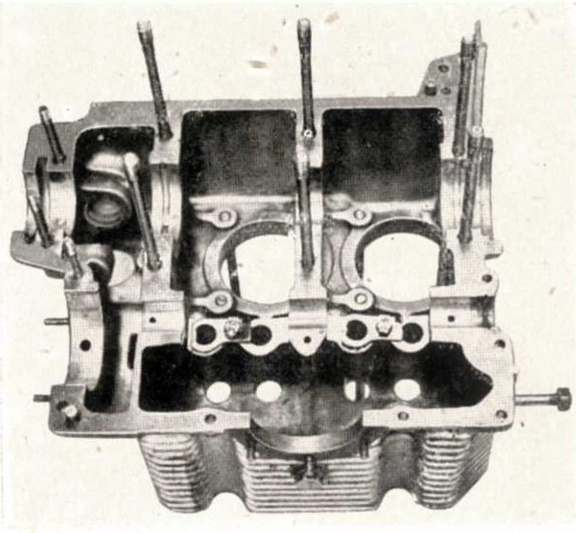


Plate 9.—Crankcase, L.H. half, interior

on top of the crankcase carry the oil cooler, dynamo and blower equipment.

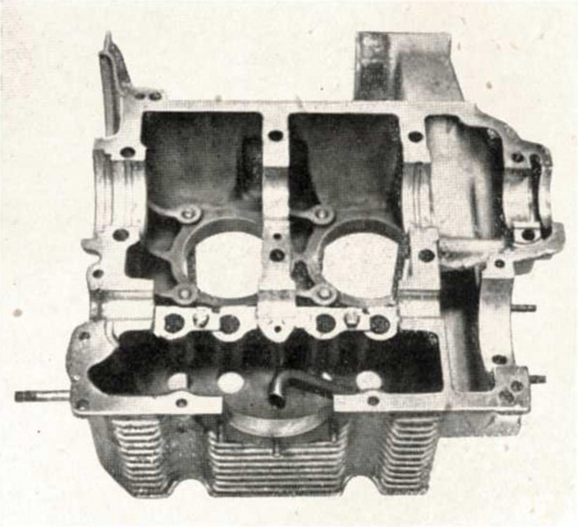


Plate 10.—Crankcase, R.H. half, interior

CRANKSHAFT

The crankshaft is a steel stamping, hardened and ground on all bearing surfaces, and supported on four main bearings. Markings indicate that the crankshaft was statically balanced only. Oil ways are drilled for pressure feed lubrication from the main journal to the connecting rod big end bearings. It is understood that work on cast crankshafts was in progress prior to hostilities.

CRANKSHAFT MAIN BEARINGS

The main bearings consist of lead bronze metal linings on thick steel shells; all the bearings are formed in the shape of a continuous ring, with the exception of the centre bearing which is split for assembly purposes. It would appear that the thick shells are introduced to give additional rigidity to the bearing, especially as these are supported in the aluminium crankcase.

CONNECTING RODS

Very short and comparatively stiff H section steel connecting rods are used; the big end bearings consist of babbit metal of thickness ·06-in. min., ·10-in. max., run directly in the rod and cap. A phosphor bronze bush is pressed into the small end. The connecting rod cap has two vertical webs for stiffness and the securing bolts are screwed into the caps, this being the only means of location. Hexagon socket type bolt heads are used.

PISTONS

Flat head aluminium alloy die cast pistons are used, having a generous amount of metal above the gudgeon pin bosses but very thin, unsplit, skirts. Two compression rings and one scraper ring are positioned at the top end.

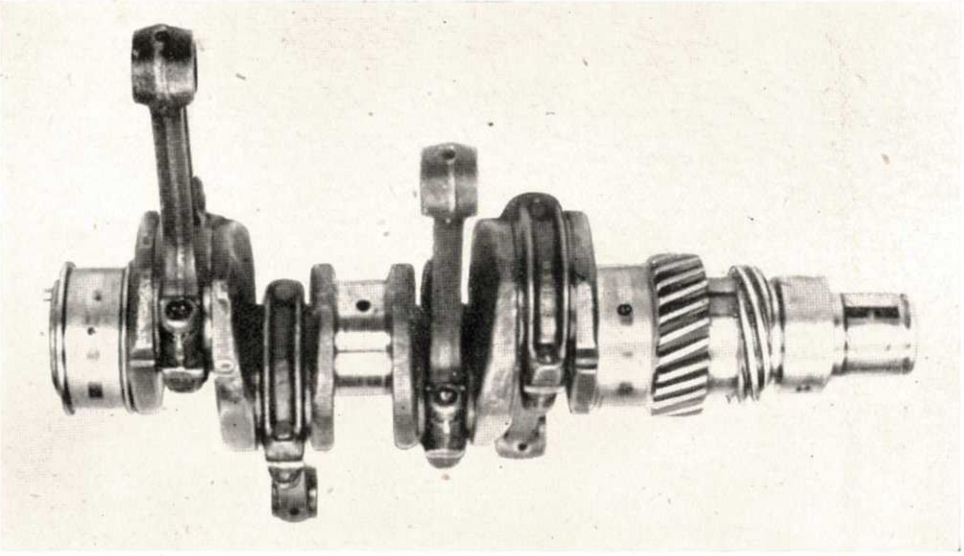


Plate 11.—Crankshaft and gear with connecting rods assembled

Fully floating gudgeon pins are fitted, and retained in the piston by means of spring steel wire rings fitted into grooves.

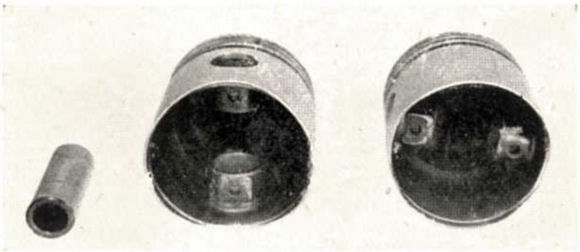


Plate 12.—Piston and gudgeon pin

CAMSHAFT

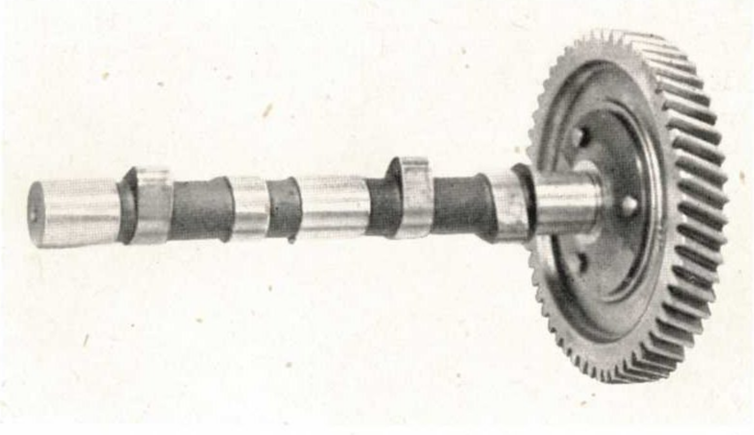
The camshaft is of cast iron, supported on three bearings, and has four cams, each of which operates two push rods and valves A flange cast at one end provides an attachment for the gear drive ; this end is also slotted for engagement with a tongue on the oil pump spindle. Single helical teeth are cut on the gear wheel (of magnesium base alloy material) the wheel being riveted to the camshaft flange. End-thrust on the camshaft is absorbed between two flanges at the driven end.

CYLINDER HEADS

The detachable cylinder heads are sand cast in pairs in aluminium silicon alloy. A recess encloses the valve gear, and the whole casting is generously finned. The valves are arranged in line (disposed horizontally), two valves being fitted for each cylinder. The two inlet valves are situated in the centre and in consequence the inlet ports are interconnected in the cylinder head casting. Seating inserts are of bronze and are either pressed or shrunk in position and retained by peening over the surrounding metal ; the valve guides are of phosphor bronze. Steel inserts for the sparking plugs are fitted and these are screwed up to a flange formed on the inserts and pegged in position to prevent them from working loose.

VALVE GEAR

Two valves per cylinder are fitted, the exhaust and inlet valves being identical. The valve springs are also interchangeable, two springs being fitted to each valve. The overhead valve gear is contained in a chamber cast integral with the cylinder head and is totally enclosed by a pressed steel cover which is held in position by a spring steel



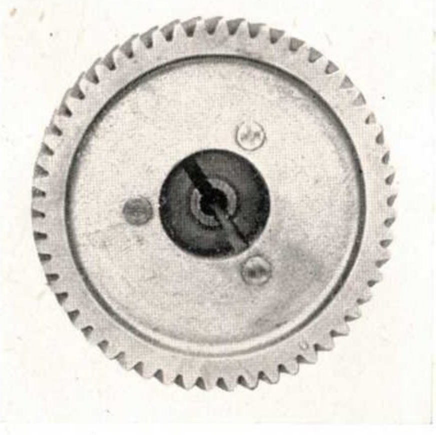


Plate 13.—Camshaft and gear assembly, also gear wheel

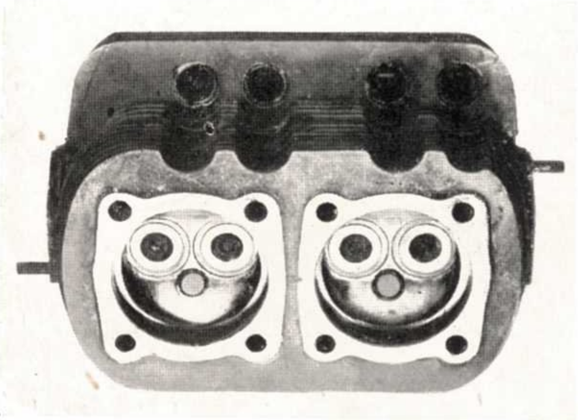


Plate 14.—Cylinder head showing combustion chamber

wire clip. The rocker arms fulcrum direct on to hardened and ground shafts, an oilway being drilled from the push rod spherical seating to the rocker shaft. Adjustment for setting valve clearance is provided by a pin screwed into the rocker arm and operating the valve. Push rods operate the valve gear and these are unusual in their design, being in effect composite tappets and rods ; the tappet ends of the push rods are guided (as a bearing), in reamed holes in the crankcase. The push rods are of long tubular

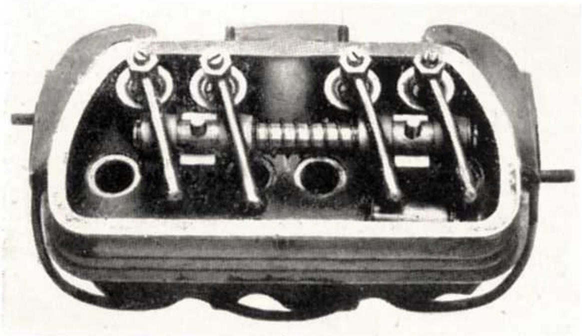


Plate 15.—Cylinder head showing valve rocker gear

construction in aluminium base alloy, both the tappet end and the opposite end (which is spherical) being hardened and ground steel components. It will be observed that this design causes slight bending to occur in the push rod whilst operating the valve,

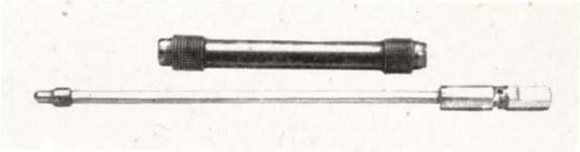


Plate 16.—Valve push rod and tube

due to the path of the rocker arm spherical end. The tappet is held against rotation, and has a radius formed at the base, at an angle to compensate for the push rod angle. Welded steel tubes enclose the push rods, and these have a series of bellows formed at each end, to act as a spring loaded seal, allow for misalignment, and assist in the machining operations of the holes in which the push rod tube fits. See Fig. 12 for Valve Lift curves (the lift was measured at the valve, and therefore includes valve gear deflection and wear).

OIL SYSTEM

The engine lubricating oil is contained in a sump formed in the crankcase, and including a detachable gauze filter. Oil is drawn from the filtered compartment through the suction tube to a gear type oil pump, housed away from the sump in the rear end of the crankcase. The pump is driven by a tongue engaging in a slot on the end of the camshaft, the pump being partly below the oil level in the sump. There are nine straight spur gear teeth on each wheel, the driving wheel being fixed to the spindle by arc process—a somewhat unusual application. The pump body is

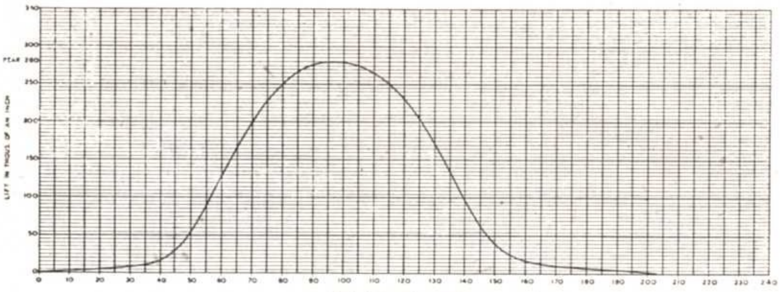


Fig. 12.—Inlet valve lift

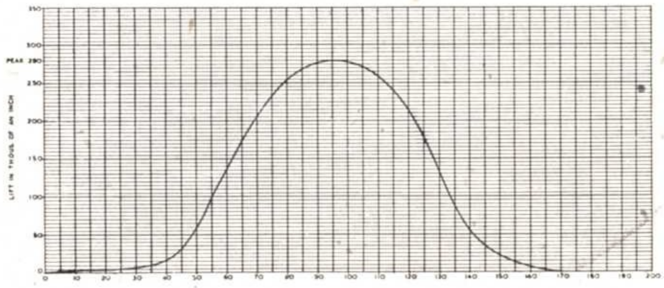


Fig. 13.—Exhaust valve lift

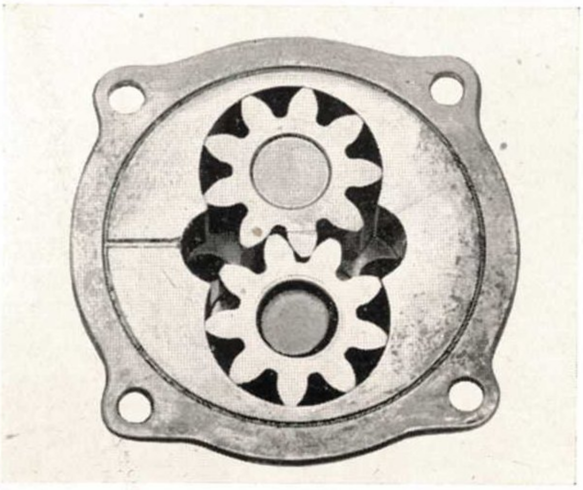


Plate 17.—Oil pump

a die casting in magnesium alloy, machined only in the oil chamber so as to clear the tops of the gear teeth. Oil is directed through drilled holes in the crankcase to the crankshaft, camshaft and push rod bearings, and there are two feeds to the crankshaft centre bearing. Oilways are also drilled in the crankshaft so as to connect the main journals with the big end bearings.

Three holes are drilled round the small end of the connecting rod, lubrication being provided by splash feed.

Oil is also fed under pressure through the push rods to the rocker arm bearings, draining back to the sump through the push rod tubes.

A tubular type oil cooler is incorporated in the system but this can be by-passed to obtain only partial oil cooling. A warning light on the instrument panel indicates when the oil pressure is insufficient.

ENGINE AIR COOLING SYSTEM

Cooling of the engine is arranged by air circulation, and since the engine is fitted at the rear of the vehicle, a blower is provided.

The engine compartment is arranged with a series of slots ; these are situated above the rear lid and provide the main air entrance.

The air circulating equipment is particularly noteworthy, being totally enclosed in a metal cowling, air access being arranged at the rear through a 6 in. dia. hole. Air is drawn through this orifice and into the cowling by means of a rotor, which is keyed to the dynamo armature shaft (at the opposite end to the drive), and runs at a speed 1¾ times that of the engine.

The rotor is a casting of magnesium alloy, and has blades arranged for circulating air by centrifugal action. The oil cooler is enclosed by the cowling and deflectors are arranged for distributing air to each bank of cylinders and the oil cooler. Provision for cooling the dynamo is also incorporated by arranging auxiliary blades on the rotor which draw air through the centre of the dynamo.

The cowling is formed in two halves from steel pressings, lap jointed on the periphery and spot welded together. It is held rigidly by a large magnesium alloy cast flange mounted on the dynamo, and has ducts arranged to enable the air to flow through the dynamo into the atmosphere.

The operation of the air cooling system is extremely noisy.

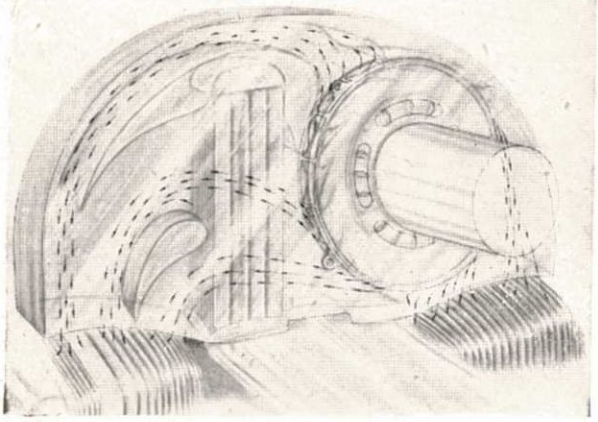


Fig. 14.—Engine air cooling system, phantom view

DYNAMO PULLEY

The pulley is of the split type, formed of two steel pressings with spacing washers between them, so that by varying the number of washers the distance between the pulley flanges can be altered so as to give a certain amount of adjustment to the belt tension.

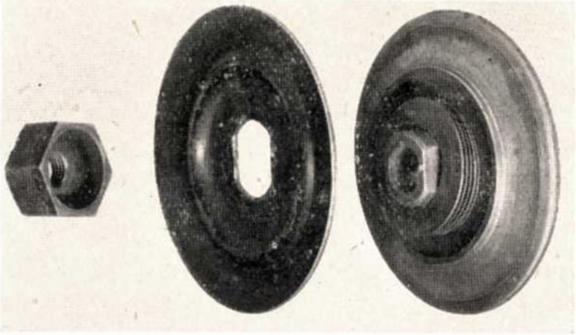


Plate 18.—Dynamo pulley construction

INLET MANIFOLD

The inlet manifold has an extremely small bore and is made from tubing with fixing flanges welded on the ends. A " hot spot " chamber (formed from two half-pressings) is welded at the centre and has a flange welded on top for the carburettor fixing. The hot spot has a small bore pipe welded on the underside, extending at each end into the exhaust pipes.

CARBURETTOR

A single downdraught Solex Type 26FVI carburettor is fitted ; this is manufactured by Volkswagen, Germany. It consists of two main die castings, i.e., float chamber and combined float chamber cover and throttle tube ; a butterfly throttle is employed. Generally, it resembles the Solex design employed in this country.

The choke is manually operated and an offset butterfly is used. This has an automatic

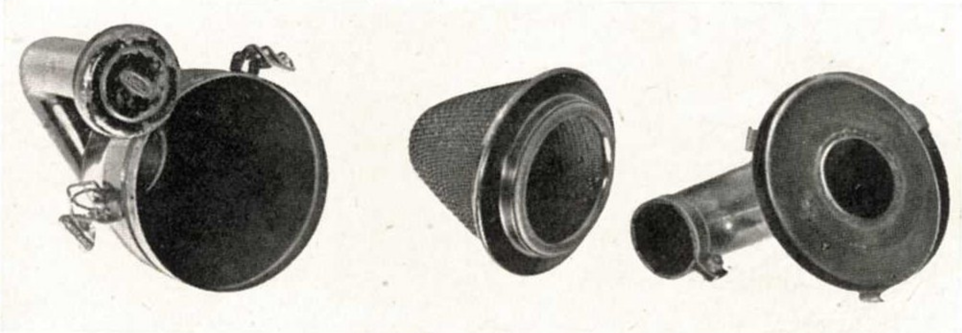


Plate 19.—Air cleaner, exploded view.

spring-loaded valve of Zenith type, which limits the value of depression while starting.

AIR CLEANER

An oil type air cleaner is fitted and is installed alongside the carburettor at about the same height to provide a compact engine unit. The filter is conically shaped, air entering tangentially just above the base of the filter body so as to create a swirling action. Any dust contained in the air is thrown against the wall by centrifugal action and is retained by the oil. The grit gradually settles to the bottom, being removed from time to time. Oil may possibly be drawn with the air into the filter, but as the passages are very fine the restriction makes it practically impossible for any dust to pass through without being caught by the oil. The filter consists of a very fine wire element housed in a wire cage and is removable.

EXHAUST SYSTEM

Four exhaust pipes lead from the cylinder heads to two cylindrically shaped silencers situated in front of the engine at the outer ends. The silencers are supported by the exhaust pipes and the whole system forms part of the engine assembly.

ENGINE UNIT MOUNTING

The engine unit, including the gearbox and axle differential, is suspended on rubber mountings arranged to permit a small rotational movement of the unit about an axis passing through its centre of gravity and coinciding with the centre-line of the vehicle in plan. This is arranged to absorb the torque reactions, but owing to the half-swing axle type of suspension employed, it is not considered good practice. Interaction takes place between the half-axle and the engine due to wheel movement or roll and engine reaction ; consequently the engine movement is restrained to some extent and limits the value of the rubber mounting.

Comparatively small movement is permitted on the engine mounting and this may have been purposely designed, having regard to the interaction. The tension on the rubber mounting is adjustable. The engine mountings consist of two rubbers vulcanised on a steel bracket bolted to the prongs at the rear end of the backbone fork which, in turn, supports the engine around the portion of the crankcase adjacent to the flywheel. This forms the main support for the engine unit on the backbone, one other point of attachment being situated at the forward end (or nose) of the unit. A rubber ring type mounting is fitted, acting principally as a location for the unit. It is housed inside a casting at the centre of the tubular cross member, i.e., centrally in the backbone fork.

ENGINE DATA

Engine No.: 001346.

Make : Volkswagen.

Type : Four cylinder horizontally opposed O.H.V. four-stroke petrol engine.

R.A.C. Rating : 12·2.

Cooling : Air.

Bore : 70 mm. (2·756 ins.).

Stroke : 64 mm. (2·52 ins.).

Total Piston Displacement : 985 c.cm. (60 cu. ins.).

Firing Order : 1, 4, 3, 2.

Direction of Rotation : Anti-clockwise (looking from flywheel end).

Valve timing (·005 in. tappet clearance) : Inlet opens, 14½° before T.D.C. ; Inlet closes, 66° after B.D.C. ; Exhaust opens, 64° before B.D.C. ; Exhaust closes, 11° after T.D.C.

Tappet Clearance : Inlet, ·005 in. ; Exhaust, ·005 in.

Valve Lift (Inlet and Exhaust) : 7 mm. (·275 in.).

Valve Rocker Lever Ratio : 1 : 1.

Throat Dia. (Inlet and Exhaust) : 24·5 mm. (·965 in.).

Angle of Seating (Inlet and Exhaust) : 45°.

Valve Spring Pressure (Inlet and Exhaust) : 44·8 lbs. closed ; 67·2 lbs. open.

Carburettor Type : Solex 26 V.F.I.

Carburettor Choke : 26 T.

Carburettor Jet Sizes : Main 120, Correction 185, Emulsion Tube 100, Pilot 45.

Volume of Combustion Chamber : 58·9 c.cm. (3·59 cu. ins.).

Compression Ratio : 5·2 : 1. This was obtained by measuring the capacity of the combustion chamber. An instruction book from a captured vehicle gave figures for light passenger carrying vehicle model K.1 (Type 82) as 5·8 : 1.

Air Cleaner : Oil Type.

ENGINE SIZES

Crankshaft
Front Steady Journal : dia. 40 mm. (1·57 ins.), length 18 mm. (·709 in.).
Main Front Journal : dia. 50 mm. (1·968 ins.), length 20 mm. (·787 in.).
Main Centre Journal : dia. 50 mm. (1·968 ins.), length 20 mm. (·787 in.).
Main Rear Journal : dia. 50 mm. (1·968 ins.), length, 29 mm. (1·14 ins.).

Connecting Rod
Big End Bearing : dia. 50 mm. (1·968 ins.), length 22 mm. (·866 in.).
Small End Bearing : dia. 20 mm. (·787 in.), length 22 mm. (·866 in.).
Centres : 129 mm. (5·078 ins.).

Pistons
Nominal Dia. : 70 mm. (2·756 ins.).
Overall Length : 71 mm. (2·795 ins.).

Piston Rings
Quantity of Rings per Piston : 2 compression and 1 scraper.
Width : top, 3 mm. (·118 in.) ; centre, 3 mm. (·118 in.) ; scraper, 3·75 mm. (·147 in.).

Gudgeon Pin
Diameter : 20 mm. (·787 in.).
Length : 60 mm. (2·362 ins.).

Flywheel
Diameter : 260 mm. (10·24 ins.).
Number of Teeth : 109.

Starter Pinion
Number of Teeth : 9.

Oil Pump
Gears : pitch dia., 27 mm. (1·06 ins.) ; width of teeth, 17 mm. (·67 in.) ; number of teeth, 9.

Camshaft Drive

	Crankshaft Gear.	*Camshaft Gear.*
Pitch dia. :	63 mm. (2·48 ins.)	127 mm. (5 ins.)
Helix angle :	23° L.H. Spiral	23° R.H. Spiral
Face Width :	20 mm. (·787 in.)	20 mm. (·787 in.)
Number of Teeth :	26	52

Valves
Inlet and Exhaust Stem Dia. : 7 mm. (·275 in.)
Inlet and Exhaust Overall Length : 100 mm. (3·94 ins.).
Inlet and Exhaust Angle of Seat : 45°.
Inlet and Exhaust Head Dia. : 28 mm. (1·108 ins.).

Induction Pipe
Bore (to Carburettor) : 24 mm. (·945 in.).
Bore of Branches : 19 mm. (·748 in.).

ENGINE MATERIAL ANALYSIS

Crankshaft : *Mn.*, 1% (approx.) ; *Cr.*, more than 0·5% ; *Ni.*, Nil ; *Mo.*, 0·2%/0·4% ; *Hardness*, Brinell 302.

Flywheel : *Mn.*, 1% (approx.) ; *Cr.*, more than 0·5% ; *Ni.*, Nil ; *Mo.*, Nil ; *Hardness*, Brinell 228.

Connecting Rod : *Mn.*, 1% (approx.) ; *Cr.*, more than 0·5% ; *Ni.*, Nil ; *Mo.*, Nil ; *Hardness*, Brinell 228.

Valves (Inlet and Exhaust) : *Mn.*, less than 1% ; *Cr.*, more than 3% ; *Ni.*, Nil ; *Mo.*, more than 0·6% ; *Hardness*, Brinell 325 Stem, Rockwell C.63 Tip.

Crankcase : Magnesium Base Alloy.

Piston : Aluminium Alloy ; *Hardness*, Brinell 106.

Cylinder : Grey Cast Iron containing Chrome and Copper ; *Hardness*, Brinell 251.

Cylinder Head : Aluminium Silicon Alloy, Silicon content 10% to 12%.

Camshaft : Cast Iron containing Copper chilled on Cams ; *Hardness*, Brinell 228 (Shaft), Rockwell C.52 (Cam Nose).

Camshaft Gear : Magnesium Base Alloy.

Crankshaft : Impervious to file.

Valve Seat Inserts : Bronze Alloy.

Crankshaft Journals : Lead Bronze.

Connecting Rod Big End Bearings : Babbitt Metal.

Push Rod (Tube) : Aluminium Alloy.

Push Rod (Head) : Hardened Steel ; *Hardness*, Rockwell C.61.

ENGINE WEIGHTS

Crankcase and Studs : 27 lbs.

Cylinders : 3·875 lbs.

Cylinder Head (with Inserts and Guides) : 7·875 lbs.

Crankshaft with Gear : 14 lbs.

Connecting Rods (with Small End Bush) : Total, ·983 lb.

Cap and Bolts : Small End, ·233 lb. ; Big End, ·750 lb.

Piston : ·485 lb.

Piston Rings (one set) : ·07 lb.

Gudgeon Pin : ·172 lb.

Push Rod : ·22 lb.

Rocker Arm (complete Adj. Pin) : ·203 lb.

Valve Springs (Inner) : ·031 lb.

Valve Springs (Outer) : ·063 lb.

Valve : ·094 lb.

Spring Cup and Collar : ·023 lb.

Total Weight of Engine including Blower Equipment, less Clutch Unit : 170 lbs.

Flywheel, Clutch and Driven Disc : 25·5 lbs.

CLUTCH

Make : Fetchel and Sach—Komet.
Type : K.10.
The design of the clutch is similar to that made by Borg and Beck, the principal difference being on the driven plate which is solid instead of having a spring cush drive

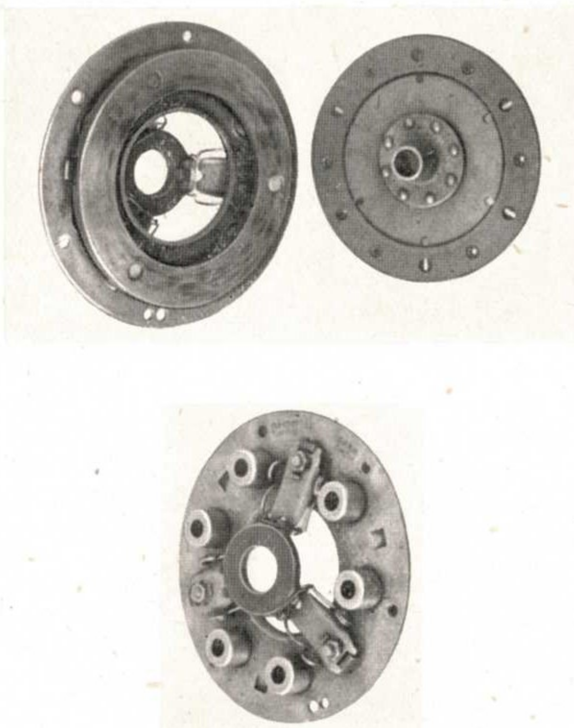


Plate 20.—Clutch unit

as generally used on the Borg and Beck clutch ; other variations are mainly constructional. The clutch is of the single plate, dry disc type, no adjustment for wear being provided in the clutch itself. An individual adjustment is provided for initially locating each release lever, for manufacturing purposes only. Three release levers are fitted, and these are interconnected to a centre plate by means of spring hooks. This is operated by a graphite release bearing housed in a neatly designed steel pressing which is connected by means of spring clips to the operating lever. The latter consists of two pressed levers welded to a steel bar, one end only being supported, and having its bearing direct in the gearbox casing. The clutch-driven plate slides on serrations instead of the more usual spline fitting. It was observed that no provision for ventilation of the clutch was arranged, since it was completely enclosed in an aluminium casing directly behind the rear axle differential.

CLUTCH DATA

Make : Fetchel and Sach.
Number of Friction Surfaces : 2.
Outer Dia. : 180 mm. (7·09 ins.).
Inner Dia. : 125 mm. (4·92 ins.).
Number of Plates : 1.
Total Area of Friction Surface : 28·5 sq. ins.
Pressure at Release Bearing : 340 lbs.
Clutch Toggle Leverage : 4·4 : 1.
Clutch Control Leverage : 10·44 : 1.
Overall Leverage to Pedal : 44·4 : 1.
Clutch Shaft Serrations : Outside dia. (shaft) 20 mm. (·79 in.) ; Inside dia. (clutch member), 18·5 mm. (·767 in.). Number of serrations, 24.

GEARBOX

General Description

The gearbox forms part of a unit which includes the axle differential and clutch operating mechanism, the whole being housed in a magnesium base alloy casting which is split longitudinally and vertically through

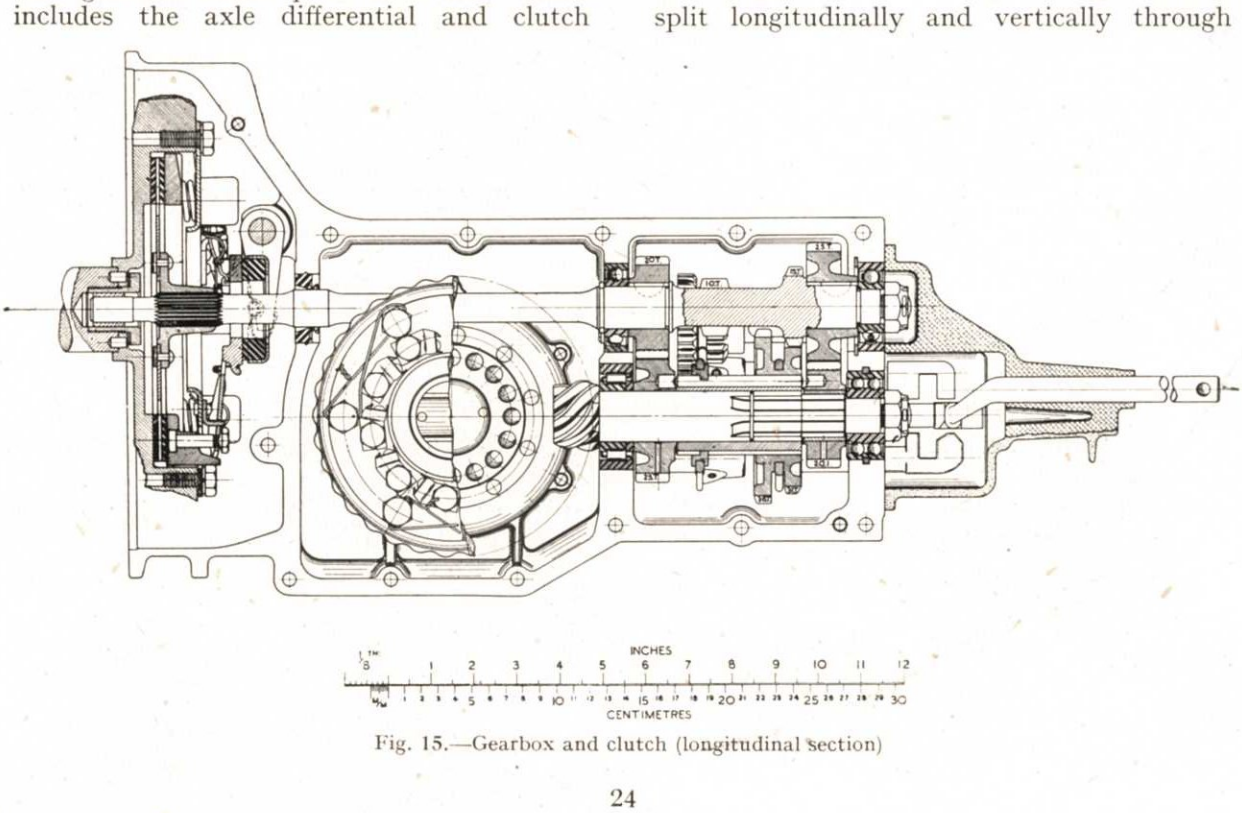


Fig. 15.—Gearbox and clutch (longitudinal section)

the mainshaft and bevel pinion shaft. The gearbox is situated directly in front of the rear axle, being driven from the engine through an extended mainshaft which passes over the axle, and is supported at the crankshaft end in a self-lubricating bronze bush. The clutch is positioned immediately behind the axle and enclosed in the same casting.

The gearbox is of the two-shaft type, having four forward and one reverse speeds. Gear changes are effected through an unusual type of engagement for third and fourth speed, the sliding gear type engagement being used for the first, second, and reverse speeds. Two trains of single helical cut gears are constantly in mesh and provide the third and fourth speeds alternatively ; the rest of the gears are straight spur type. Dismantling and assembly were very easy on account of the split casing, which enabled the mainshaft and bevel pinion shaft to be assembled as complete units. The usual type of selector controls are fitted, these being enclosed in a cover in front of the gearbox and operated by a remote control lever of the ball change type.

Gear Engagement.—The gear engagement on the bevel pinion shaft provides a noteworthy feature. Nine pins fit in corresponding semi-circular grooves in the sleeve which is splined on to the shaft, and also in semi-circular grooves in the centre member. The pins act as the driving medium for the centre member, which gives either first or second speeds when in mesh. To obtain third or fourth speeds the pins are moved along the grooves by the selector and the ends engage with corresponding holes in one of the constant mesh gears. This design replaces the normal dog engagement and consequently reduces the overall length of the gearbox ; it also provides easy engagement which is simple to produce.

Constructional Details of Gearbox

Gearbox Casing.—The gearbox casing is a magnesium base alloy sand casting formed in two halves dowelled and bolted together. Apart from the gears it also houses the rear axle differential, clutch unit, and carries the starter motor on the R.H. half. One oil filler serves both gearbox and axle.

Condition of Gearbox

Very little signs of wear were observed, and the condition was good.

Mainshaft Assembly

The mainshaft is produced from an electrically upset forged bar having the first and second

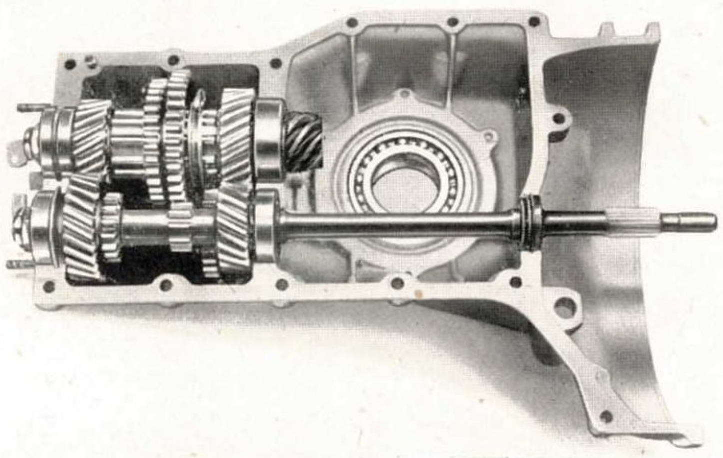


Plate 21 (above).—Gearbox and gears (assembled in L.H. interior casing)

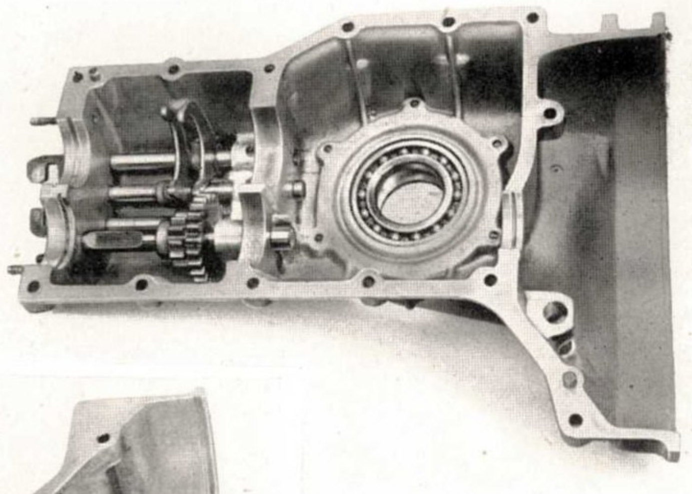


Plate 22 (right). — Gearbox, showing selector control and reverse wheel (L.H. interior casing)

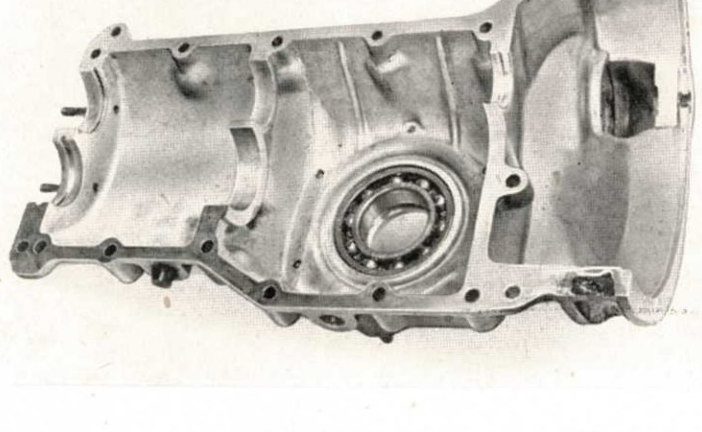


Plate 23 (left). —Gearbox casing, R.H interior speed teeth integral; the third and fourth speed gears are keyed on, ball races being fitted at each end and secured by a nut and split pin to form a complete assembly.

Bevel Pinion Shaft Assembly
The bevel pinion shaft has a roller bearing at the pinion end and a double row ball race at the opposite end. The third and fourth speed idler gears run directly on the shaft, interposed between them being a composite spline fitting on which slides the combined first and second speed gear. These are secured by nut and split pin to form an assembly.

Gear Selector Control
Three gear selector shafts are housed in the left-hand half of the gearbox casing, the operating lever being situated at the front end in a magnesium base alloy die cast cover which is bolted to the gearbox casing. The nose of the cover is fitted with a rubber block, thus providing a mounting which locates the complete power unit in the backbone chassis.

Gear Control
A ball change type of remote gear control lever is used, pivoting in a pressed steel housing bolted on top of the backbone. A tubular control rod connects the gear lever with the selector, the control being located inside the backbone. The front end of the rod is supported inside the backbone and the usual type of ball and cup fitting between the lever and rod is employed.

GEARBOX DATA

GEAR SIZES

Gear No.	*Gear Ratio.*	*Pitch Dia. (appro.) Driving.*	*Driven.*	*Gear Width Driving.*	*Driven.*	*No. of Teeth Driving.*	*Driven.*	*Helix Angle.*
1st	3·6 : 1	28 mm. (1·10″)	96·5 mm. (3·80″)	15·5 mm. (·61″)	10 mm. (·787″)	10	36	Straight
2nd	2·07 : 1	41 mm. (1·614″)	83·5 mm. (3·287″)	10 mm. (·394″)	10 mm. (·787″)	15	31	,,
3rd	1·25 : 1	55·5 mm. (2·185″)	69·5 mm. (2·736″)	20 mm. (·787″)	20 mm. (·787″)	20	25	28°
4th	0·8 : 1	69·5 mm. (2·736″)	55·5 mm. (2·185″)	20 mm. (·787″)	20 mm. (·787″)	25	20	28°
Reverse	6·6 : 1							

BEARING SIZES

	Outside Dia.	*Inside Dia.*	*Width.*
Mainshaft Ball Race	52 mm. (2·047″)	25 mm. (·98″)	15 mm. (·59″)
,, ,, ,, ...	,,	20 mm. (·787″)	,,
Bevel Pinion Shaft Roller Race...	62 mm. (2·44″)	30 mm. (1·18″)	20 mm. (·787″)
Bevel Pinion Shaft Double Row Ball Race ...	52 mm. (2·047″)	20 mm. (·787″)	22 mm. (·866″)

GEARBOX MATERIAL ANALYSIS

Part.	*Mn.*	*Cr.*	*Ni.*	*Mo.*	*Hardness.*
Mainshaft	more than 0·6%	more than 0·5%	Nil	less than 0·5%	Rockwell C.62
Bevel Pinion Shaft	,, ,, 0·6%	,, ,, 0·5%	Nil	,, ,, 1·0%	C.60
3rd and 4th Gears ...	,, ,, 0·6%	,, ,, 0·5%	Nil	Trace	C.62
1st and 2nd Gears ...	,, ,, 0·6%	,, ,, 0·5%	Nil	less than 0·5%	C.64
Sliding Collar ...	,, ,, 0·6%	,, ,, 0·5%	Nil	,, ,, 0·5%	C.58
Mainshaft Sleeve ...	,, ,, 0·6%	,, ,, 0·5%	Nil	Trace	C.62
Selector Shaft ...	,, ,, 0·6%	,, ,, 0·5%	Nil	0·3% approx.	C.64
Selector Fork ...	,, ,, 0·6%	,, ,, 0·5%	Nil	0·5%	Superficially hard

General Description

A spiral bevel pinion formed on the gearbox output shaft drives the crown wheel, and this transmits the drive to the road wheels through a " limited slip " type differential which is a noteworthy feature. The drive to each wheel is arranged through half-axle shafts enclosed in tubular casings which act as swinging half-axles. On the outer end a final gear reduction box is fitted and the whole assembly (with the road wheel) oscillates about a " pot " type universal joint, which is housed inside the differential cam rings, and in effect forms the " pot." The axle shafts have forged ends which are hardened and ground and these engage with cylindrical segment members (also hardened and ground), which are located in the " pot " and form the universal driving joint.

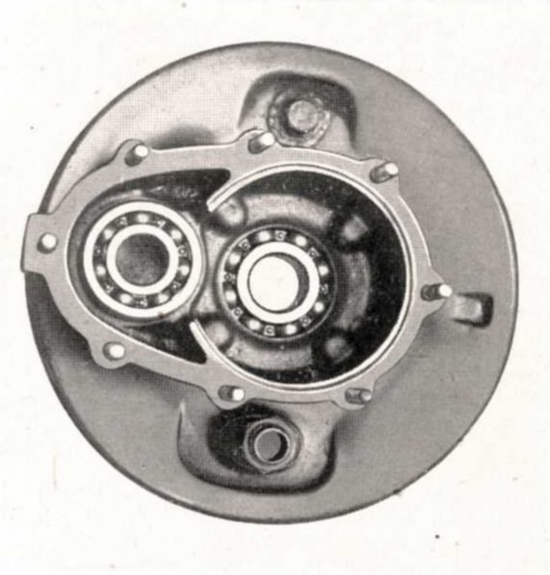


Plate 25.—Rear axle reduction gear casing and brake back plate

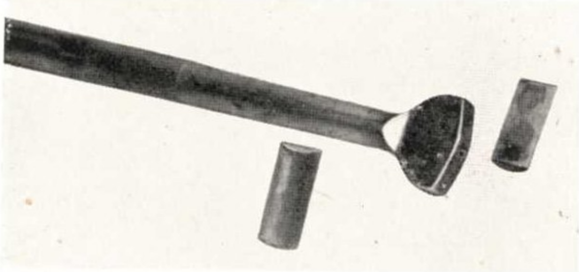


Plate 24.—Rear axle shaft end and cylindrical segment for universal joint

Splines are arranged at the outer end of the shaft for a gear reduction drive. This consists of a pair of straight-toothed spur gears completely enclosed in cast iron casings and supported by ball races, filler plugs being provided in each casing for lubrication purposes. The final gear reduction appears to have been introduced primarily in order to obtain lower gear ratios in a simple manner for military vehicles. Furthermore, it provides an increased ground clearance for the axle casing and power unit, which is an advantage when travelling across country. The differential unit is mounted on ball races which are housed directly in the axle casing and it was observed that the two half-axle shafts not only formed component parts of the differential unit, but they cannot be removed without taking the axle and gearbox unit out of the chassis and dismantling it. The axle casing consists of steel tubing, to which is welded a spherical end with both internal and external polished surfaces. This is held between the axle casing and a magnesium base alloy cover and forms the location about which the axle oscillates. A concertina form of rubber cover is fitted to prevent ingress of dirt to the seating.

Detail Description

Differential. — The differential gear is a " limited slip " type, being a cam form which follows the same principle as the one developed by a German gear manufacturer, Zahnradfabrik Friedrichshafen, in 1931. This is patented by Gottfried Weidmann, German Patent Spec. No. 639876 and British Patent Spec. No. 431020. This type of differential offers considerable advantages when the vehicle is travelling across country.

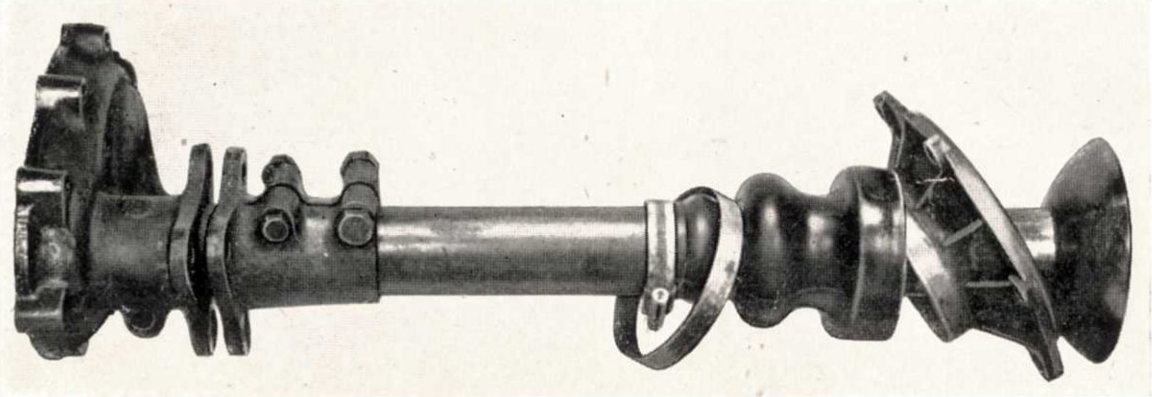


Plate 26.—Rear axle tube and shaft complete

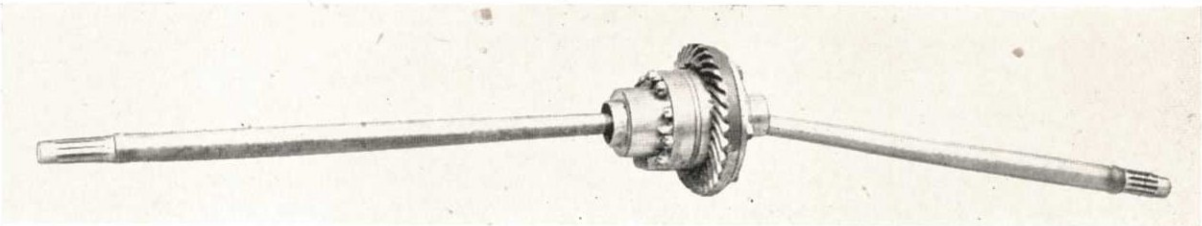


Plate 27.—Differential and axle shaft assembly

The phantom view, Fig. 16, shows the construction of the differential mechanism. This consists of two hardened steel disc members or cam rings which are mounted fast on to the axle shafts and are provided with recessed cam surfaces. Between these surfaces are interposed 17 hardened steel dog transmitting elements or plungers which are supported in holes or seatings in a hardened steel carrier member. The plungers are axially movable into the recesses, to permit differential action of the cam rings.

The above unit is held in a steel casing formed in two halves and secured to the plunger carrier and crown wheel by bolts and nuts, pressed steel scoops being attached for lubrication purposes. Thrust washers of plastic material are interposed between the cam rings and the differential casings.

The differential behaves as follows under various conditions :

(*a*) When one of the wheels meets so high a resistance as to exert a strong braking force—such as would occur when the vehicle deviates from a straight course—then the cam ring driving the inner road wheel may come practically to a standstill and the locked cams of this ring strongly resist the push of the sliding plunger. At the same time the cam ring connected to the outer road wheel offers less resistance and the ends of the plungers abutting against these cams push them forward, simultaneously moving up and down over the cams of the ring which has the higher resistance in the inner wheel. Owing to the friction of the sliding plungers

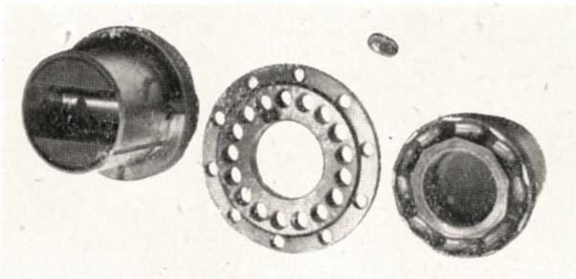


Plate 28.—Differential, exploded view

in their carrier and on the cams, this action takes place only when a relatively powerful resistance is met by one of the road wheels. Minor resistances leave the drive unaffected as the road wheels operate as though they were attached to a solid axle.

(*b*) When each rear wheel of the vehicle offers the same resistance, the plungers rotating with the carrier driven by the engine will take both cam rings with it so that both wheels rotate at the same speed.

(*c*) Owing to the driving wheels being relatively rigid one with the other, starting on slippery ground is facilitated.

(*d*) When both road wheels are raised from the ground and the crown wheel is prevented from rotating, if one wheel is revolved the other wheel turns in the opposite direction, functioning in a similar manner to the usual type of differential. It differs only in that in the conventional type of differential, wheel speeds are identical, whereas in this

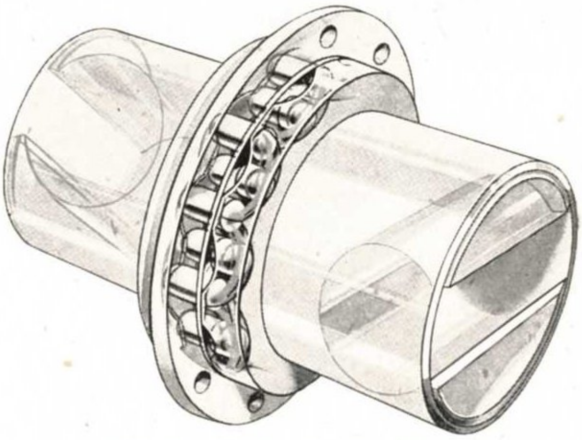


Fig. 16.—Differential, phantom view

case one wheel revolves faster than the other in the ratio of 9 turns to 8 turns. Therefore the torque transmitted to one cam ring and its corresponding half-axle exceeds that transmitted to the other in the ratio of 9 : 8, i.e., $12\frac{1}{2}\%$.

Referring to the development drawing, Fig. 17, it will be observed that ring A has eight and ring B has nine concave surfaces spaced equidistantly ; this variation enables several of the surfaces to be located simultaneously in a position to be driven by the corresponding plungers as the drive picks up. This is known as the " locked " position. If the cam rings were provided with the same number of inclines, this would give all the plungers identical positions relative to all inclines and lead to floating (or slip) if the plungers adapted to drive one of the cam rings were located at the apices of the inclines.

The operation of the differential is substantially as follows : Rotary movement applied to the bevel wheel is conveyed to the carrier and its plungers, which, in turn, drive the two cam rings in such a way as to permit differential action.

Assuming that one of the cam rings is stopped, the plungers continue to drive, during their rotary movement, the other cam ring. This is caused to rotate at the same speed as the bevel wheel plus a further increase in speed due to the arcuate movement of the ends of the plungers on the inclines of the stationary cams.

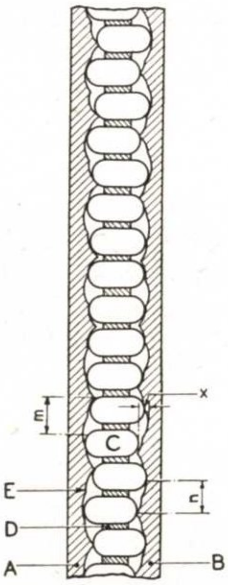


Fig. 17.—Differential, development drawing

At this instant, in addition to their rotary movement, the plungers move transversely in their seatings in the carrier. This particular movement of the plungers operates through reaction, by bearing against the stationary cam ring and imparting to the moving cam wheel an additional angular velocity so that the final speed of the moving cam wheel is substantially twice that of the bevel wheel. By way of example, assuming that cam ring A is stationary, at each movement of the carrier D equal to the circumferential length *m*, the plunger which, at the beginning of the movement, is at the bottom of the incline E, will, at the end of the movement, be at the succeeding apex. The plunger has therefore been subjected to a movement towards the cam wheel B in such a manner that this wheel has been caused to move relative to the plunger through a distance *n*, corresponding to one half of its inclines. The resultant movement of cam wheels B to A is finally *m* plus *n*.

If, now, instead of being stationary, one of the cam rings has a movement relative to the other (which is the condition when the vehicle travels round a curve), the carrier D which is assumed to rotate at constant speed, imparts to the two cam rings a difference in speed proportional to the difference of the paths travelled by the road wheels.

The plungers C always engage with the cam ring of which the speed is reduced, so as to transmit to the other cam ring an increased speed of $\frac{m}{n}$ or $\frac{n}{m}$ of the slowing down of the other.

When the plungers, by engaging with the cam wheel which rotates at the slower speed, are adapted to transmit to the other cam wheel a supplementary speed, at this moment it must supply the bevel wheel with supplementary work for overcoming the relatively high friction of the plungers which bear against the cam wheel moving at the lower speed, and consequently always tends to drive this cam wheel at the same speed as the bevel wheel. Thus the differential movement is retarded.

Condition of Differential

The holes (or plunger seatings) in the carrier showed signs of considerable wear — i.e., scuffing—and the plungers were a slack fit in the seatings. Considerable hammering had occurred on the spherical ends of the plungers, although the cams were in good condition—this being the case generally. During road tests with the vehicle the differential was observed to be noisy.

Rear Hubs

The rear hubs are in one piece with the brake drums, being made of malleable cast iron. The road wheels are attached to the side of the brake drums in the same manner as those at the front, the only major difference being the spline fitting required on the rear hubs for fixing to the axle shaft.

REAR AXLE DRIVE DATA

Spiral Bevel Drive :

Part.	*Pitch Dia.*	*No. of Teeth.*	*Spiral Angle.*	*Face Width.*
Pinion ...	44 mm. (1·73″)	7	55°	22 mm. (·87″)
Crownwheel	165 mm. (6·50″)	31	55°	22 mm. (·87″)

Hub Spur Gear Drive :

Driving Pinion	64 mm. (2·52″)	15	Straight	30 mm. (1·18″)
Driven Wheel	87 mm. (3·43″)	21	Straight	30 mm. (1·18″)

Gear Ratios :

Bevel gear, 4·43 : 1 ; spur gear, 1·40 : 1 ; overall axle gear ratio, 6·20 : 1

Rear Axle Bearing Sizes :

Part.	*Outside Dia.*	*Inside Dia.*	*Width.*
Differential Case R.H. Ball Race ...	90 mm. (3·54″)	50 mm. (1·97″)	20 mm. (·79″)
Differential Case L.H. Ball Race ...	90 mm. (3·54″)	50 mm. (1·97″)	11 mm. (·43″)
Hub Driving Pinion Ball Bearing (Inner)	72 mm. (2·83″)	30 mm. (1·22″)	19 mm. (·75″)
Hub Driving Pinion Ball Bearing (Outer)	62 mm. (2·40″)	25 mm. (·98″)	17 mm. (·67″)
Driven Gear Ball Bearing (Inner) ...	72 mm. (2·80″)	30 mm. (1·22″)	19 mm. (·75″)

Angular Movement of Half Axle :

Laden position 9¼°

At laden position 0° ; at full bump 6½° ; at full rebound 9¼° ; total angular movement 15¾°.

Rear Axle Weights :

Transmission Unit with Clutch and Starter less Brake Shoes and Drums : 147 lbs.

REAR AXLE MATERIAL ANALYSIS

Part.	*Mn.*	*Cr.*	*Ni.*	*Mo.*	*Hardness.*
Crown Wheel ...	0·6/1·0%	more than 0·5%	Nil	Trace	Rockwell C.62
Differential Casing	0·6% approx.	Nil	Nil	less than 0·5%	
Differential Cam Ring	0·6% approx.	0·5%	Nil	less than 0·5%	(" Pot ") (fitting Brinell 338)
Differential Cam Ring Sleeve					(Outside dia. Rockwell C.58)
Differential Plunger Carrier	0·6% approx.	more than 0·5%	Nil	less than 0·5%	Rockwell C.60
Differential Plunger					Rockwell C.64
" Pot " Joint Cylindrical Segment	less than 1·0%	Nil	Nil	less than 0·5%	(VPN.50 kilos. 878)
Axle Shaft					(Forged end VPN.50 kilos 610)
	less than 1·0%	1·0% approx.	Nil	less than 0·5%	Splined end Brinell 293
Hub Driving Pinion	0·6%/1·0%	less than 1·0%	Nil	Trace	Rockwell C.60
Hub Driven Gear...	1·0%	less than 1·0%	Nil	,,	Rockwell C.60
Hub Driven Gear Shaft	0·6%/1·0%	less than 1·0%	Nil	,,	Brinell 281
Hub Gear Casing ...	0·6%/1·0%	Nil	Nil	,,	Brinell 148
Axle Shaft Tubular Casing					Brinell 229

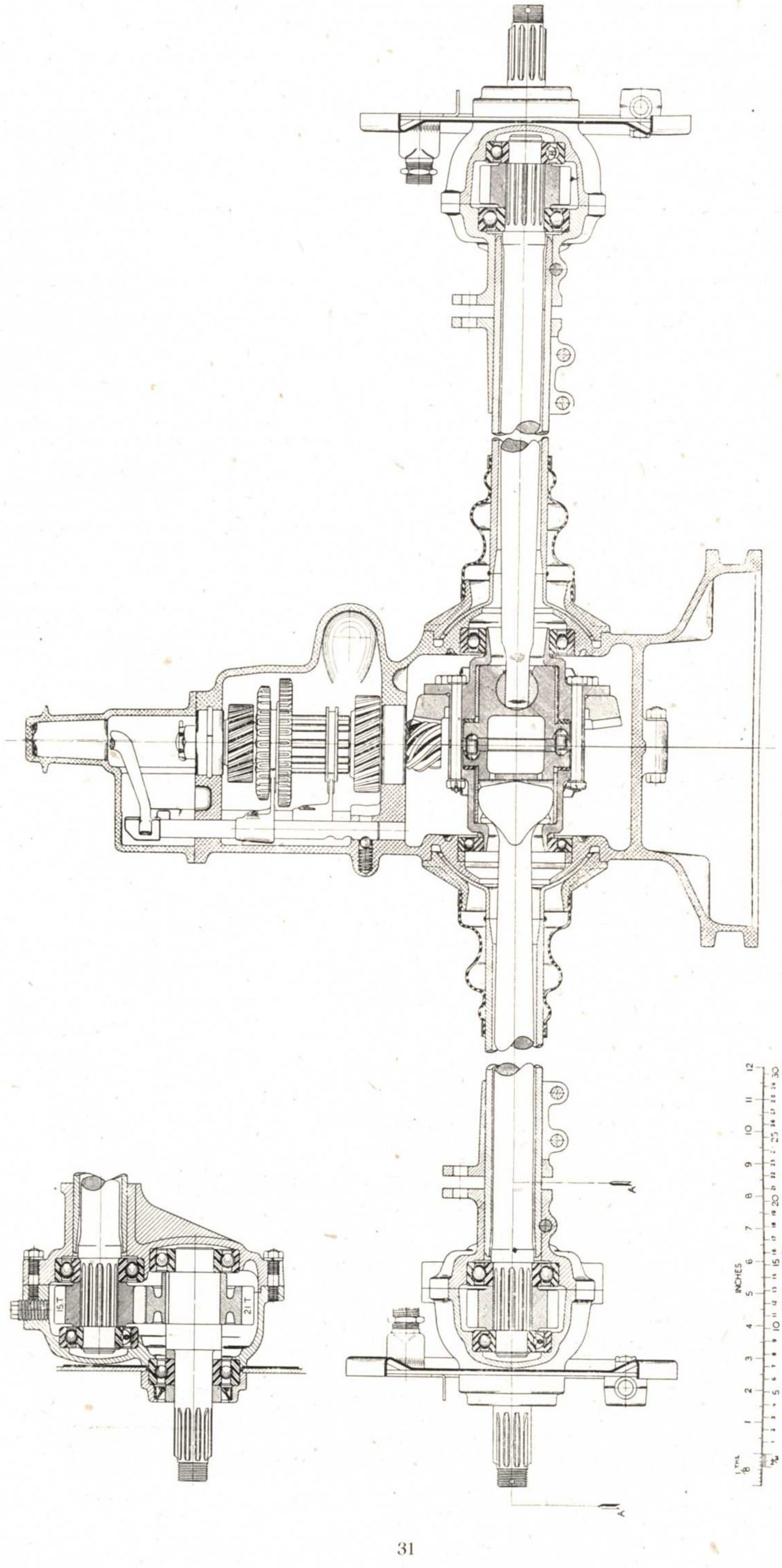


Fig. 18.—Rear axle and gearbox (cross section)

REAR SUSPENSION

General Description

Independent rear wheel suspension is fitted. It consists of torsion bars situated transversely in front of the rear axle and enclosed in a tubular cross member forming part of the underframe. Longitudinally swinging arms are attached to the outer ends, which have a trailing action. In turn, these carry the outer ends of the swing half-axle casings to which they are rigidly connected. The suspension linkage for each wheel thus represents two sides of a right-angled triangle, the wheel being situated at the right-angled corner. Consequently the wheels oscillate about an axis formed by the hypotenuse of a triangle; the hypotenuse intersects the centres of the swing axle spherical seating and the longitudinal arm bush. This structure is suspended on the torsion bars and owing to these being arranged transversely, the longitudinal arms are made flexible to allow for misalignment. This form of suspension is notable for its simplicity; it entails only one universal driving joint per half-axle and the longitudinal arm which serves the dual purpose of the torsion bar suspension arm and the brake torque arm. Furthermore, only two bearings are used in the linkage for each wheel, i.e., the half-axle spherical seating and the torsion bar rubber bush. Torsional movement is restricted by stops arranged on brackets welded on to the tubular cross member, which also carry double acting type shock absorbers, of the detachable hydraulic lever arm type. No means of adjustment is provided for the torsion bars, winding of which may occur on account of initial loading and fatigue, except by dismantling the torsion bars and re-positioning on the serrated fitting. Comparatively short torsion bars of robust circular section are used and consequently the suspension is fairly stiff—much stiffer than that fitted to the front wheels.

Means are provided whereby the torsion bars can be extracted in the event of failure, and this without disturbing the road wheel and longitudinal arm. The outer ends of the torsion bar are supported in rubber bushes which are fairly hard and conically seated, so that they are wedged on both the inside and outside diameters.

Constructional Details

Two torsion bars of circular section are fitted, and these have serrations on each end, those at the inner end being smaller in diameter than at the outer, facilitating assembly and dismantling without disturbing the road wheel and longitudinal arm.

The torsion bars are enclosed in a substantial tubular cross member situated transversely and forming part of the underframe structure. At the centre of this member a malleable iron casting is welded in position and this has a serrated hole for the torsion bars. Malleable cast iron brackets are welded to the extremities of the tubular members, serving the purpose of housing rubber bushes for supporting the torsion bars, restricting the wheel movement by means of stops acting against the longitudinal arms and providing an anchorage for the shock absorbers. The longitudinal arms are of built-up construction, each consisting of a pressed steel strip butt welded to a steel stamped boss at one end, the latter being serrated to fit the torsion bar. The method of welding across the strip is shown in the drawing of the rear suspension, being arranged cheaply and efficiently.

The opposite end is fork shaped to fit over the axle casing, facilitates replacements of swing arms failures, and is rigidly secured to the axle brackets by means of three bolts. Swing arms are thus easily replaced in case of failure.

At the extremities of the tubular cross member are fitted magnesium base alloy die cast covers which form the closure for the torsion bars and also support the outer rubber bushes.

The torsion bar swing arm or strut is located above the wheel centre, and it is claimed in

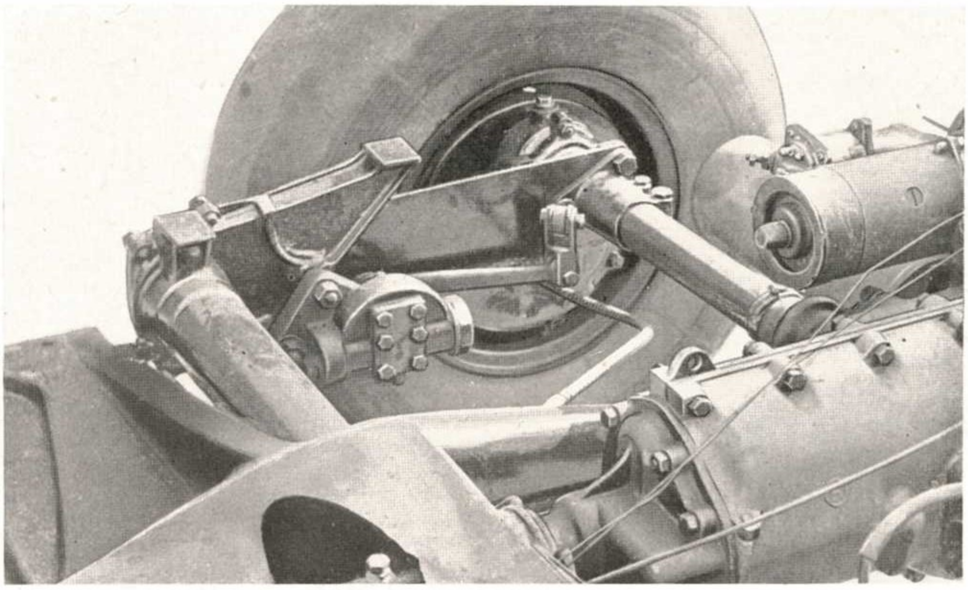


Plate 29.—Rear suspension, R.H. wheel

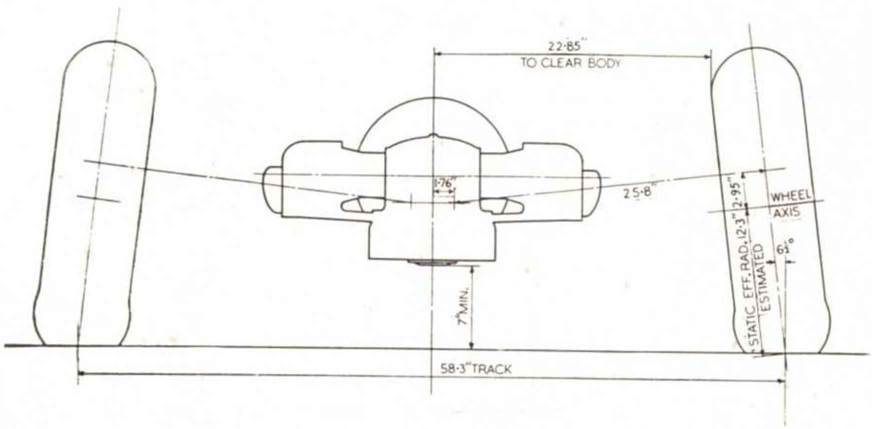


Fig. 19.—Rear suspension, minimum ground clearance

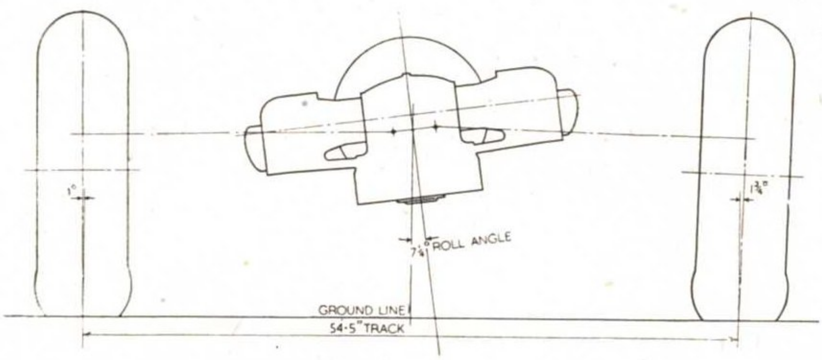


Fig. 20.—Rear suspension, maximum roll position

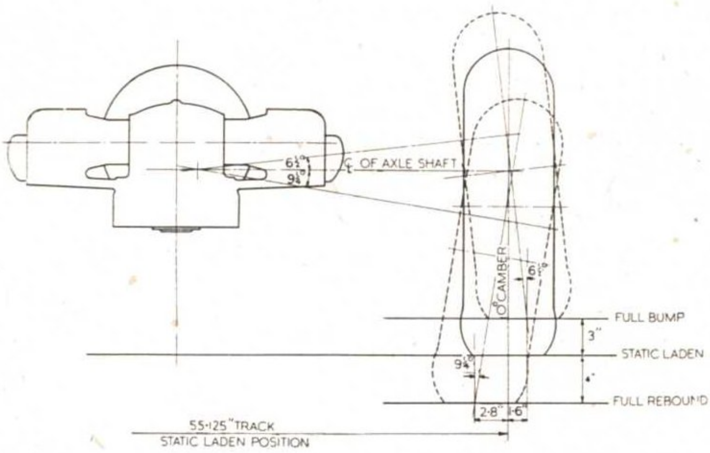


Fig. 21.—Rear suspension, wheel movement

British Patent Spec. No. 544748 taken out by F. Porsche that the stresses in the strut are minimised and consequently a light and cheap construction is possible.

It also appears, however, that improved ground clearance is gained due to the raised position of the torsion bar relative to the vehicle, which is thus more suitable for cross-country work. With the exception of the hub reduction gear, this arrangement would permit all the components to be interchangeable with the original design, as far as can be ascertained.

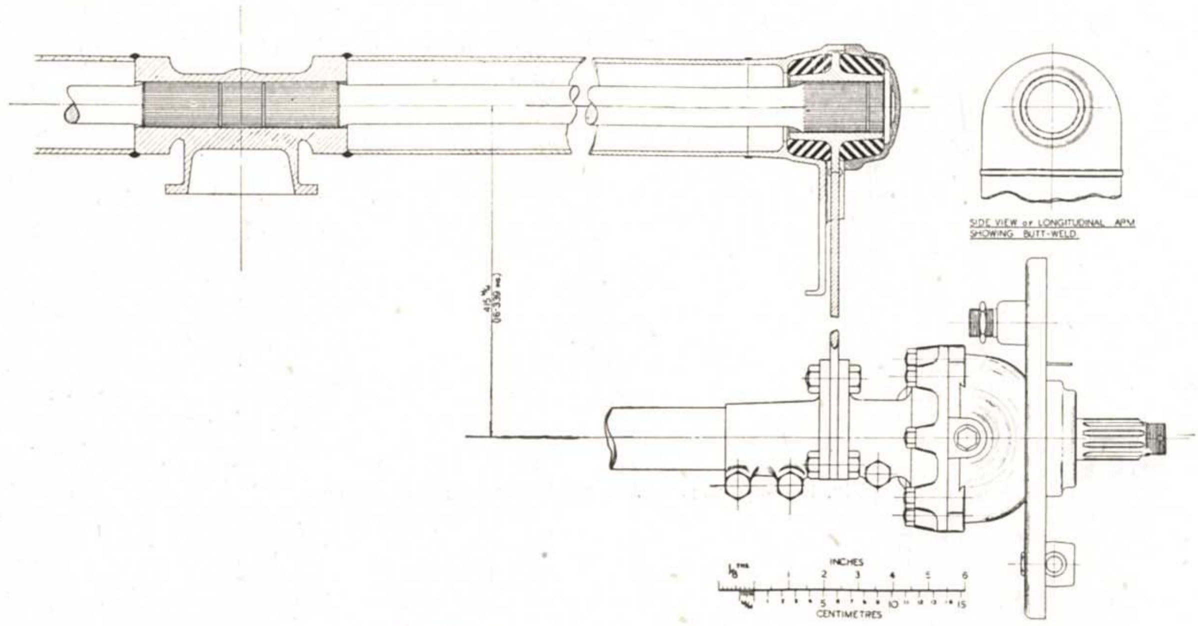


Fig. 22.—Rear suspension, R.H. side, plan

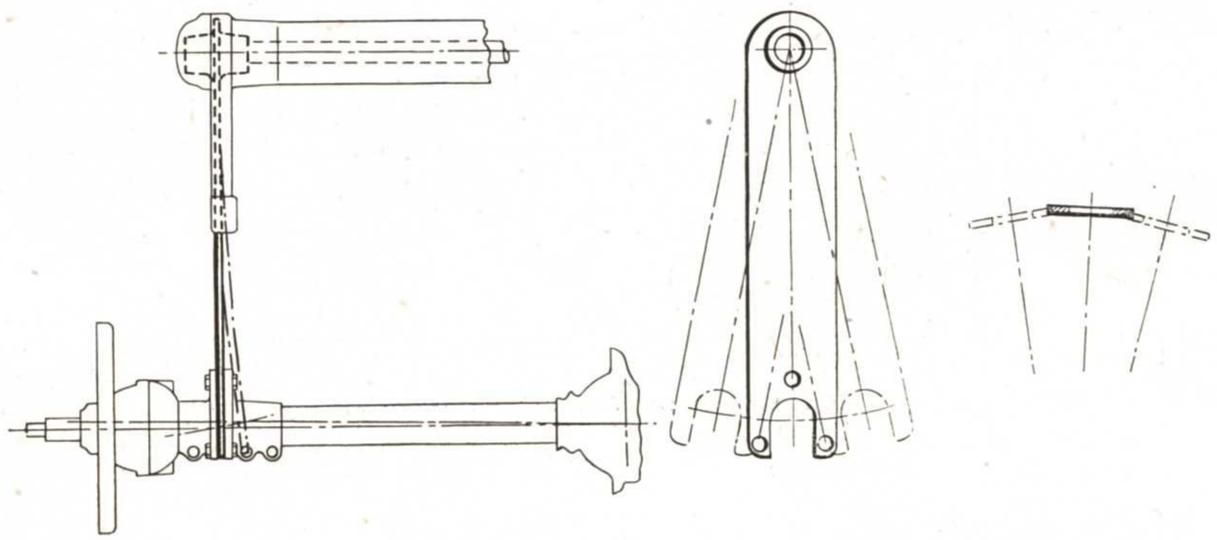


Fig. 23.—Rear suspension, longitudinal link, action diagram

REAR SUSPENSION DATA

Weights.		*Unsprung Weight.*
Rear Axle Shaft	7·34 lbs.	4 lbs.
Rear Axle Casing complete	28·125 lbs.	24·25 lbs.
Rear Hub and Brake Assy.	18 lbs.	18 lbs.
Swing Arm	—	1·72 lbs.
Wheel	12·75 lbs.	12·75 lbs.
Tyre	20·5 lbs.	20·5 lbs.
Inner Cover	3·25 lbs.	3·25 lbs.
	Total	84·47 lbs. per wheel
		168·94 lbs. both wheels
		(169)

Laden Sprung Weight at Rear Wheels

1,598 lbs. — 169 lbs. = 1,429 lbs. = 715 lbs. per wheel.

Swing Arm centres 16·34 ins.

Torsion Bar

Round Bar : 1·093 ins. dia.
Effective Length : 18 ins.
Rate of Spring : 352 lbs. per in./per wheel.
Torsional Stress : 20·2 tons/sq. in.

Wheel Movement

Total : 7 ins.
Static laden to full bump : 3 ins.
Static laden to full rebound : 4 ins.

Track

55·125 ins. (4 ft. 7⅛ ins.) at static laden position.

Wheel Camber

0° at static laden position.

Ground Clearance

With 12·3 effective radius tyre :

Lowest sprung point is the engine sump drain plug.

Ground clearance = 10 ins. static laden position.

FRONT SUSPENSION AND STEERING HEAD
(including Speedometer Drive)

General Description

Independent front wheel suspension is fitted, of a type which can be described as the "Longitudinal Link." It has a trailing action, and is suspended by an ingenious design of torsion bar consisting of four rectangular shaped strips placed together (in lieu of the usual round bar section) a considerable increase in effective length being gained, and in consequence a greater degree of resiliency. Although roughly 170 per cent. less efficient than round bar of equal weight, the arrangement is nevertheless very compact and cheap. There are two torsion bars housed in superimposed cross tubes attached to the underframe; each bar is fixed to the tube at the centre, the links attached to the outer ends carrying the steering head. This forms a parallel link motion imparting purely torsional movement to the bars, which are limited on bump and rebound by stops arranged on the cross tube bracket. Detachable shock absorbers of the hydraulic single-acting barrel type are fitted. No means of adjustment is provided for the torsion bars, winding of which may occur, due to initial loading or fatigue; the fact that the bars are not highly stressed may be the reason for omitting the adjustment.

Although it is understood that Dr. F. Porsche was partly responsible for the design of this vehicle, the front suspension (which follows the same principles as the "Porsche" torsion bar system) differs in regard to the torsion bar, also the connection between the swing arms and the steering head. Instead of a ball seating, the normal "swivel pin" type is used, and this is noteworthy in that the swivel pin is constructed in two parts, thereby enabling the spacing between the swivel-pin centres and also the swing arm crosshead bushes to be as wide as that which would be obtained if ball seatings had been employed.

CONSTRUCTIONAL DETAILS

Front Suspension

The front suspension, including wheels, shock absorbers, steering gearbox unit and track rods, can be assembled as a complete unit and attached to the backbone of the underframe by means of four bolts. The main structure which houses the torsion bars consists of two parallel spaced cross tubes bridged by four pressed steel brackets welded on equidistantly. The two central brackets act as support mountings, whilst the other two, at the extremities carry stops for restricting the up and down motion of the wheel, an anchorage is also provided for the shock absorber. The torsion bars, which are interchangeable, are fixed to collars midway in the cross tubes which, in turn, are held against rotation by indentations in the tube and centre pins (see Fig. 27). At the outer ends the suspension links (which are steel stampings) are secured to the torsion bars by centre pins and square hole fittings. Each link oscillates on two bushes made from a plastic base material; these are supported in the cross tube and facilities for lubrication are also provided by grease nipples screwed into the tubes. Rubber seals prevent the ingress of dirt to these bearings.

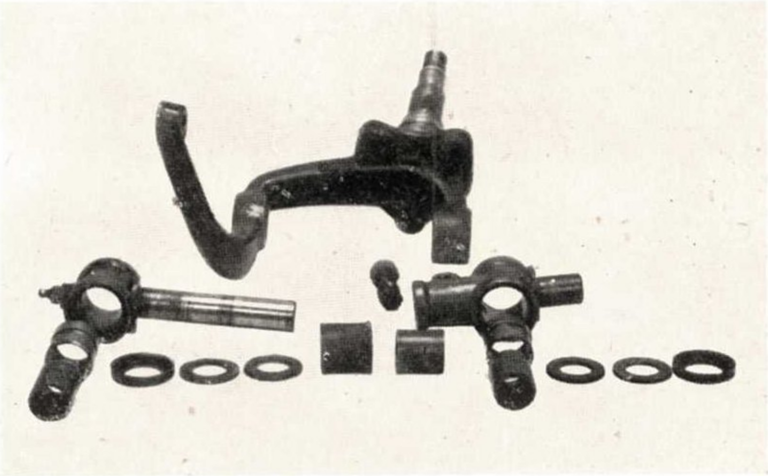


Plate 31.—Steering head, R.H. exploded view

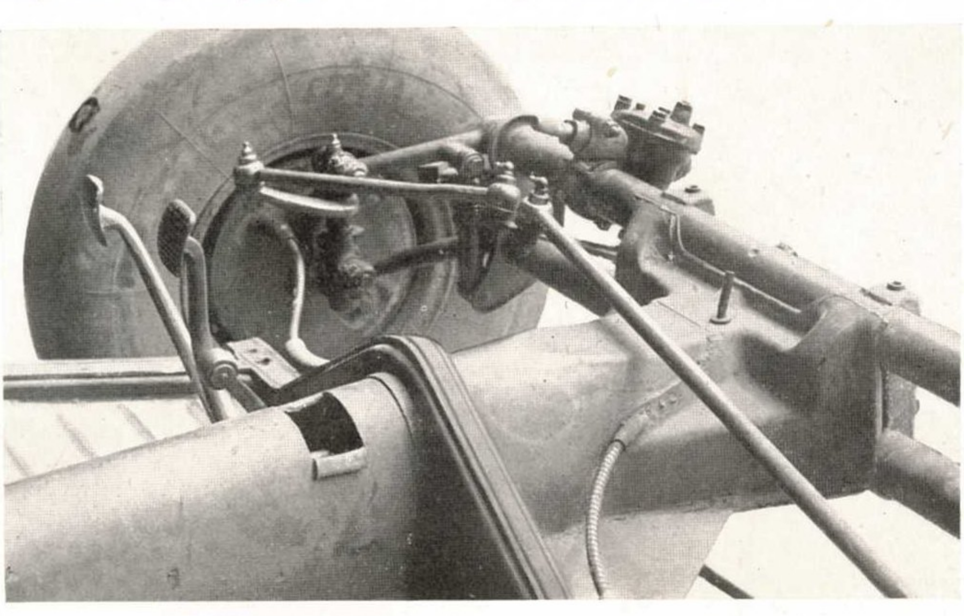


Plate 30.—Front suspension unit.

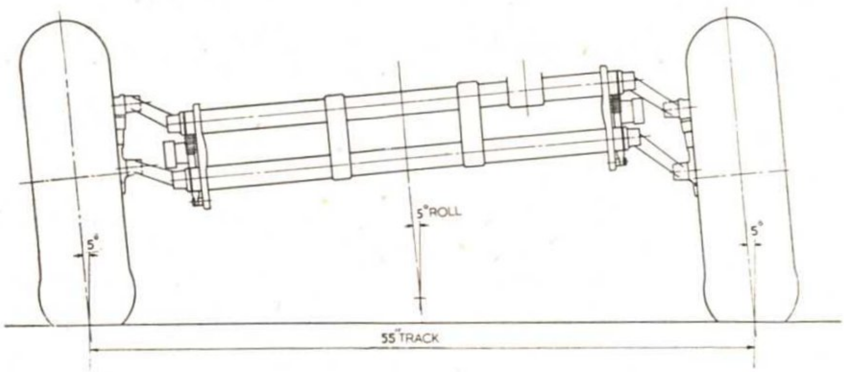
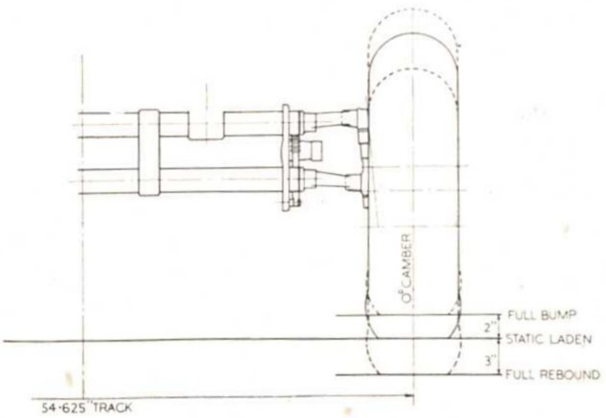


Fig. 24.—Front suspension, maximum roll position

Fig. 25.—Front suspension, wheel movement



CONSTRUCTIONAL DETAILS

Steering Head

The steering head incorporates a swivel pin of built-up construction comprising two parts, each made from a steel stamping, and held together—with the stub axle in position—by means of locating bolts (see Plate 31 and Fig. 26). Each half swivel pin has a cross-head in which plastic base bushes and loose thrust washers are fitted. The complete swivel pin assembly oscillates on these bearings, which are situated transversely on overhung hardened steel pins attached to the swing arms. The pins are adjustable for wear on the thrust faces, employing the same method as is used on the steering gearbox sleeve, i.e., a slow helix groove provided on the outside diameter of the pin, which fits into the swing arm and is located by a pinch bolt. When the pin is rotated it is compelled to move endwise by the pinch bolt, thus taking up end play. The swivel pin bearings are of bronze and the thrust washers on these are of plastic base material. Lubrication is arranged by means of one grease nipple on top of the upper half swivel pin and supplying cross-head bearings, swivel pin bearings and thrust washers. This necessitates fitting the cross heads with steel sleeves having annular grooves, in order to provide oilways for the swivel bearings.

Stub Axles

The stub axles are steel stampings resembling the shape employed for " Reverse Elliot " type axles. They are compact, inasmuch as the steering arms are formed integral.

Front Hubs

The front hubs are of malleable iron cast in one piece with the brake drums. A noteworthy point is the provision of five tapped holes in the back of the brake drum for fixing the road wheels. Fixing is effected by means of set bolts having spherical seatings under the head ; no spigot location is arranged. Cup and cone type bearings are used, loose cups and cones being fitted with caged balls. No facilities are provided for greasing the hub bearings. Hub retainer caps are fitted into recesses in the end of the hubs, being held by means of a press fit.

Speedometer Drive

The speedometer drive is neatly housed inside the left-hand stub axle. It consists of two spindles arranged approximately at right angles to one another, having skew gear form of drive. One spindle is disposed along the axis of the stub axle and is driven off the hub cap by means of a split pin, which locates in a slot in the end of the spindle. The other spindle is arranged vertically and close to the swivel pin, so that the position of the speedometer drive cable is not unduly altered by the road wheel steering movement.

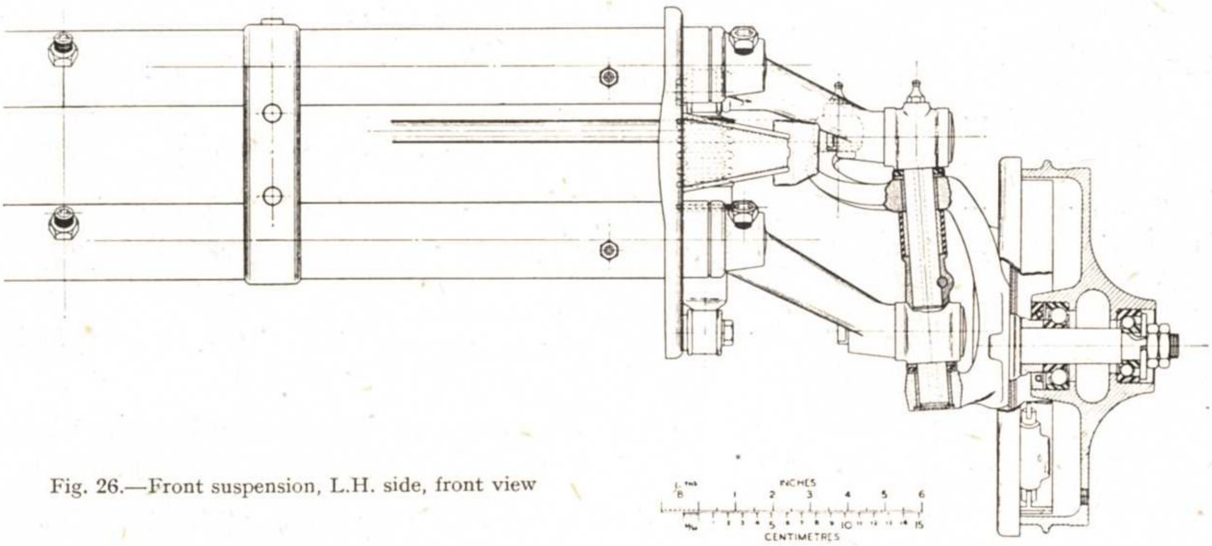


Fig. 26.—Front suspension, L.H. side, front view

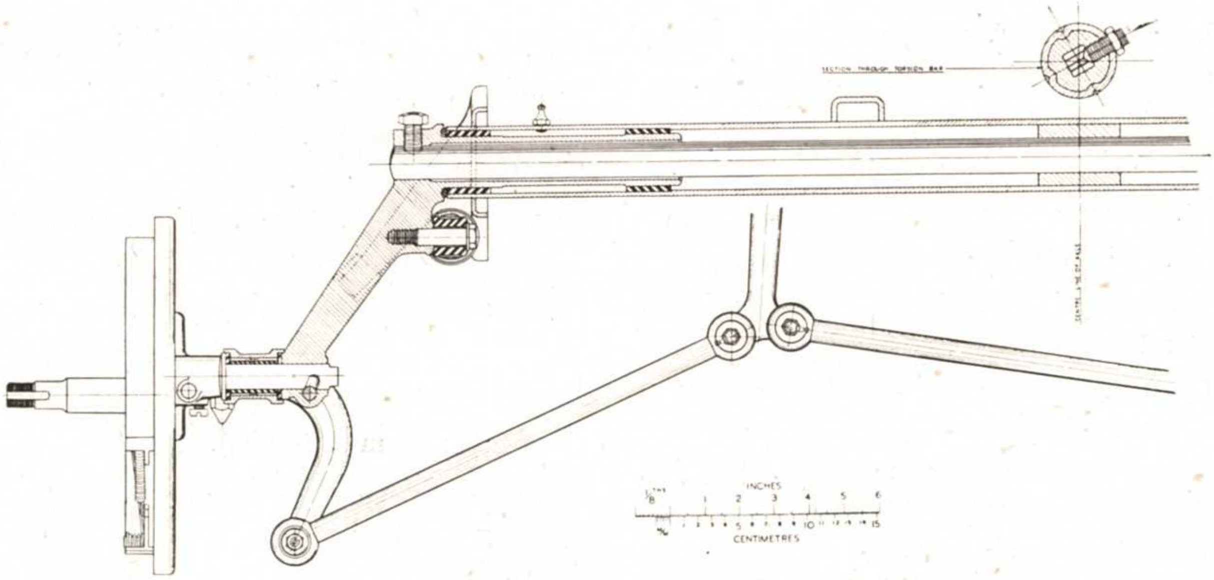


Fig. 27.—Front suspension, L.H. side, plan view

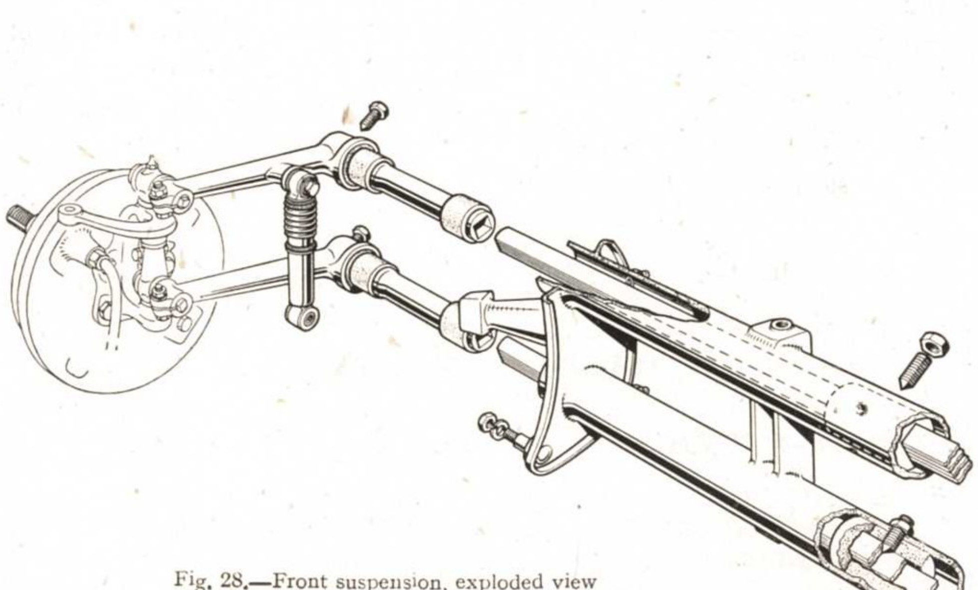


Fig. 28.—Front suspension, exploded view

FRONT SUSPENSION DATA

Weights.			*Unsprung Weight.*
Front hub and stub assy.	24·94 lbs.	=	24·94 lbs.
Top link	4·44 lbs.	=	1·69 lbs.
Bottom link	4·28 lbs.	=	1·61 lbs.
Track Rod (short)	1·44 lbs.		
Track Rod (long)	2·78 lbs.	=	1·06 lbs. total
Wheel	12·75 lbs.		12·75 lbs.
Tyre	20·5 lbs.		20·5 lbs.
Inner Cover	3·25 lbs.		3·25 lbs.
		Total	65·8 lbs. per wheel
		=	131·6 lbs. both wheels
			(132)

Laden Sprung Weight at Front Wheels

992 lbs. – 132 lbs. = 860 lbs. = 430 lbs. per wheel.

Suspension Links

Centres : 5·875 ins.

Torsion Bar

Four blades comprise one torsion bar; 2 torsion bars used.

Overall effective length : 37 ins. (18½ ins. centreline of vehicle to link).

Width of blade : ·734 in.

Depth of blade : ·183 in.

Rate of spring : Total 130 lbs. per in. per wheel

Swivel Pin Inclination : 4° 30′.

Wheel Camber : 0°.

Castor Angle : 2° 30′.

Tyre Offset (at 12·3 effective radius) : 2·31 ins.

Wheel Movement (total) : 5 ins.

Wheel Movement (static laden to full bump) : 2 ins.

Wheel Movement (static laden to full rebound) : 3 ins.

Track : 54·625 ins. (4 ft. 6⅝ ins.).

Swivel Pin Bearings

Diameter : 20 mm. (·79 in.).

Length : 22 mm. (·87 in.).

Bearing Spacing : 5·2 ins. centres.

Suspension Link Bearings

Small : dia., 18 mm. (·71 in.); length, 33·5 mm. (1·32 ins.).

Large : dia., 37 mm. (1·45 ins.); length, 32 mm. (1·26 ins.).

SUSPENSION DATA

Part.	*Mn.*	*Cr.*	*Ni.*	*Mo.*	*Hardness.*
Front Suspension Torsion Bar	More than 1·0%	More than 1·0%	Nil	Trace	Brinell 415
Rear Suspension Torsion Bar	do.	do.	do.	More than 1·0%	do.

FRONT SHOCK ABSORBERS

The front shock absorbers are fitted between the suspension top link and the chassis cross tube outer bracket, one per wheel being employed. The anchorage consists of rubber bushes having steel inner sleeves.

Construction

The general construction is in the class known as direct acting or telescopic type shock absorbers. Refer to sectional arrangement drawing Fig. 30

It consists essentially of a steel cylinder closed at the bottom, a piston reciprocable in the cylinder with a light loaded non-return valve opening on the up stroke of the piston, and a more heavily loaded valve opening on the down stroke of the piston.

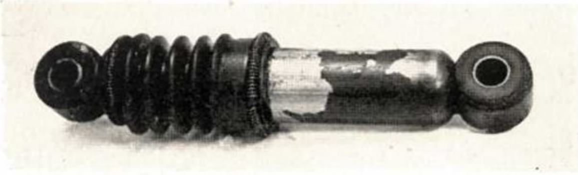


Plate 32.—Front shock absorber, exterior

Attached to the upper end of the cylinder is a deformable rubber bellows having free communication with the cylinder and serving for the accommodation of working liquid at approximately atmospheric pressure.

The piston is an aluminium casting and houses the only two valves in the construction. The main resistance relief valve is a simple steel cone but is spring loaded in an unusual manner as shown on the sectional arrangement. The valve spring (a coil spring) is not concentric with the valve and only the outside of the bottom coil presses on the valve. Presumably this is to get a larger diameter spring with a low rate, and so limit the build up in resistance with an increase in speed to as low a value as possible. The low resistance recuperating or transfer valve, consists of a steel disc held very lightly on its seat by a coil spring.

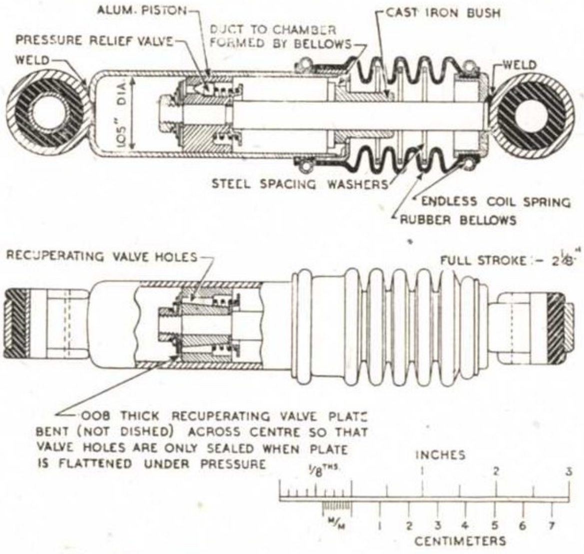


Fig. 30.—Front shock absorber, sectional view

The piston rod guide is made from cast iron and is held in position by a steel cap which is a press fit on the top of the cylinder. The fixing eyes are welded on, one to the bottom of the cylinder and the other to the piston rod.

The combination of cylinder and rubber bellows is covered by British Patent No. 495621 held by Fichtel & Sachs Aktiengesellschaft.

The fluid capacity of the shock absorber is very small and it was not possible to use any of the fluid for testing, but it is apparently a light mineral oil, very similar to Luvax PF94. Topping up can only be done after removing the bellows from the piston rod.

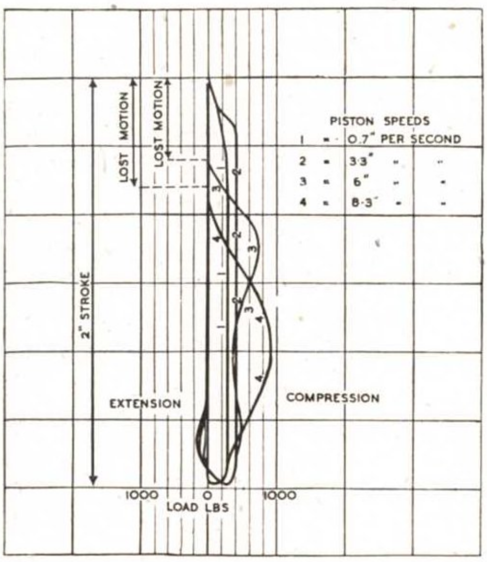


Fig. 29.—Front shock absorber, work diagram

Operation

The shock absorber is of the single acting type, but is unusual in that the main resistance stroke is on the compression or shortening of the distance between the eyes. Compression of the road spring will be unresisted.

The unit is filled to the top of the cylinder while it is held in the fully extended position. On shortening the shock absorber the piston rod enters the cylinder and oil is displaced unhindered through two large ducts in the piston rod guide into the rubber bellows. Attention is drawn to the recuperating valve plate shown in Fig. 30 which is bent to form a bleed passage for the oil at very slow piston speeds. As the pressure in the working chamber rises, the plate is flattened and the size of the bleed reduced until finally all the oil must pass through the pressure relief valve.

Results

The Work Diagram Fig. 29 shows the resistance obtained at various piston speeds and brings out the fact that at the higher speed, oil does not enter the main resistance chamber quickly enough, and that lost motion takes place at a piston speed of 6 inches per second. This lost motion is about 30% of the total stroke.

REAR SHOCK ABSORBERS—BOGE-ELASTIC

The shock absorbers are of the piston operated, double-acting hydraulic type. The body of the unit is bored to take two pistons, one on either side of a rocker arm which is held centrally between them. The rocker arm pivots about a shaft provided externally with a lever arm. Vertical movement of the car axle relative to the chassis, causes the lever arm to swing through an arc thus rotating the rocker shaft and arm ; the latter pushes one piston towards one end of the cylinder and withdraws the other piston from the opposite end of the cylinder. Since both ends of the cylinder are closed, a high pressure is built up in the oil at one end of the unit whilst a decrease in pressure occurs at the other end. A non-return recuperation valve situated in the piston head allows oil to pass from a reservoir to the low pressure end, thus keeping this normal. This leaves the oil pressure on the one piston head opposing lever arm movement. In order to spread the absorption of the shock, a leakage path is provided from each end of the cylinder to the reservoir, thus reducing the rate at which the pressure is built up. Finally, blow-off valves are fitted which limit the pressure reached, thereby controlling the resistance offered by the shock absorber.

When the lever arm is moved in the opposite direction, the function of the two pistons are interchanged. As is frequently the custom with German shock absorbers, the units are arranged to give a low resistance in the direction of the initial shock and a high resistance in the reverse direction to dissipate the energy stored in the springs.

Constructional Details

The components of the shock absorber are shown in Plate 33.

Both pistons are incorporated in a single casting, ground cylindrically at the ends. Some leakage is provided by grooves cut longitudinally in the ground portion. The centre of the casting is cut away to take the rocker arm, which is held between steel pads fitted into holes in the inner faces of the pistons. One pad is spring loaded to take up any possible clearance between the pad and the rocker arm, thus preventing knocking when the stroke is reversed.

The recuperation valves are screwed into the outer faces of the pistons and are off-centre. They consist of a spring-loaded disc seating on an orifice which faces a hole drilled through the piston so as to communicate with the cut-away portion or reservoir. When the pressure in the cylinder drops, the excess pressure in the reservoir pushes the disc from the orifice, thus allowing oil to pass through the orifice, round the disc and into the cylinder.

When the pressure rises in the cylinder it merely seals the orifice more effectively.

A single drop forging forms the rocker arm and shaft.

The ground shaft is supported at one end in the body casting and at the other end by

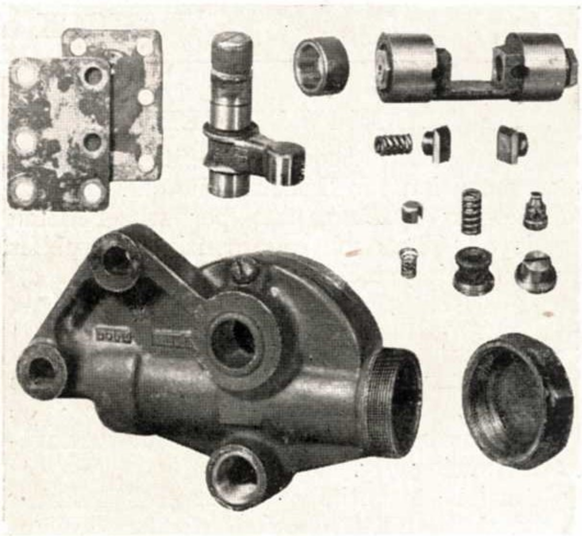


Plate 33.—Rear shock absorber, exploded view

a cast iron bush with brass lever. A rubber gland seals the bearing at the lever arm end whilst a steel plate and fibre gasket cover the other end. The lever arm—7⅝ ins. long—is held on the shaft by a self-cutting spline.

The shock absorber body is an iron casting, 7 ins. × 4½ ins., overall size. The cylinders are bored from one end, the opposite end being closed. The open end is sealed by a dish-shaped disc and rubber washer, which are held in position by a hexagon-headed cover. A tapped hole is provided in the top of the body for filling and topping-up, and this is normally sealed by a round-headed screw and fibre washer.

The arrangement of the blow-off valves is shown below. " A " and " B " are holes drilled through from the ends of the body to the valve housing. These holes are drilled before the cylinders are bored, and in the

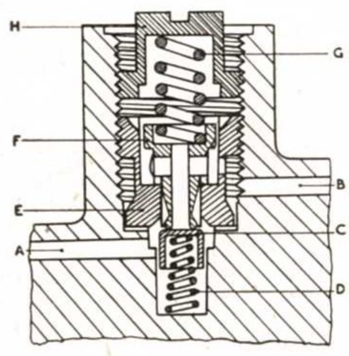


Fig. 31.—Rear shock absorber valve, section view

case of the closed end a brass plug is inserted to form a seal. " C " is a cup loaded by a helical spring " D." The slides of the cup are slotted to allow free circulation of the oil in the lower chamber. The cup presses against the bottom of the valve " F " and in its normal position seals the bolt through the centre of the valve " E." The valve housing is screwed into the body by means of slots milled in the top and sealed by a fibre washer. The valve rests on a shoulder of the housing so that in its normal position oil can pass through from the lower chamber only by means of a leakage path provided by two slots milled in the valve seating. Two holes in the valve walls allow oil to pass from the centre to the outside of the valve and three holes in the valve housing allow oil to circulate between this point and hole " B." The valve is loaded by a spring " G," which locates at opposite end in a screwed cap " H," the position of which can be adjusted by means of a slot in the top. The whole is finally enclosed by means of a hexagon-headed cover.

When the pressure commences to rise in " A," oil passes through the leakage paths into the upper chamber and thence through the holes in " E " and out through " B " to the other side of the shock absorber. When the pressure in " A " rises above the desired maximum, the pressure on the underside of " C " is sufficient to overcome the spring " G " thus causing the valve " F " to lift. This allows the oil to pass rapidly round the valve, relieving the pressure and preventing any further increase above the desired maximum. When the pressure in " B " is rising, oil first leaks into the same path as for " A," but in the reverse direction. Oil also circulates into the centre of the valve and when the desired maximum pressure is exceeded it presses the cup " C " away from the valve against the pressure of the spring " D," thus allowing rapid leakage past this point and relieving the pressure.

The valve gear is adjustable. By varying the slots cut in the valve seating the leakage can be adjusted so as to vary the rate at which pressure is increased. The compression of the spring " D " can be adjusted by turning the cap " H," thus varying the blow-off pressure for the cylinder to which this is connected. Variation of the blow-off pressure for the other cylinder can be effected only by the choice of the spring " D."

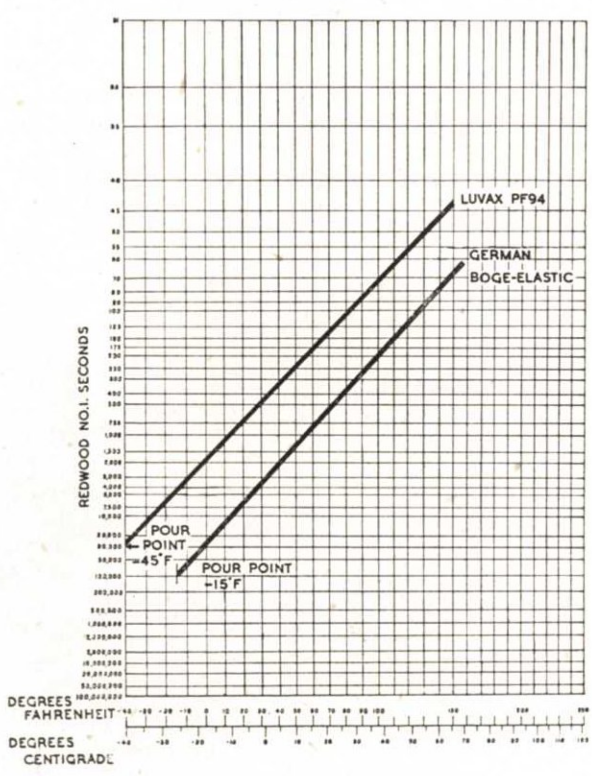


Fig. 32.—Rear shock absorber valve, temperature diagram

Test Results

The shock absorber was tested on a work diagram machine which gives torque in inch-pounds against a function of the vertical movement of the lever arm. Speeds of 20, 100, 180 and 250 degrees per second were used and the resultant diagrams are attached. From these it will be seen that the resistance is exerted principally with downward movement. At the standard test speed of 100° per sec. a maximum torque of 1,700 in.-lb. is obtained, while 250 in.-lb. is the maximum reverse torque neglecting the inertia oscillations produced by the testing machine.

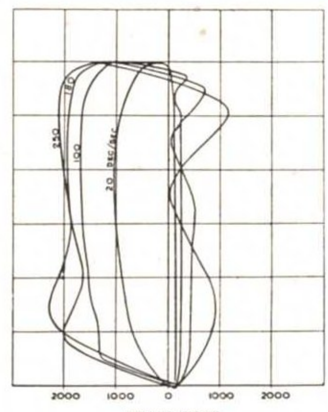


Fig. 33.—Rear shock absorber, work diagram

Viscosity and pour point tests were made on a sample of the oil ; these results being as shown on the accompanying curve, together with a curve of the oil used in " Luvax " piston type shock absorbers. It will be seen that the German oil has a higher viscosity than the " Luvax," whilst in addition the pour point is only —15° F. compared with —47° F. for the " Luvax " oil. This would prevent the unit from being used in cold climates.

General Description

Steering control conforms with Continental practice, being on the left-hand side of the vehicle. The steering gear consists of a separate steering box which is connected to the inner column through a fabric universal coupling joint at the lower end, thus insulating the handwheel from road shocks. The steering box is rigidly clamped to the upper torsion-bar cross tube on the front end of the chassis under-frame. The track rod is divided, giving independent steering as well as suspension, and adjustment is provided for setting the track.

Track Rod System

The ball joints of the track rod system are positioned so that correct geometry is maintained during the bump and rebound movement of the wheel. For example, the wheel travels up and down through an arc of radius equal to the suspension link, causing the outer steering arm ball joints (which are attached), to follow the same path. The inner track rod ball joints, attached to the steering box lever, are positioned relative to the outer joints so that the track rods generate a cone whose apex is at the inner joint. Thus directional control of steering is accurately maintained.

Turning Circle

The turning circle, ascertained when the vehicle was first received, is 30 ft. 5 ins. on right-hand lock and 36 ft. 8 ins. on left-hand lock. The left-hand lock was limited by the steering box stop and the right-hand lock by the tyre fouling against the suspension link. The uneven locks were due to the steering column location in the body, necessitating the steering unit being lined up in an incorrect position on the chassis cross tube. This in turn causes the rocker lever in the steering box to be out of the central position for straight ahead driving.

Since neither the body nor the chassis appear to have been damaged to any great extent, it would seem that this is bad design, especially in view of the absence of locating means for the steering box on the cross tube. It was ascertained that when the steering box is correctly positioned, both locks are limited by the tyres fouling the suspension links. With the narrower tyres originally specified for the Volkswagen, the locks were restricted by the stops in the steering box, which also is bad practice in view of the fact that thrust loads on full lock are transmitted through the steering box.

Description of Steering Box

This is of the worm and rocker arm type (with segment nut interposed), and has a low efficiency. Its steering ratio characteristics provide a lower ratio in the straight ahead position than on lock. The design is unusual, being as follows: A stem having a thread similar in form to that of the Acme, operates a segmental nut provided with four threads and having approximately one-third circumferential engagement. The nut is hemispherical in shape and fits into a correspondingly shaped seat on the rocker shaft. The nut acts as the medium through which rotation of the stem causes angular displacement of the rocker shaft, and the nut oscillates in the seating during alternating locks. The nut therefore moves around the thread, contact between the two being maintained by a spring and causing the rocker shaft to move endwise. It was observed that the nut had been over-riding its seating, causing considerable oval wear in the latter. This may be attributed to neglect in adjusting the spring when end play occurred, or alternatively the spring pressure may have been insufficient to withstand the thrust loads experienced on this vehicle.

This design of steering gear follows the principle described in Patent No. 384195 applied for by Wanderer Motor Co. and F. Porsche in 1931. It is claimed in this that the spring which presses the nut against the thread eliminates the shock loading from the hand wheel.

CONSTRUCTIONAL DETAILS

Steering Box Unit

This is a malleable iron casting having an integrally formed half-round mounting, the corresponding clip being a pressing. The rocker shaft is supported directly in the casing and a rubber oil seal is fitted at the lower end. The stem is supported on self-contained cup and cone type ball races, the

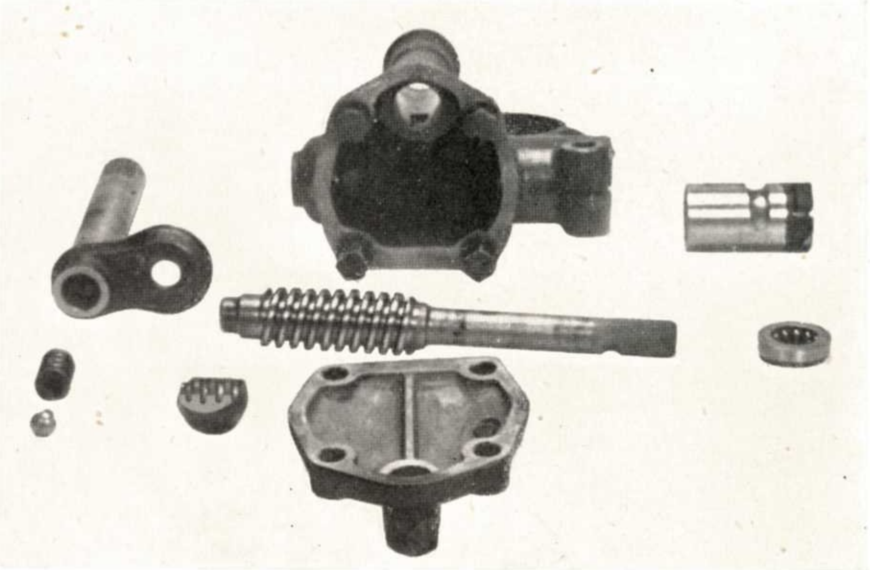


Plate 34.—Steering unit, exploded view

method of adjustment for wear being noteworthy, as follows :—A sleeve having a slow helix angle groove cut on the outside diameter fits into the casing and is held by a pinch bolt. When the latter is loosened and the sleeve is rotated, it is compelled to move endwise by the pinch bolt, thus causing the bearing cup to move and take up end play. The stem is made of hardened steel, has a fixing groove milled at one end and fine serrations rolled at the same end. This provided the means of attachment for a fabric coupling which is connected to the steering column in a similar manner.

A magnesium base alloy die cast steering box cover is used ; this incorporates an adjuster for the rocker shaft spring and a filler plug.

Steering Column

A tubular inner column is fitted, split at the lower end for clamping on to the fabric coupling flange and having an adaptor welded on the top end, with coarse serrations for the handwheel fixing.

Steering Wheel

The steering handwheel is of the three-spoke, solid type, having a composite construction with plastic base black covering. The hub is of aluminium base alloy and made by Petrilenkrad of Aschaffenburg.

Track Rod

The track rods are of tubular construction, having ball type joints with independent grease nipples, the sealing of these joints being effected by synthetic rubber washers. The ball joint housings are of stampings fitted into tubes, a pressing operation being performed on the exterior of the tube to obtain a tight fit followed by welding. Adjustment for track is provided on the long track rod, the ball joint being screwed into one end of the tube.

The design of the ball joints could not be ascertained without risk of damaging the seal provided by a Welch type plug. Since the track rods are formed in one piece with the joints by the method previously described, this entails replacing the complete rod when the joints have worn excessively. It was apparent that the joints have spherical seatings and the ball pins have taper end fitting, the joints being upcast on all the levers. Lubrication is arranged by the provision of grease nipples.

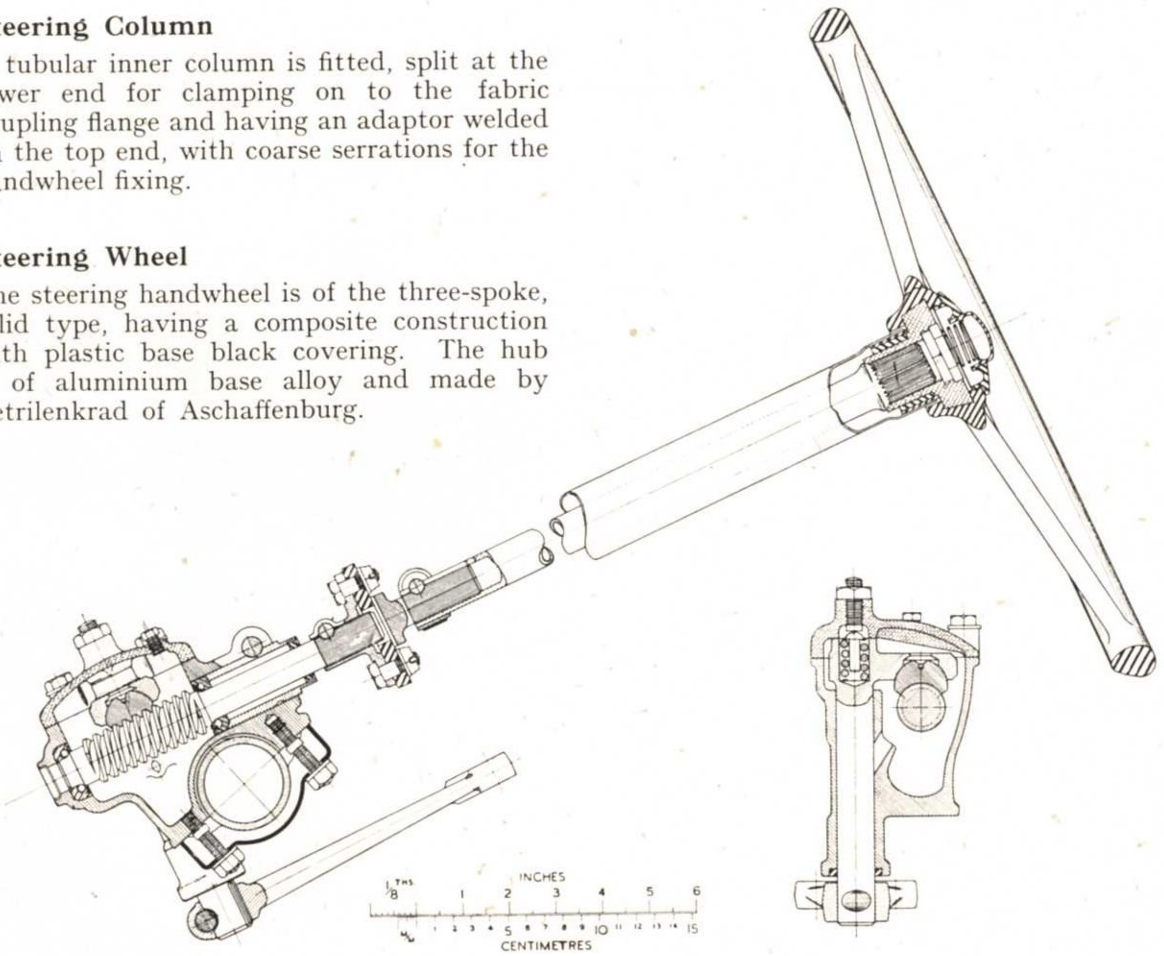


Fig. 34.—Steering box and column, sectional view

The inner column is enclosed in a thin section tube which is supported at each end in rubber grommets on the body dash and panel rail. The handwheel hub is supported on a plastic base bush fitted in the tube.

STEERING DATA

Overall Ratio (straight ahead) : 15·7 to 1.
Overall Ratio (at R.H. full lock position) : 13·9 to 1.
Overall Ratio (at L.H. full lock position) : 11·7 to 1.
Handwheel movement (overall) : 2·75 turns.
Handwheel movement (central to R.H. full lock) : 1·5 turns.
Handwheel movement (central to L.H. full lock) : 1·25 turns.

Turning Circle (R.H. lock) : 30 ft. 5 ins.
Turning Circle (L.H. lock) : 36 ft. 8 ins.

Rocker Arm

Centres : 1·4 ins.
Shank Dia. : 22 mm. (·87 in.).
Shank Length to Steering Lever : 4·75 ins.

Stem Thread

Top Dia. : 27 mm. (1·06 ins.).
Bottom Dia. : 20 mm. (·79 in.).
Number of Starts : 2.
Lead : 12·5 mm. (·49 in.).
Pitch : 6·25 mm. (·245 in.).
Angle between sides of thread 18° included.

Handwheel

Outside Dia. : 15·50 ins.
Serrated Fitting : 24 mm. (·95 in.) O/dia. shaft ; 22 mm. (·87 in.) I/dia. hub ; 24 serrations parallel.

Inner Column

22 mm. (1·06 ins.) O/dia. × 16 mm. (·63 in.) I/dia. × 37 in. approx. length.

Cup Ball Race

32 mm. (1·26 ins.) O/dia. × 10 mm. (·39 in.) wide.

Type F — 47 — 05.

Outer Tube

40 mm. (1·57 ins.) O/dia. × 1 mm. (·04 in.) thick.

Track Rod (long) : 18 mm. (·71 in.) O/dia. ball joint centre 31 ins.

Track Rod (short) : 16 mm. (·63 in.) O/dia. ball joint centre 13·75 ins.

The braking system provides for both foot brake and hand brake operation on all four wheels, the same cable gear being utilised in each case. Provision is made for the hand brake and foot brake to operate independently of one another despite the use of the same cable gear. The cable operates through guide tubes and flexible conduit on the non-compensated system. Two-shoe internal expanding brakes are used, cheapness of design and construction appearing to be the principal objects.

BRAKE SHOES

General Description

Two-shoe type internal expanding brake shoes are used, operated at the tips by a floating type of mechanism. The latter consists of a bell crank lever so arranged that the operating cables are at right angles to the brake back plate. Adjustment for shoe wear is provided opposite the shoe tips, i.e., at the fulcrum or anchorage. Malleable iron castings are used for the brake drums.

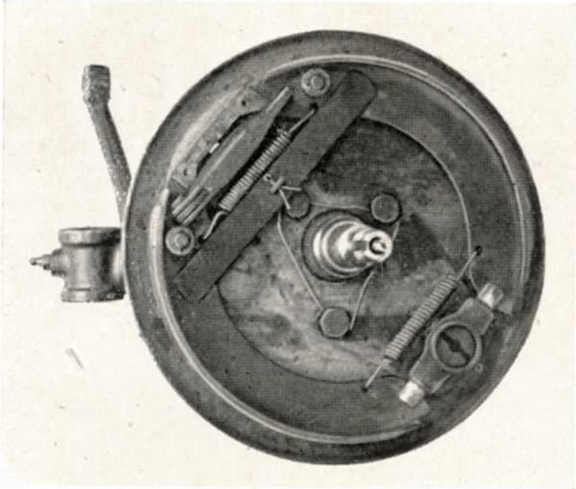


Plate 35.—Brake shoe assembly, L.H.

Floating Operation

This is shown in Fig. 35, and consists of a steel bell crank lever attached to a pressed steel housing, forming a self-contained operating unit. The operating unit is located in notches cut in the shoes and retained by the shoe return springs.

The whole is arranged to float and thus equalise the force applied to the shoes. The effort is applied at the operating lever, involving a high unit pressure at the reaction points between the operating unit and the back plate. Since sliding or wiping takes place during brake operation, a high frictional resistance occurs, thus impairing the efficiency.

Adjuster

The adjuster mechanism is arranged in a steel stamped housing which also serves as an anchorage and is welded to the back plate. Shoe adjustment is performed by rotating a hexagon-headed screw inside a threaded sleeve in the housing ; this sleeve is compelled to move axially being held against rotation by a split pin fitting in a slot. Movement for the adjustment of clearance is conveyed to the shoes through hardened steel plungers, which fit in the housing and have chamfered ends for engagement with a shoulder on the sleeve. The adjusting screw is locked in position by means of radial serrations locating in corresponding serrations formed on the brake back plate and held in contact through the pressure exerted by the brake shoe return springs.

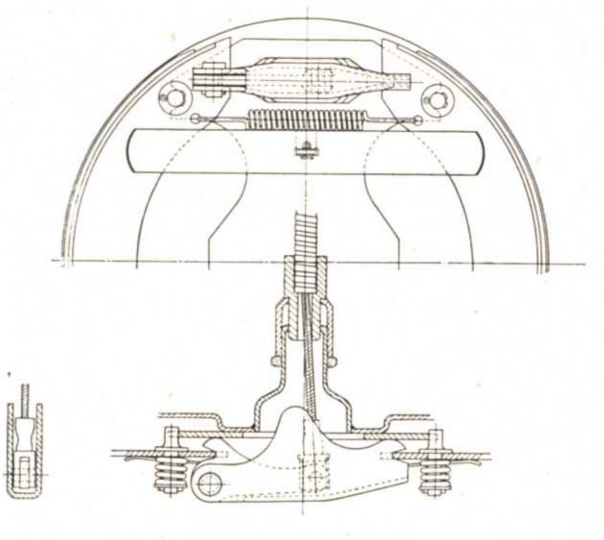


Fig. 35.—Brake shoe operation

Shoe Linings

Moulded linings having an asbestos base with copper content are riveted to the pressed steel shoes.

Brake Drums

The brake drums are integral with the hubs and strengthened by ribs on their outer periphery. Water-excluding means is provided by fitting a deflector cover, which is clipped on to the outside of the back plate.

Other Details

The brake back plates are steel pressings, the fronts not being interchangeable with the rear owing to differences in fixings, etc. Reinforcement plates are welded on, providing rigidity for the fixing, operation point and anchorage..

BRAKE CONTROLS

General Description and Construction

As previously mentioned, the foot brake operates the brakes on all four wheels. The controls are mainly cable and the system is non-compensated. The brake pedal forms part of a sub-assembled unit comprising all pedal controls—i.e., accelerator and clutch—which is bolted to the underframe backbone and constitutes a rigid anchorage. The pedal is a steel stamping, keyed and bolted to the operating lever shaft ; this consists of a steel stamping having the shaft and lever formed integrally. The pedal assembly fulcrums on self-lubricating bushes, and these are offset in relation to the pad. The front of the backbone is open-ended to receive a control head which forms the point of attachment for the four cables. The cable end ferrules are located in the control head, which is a steel stamping and is welded to the end of a channel member. This forms the compression member which is operated by the pedal and is slotted at the rear end attachment to permit independent operation of the hand brake. The front end of this member is supported in a pressed steel strip on which it slides during operation. The control head is also connected to a compression rod from the hand brake, and this fits snugly inside the channel member locating on a spherically ended lever, bearing in a hole in the end of the rod. The latter is also slotted to permit independent operation of the footbrake.

The compression members are returned to their original positions after operation by means of a coil spring situated at the front end of the backbone.

The cables are completely enclosed in rigid tubing and flexible conduit ; the rigid tubes being welded to the backbone act as guides. No arrangement for greasing is provided, and there is also no provision for adjusting the cable for stretch, except for a small amount on the back plate abutment for the conduit. This latter adjustment appears to be sufficient only to cope with possible variations in production. Owing to the disposition of the control head there is great disparity between the lengths of the front and rear cables.

HANDBRAKE UNIT

General Description and Construction

The handbrake is arranged in a horizontal position and is fitted between plates welded on top of the backbone, which provides a rigid mounting. The handbrake lever is a folded steel pressing and fulcrums direct on a hardened steel pin, normal type ratchet and pawl (with concealed plunger rod operation) being fitted. The whole unit forms an independent assembly and is cheaply constructed. Further observation revealed that the pawl was produced from the ratchet pressing, thus obtaining both cheap and light construction.

CONTROLS

Brake, Clutch, and Accelerator Pedal Assembly Unit

This assembly consists of a housing made from a steel stamping and tubing welded together. The former is arranged to carry the accelerator pedal from an independent fulcrum and also forms the mounting face to the chassis. Both the brake and clutch pedals are attached to shafts carried in self-lubricating bushes, and it was noted that the clutch shaft fitted inside the braked shaft. This is not generally considered good practice owing to the possibility of one shaft sticking or seizing inside the other, in point of fact the brake pedal did not operate very

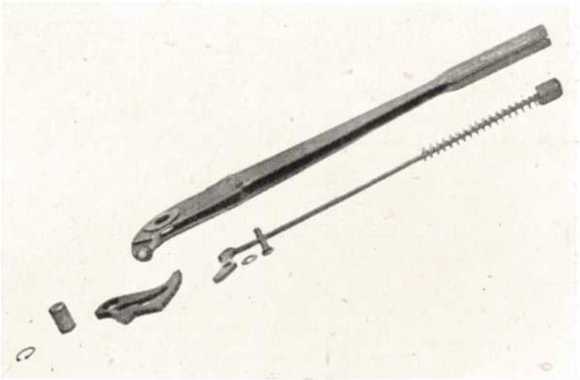


Plate 36.—Handbrake, exploded view

freely on the shaft owing to the accumulation of dirt. The accelerator pedal is a flat steel pressing and has a bobbin or roller type operation, produced from plastic base material.

The accelerator pedal is connected to the carburettor by piano wire operating inside steel tubing which is located inside the backbone.

The choke control is arranged similarly, but is hand operated by a knob situated on top of the backbone.

The clutch control is operated by means of stranded wire, directly connecting the pedal to the operating lever at the rear. The wire is adjustable and fits inside a tube housed in the backbone.

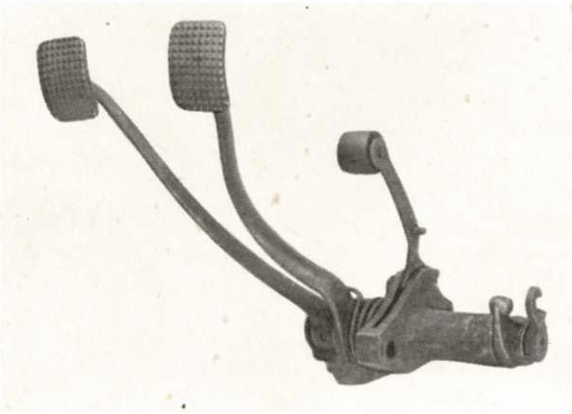


Plate 37.—Pedal unit

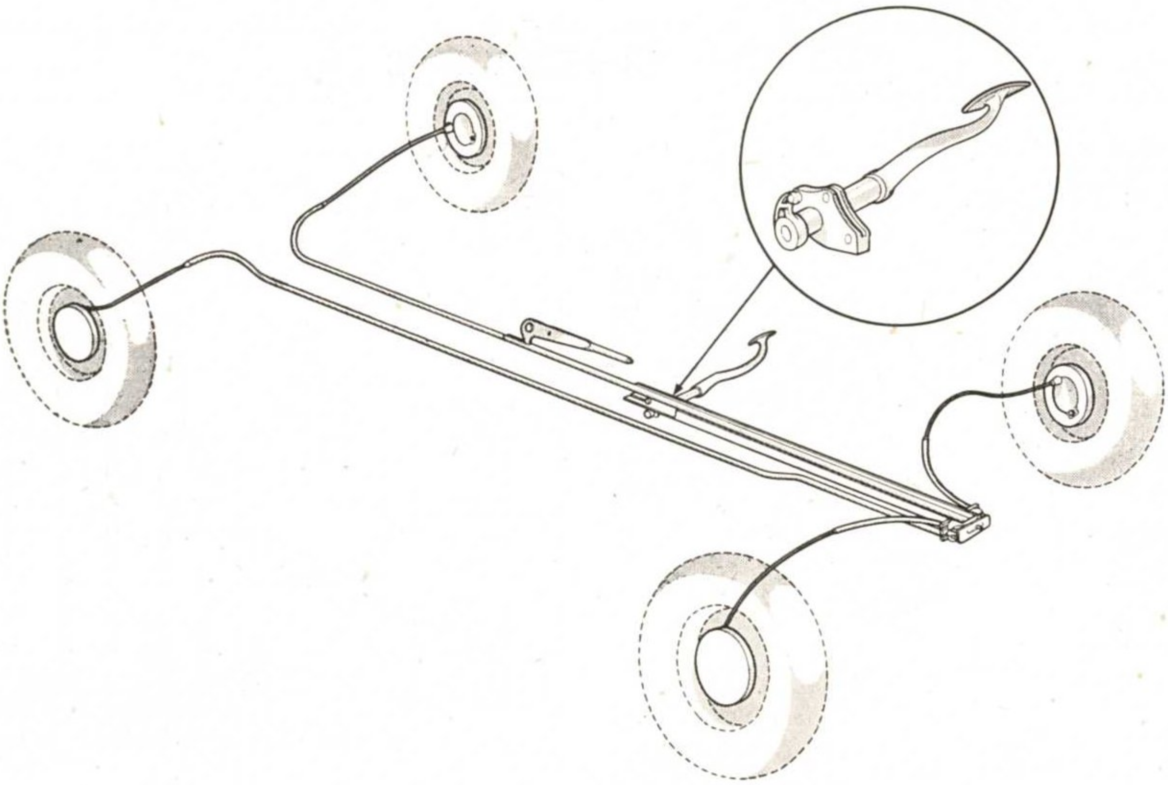


Fig. 36.—Footbrake and handbrake controls

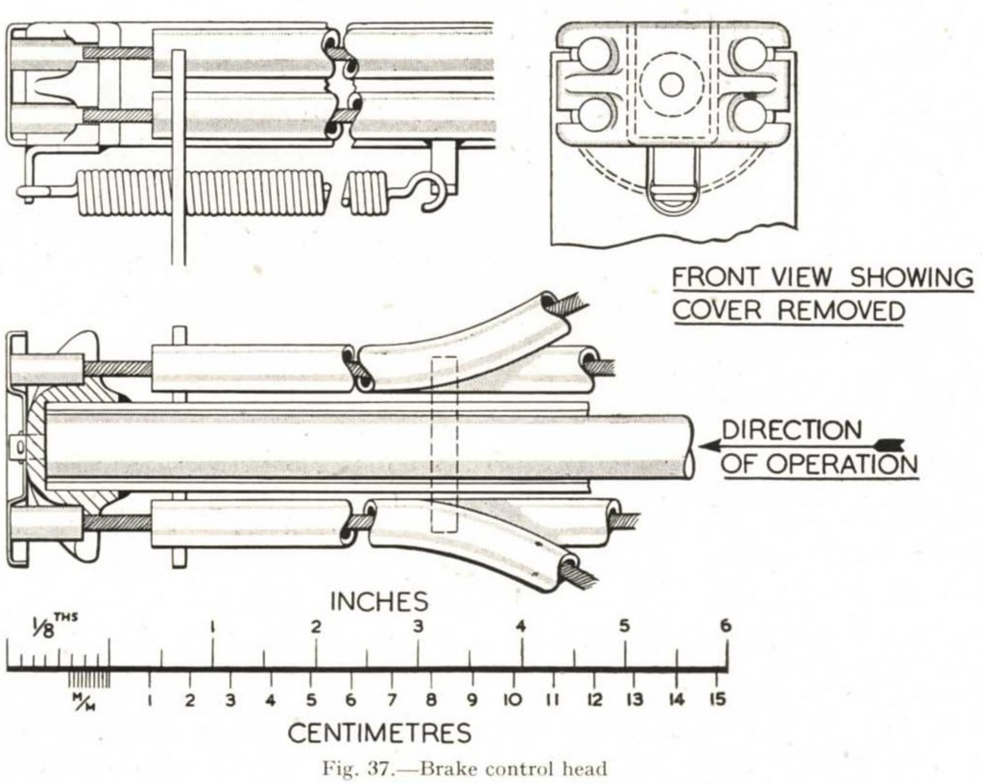


Fig. 37.—Brake control head

BRAKES—General Data

Brake shoe floating bell crank leverage:
$\frac{50\text{ mm.}}{14\text{ mm.}} = 3{\cdot}57 : 1.$

Pedal leverage (to bell crank lever):
$\frac{215\text{ mm.}}{25\text{ mm.}} = 8{\cdot}6 : 1.$

Pedal leverage (to shoe tip): = 30·7 : 1 overall.

Brake power ratio: 50% front and 50% rear.

Handbrake leverage (to bell crank lever):
$\frac{305\text{ mm.}}{41\text{ mm.}} = 7{\cdot}43.$

Handbrake leverage (to shoe tip) = 26·5 : 1 overall.

Brake drum (inside dia.): 9 in.

Brake shoe lining (width): 1·15 ins.

Brake shoe lining (effective angular contact): 116° per shoe.

Brake shoe lining (effective area): 84·2 sq. ins. total

Laden load per sq. in. lining: 30·75 lbs.

Diameter of brake cable (stranded wire): 0·14 in.

Handbrake unit weight: 1·125 lb.

Brake, clutch and accelerator pedal unit: 5·47 lb.

WHEELS

Size : 4·25 × 12.

Type

Flat base rim type of two-piece pressed construction. The nave is integral with one half of the rim. The other half of the rim is in the form of a flange bolted to the upper periphery of the nave. (See drawing.)

Hub Fitting

Five-stud of conventional Continental type.

Weight

$12\frac{3}{4}$ lb.

TYRES

General Description

The tyre used is apparently a plain tread aeroplane tyre as listed in German data books. Its adoption on a wheeled vehicle has presumably been governed by considerations of tractive effort on loose sandy surfaces and under such conditions it should give quite satisfactory performance. Tread life, under even intermittent road work, would be very small. None of the tyres appears to have worn much and no signs of uneven wear were evident. The spare wheel had not been used.

Construction

The tyre is of the ordinary pneumatic type and embodies no bullet proofing features. The tube is conventional, and is fitted with a rubber covered valve singly bent to suit the wheel. Synthetic rubber is used for the tread and side walls of the cover.

Nominal Size Marking

690 × 200 (8·00 — 12).

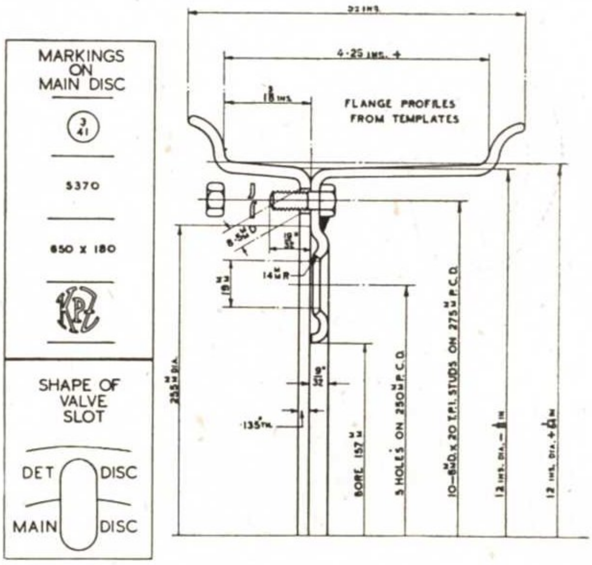


Fig. 38.—Wheel, cross section

Manufacture

Continental.

Side Wall Markings

45415482 B.S. PF1. A1.

Inflated Dimensions

Overall Diameter : 26·4 ins.
Overall Width : 7·6 ins.
Tyre Pressure estimated : front, 15 lbs. per sq. in. ; rear, 18 lbs. per sq. in.
Effective Rad. measured : 12·3 (static laden condition)

Tread Pattern

Plain.

Weights

Cover, $20\frac{1}{2}$ lb. ; tube, $3\frac{1}{4}$ lb.

Rim Fitment

Rim Section : 4·25 ins. Rim dia. : 12 ins.

LUBRICATION

The lubrication system is arranged for manual operation through the usual type of grease nipples, the design being such that these are reduced to a minimum. In some cases grease points are also arranged where bushes are made from plastic base material. The tool kit (including the grease gun) was missing and, therefore, the type of gun used is not known. The oil capacities of the various units and also the types of oil used for refilling are as follows :—

Engine Sump : $3\frac{3}{4}$ pints
Engine Air Cleaner : $\frac{1}{4}$ pint.
Gearbox and Rear Axle : 1 gall. Triple Shell (Heavy).
Rear Axle Reduction Boxes : $\frac{1}{4}$ pint each. Shell Spirax Gear Oil.
Steering Box : $\frac{1}{3}$ pint. Shell Spirax Gear Oil.

BODY-CONSTRUCTIONAL DETAILS

An open type tourer body is fitted, which is almost entirely fabricated from flat steel panels of approximately 20 S.W.G. (·036) thickness, ribbed for stiffening.

A collapsible cape cart type of hood is employed and is covered with woven fabric. Removable side curtains with celluloid windows of conventional type are also provided. The hood frame is of tubular steel and the fabric cover is secured to the body by means of straps passed through loops welded to the body.

Seating is arranged for three persons; two front seats and one rear seat on the left-hand side. Tubular steel is used for the seat frames, the front being of the " Bucket " type with coiled steel tension springs for cushioning effect. The seats are covered by thin wadding pads stitched between hessian canvas inside and enamelled duck on the outside. The tubular top rail is also used as a brace across the body between the B and C posts.

The space normally occupied by the right-hand rear seat is used to accommodate a steel trunk, access to which is gained by opening the right-hand rear door, which is provided with a rubber seal to prevent ingress of water and sand. Behind this and the rear left-hand seat is a second trunk which is opened at the top, using a lid of precisely the same size and shape as the rear engine compartment lid, but having a small extension piece at the front to form a water drip. On top of this lid are felt-lined crates, presumably for carrying batteries for wireless purposes. It would be impossible to open this lid when the batteries are in position.

The windshield is designed to fold forward to an approximately horizontal position; spring clips (with rubber cushions) are arranged on the scuttle at the front to hold the windshield in the down position.

The spare wheel is mounted on the front scuttle, which is suitably reinforced at this point, and has a semi-tubular column running from the dash to the extreme front end. This column can accommodate tools or miscellaneous articles, the dash end being left open.

The doors and locks are designed so that all four doors (which are hinged on the centre pillar) are interchangeable, but the right-hand rear door is provided with extra members to accommodate sealing rubbers for the trunk already mentioned.

The engine compartment at the rear is divided from the body proper by a sheet metal wall, stiffened with ribs and V-section reinforcements. The lid is fitted with a piano-hinge and a stay to hold it in the open position. The walls of the engine compartment carry brackets of various designs to carry tools, spare oil, cans, etc., the bottom being open to accommodate the engine. The joint between the engine compartment and the floor is effected by the forked rubber sealing strip shown in the illustrations (Figs. 50 & 51).

Slots are provided in the rear of body for permitting entry of air into rear compartment for cooling engine.

No padding or trim pads are employed except on the seat and battery crates as already mentioned. The same paint finish is used for both inside and outside.

UNDERFRAME-CONSTRUCTIONAL DETAILS

The underframe is designed to utilise sheet metal wherever possible.

The main floor is of sheet metal, approximately ·048 in. thick and ribbed for stiffening, whilst down the centre runs a semi-tubular " backbone " approximately ·098 in. thick. This backbone is arranged at the front to carry the torsion bar tubes, and at the rear is forked to form the engine cradle.

Mounted on the backbone is the handbrake lever, the latter lying in the horizontal plane when in the " off " position. The bottom of the backbone is closed by ribbed plate spot-welded in position.

Foot pedals are carried on the side of the backbone and are extended by means of cranked levers to a position convenient to the driver.

The body structure is attached to the underframe by means of bolts, a continuous rubber insulating strip being employed between the two.

The main outside joints are of the clinched flange type. Elsewhere spot-welding is employed throughout, reinforced with occasional gas-welding and rivets, where access is difficult for welding dies, or where additional strength is required.

The petrol tank is suspended in the right-hand side of the dash and is fabricated from sheet steel, roller-welded at the joints. Leaks in the joints have been filled with solder.

The vehicle has been repaired at some points, i.e., three door hinges and the handbrake lever have been broken, repairs being effected by gas-welding.

In addition a hole has been cut in the backbone to service the foot pedals; this hole has been left open.

The main floor is covered with wood-slat staging.

Approximately 100 lb. of sand was found inside the vehicle, some of which had accumulated in the hollow section box members.

Covering the front torsion bars, steering gear, etc., is a sheet steel shield; this is omitted from the illustrations for clarity.

The rear seat cushion was missing from the sample vehicle.

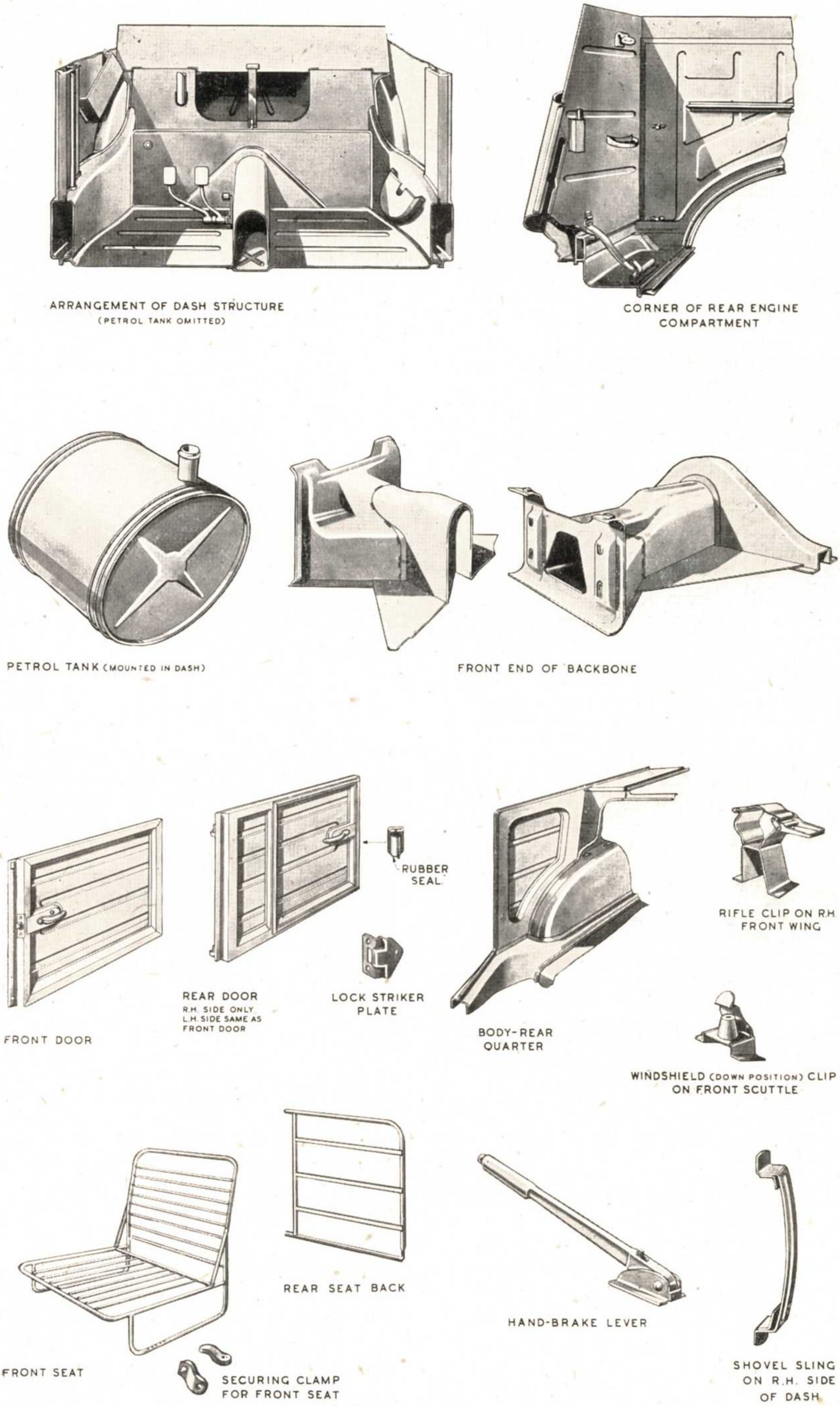


Fig. 39.—Body details

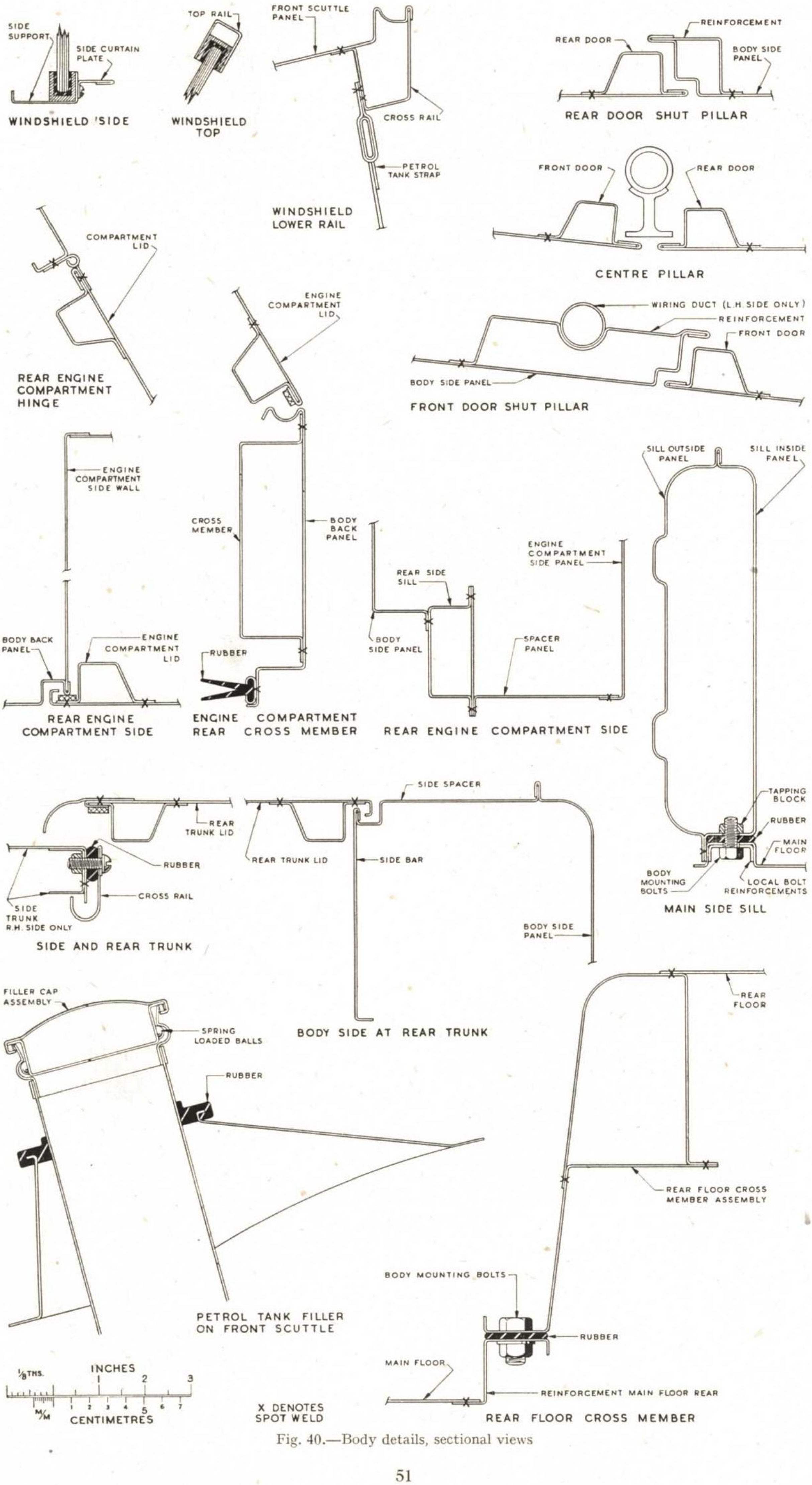


Fig. 40.—Body details, sectional views

Weight—Body : 504 lbs.

This included wings, headlamps (but not side lamps), collapsible hood, windscreen trafficators, floor (rear of " heelboard "), steering wheel and box.

Weight—Underframe and Floor : 196 lbs.

This includes main floor and foot pedals, change-speed lever, handbrake lever (with control links running through backbone) and tube for rear torsion bars.

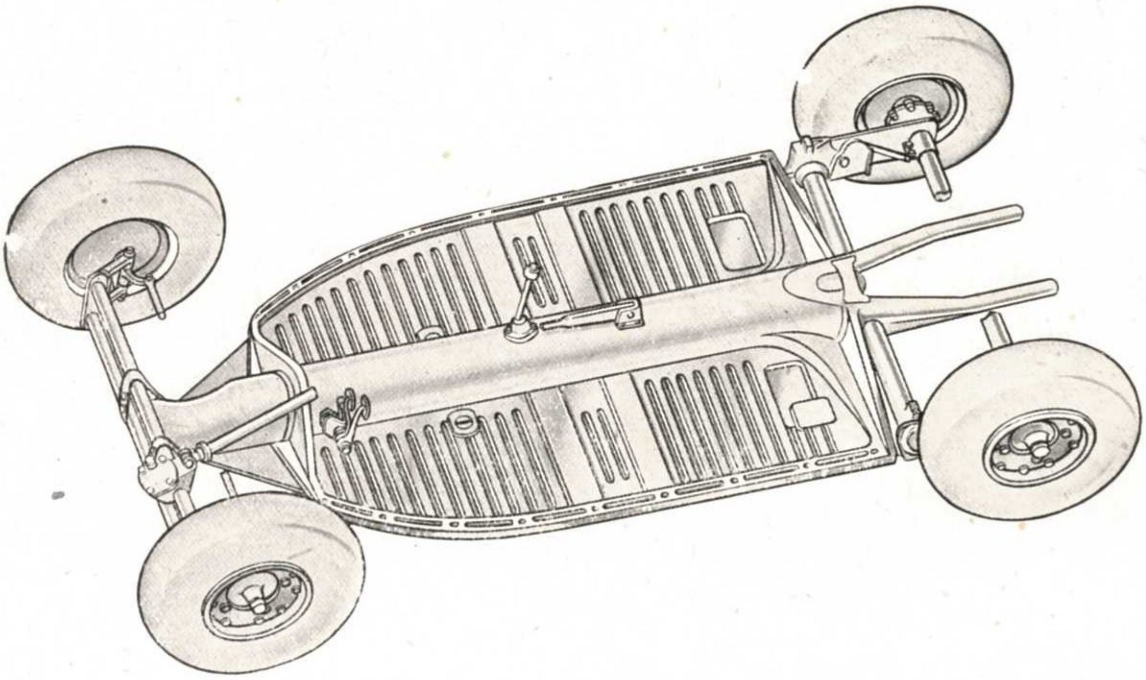


Fig. 41.—Underframe, top

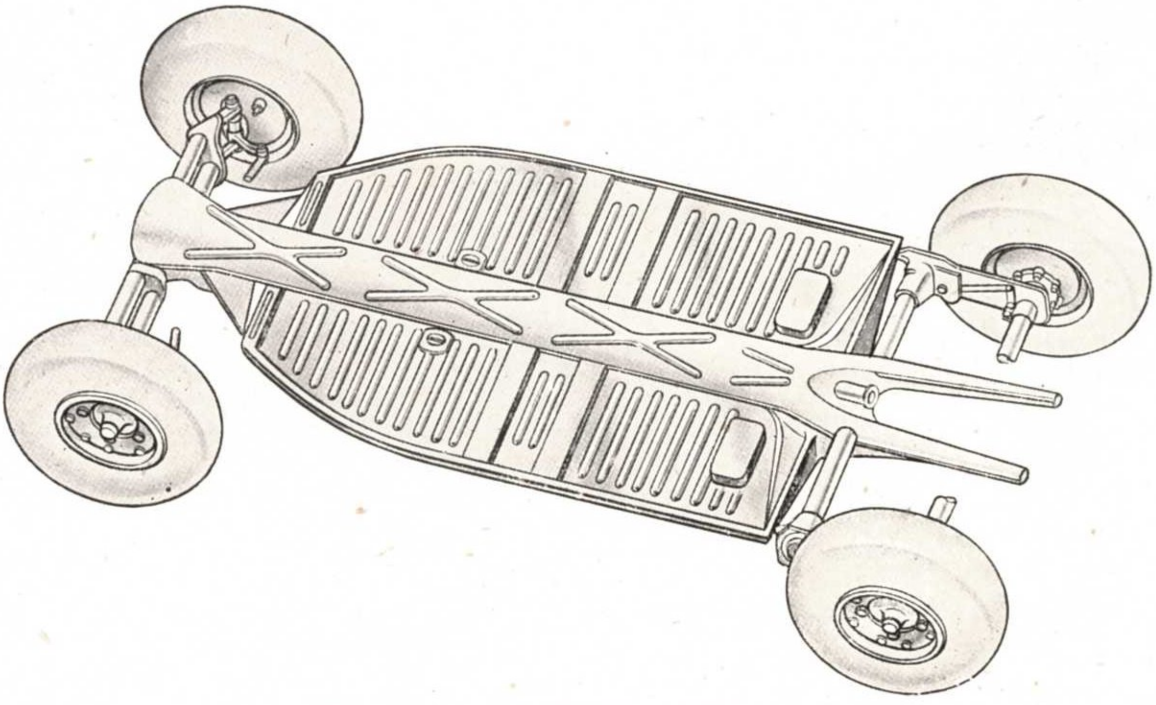


Fig. 42.—Underframe, underside

IGNITION EQUIPMENT

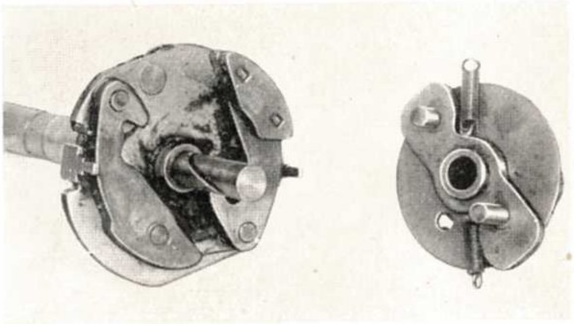
The ignition equipment comprises a Bosch distributor, Type VE4BS276, Bosch ignition coil, Type TL6, and normal rubber insulated ignition cable fitted with suppressors at the plug ends.

Distributor, Type VE4BS276

The distributor is of the four-cylinder type, fitted with a single contact breaker and provided with an automatic timing control of the usual centrifugal type.

The distributor body is of cast iron $2\frac{9}{16}$ ins. diameter. The shaft runs directly in the cast iron without bearing bushes. No means of lubricating the bearing is provided—this is presumably dependent upon splash from the engine. An oil-excluding thread is cut at the top of the shaft to prevent the ingress of oil into the distributor body and the shaft bearing is relieved for approximately $\frac{5}{8}$ in. at its centre. Experience has shown that cast iron distributor bearings are prone to seize unless positively lubricated, and it is likely that trouble may occur in service due to this.

The automatic advance mechanism is of the usual Bosch design as shown in Plate 38.



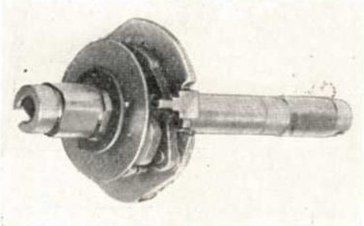


Plate 38.—Distributor automatic advance mechanism

The short projections on the weights at the pivot end act directly on pins attached to the cam foot, control being applied by two springs which are extended round the curved faces of the cam foot as the cam advances, and this produces a kinked curve characteristic. Both control weights are in the form of single laminations and the cam foot is attached to the cam body by being forced on, the cam body afterwards being lightly riveted over. A circular plate is clamped between the cam foot and the cam body and projections raised on this plate form anchorages for the springs, the other ends of which are attached to the upturned ends of a steel strip screwed to the underside of the action plate. Slots are provided in the strip for adjustment

Plate 39.—Distributor, showing contact breaker

purposes and the spring pillars form the stop for the weights. The range of advance is limited by one of the cam pins which is longer than the other and operates in a hole in the action plate. The cam bearing is $1\frac{1}{32}$ ins. in length and the shaft is relieved in two places by grooves $\frac{7}{32}$ in. wide. The cam and shaft are unhardened ; the former showed distinct signs of scoring. The control weights and bearing pins are hardened and the latter are secured to their respective components by having metal forced into grooves in the pins. A curve of the automatic advance characteristic is attached.

The distributor shaft is driven by an offset dog which forms a semi-universal joint. The dog is secured to the shaft by a pin $\frac{5}{32}$ in. diameter, the pin being a drive fit in the shaft and a slack fit in the dog, which is bored out larger than the shaft diameter. This allows the dog to be self-aligning in a direction at right angles to the dog. The pin is retained in position by a circular spring wire fitted into a groove in the dog and over the ends of the pin.

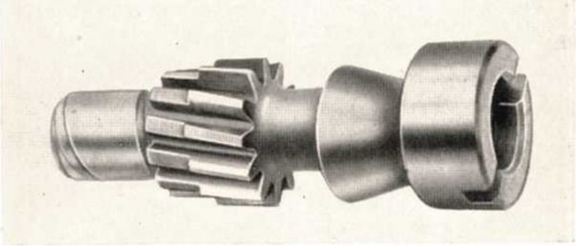


Plate 40.—Distributor driving shaft

The metal contact breaker plate is pierced with six holes of $\frac{7}{16}$ in. diameter in order to reduce the weight. Contact breaker adjustment is made by a screw having an eccentric head which moves the stationary contact plate between predetermined limits. The contact breaker lever is of the lightened type, having a blued steel spring riveted to it ; the same rivet is also used to secure the bakelised fabric heel. No cam lubrication is provided. The tungsten contacts are brazed directly on to the steel lever shell and on to the angle plate.

The condenser is of conventional construction and has the live connection—a round wire enclosed in insulating tubing—brought through a bakelised fabric washer and connected to the low tension terminal of the distributor. The condenser securing clip is projection-welded to the steel case.

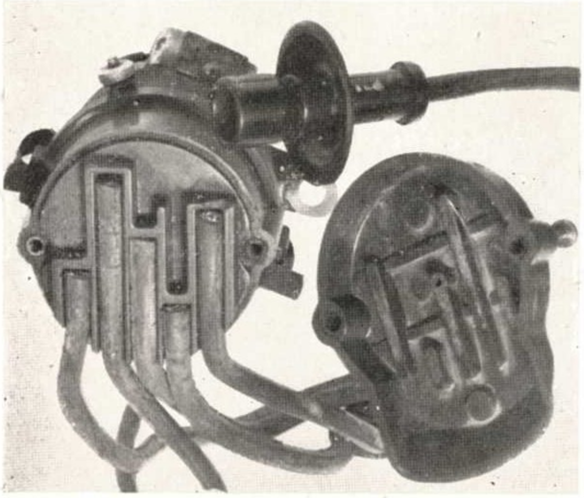


Plate 41.—Distributor, showing H.T. wires

The rotor arm is of circular shape, the brass electrode being moulded in.

The distributor moulding is of the horizontal outlet type with a loose cover and a shroud to protect the leads from water where they emerge from the moulding. Grooves are moulded in the distributor to take the cables, which are pierced by studs fitted in the distributor.

The track diameter is 43 mm. and the material used appears to be wood-filled bakelite, since it tracks very readily on 2 mm. and 8 mm. gaps.

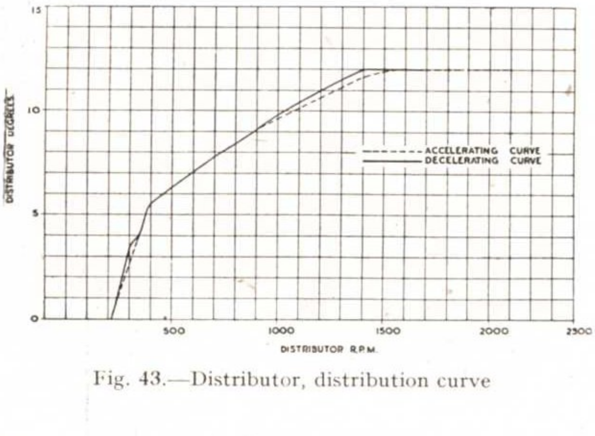


Fig. 43.—Distributor, distribution curve

Further details of the distributor are given below :

Weight of complete distributor ...	2 lb. 4 oz.
Shank length (under lever) ...	1 11/32 ins.
Shank diameter	1·062 ins.
Shaft diameter	·490 in.
Shaft protrusion	21/64 in.
Dog width	·176 in.
Dog diameter	·984 in.
Dog bore	17/32 in.
Dog protrusion	·532 in.
Clamping plate thickness	·102 in.
Outside diameter of moulding ...	2 15/16 ins.
Track diameter	43 mm.
Distance between electrodes ...	25 mm.
Contact pressure	12 oz.
Condenser capacity	·29 mfd.
Condenser internal resistance ...	·21 ohms
Contact closed period 55° with ·012 in. gap.	

Ignition Coil, Type TL6

The coil is of the orthodox outside primary type assembled into a can on which the fixing strap is secured by spot-welding. The strap is provided with two elongated holes for securing to the engine and the insert in the moulded top is rolled over the edge of the can. The primary leads are brought through and soldered to 2 B.A. terminals moulded in the coil top, and the high tension terminal is of the push-in type. The seams in the can do not appear to be soldered.

The resistance of the secondary winding is 3,700 ohms, and the primary inductance 9 M.H. The primary standstill current is of the order of 5 amperes and the temperature rise 119° C. By way of comparison, the Lucas 6Q6 coil has a standstill current of approximately 4 amperes and a temperature rise of 100° C.

Dimensions of the coil are as follows :

Diameter of can	2 3/64 ins.
Length of can	4 7/16 ins.
Overall height (approximate, owing to broken moulding) ...	5 3/4 ins.

H.T. Cables and Suppressors

The cable is of the 7 mm. rubber covered type having an unusually large core of 64 strands of ·012 in. tinned copper wire (as compared with 40 strands of ·010 in. wire used in standard English 7 mm. cable and 19 strands of ·012 in. wire in the latest screened cable) As a result of this large core the rubber section of the cable is considerably reduced, there being approximately only 2 mm. of rubber per side. This considerably reduces the dielectric strength. The times of break-down with different potentials are as follows :

12 KV	6 min. 0 sec.
15 KV	2 min. 50 sec.
20 KV	30 sec.

Standard Lucas 7 mm. rubber covered cable withstands 20 KV for five minutes. Trouble in service may therefore be expected with the German cable.

The rubber insulation, which is made up with an inner layer of white and an outer layer of grey rubber, is very loose on the cable core. The formation of air pockets adjacent to the core is very undesirable, as they are liable to produce premature ozone failure of the inner rubber dielectric. Ozone test results suggest that the rubber dielectric is not synthetic, failure occurring after 1 min. 30 sec. at 20 KV potential.

At the plug end of each lead is a bakelite moulding which houses the suppressor. The bakelite is a wood-filled material, and the suppressor is wire wound and connected to brass end caps. Contact with the cable is made by a wood screw secured in the moulding and the suppressor is secured between the screw and a plug screwed into the other end of the moulding. A spring clip in the screwed plug enables it to be clipped on to the sparking plug. A flange-shaped rubber is threaded over the suppressor moulding, presumably to prevent the sparking plug pockets in the cylinders from becoming filled with dirt and sand. The suppressor in the coil lead is of the usual tubular type with wood screws at each end.

Details of the suppressor are as follows :—

Overall length of moulding ...	$2\frac{3}{8}$ ins.
Length of suppressor resistance	·900 in.
Suppressor resistance ...	10,000 ohms
Flange diameter of the rubber	$1\frac{3}{4}$ ins.
Length of tubular suppressor...	$2\frac{3}{16}$ ins.

BOSCH DYNAMO, TYPE RED 130-6 2600 AL89

The dynamo is of the six-volt type and arranged for negative earth connection. Rotation is anti-clockwise as viewed from the driving end.

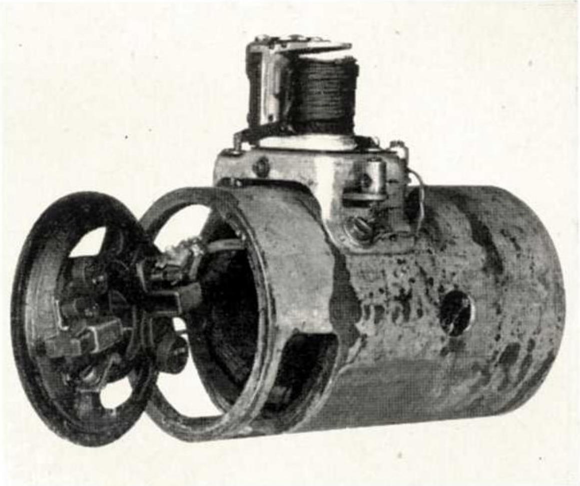


Plate 42.—Dynamo body, showing field winding, brush holder and regulator

The dynamo is a $3\frac{1}{2}$ ins. outside diameter ventilated machine, with an F Type regulator unit mounted on the yoke. Extended through bolts are provided at the driving end, so that the machine can be mounted on a flange incorporated in the engine casting. The shaft is extended at both ends to provide for a belt drive at the driving end, and it is assumed that a fan is fitted at the other end, although this was not on the dynamo when received.

The field coils are taped with crepe paper and treated with the usual varnishing process. The regulator is a Bosch F Type, in which both the cut-out and regulator are operated by one armature. A diagram of the connections and terminal markings is shown below. The contacts were badly burnt and adjustment had to be made to the second contacts on the regulator before the latter would operate.

In other respects the dynamo and regulator units follow conventional design.

Curve No. A/2439 shows the output of the dynamo under hot and cold conditions, whilst Curve No. 2440 shows the temperature rise on the yoke after a heat run of 2 hours at 6·75 volts, 20 amperes and 3,000 r.p.m. A pulley incorporating a fan was fitted to the dynamo for the purpose of the heat run.

Weight of dynamo, complete with regulator	$11\frac{1}{4}$ lb.
Open circuit regulated voltage ...	7·0 volts
Cut-in voltage of cut-out	7·4 volts
Drop-out voltage of cut-out ...	4·8 volts
Regulator points resistance ...	7·5 ohms

Plate 43.—Dynamo armature and commutator assembly

Design Data

Yoke : Outside diameter $3\frac{1}{2}$ ins. ; inside diameter $3\frac{1}{16}$ ins. ; length $5\frac{13}{16}$ ins.

Field : Number of poles 2 ; pole chord 1·969 ; pole arc/pole pitch 0·60 ; bore of poles at centre 2·33 ins.—at tips 2·33 ins. ; air gap length ·055 in. per side.

Armature : Diameter 2·22 in. ; length 2·5 in. ; Number of slots 15 ; type of slot—open, skewed.

Commutator : Diameter 1·272 ins. ; length $\frac{15}{16}$ in. ; number of segments 30.

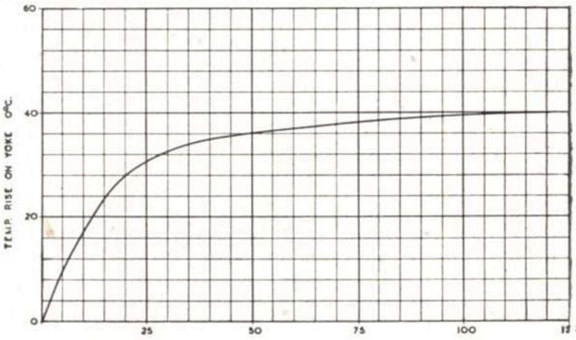


Fig. 44.—Distributor, temperature rise

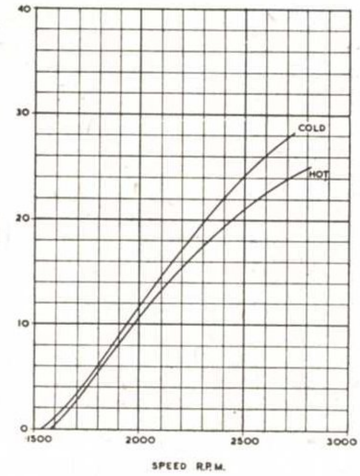


Fig. 45.—Distributor, output

Brushes: Type of support—box; trigger spring; brush arms 2; brushes per arm 1; length $\frac{17}{32}$ in.; width $\frac{7}{32}$ in.; copper type.
Bearings: Commutator end—diameter 1·378 ins.; width $\frac{7}{32}$ in.; ball bearing. Driving end—diameter 1·378 ins.; width $\frac{7}{32}$ in.; ball bearing.

BOSCH STARTER, TYPE EEDD 4-6 L3P

The starter is of the six-volt type and arranged for negative earth connection. Rotation is anti-clockwise as viewed from the drive end.
The starter has an outboard drive of the "screw-push" type with solenoid engagement, the solenoid being mounted on an extension integral with the drive end bracket. The commutator end bracket is secured to the yoke by means of four projection welds, the drive end bracket being secured by

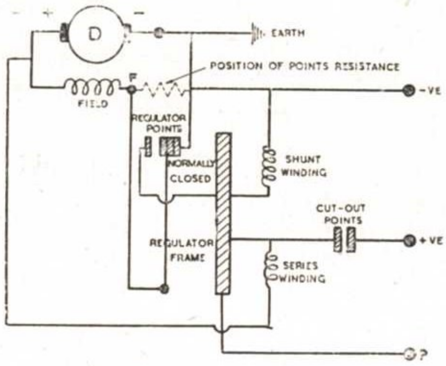


Fig. 46.—Distributor, circuit

means of two hook bolts. These methods of securing the end brackets are employed because, as the result of fullest use having been made of the available field winding space, there is no room for through bolts.
There is no intermediate bracket or bearing, the second bearing being provided in the flywheel casing when the starter is fitted to the engine.
The pinion is provided with a free wheel to prevent it becoming damaged when over-run by the engine flywheel.
An interesting feature of the starter is a device for slowing down the armature when the pinion is disengaged, so that if a second engagement is necessary the pinion will have ceased to rotate or will be moving only slowly when re-engagement is made. This slowing down is obtained by means of a small friction clutch operating at the commutator end in the following manner:

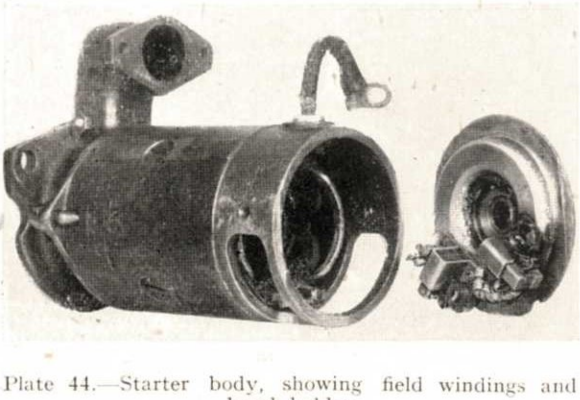


Plate 44.—Starter body, showing field windings and brush holder

A plate is fitted on the shaft near the commutator, two flats on the shaft ensuring drive for the plate. On the plate are two dogs, diametrically opposite, fitting into two semi-circular brake shoes located in a housing adjacent to the bearing. Loading is applied to these two shoes by means of a jump ring located in a groove in the brake shoes. The approximate torque required to turn the armature against this clutch is 1·6 lb. inches.
Weight of starter (with solenoid): 13½ lb.
Weight of starter (without solenoid): 12¼ lb.

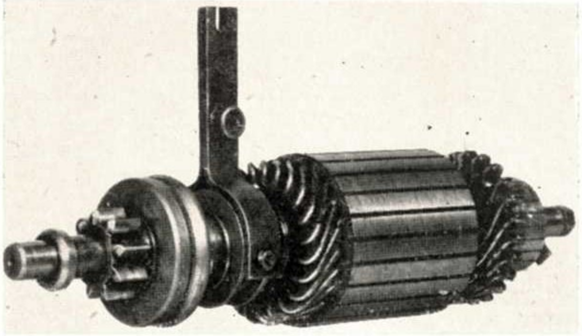


Plate 45.—Starter armature and commutator

Design Data

Yoke: Outside diameter $3\frac{9}{16}$ ins.; inside diameter $3\frac{1}{8}$ ins.; length $5\frac{1}{2}$ ins.
Field: Number of poles 4; pole chord 1·25 ins.; pole arc/pole pitch ·67; bore of poles at centre 2·403 ins.—at tips 2·403 ins.; air gap length ·020 in. per side.
Armature: Diameter 2·363 ins.; length $2\frac{7}{16}$ ins.; number of slots 23; type of slot—semi-enclosed, straight.
Commutator: Diameter 1·409 ins.; length $\frac{7}{8}$ in.; number of segments 23.
Brushes: Type of support—box; spring lever. Two brushes—length $\frac{5}{8}$ in.; width $\frac{9}{32}$ in.; depth $\frac{3}{4}$ in.; grade 131.
Pinion: 9 teeth.

SOLENOID STARTER SWITCH

The solenoid starter switch is mounted on an extension integral with the drive end bracket of the starter.
It consists of a solenoid of conventional design with a conical plunger and core. A push rod is fitted at the conical end of the plunger which carries a copper contact plate. When the switch is operated the spring-loaded contact moves to bridge two contacts fitted in the end of the switch housing, and so completes the circuit from the battery to the starter. At the opposite end of the plunger is fitted a forked extension piece which is connected mechanically to the starter pinion. Thus operation of the starter switch—in addition to completing the circuit to the starter—also causes the pinion to move into engagement with engine flywheel. A spring is provided which ensures that when the switch is released the contacts are separated and the pinion is moved out of engagement with the flywheel.
The solenoid is provided with two windings, one of high resistance and the other low. The reason for this is not known, but it may be necessary to obtain satisfactory engagement of the pinion.

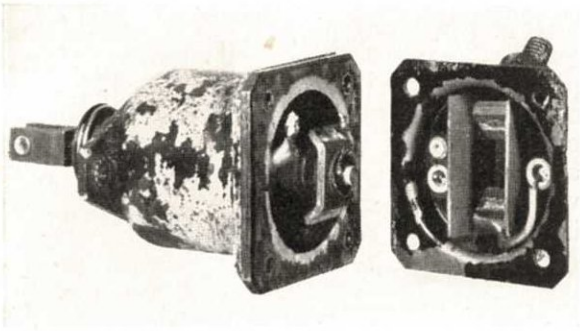


Plate 46.—Solenoid exterior, with cover removed

Design Details

Resistance between main contacts and winding terminal = 0·14 ohms.
Resistance between main contacts and case = 0·32 ohms.
Pull-on volts = 4·1 with low resistance winding.
Drop-off volts = 0·4.
Pressure on plunger to close contacts = $9\frac{1}{4}$ lb.
Pressure on plunger to push right home = $19\frac{1}{4}$ lb.
Volt drop across contacts with 6 volts on low resistance winding = ·059 at 20 amps.
Plunger travel to close contacts = $\frac{5}{16}$ in.
Total plunger travel = $\frac{13}{32}$ in.
Weight of unit = $1\frac{1}{4}$ lb.

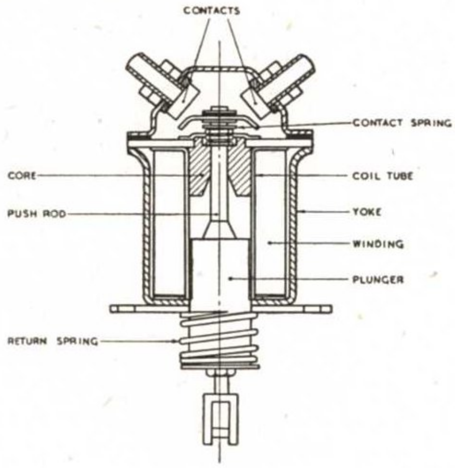


Fig. 47.—Solenoid, section

Dimensions :

Length of yoke	=	$1\frac{7}{8}$ ins.
O/D of yoke	=	$1\frac{7}{8}$ ins.
I/D of yoke	=	$1\frac{3}{4}$ ins.
Plunger diameter	=	0·748 in.
Plunger angle	=	60°.

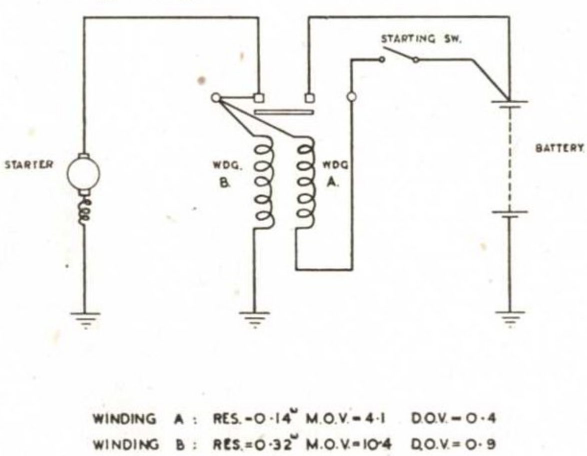


Fig. 48.—Solenoid, connections

Length of core	=	$\frac{7}{32}$ in.
Length of plunger	=	$1\frac{5}{8}$ ins.
Length of core	=	$\frac{5}{8}$ in.
O/D of winding	=	$1\frac{5}{8}$ ins.
I/D of winding	=	$\frac{25}{32}$ in.
Length of winding	=	$1\frac{5}{8}$ ins.
S.W.G. of wire	=	19.
Push rod diameter	=	0·236 in.

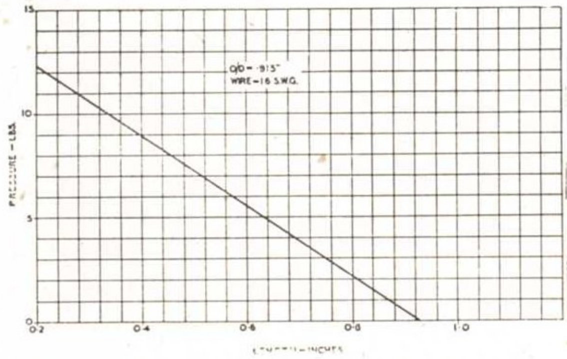


Fig. 49.—Solenoid, characteristic of plunger return spring

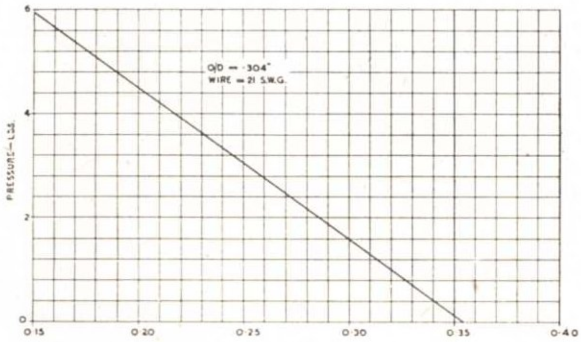


Fig. 50.—Solenoid, characteristic of contact spring

VARTA BATTERY, TYPE 937B

The battery is a six-volt unit of conventional design as shown below.

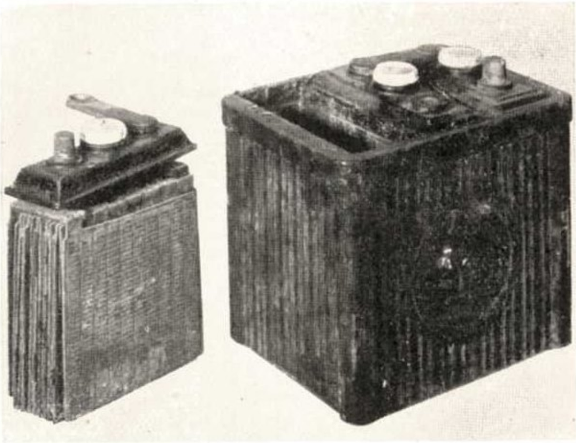


Plate 47.—Battery, showing cell removed

Constructional Details

Weight with acid : 36 lb. 2 oz.
Dimensions : Length over lugs, $8\frac{7}{8}$ ins. ; length without lugs, $8\frac{7}{16}$ ins. ; width, $6\frac{7}{8}$ ins. ; height over terminals, $8\frac{1}{2}$ ins. ; height over container, $7\frac{9}{16}$ ins.
Container and lid material : Low grade ebonite.
Plates : 13 per cell. Dimensions : $5\frac{5}{8}$ ins. × $4\frac{7}{8}$ ins. ; positives, $\frac{3}{32}$ in. thick ; negatives, $\frac{1}{16}$ in. thick.

Separators: Wood, grooved on one side with thick webs.

Vent plugs: Porcelain, centre hole and screw thread type.

Baffle plate or separator protector fitted.

Performance

Condition as received: Partially discharged, specific gravities of 1·194, 1·205 and 1·168 (at 60° F.) per cell respectively.

Charged at 6·5 amps. for a total period of 28¾ hours.

Maximum temperature during charging 95° F.

Specific gravities of three cells after conditioning charge: 1·251, 1·262 and 1·258 at 60° F.

First Discharge at 6.3 amps. without adjusting specific gravity.

Capacity 14·2 amp. hours to 5·40 volts at 71° F.

Cell 1. 22·0 amp. hours.

Cell 2. 12·3 amp. hours.

Cell 3. 14·5 amp. hours.

Second Discharge at 6.3 amps. after adjusting electrolyte to 1·292 specific gravity at 60° F.

Capacity 14·5 amp. hours to 5·4 volts at 80° F.

Cell 1. 28·5 amp. hours.

Cell 2. 15·0 amp. hours.

Cell 3. 16·5 amp. hours.

Continuous Discharge at 189 amps. commencing at 75° F.

Specific gravity before discharge: 1·295 (at 60° F.).

Voltage after 5 secs.: 3·80.

Duration of discharge to 3·0 volts: 42 secs.

Owing to the poor performance of the battery at 75° F. no further tests were made at 0° F. or —21° F.

SWITCHGEAR AND INSTRUMENTS

The speedometer, lighting switch, speedometer light switch, ignition switch and warning lights are fitted in a moulded panel which is mounted on a metal facia plate incorporating the starter operating switch, control switch for hooded headlamp and distance indicating lamp, inspection lamp socket and two fuse boxes.

Main Lighting Switch

This is fitted on the right-hand side of the moulded panel. It controls the main and pilot bulbs of the two normal headlamps and also the tail lamp. An interesting feature of the switch is that the stationary contacts are moulded integrally with the panel plate, whilst the rotor assembly is incorporated in the circular control knob. The switch has three positions with a central "off" position.

Speedometer Light Switch

The design of this switch is similar to that of the main lighting switch. It is fitted on the left-hand side of the moulded panel.

Ignition Switch

This is fitted at the bottom of the moulded panel. It is of the normal Yale lock type of construction. Owing to the switch having been damaged it was not possible to carry out any tests.

Switch controlling Hooded Headlamp and Distance Indicating Lamp

This switch is mounted on the right-hand side of the steel facia plate. It incorporates a wire-wound resistance which is arranged to be connected in series with the hooded headlamp so that the light given by the lamp can be adjusted according to operational conditions. The switch has five positions as follows:

O. Hooded headlamp off. Distance indicator lamp off.

H. Hooded headlamp off. Distance indicator. lamp on.

V. Hooded headlamp connected through 0·95 ohms resistance. Distance indicator lamp on.

V. Hooded headlamp connected through 0·4 ohms resistance. Distance indicator lamp on.

V. Hooded headlamp fully on. Distance indicator lamp on.

The resistance is wound round the ribbed body of the switch, which is approximately 2⅛ ins. diameter and 1¾ ins. long. The resistance wire is protected by a perforated steel outer cover and has a diameter of ·052 in. and a length of approximately 4 ft.

Starter Operating Switch

The original switch has been removed and replacement Lucas unit fitted.

Dipper Switch

The dipper switch controlling the change-over from the main driving light filament of the headlamps to the dipped filament is fitted in the floor board on the left-hand side. It is of the standard "push-push" design arranged for foot operation.

Inspection Lamp Socket

This is of the single pole "push-in" type.

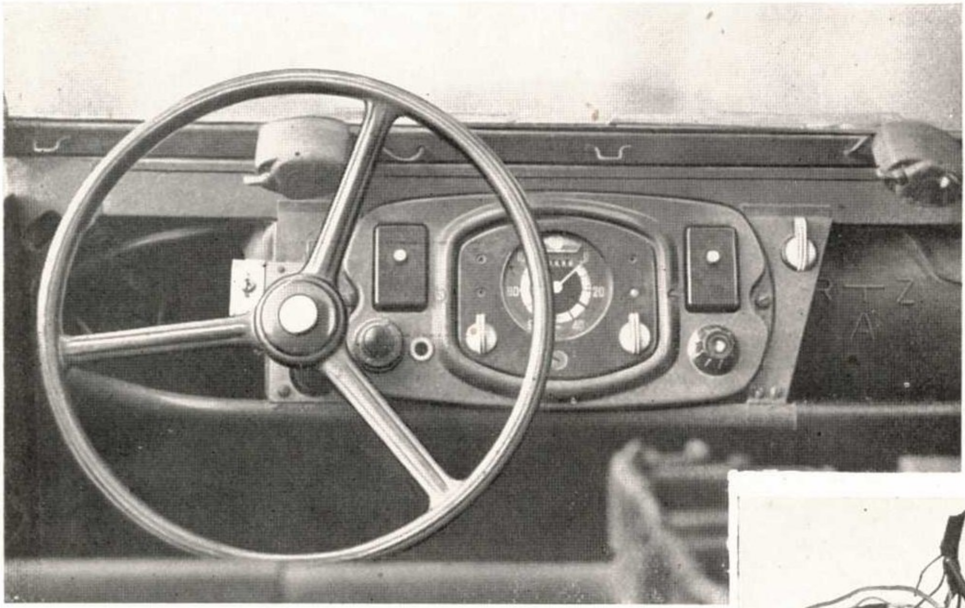


Plate 48.—Interior, showing facia panel

Warning Lamps

Four warning lamps are provided in the moulded instrument panel, two being fitted on either side of the speedometer. Apparently only two of the warning lamps are used, the top one on the left-hand side (coloured red), for the ignition, and the bottom right-hand (coloured blue), for the head or spot lamps.

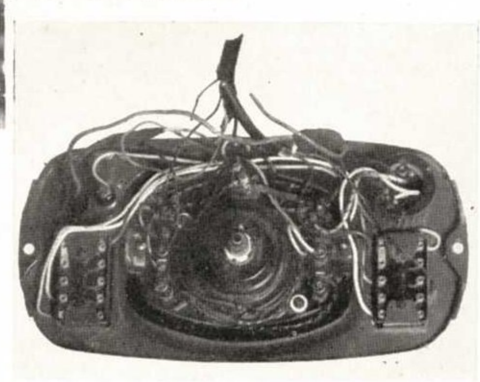


Plate 50.—Facia panel, rear view, showing wiring

Plate 49.—Facia panel, front view, showing fuse box cover removed

The warning lamp bulbs are 6 volt, 1·2 watt; the approximate dimensions of the glass bulb being ·270 in. diameter and ·25 in. long. The bulbs are provided with miniature bayonet caps of the centre contact single pole type. The bulbs are housed in tubular brass spinnings ·378 in. diameter and $\frac{23}{32}$ in. long. This assembly—including a spring loaded contact plunger—fits into a raised portion at the back of the moulded panel.

Fuses

Two fuse boxes are fitted on the metal facia plate. Each box houses five fuses protected by a moulded cover, on the inside of which an illustrated card is fitted to identify the circuits which the fuses protect. The fuses are of the 15 amp. size and have steatite bodies with metal end caps. The tinned copper fuse wire is located in a groove in the steatite body and the ends are secured under the metal caps.

The fuses are secured in position by locating one end in a conical recess in a terminal while the other end fits in a location in a spring contact blade.

These fuses are connected in the following circuits:—

Left-hand Fuse Box

- Electric Horn.
- Pilot bulbs in left- and right-hand head-lamps.
- Dipped beam filaments in left- and right-hand headlamps.
- Main filament in left-hand headlamp.
- Main filament in right-hand headlamp.

Right-hand Fuse Box

- Hooded driving lamp.
- Distance indicating lamp.
- Trafficators and windscreen wipers.
- Spot light.
- Inspection lamp.

In addition, a separate fuse box containing three fuses is fitted in the engine compartment at the rear of the vehicle; these fuses are provided for the protection of the left-hand tail lamp, right-hand tail lamp and the stop lamp.

A test was carried out on one of the fuses, which blew at 25 amps. when the current was raised at the rate of 2 amps. per second. The total voltage drop across each pair of terminals with 10 amps. passing was ·240—·260 volts.

WIRING

The wiring incorporates numerous types of cables. Some consist of bare copper wire with synthetic covering, some are of tinned copper with a cotton covering and a cotton

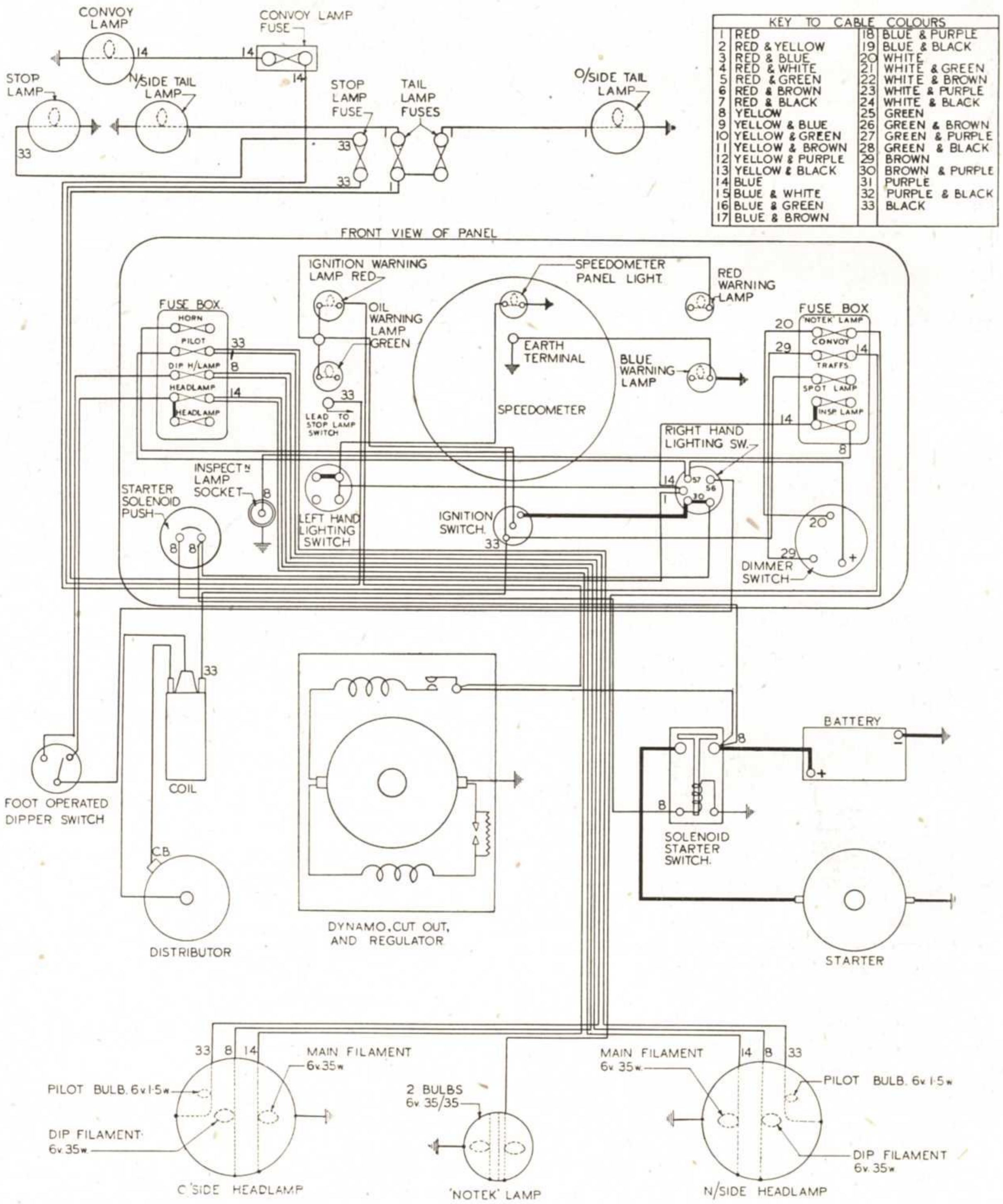


Fig. 51.—Wiring diagram

braiding overall with no rubber insulation, whilst still more are of tinned copper wire with a wrapping ·001 in. thick of black varnished material and varnished cotton braiding. The starter cable is 4 ft. 6 ins. long and is of ·442 over-all diameter. It consists of 37 strands of ·044 in. diameter conductors with a covering of rubber ·060 in. thick and black cotton braiding.
A 19/·024 cable is used for the main dynamo circuit. It has a polyvinyl chloride covering of ·025 in. thickness, the over-all diameter of the cable being ·168 in.
The negative terminal of the battery is earthed to the chassis by a bare copper braid 11 in. long, 1¼ ins. wide, and ·080 ins. thick.

LIGHTING EQUIPMENT

The lighting equipment comprises the following components :

(a) 2 Headlamps of identical type. On one lamp the aperture was restricted by the fitting of a leather cover and on the other by means of paint.
(b) 1 Notek Headlamp provided with single-slot mask and cowl.
(c) 1 Hella spot light.
(d) 1 Notek distance indicating rear lamp and stop light.

(a) Headlamps

Each lamp contains an aluminium reflector held in place by a single spring. The reflector is burnished and lacquered on the inside, but has a poor finish. Both main and pilot bulbs are mounted on a plate at the back of the reflector in a similar fashion to Lucas D Type lamps. The main bulb is of Lucas-Graves type with 6 volt 35 watt filaments. The pilot bulb is a single pole 6 volt 3 watt midget type. Contact is made by brass clips to which the connecting wires are attached.

Plate 51.—Headlamp

The front glass has a total diameter of 17 cms. (6·8 in.). The effective aperture, however, is a central spot of about 4 × 2 cm. (1·6 × 0·8 in.). There is no positive location of the rim, which is held in position by a single screw. The maximum output is 475 candles with the main filament in action, and 300 candles with the dip filament. The total spread of the beam is 15° in the horizontal and 4° in the vertical plane.

(b) Notek Headlamp

The lamp body consists of two parts connected by three screws. The bottom piece is die cast, carrying the reflector and bulb, and the top, containing the lens and cowl, is of pressed steel. Between the two is fitted a rubber gasket. The bulb is of Lucas-Graves type, using only the Vee filament, which is rated at 6 volts 35 watts. It is horizontally mounted with the filament towards the reflector. The bulb has a locating device and can only be removed by releasing two screws.
There is no wiring in the lamp, connection being made by a plug socket fitted with a locking device.

Plate 52.—Notek headlamp

The reflector has an effective width of 2·25 cm. (0·9 in.) and a length of 13·5 cm. (5½ ins.) at the aperture. The focal length is 2 cm. (0·8 in.). The mirror body forms a frame for the purpose of preventing distortion, the axis of the mirror being dipped slightly below the horizontal.
The front glass consists of plano-convex flutes, five flutes per inch ; it is held in

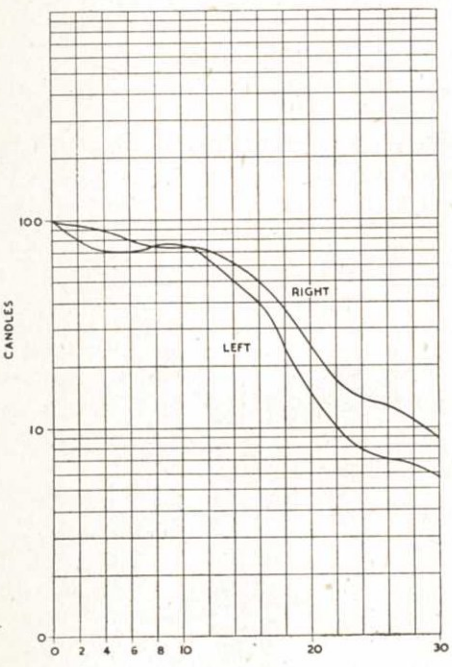


Fig. 52.—Notek headlamp, horizontal beam distribution

place by a spring device. The effective aperture is 1·2 × 10·5 cm. (0·48 in. × 4·2 ins.). The length of the cowl is 10·5 cm. (4·2 ins.) (measured from the front of the lens), and cuts off 7 mm. below the bottom edge of the lens aperture.

The beam distribution curves shown in Figs. 52 and 53 were taken with the lamp as received, with dirty reflector and lens. The maximum brightness of the beam was 1·0 F.C. After cleaning, this rose to 1·4 F.C. The cut-off is very sharp and 6° below the horizontal plane.

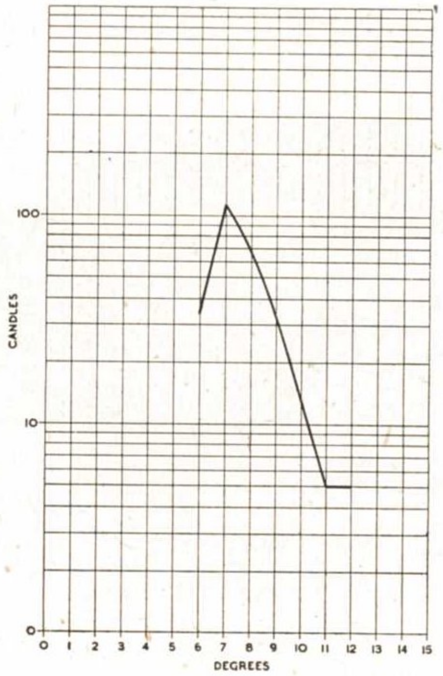


Fig. 53.—Notek headlamp, vertical beam distribution

(c) Hella Spot Light

The lamp body functions as the reflector; it is of brass, painted on the outside and silvered and lacquered on the inside. The front glass is fixed to the reflector by a split ring which is tightened by a screw to hold the glass in position. The glass is marked "Hella" and is clear in the centre with three flutes on either side. The diameter of the glass is 11 cm. (4·4 ins.). The focal length of the reflector is 2·5 cm. (1 in.).

The bulb was broken when received, consequently no photometric measurements have been carried out. It is rated at 6 volts 25 watts

Plate 53.—Hella spot light

with a coiled coil hacksaw filament and single pole adaptor. At the back of the lamp is a switch acting on a contact spring on the bulb socket. Over the whole lamp there is a rubberised canvas cover with a narrow slot in the centre 2·5 × 0·5 cm. (1 in. × $\frac{1}{4}$ in.).

(d) Notek Distance Indicating Rear Lamp and Stop Light

The die-cast body contains three 6 volt 10 watt festoon bulbs, two mounted horizontally and one vertically. The vertical bulb illuminates the distance indicator lamp. The distance indicator has four rectangular windows, the two outside windows being larger (2·2 × 3·2 cm.) than the two inner windows (1·8 × 3·0 cm.). The distance between the two inner windows is 3·8 cm., and between the two pairs of windows on either side of the centre it is 1·5 cm.

The underlying principle of the distance indicator is the dependence of the resolving power of the eye on the apparent angle of an object.

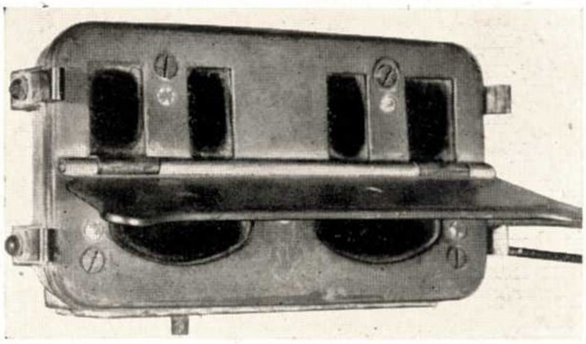


Plate 54.—Notek distance indicator, rear lamp and stop light

The four windows indicate two limit distances.

1. The fusion of the two pairs of windows.
2. The fusion of all four windows.

Taking the average angular distance for the resolving power of one degree, these two distance limits will be 50 metres and 140 metres respectively. The difference in the sizes of the outer and inner windows enables the observer to estimate intermediate distances according to the extent to which the smaller window merges with the larger.

The stop-tail lamp and rear lamps make use of the two horizontally mounted festoon bulbs and have orange and red glasses respectively. The change-over from normal running to convoy work is effected by a hinged flap held in position by spring clips. This flap contains a hole 0·5 mm. diameter which is positioned over the rear lamps when the flap is in the convoy position.

A window (which can be obscured by a shutter) illuminates the number plate of the vehicle.

ELECTRIC HORN manufactured by the Metallische Industrie A.-G., Lippstadt

The horn is of the H.F. type, i.e., an armature attached to the diaphragm impacts on the magnet core and at the same time operates a side contact breaker. To make the side thrust of the contact breaker as small as possible, the magnet core is very narrow and rather long, and is of laminated construction. This is offset to some extent by the abnormally high contact pressure : 7 lb. instead of the usual 3–4 lb. It is not obvious why this is so. Adjustment of the contact breaker from the back of the horn is by means of a spring-loaded screw which raises the contact breaker bodily about the other fixed end.

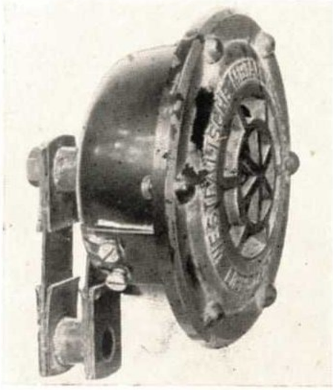


Plate 55.—Electric horn, exterior

The high frequency component of the note is generated by a " swinging plate " attached centrally to the underside of the diaphragm, between the latter and the laminated armature —this, presumably, because the tone disc is still a Bosch patent. It is not nearly so effective as the external tone disc.

The special feature of this horn is that the body and front grille are in moulded bakelite instead of metal pressings or castings. The magnet core is moulded in the body, a bakelite flash round the core providing the coil insulation. Plain enamelled wire is used for the coil, which is retained in the core by two clips.

The contact breaker bracket also carries a small cylindrical condenser, attached by a single through bolt.

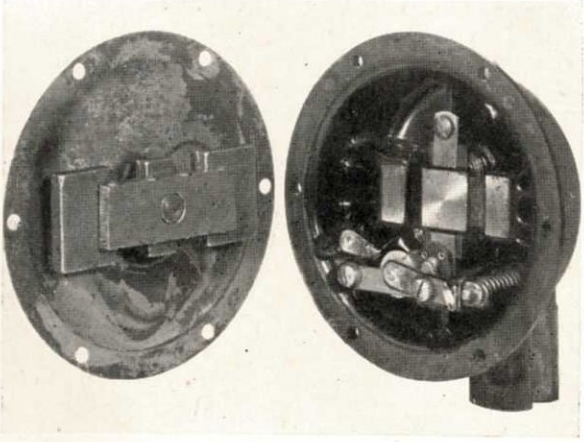


Plate 56.—Electric horn, interior

The moulded construction is very neat and light and allows the terminals to be incorporated directly without any additional insulation. The front grille has holes tapped directly in the bakelite (moulded threads). The average thickness of the bakelite body wall is only ·10 ins. to ·125 in.

A bolt attached to the magnet core projects through the back of the body and carries a laminated spring bracket of Bosch pattern.

Performance

The sample examined was a 6 volt horn.

Current Consumption

	German horn	HF.1235
4 v.	2·0	
6 v.	3·1	3·0—4·0
7·6 v.	3·8	4·0—5·0

The current consumption is fairly low, some advantage being gained from the use of a laminated magnet.

NOTE.—The fundamental frequency is approximately that of the Lucas Type HF.1235. The note is fairly loud and clear over the voltage range, but the tone is rather flat with a less well-marked high frequency whistle than that of the Lucas horn, the German horn having a fairly distributed frequency spectrum. Its overall loudness is slightly greater than that of the Lucas horn due to the larger diaphragm.

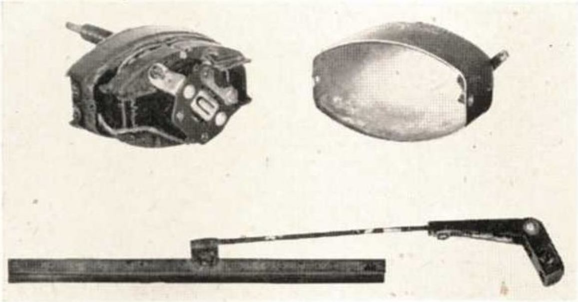


Plate 57.—Windscreen wiper, exploded view

General Remarks

The diaphragm was very rusty, the paint protection being inadequate. The front grille was broken in two places and it is suggested that although the bakelite construction has many advantages it is not sufficiently robust for Army vehicles.

WINDSCREEN WIPER

Two separate windscreen wipers are provided, and these are fitted at the bottom of the screen—on the off and near sides respectively. There is no marking on the wiper to indicate the make but it is similar in general shape, motor and gearing to the Bosch W.V. Type wiper. The wiper is marked " 12V " on its back cover, but all the electrical equipment on the vehicle is 6 volt. From its performance on a 6 volt supply it would appear that the marking on the wiper is incorrect.

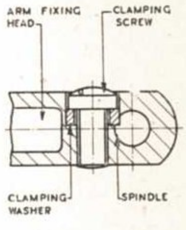


Fig. 54.—Wiper arm and spindle section

Details of the design and performance of the wiper are as follows:

Approximate External Dimensions

Length : $3\frac{3}{16}$ ins.
Maximum width : $1\frac{15}{16}$ ins.
Minimum width : 1 in.
Overall height (excluding wiping spindle bearing but including bearing flange) : $2\frac{1}{2}$ ins.

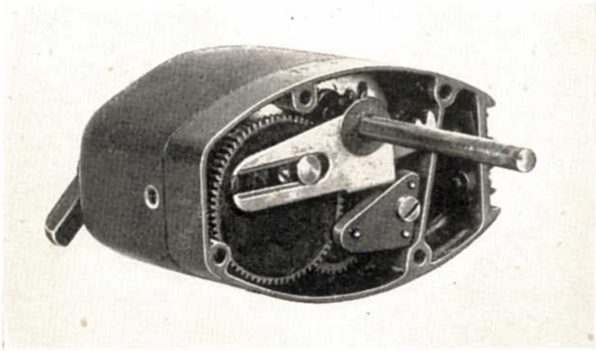


Plate 58.—Windscreen wiper, rear cover removed

Wiping spindle bearing : $1\frac{3}{8}$ ins.
Spindle extension through bearing : $\frac{5}{8}$ in.
Length of switch lever : $1\frac{1}{32}$ ins.

Total Weight

18 oz. approximately.

Details of Field System

Number of poles : 2.
Inside diameter between poles 1·420 ins. and 1·432 ins. (difference due to incorrect setting of pole halves).
Height of laminations : 10·5 mm.—11·0 mm.
Pole arc : 120° approximately. Arc length 37 mm.
Area of pole face : 400 sq. mm.
Field shunt connected, consisting of 2 coils in series having a total resistance of 6·2 ohms.

Details of Armature

Number of poles : 3.
Outside diameter : 1·390 ins.
Air gap (average) : ·018 in. per side.
Armature core length ·473 in. (12 mm.).
Pole arc 80° approx. Arc length 23 mm. approx.
Resistance between segments : 1·5 ohms.

Commutator

Number of segments : 3.
Overall length : approximately $\frac{5}{16}$ in.
Diameter on brush track : 0·393 in.

Brushes

Dimensions : $\frac{5}{16}$ in. × $\frac{3}{16}$ in. × $\frac{1}{8}$ in. approx.
Not fitted with pigtails.
Spring pressures : 110 gms. each.

Circuit

Earth return wiper. The switch lever completes the circuit from a brass strip fastened to the brush plate (and connected to one brush box), to an earthed terminal via the cover.

Gearing and Final Drive Details

Armature pinion : 6 teeth.
Inter-gear (" Tufnol " or similar material) : 39 teeth.
Inter-pinion : 7 teeth.
Guide wheel : 70 teeth.
Total gear ratio : 65 : 1 reduction.
Oscillating mechanism consists of a rack pivoted at a radius of $\frac{5}{16}$ in. on the guide wheel, driving a toothed wheel of approximately $\frac{1}{2}$ in. pitch circle diameter and mounted on the final wiping spindle, thus giving a theoretical angle of wipe of 140°.
The following performance test results were obtained when driving the single arm and blade (details of which follow) on a dry clean screen. Wiper at room temperature.
Applied voltage : 6 volt.
Current : 1·9—2·0 amps. (approximately).
Wiping speed : $26\frac{1}{2}$ wipes per minute.
Angle of wipe : 125°.

After Half-hour Run

Current : 1·4—1·5 amps. (approximately).
Wiping speed : 35 wipes per minute.
Heating : satisfactory.

Further Tests taken at Room Temperature

Oscillating shaft stall torque : 150 oz.-in. (approx.)
Armature stall torque : 6 oz.-in. (approx.).
Stall current : 4·1—5·0 amps. (approx.).
Armature speed (running light) : 1,750 r.p.m.
Light running current : 1·98 amps.
Armature flux with 6 volts on field (cold) : $11\frac{1}{4}$ K.L.

Arm and Blade Details

Effective length of arm (from spindle centre to blade pivot point) : $7\frac{1}{4}$ in. (approx.).
Length of blade : 7 ins.
Blade pivot point from end furthest from driving spindle : $3\frac{3}{4}$ in.
Blade consists of 2 plys of rubber, ·020 in. thick, with a metal separating piece inside the channel.
The fixing means for the arm consists of a clamping washer which is forced against the arm by pressure applied through the clamping screw.

ACKNOWLEDGMENTS

In compiling this Report we desire to acknowledge the valuable assistance given by the following firms in respect to the information concerning the items stated :

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Engineering Dept.
HUMBER LTD.
COVENTRY

Sept. 1943.