No 691.

The Griffon

ROLLS-ROYCE

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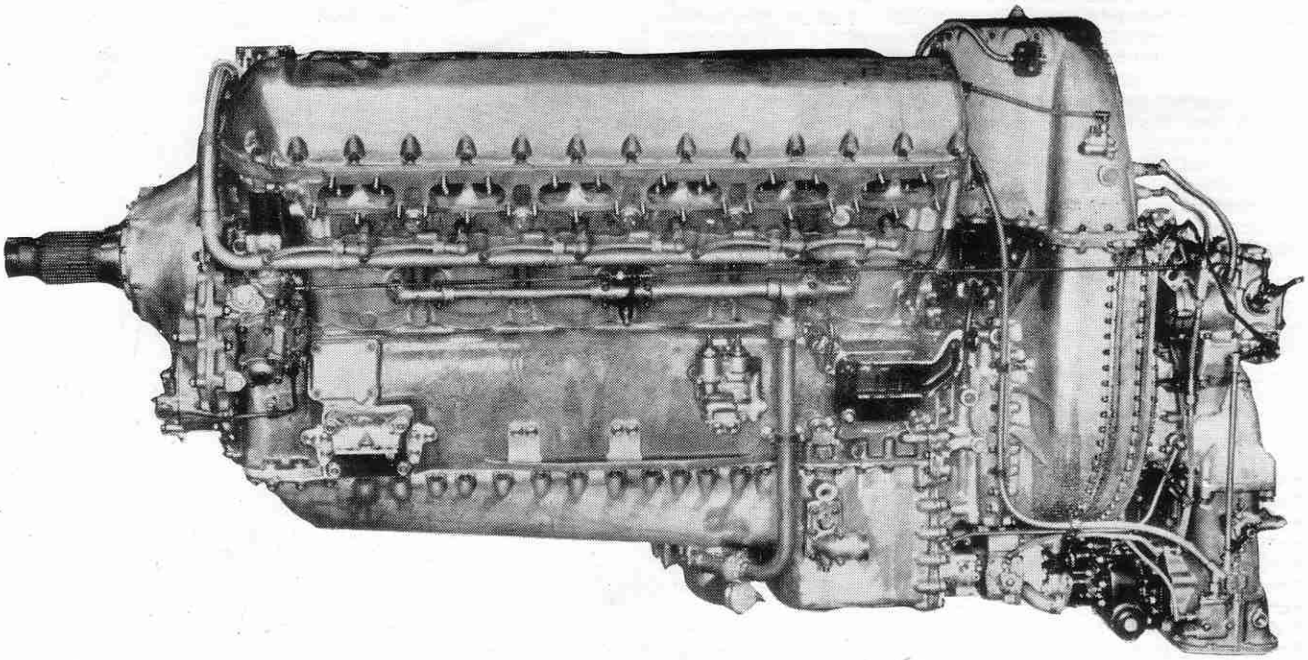
A CLASSIC DESIGN

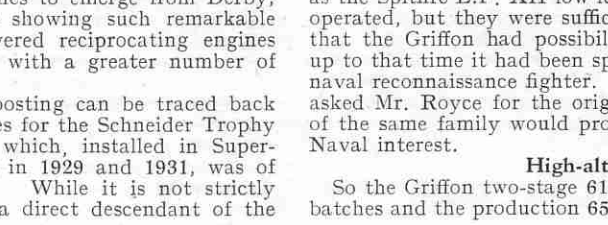


The Rolls-Royce Two-Stage Griffon

LATEST OF A LONG LINE of classic aero-engines, the Rolls-Royce Griffon 65 represents the adaptation of the two-speed two-stage supercharger with intercooler, as developed originally for the Merlin 61 series, to the basic Griffon design. With a total capacity of 36.7 litres, the Griffon, according to Sir Roy Fedden, represents about the peak size for a 12-cylinder type, and may therefore be the last of the 12-cylinder in-line liquid-cooled upright Vee aero-engines to emerge from Derby, particularly as the gas turbine is showing such remarkable increase of power, and higher-powered reciprocating engines will probably be of different form with a greater number of cylinders.

Much of the progress in high boosting can be traced back to the development of racing engines for the Schneider Trophy Contest. The Rolls-Royce "R," which, installed in Supermarine seaplanes, won the Contest in 1929 and 1931, was of the same capacity as the Griffon. While it is not strictly accurate to refer to the latter as a direct descendant of the "R" engine, there is some connection between the two designs. Following upon the production of the racing Rolls-Royce "R," the Admiralty became interested in a de-rated version for torpedo-bomber work. Accordingly, some tests were made, but the project was eventually abandoned. Resulting from this development work a crankshaft design was evolved which subsequently was adopted for the Griffon, the reliability of which, and of its crankshaft in particular, can be attributed to some extent to those experiments with the earlier engine.

In 1938 Admiralty interest was again revived in a piston engine of similar capacity to the "R," and the prototype Griffon was produced and bench-tested. It was flight-tested in a Hawker Henley and in a Fairey Battle. Following the outbreak of War most of the Rolls-Royce effort was concentrated on the development of the Merlin and it was not until the end of 1942 that the larger capacity single-stage Griffon II was ready for production. About that time the Focke-Wulf Fw 190 high-altitude fighter appeared and the Merlin two-stage engine was introduced to meet it—a reply that was eminently successful. As a result the Germans de-rated the Fw 190 for use as a high-performance combat fighter and for their low-level "tip-and-run" raids. Again Rolls-Royce came to the rescue and turned out 100 Griffon II engines in a few weeks for installation in the Supermarine Spitfire F. VIII airframe, which combination became known as the Spitfire L.F. XII low-level fighter. Only two squadrons operated, but they were sufficient to prove to the Air Ministry that the Griffon had possibilities for further development, as up to that time it had been specified only for the Fairey Firefly naval reconnaissance fighter. As in 1914, when the Admiralty asked Mr. Royce for the original Eagle design, so the Griffon of the same family would probably have never existed but for Naval interest.



High-altitude Boost

So the Griffon two-stage 61 was produced in small prototype batches and the production 65 series followed. The opportunity was taken of effecting a general tidying-up of the basic design. Improvements effected included the internal housing of the pressure oil pumps and the removal as far as possible of all external piping. With the incorporation of the two-stage supercharger there was a rearrangement of its drive which was taken through a short torsion shaft from the rear of the crankshaft as opposed to the long drive from the forward end as on the single-stage Griffon.

A modified form of boost control was adopted and an injection carburetter was fitted in place of the normal instrument. This form of low-pressure fuel injection ensures that a power plant is fully aerobatic and suffers from no negative "G" fuel supply troubles in unusual flying attitudes.

There are certain details which distinguish the Griffon from the smaller Merlin, for while the best features of the older design have been retained it is in no way correct to refer to the Griffon as a scaled-up Merlin. For example, the camshaft drive is at the front of the engine as is the duplex magneto, a location which

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promotes accessibility and reliability. This arrangement gives neater disposition, and, in addition, provides some relief in the length of the engine, which, although having a cylinder bore greater than that of the Merlin, is only some 3 ins. longer overall. As shown in the diagram, the frontal areas of the two engines differ very little, that of the Merlin being approximately 7.5 sq. ft., and that of the Griffon some 7.9 sq. ft. To comply with Air Ministry standardization the Griffons are of opposite hand rotation to the Merlins.

As the camshaft and magneto drives are at the front, the back end is clear for a neater arrangement of supercharger drive, and a simple change gear mechanism replaces the compound gearing and friction clutch assembly of the Merlin. This improvement is illustrated best by a comparison of the wheel-case assemblies of the two Rolls-Royce designs which affords a striking demonstration of the advantage taken by long-established design staffs of lessons learned from earlier efforts.

Special Features

One of the most important new ideas formulated for the Griffon is the end-to-end internal high-pressure lubrication of the crankshaft. Oil is delivered into each end of the crankshaft instead of the more usual practice of delivery to the main bearing caps. That these refinements are more than satisfactory is proved by the fact that no major modifications to the Griffon have been necessary as a result of Service use.

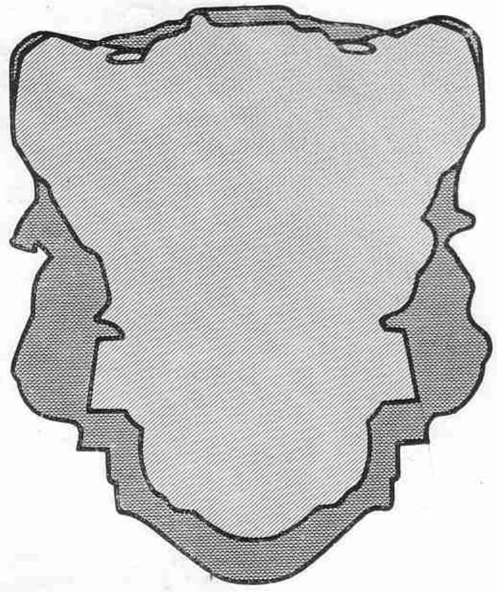
Two-stage supercharging necessitates the addition of a separate coolant pump to pass cooling fluid through the system. This pump is located at the base of the " gear tower " at the rear of the engine and may be seen in the Clark drawing which accompanies this article. The automatic boost control is similar to the unit used on the Merlin 60 series engine. The boost pressure is determined by an aneroid opposed by a variable spring loading. The exact loading is determined by a datum cam which, on reducing the pressure, increases the boost. The interconnected controls and ignition timing unit are individual features of the Griffon which call for some description as both are noteworthy for ingenuity of detail design.

To eliminate one of the controls which the pilot has to operate and to relieve him of the responsibility of selecting the proper r.p.m. for any particular flying condition the throttle and airscrew controls are interconnected. By operating the throttle lever a progressive increase of power is obtained from slow running to maximum performance.

Full movement of the throttle gives maximum r.p.m. and boost. At intermediate positions suitable combinations of boost pressure and r.p.m. are obtained. In normal operational flying, control of boost and r.p.m. is by throttle lever only, but another lever for over-riding manually the control to the constant-speed unit is provided for use in certain special circumstances as, for example, (i) in landing on aircraft carriers to obtain fine pitch for deceleration, and (ii) for taking-off carriers to obtain maximum r.p.m. with lower boost than at maximum take-off boost in order to reduce the tendency of the aeroplane to swing.

Ignition Timing and Automatic Boost

The duplex magneto is mounted at the forward end of the crankcase between the cylinder blocks. It runs at half engine speed. This compares with the two magnetos on the Merlin



The inner outline represents the Merlin and the outer the Griffon frontal area to the same scale.

which are mounted at the rear of the engine and run at one and a half times engine speed. This duplex magneto on the Griffon is driven by an inclined shaft and suitable couplings. Incorporated in these drives is a hydraulic ignition timing relay, which replaces the conventional type of advance and retard device. Control of the timing unit is effected by the pilot's throttle lever, the ignition being advanced or retarded with movement of the throttle lever. The inclined shaft is helically splined at its upper end and its angular relation is determined at its lower end by the unit. The mechanical operation of this assembly is the subject of the diagram below, but the principle of the arrangement is that the drive to the magneto is advanced or retarded, and therefore the magneto contacts always break at the same relative position of the rotor and maximum efficiency is obtained under all conditions. The oil relay mechanism is adopted because the force required to produce rotational movement of the magneto shafts would need considerable manual effort on the part of the pilot owing to driving torque.

Control of boost pressure is provided for the purpose of maintaining automatically, within limits, the pressure selected by the pilot. The unit consists of an aneroid-controlled relay piston interconnected with the pilot's throttle control and the carburetter throttle valves through a differential and is capable of moving the butterflies independently of the throttle control to adjust the pilot's throttle opening to compensate for changes in altitude.

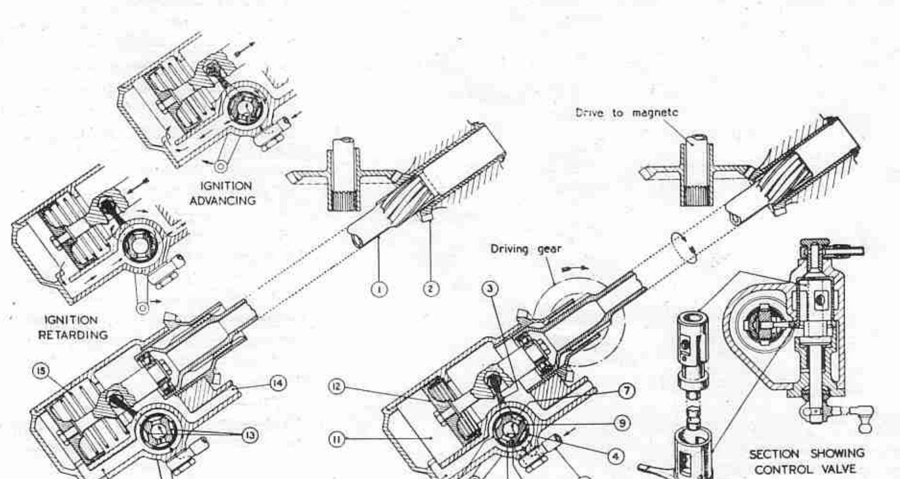


DIAGRAM OF IGNITION TIMING UNIT. —As the throttle is opened the ignition is advanced by lever 8, which rotates the inner valve 6 in a clockwise direction. This places the ports 7 of the valve 6 and the ports 9 of the sleeve 4 in register, thus enabling main pressure oil from pipe 5 to flow to the lower end of cylinder 11 through passage 10. Oil pressure in the cylinder forces piston 12 and shaft 1 in an upward direction. As shaft 1 is helically splined to bevel gear 2 a rotary motion is imparted to this gear and transmitted through the intermediate gear and coupling shaft to the magneto rotor shaft, thus advancing it relative to the contact breakers. Sleeve 4 with arm 3 is actuated by piston and cuts off oil supply when the position is stabilized. Ignition is retarded when throttle is closed by anti-clockwise rotation of valve 6 which places ports 9 in register with grooves 13 in inner valve 6. Through this valve cylinder oil is discharged to the upper side of the piston and thence by passage 14 to the reduction gearcase. The piston is then returned to its retarded position by the spring 15, and its downward movement expels oil from the cylinder through the passage 10.

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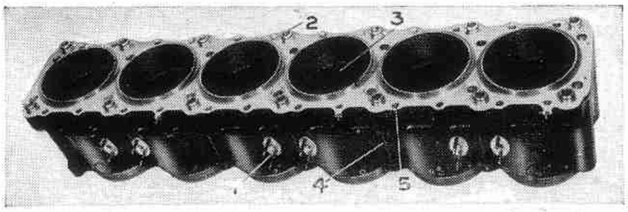


Griffon cylinder block starboard side showing (1) coolant inlets, (2) coolant outlets to cylinder head, (3) cylinder liner, (4) cylinder stud guard tubes, (5) head to skirt stud-holes.

General Construction

For over 30 years Rolls-Royce engineers have been responsible for much of the evolution of the upright Vee 12-cylinder liquid-cooled aero-engine. We may therefore expect to find the Griffon, as the latest example of this classic design, incorporating all the desirable features that the experience gained from the passage of time in development has dictated. To place on record what must be essentially a superficial review of the constructional features of this engine is therefore of historical value, for there is no doubt that this type of layout, coupled with the name of Rolls-Royce, has played a vital part in the progress of aeronautics in this country in particular, and has led the field in high-power liquid-cooled aircraft power plants throughout the World.

Two monobloc castings of six cylinders each are mounted at 60 degrees on the inclined upper faces of a two-piece crankcase. Each block consists of a light-alloy skirt with separate light-alloy cylinder head. Separate cylinder liners in high content carbon steel protrude slightly at both ends. The flange at the top of each liner is sandwiched between the head and the skirt to provide axial location and has the advantage of rendering the liner practically unstressed in the static condition. A further advantage of this arrangement is the elimination of internal coolant leaks and allowance being made for unequal expansion by locating the lower ends of each liner in a sliding gland. Gas tightness is attained by the use of soft aluminium alloy rings.

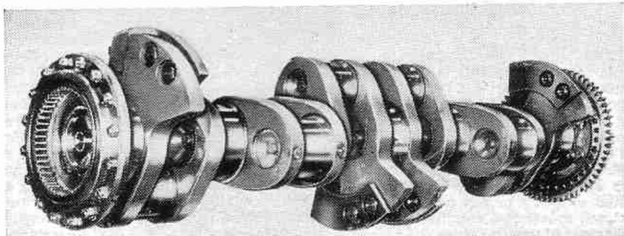
The cylinder assemblies are attached to the crankcase by 14 long studs which pass through tubes in the cylinder block skirt and head. The tubes are sealed against coolant leaks and serve as lubricant drains for the overhead valve gear. A further series of small studs form a secondary tie between head and skirt.

In addition to carrying the cylinder blocks, the upper portion of the crankcase, cast from aluminium alloy, accommodates the crankshaft main bearings. At the front end of this upper half an integral extension forms the rear part of the casing for the airscrew reduction gear and also contains the camshaft and starter motor drives. A composite facing at the rear end of the crankcase assembly provides an attachment for the wheelcase. The crankcase is divided horizontally a short distance below the crankshaft axis, the lower portion containing the oil-pump assembly, and also the main coolant pump, which is driven through the same train of gears.

Internal Arrangement

There are seven main bearings consisting of split steel shells lined with lead bronze alloy, and fitting into semi-circular recesses machined in the top half of the crankcase and held in position by forged light-alloy bearing caps and nickel steel studs. In addition to these studs 16 bolts pass transversely through the caps and the whole width of the crankcase, a system which gives great rigidity and at the same time allows withdrawal of the lower half crankcase without disturbing the crankshaft assembly.

A nitrogen-hardened chrome molybdenum steel forging, the hollow crankshaft is machined as a one-piece job and has seven journals and six throws. Balancing is effected by integral extensions of the webs and by separate balance weights which are secured by taper bolts to the extensions at each end and at the centre of the shaft. Crankpins and journals are bored and fitted with oil-retaining caps and the webs are drilled to allow oil to be fed axially from each end of the crankshaft to the main journal and connecting-rod bearings. The front and rear journals are flanged to receive at the front an internally splined driving ring and at the rear the spring drive assembly.



Crankshaft showing supercharger spring-drive gear at rear and reduction gear driving ring at front.

Spring Drive

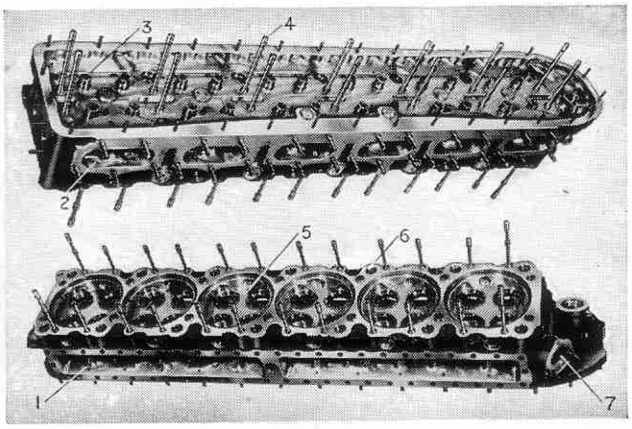
This assembly provides a drive to the wheelcase and supercharger, and is torsionally flexible to absorb the considerable inertia or flywheel effect of the supercharger. Normal torsional fluctuations of the crankshaft are absorbed by the flexible drive, but under abnormal running conditions or rapid acceleration a rigid secondary drive comes into operation, which limits the angular movement between the crankshaft and the driven components.

Wheelcase

The wheelcase, which is an aluminium alloy casting secured by studs to the rear end of the crankcase, houses the two-speed supercharger drive, and also the drives to the auxiliary gearbox couplings, the engine-speed indicator, the constant-speed unit, intercooler pump and fuel pump. It also provides a drive for the oil and coolant pumps situated in the lower half of the crankcase.

Supercharger

On the back of the wheelcase is bolted the supercharger unit. The two-stage centrifugal supercharger is virtually two separate superchargers in tandem, the first and second stage impellers being fitted to a common shaft. Cooling of the charge is provided for by an intercooler situated between the second stage supercharger outlet and the induction trunk, and also by circulation of coolant in the panel between the two stages.



Plan and inverted views of cylinder head which depict (1) inlet port, (2) exhaust port, (3) valve guides, (4) camshaft bracket studs, (5) combustion chamber, (6) coolant inlets, (7) coolant outlet.

This coolant system is quite separate from the main engine cooling. Heat exchange from this coolant is by an independent radiator in the aircraft system and the intercooler incorporates integrally its own header tank.

The automatic boost pressure unit has already been described and the two-speed supercharger drive is shown diagrammatically. Selection of speed is made automatically by a change-over mechanism incorporating an electro-pneumatic hydraulic system controlled by an atmospheric aneroid. The hydraulic pressure for operating the centrifugally loaded clutches of the two-speed mechanism is supplied by a small pressure pump.

Pistons, Connecting Rods, and Valve Gear

Machined from forgings of R.R. 59 light alloy, the pistons each carry two compression rings with one drilled scraper above the gudgeon pin and another below. The fully floating gudgeons of hardened nickel steel are located by circlips. The connecting rods are nickel steel forgings of " H " section, machined all over. Each assembly consists of a plain and a forked rod, the latter carrying a split nickel steel bearing block, the halves of which are secured to the forked rod by four bolts. This bearing block retains a split flanged thin steel shell lined with lead bronze, which runs directly on the crankpin. Similar shells are fitted to the plain rod and work on the outer surface of the forked rod bearing block. The small end of each rod houses a fully floating bronze bush.

There are two inlet and two exhaust valves per cylinder forged from KE.965 steel with " Brightray " protection. The exhaust valves are sodium cooled. Two concentric coil springs

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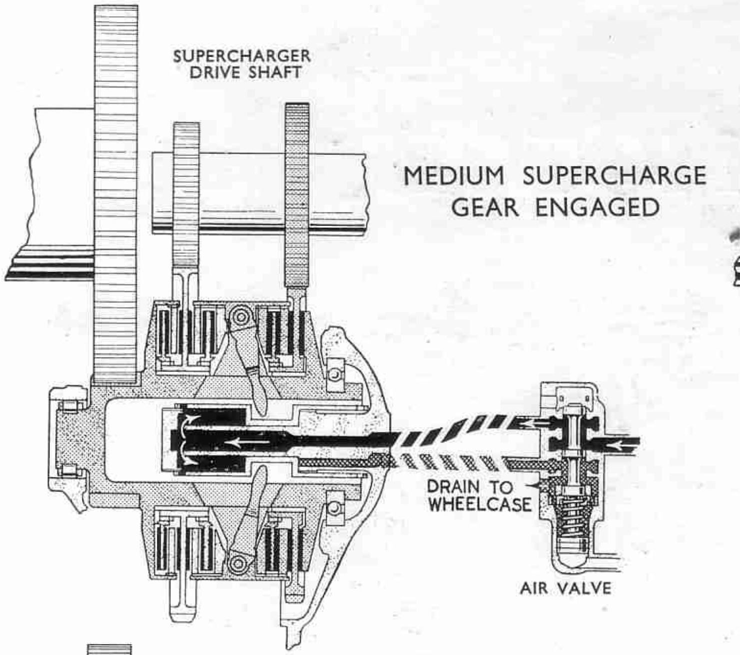
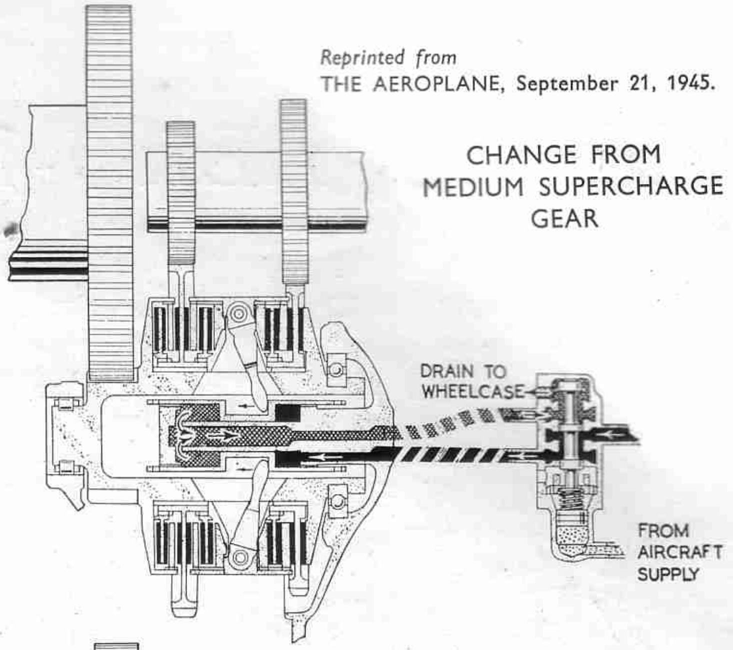
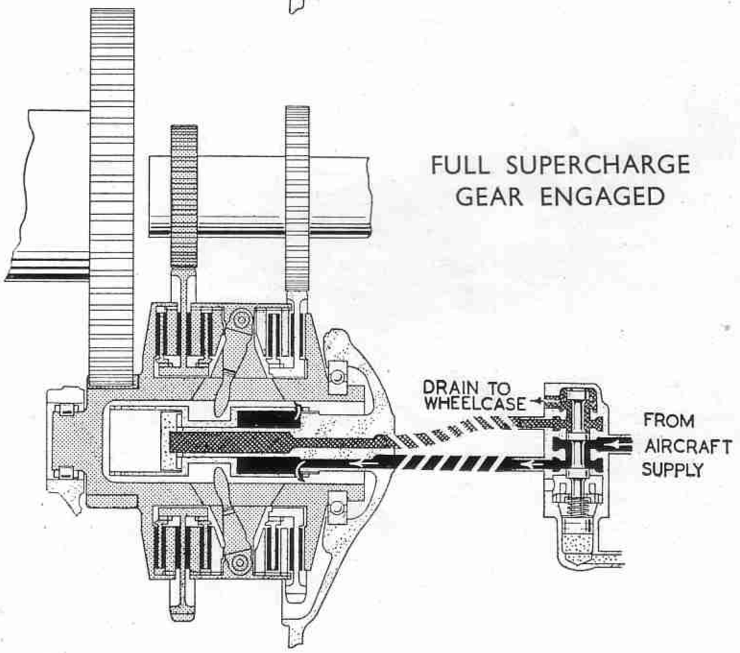
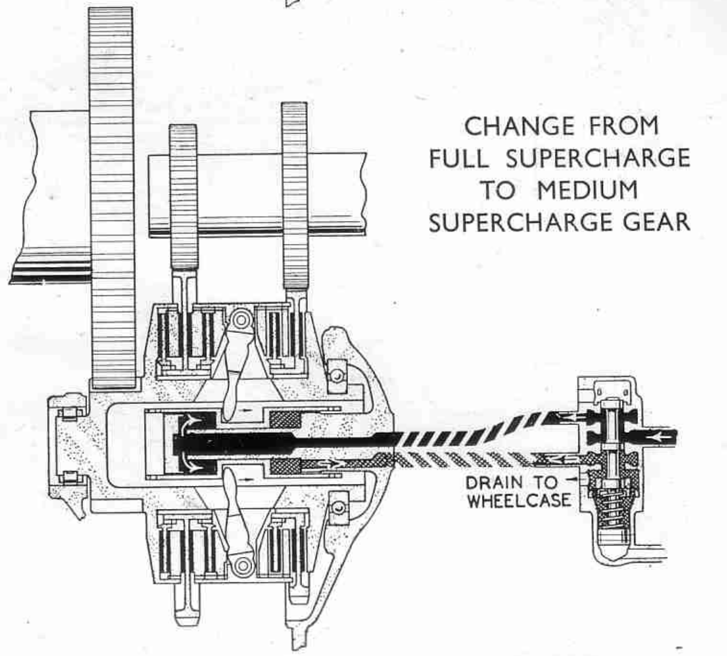








SUPERCHARGER GEAR-CHANGE MECHANISM.

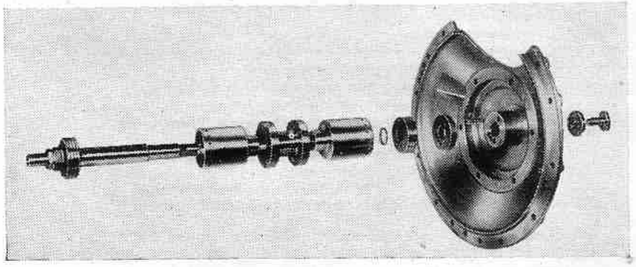
These diagrams illustrate the operation of the gear-change mechanism. A two-position piston valve connects the front and rear ends of a double-acting hydraulic cylinder to either a high-pressure oil supply or to the wheelcase scavenge circuit, as shown. Hydraulic pressure causes the cylinder unit to move between two stationary pistons in the bore of the wheelcase layshaft which carries the supercharger driving clutches. Movement of the cylinder unit to the front or rear end of the stroke causes the clutch weights to move to the corresponding side of their pivots. Further movement of the clutch weights is then induced by centrifugal force until the required clutch is brought into engagement. Radial holes in the ends of the cylinder relieve the pressure at the end of travel in either direction. The two-position piston valve is normally maintained in the lower (M.S.) gear by a coil spring. In the higher (F.S.) gear the underside of the piston is connected to the aircraft compressed air system, causing the piston valve to rise and F.S. gear to be selected.

KEY

- CHANGE GEAR OPERATING OIL FROM PUMP
- DRAIN OIL
- COMPRESSED AIR
- COMPONENTS TRANSMITTING DRIVE TO SUPERCHARGER

are fitted to each valve stem. The silichrome valve seats are renewable. Inlet guides are of cast iron and exhaust valve guides are phosphor bronze.

A single camshaft, mounted in seven pedestal brackets fixed to the top of each cylinder head, operates the valves through rocker arms fitted with spherical-headed adjustable tappet screws. These centrally disposed camshafts, which are similar for each cylinder block, are driven through spur gears, bevel gears and inclined shafts from the reduction gear wheel.



Exploded view of supercharger gear-change mechanism. This photograph should be compared with the functional diagrams.

Airscrew Drive

The airscrew drive consists of single spur reduction gearing housed partly in the casing formed integrally with the crankcase as previously mentioned, and partly in a casing bolted to the crankcase front end. The hollow driving pinion is mounted in two roller bearings and is concentric with, and driven by a hollow coupling shaft which is splined at both ends. One end engages with a splined driving ring on the crankshaft and the forward end with the internal splines on the driving pinion. The chief purpose of this coupling shaft is to insulate the reduction gear unit from crankshaft loadings and torsional vibrations.

Directly behind the reduction gear housing is mounted the duplex magneto—really two 12-cylinder units in one casing, for it has two separate circuits electrically independent of each other, although the timing is synchronized. The differential action for advance and retard of the shaft drive

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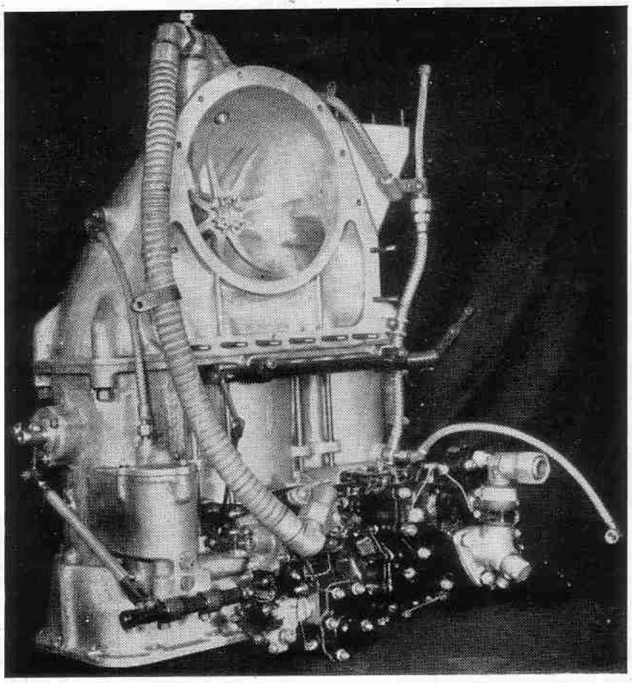

Central entry supercharger intake and Rolls-Royce Bendix-Stromberg carburetter. Fuel is injected at low pressure from jets seen at the centre of the "octopus."

to the magneto has already been described. The fully screened ignition harness consists of four metal conduits coupled with metal braiding which carry the ignition leads by short metal braid connections to the sparking plugs.

Induction

The Rolls-Royce Bendix-Stromberg injection carburetter is a radical departure from previous practice and is the outcome of long research and extensive tests. It represents a new approach to the problem of fuel feed in that it uses the simple method of metering fuel through fixed orifices according to air venturi suction combined with the modern function of atomising the fuel spray under positive pump pressure. The advantages of such a system may be briefly stated as follow:—(i) No ice formation from vaporization; (ii) complete manœuvrability characteristics; (iii) automatic and accurate metering; (iv) pressure atomisation gives economy, flexibility and smooth running; (v) simple and uniform adjustment; and (vi) protection against fuel boiling and vapour lock.

The carburetter is of the triple-choke updraught type and the throttle control unit consists of three butterflies mounted on a common shaft and connected to the automatic boost control unit. Each choke is fitted with a large venturi with impact tubes and two small venturis.

Fuel is supplied to the carburetter under pressure by a vane-type pump and passes to the control unit through filters and vapour separators. An automatic mixture control is provided, which, in conjunction with the throttle control, gives a measure of mass airflow; this is communicated to the regulator, which suitably adjusts the fuel pressure to the metering jets. These give the correct fuel/air ratio to the cylinders. Corrections for enrichment under high power conditions are made automatically by further jets.

The injector nozzle is supplied with metered fuel direct from the fuel control unit. Fuel is sprayed under pressure directly into the first stage supercharger eye. The accelerator pump is of the vacuum-operated type and sprays fuel into the supercharger eye from a separate nozzle. The mixture is taken through both superchargers through the intercooler to the induction manifolds in the "Vee." Flame traps are provided in the manifolds as a precaution against backfire.

Main Cooling

A centrifugal pump circulates the coolant to and from the cylinder blocks to a small-capacity header tank and thence through a radiator back to the pump inlet. The flow of

ROLLS-ROYCE GRIFFON 65

GENERAL SPECIFICATION

Type.—Pressure liquid-cooled in-line V included angle of 60 degrees.
Number of cylinders.—12 arranged in two monoblocs of six with separate heads.
Type of crankshaft.—Counterbalanced six throw.
Number of main bearings.—Seven.
Type of big-end.—Steel-backed lead-bronze.
Crankcase material.—Cast aluminium (R.R.50).
Crankcase construction.—Two-piece. Top half seven-panel casting with separate main bearing caps. Separate sump (split below crankshaft centre line).
Valve type.—Poppet.
Valve timing.—Inlet opens 24 degrees before T.D.C., closes 44 degrees after B.D.C. Exhaust opens 64 degrees before B.D.C., closes 4 degrees after T.D.C.
Reduction gear.—Single spur.
Airscrew shaft size.—No. 5 S.B.A.C.
Airscrew rotation.—Left-hand (clockwise from front).
Type of supercharger.—Centrifugal two-speed, two-stage with intercooler.
Type of carburetter.—R.R. Bendix-Stromberg, pressure injection type, 9T/40/1 triple-entry, updraught.
Magneto.—B.T.H. CSH.12-128/3 duplex with integral distributors.
Sparking-plug type.—Lodge R.S.5/5 or 5/6 or K.L.G. R.C.5/3. 14 mm.
Ignition timing.—Inlet sparking plugs 45 degrees T.D.C. Exhaust sparking plugs 49 degrees T.D.C. (Range 35 degrees fully advanced.)
Cylinder bore.—6.0 ins.
Stroke.—6.6 ins.
Unit capacity.—186.6 cubic ins.
Total swept valume.—2,239 cubic ins., 36.7 litres.
O.A. length.—81 ins. (to airscrew collet).
O.A. height.—45 ins.
O.A. width.—29.5 ins.
Frontal area.—Engine, 7.9 sq. ft.
Distance.—Centre to centre of cylinders, 6.9 ins.
Weight.—Contract dry weight, 2,090 lb.
Percentage unit cooling area.—Not disclosed.
Piston area per cylinder.—28.28 sq. ins.
Inlet port area.—(Valve throat) 5.54 sq. ins. per cylinder.
Exhaust port area.—(Valve throat) 4.12 sq. ins. per cylinder.
Gudgeon diameter.—1.5 ins.
Total gudgeon bearing area.—6.83 sq. ins.
Gudgeon bearing area—in rod.—2.976 sq. ins.
Gudgeon bearing area—in piston.—3.854 sq. ins.
Length of piston.—3.75 ins. total; 2.884 "Rubbing," i.e., less ring grooves, undercuts, etc.
Compression ratio.—6 : 1.
Compression rings.—Two.
Scraper rings.—Two (one above gudgeon and one below).
Connecting-rod length, centre to centre.—10.65 ins.
Big-end diameter.—Forked rod, 3.1 ins. Plain rod, 3.773 ins.
Big-end area.—Forked rod, 6.28 sq. ins. Plain rod, 2.61 sq. ins.
Main-bearing diameter.—3.75 ins.
Main-bearing area.—Centre, 5.45 sq. ins. Ends and inters., 5.12 sq. ins.
Valve lift.—.570 in.
Impellor diameter.—First stage, 13.4 ins. Second stage, 11.3 ins.
Impellor tip speed.—

"M"	1,071 ft. sec.	"F"	1,391 ft. sec.	Cruising.
"M"	1,228 ft. sec.	"F"	1,594 ft. sec.	Max. power.

Equivalent tip speeds.

Airscrew reduction ratio.—0.5102 : 1.
"M" gear ratio.—5.84 : 1.
"F" gear ratio.—7.58 : 1.

PERFORMANCE

Maximum b.h.p.—2,220.
Maximum r.p.m.—2,750.
Pressure velocity main bearings.—Not disclosed.
Fuel specification.—100 octane.
Oil specification.—D.T.D. 472B.
Maximum b.m.e.p.—286 lb./sq. in.
Maximum i.m.e.p.—Not disclosed.
Bore to stroke ratio.—1 : 1.1.
Maximum mean piston speed.—3,025 ft./min.
Power per cubic in.—.992 h.p.
Power per litre.—60.5 h.p.
Power per sq. in. of piston area.—6.54 h.p.
Power per sq. in. of inlet valve area.—33.39 h.p.
Power per sq. in. of exhaust valve area.—44.92 h.p.
1 ata manifold pressure maintained to F.S. 39,500 ft.
Power/weight ratio.—.941 lb./h.p.
Weight per sq. in. total piston area.—6.159 lb.
Power per sq. ft. frontal area.—281 h.p.

DATA

Inlet to exhaust port area ratio.—1.346.
Piston area to inlet valve area.—5.103.
Piston area to exhaust valve area.—6.867.
Cylinder bore to gudgeon diameter ratio.—4.
Ratio of pin area in rod.—.436.
Ratio of connecting-rod length to crank throw.—1.614.
Weight of piston and rod assembly cylinder.—12.23 lb.
Total weight of piston and rod assembly engine.—146.8 lb.
Weight of assembly per sq. in. piston area.—.433 lb.
Weight of assembly per 100 c.c. swept volume.—.400 lb.
Maximum internal compression ratio of blower.—5.3:1.
Auxiliary drive speeds.—(Ratio relative to crankshaft.)
Starter.—1 : 1.
Tachometer.—0.250.
Accessory drive faces.—Hydraulic pump, electric generator, air compressor, vacuum pump—all fitted to gearbox.
Gearbox input.—0.984.
Oil pumps.—0.984.
Fuel pump.—0.887.
Magneto.—0.500.
Constant speed unit.—0.820.
Type of starter.—Coffman L5 combustion starter.
Ratio of total piston area to frontal area.—.298.
Ratio of power per sq. in. piston area to sq. in. frontal area.—3.35.
Eye area of impellor.—56.1 sq. in. free: 40.5 sq. in. restricted due to tail end bearing support.
Maximum boost.—18 lb./sq. in.
Rated height.—4,250 ft. in M.S. 18,500 ft. in F.S.
Cruising boost.—7 lb./sq. in.
Coolant specification: engine and intercooler systems.—70 per cent. water + 30 per cent. ethyleneglycol.
Coolant pump drive ratio.—1.793.
Intercooler coolant pump.—1.799.
Maximum angularity of conn. rod.—18 degrees.
Coolant pressure.—30 lb./sq. in. (Header tank).
Cam base circle diameter.—1.150 ins.
Cam width.—.5 in.
Camshaft-bearing area.—1.700 sq. ins.
Position of sparking plugs.—Two per cylinder diametrically opposite and radially disposed, one each at inlet and exhaust sides.

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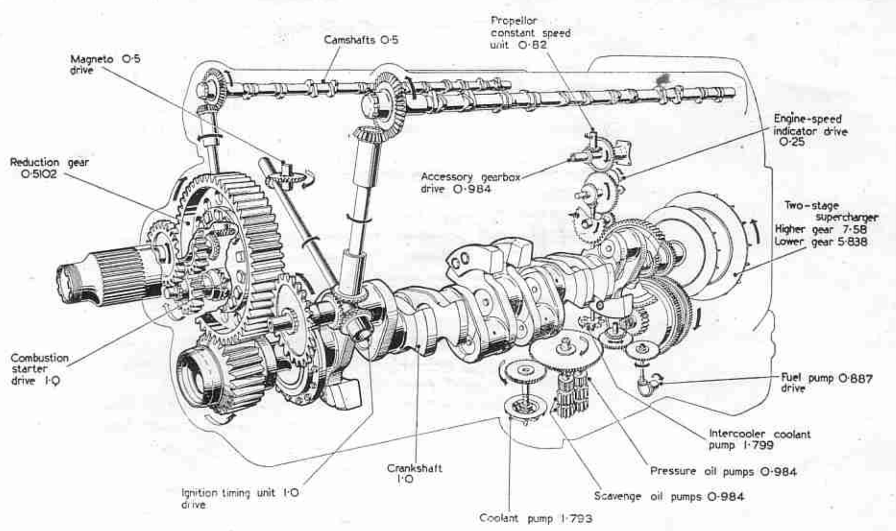

The shaft and drive layout of the Griffon 65. The ratios quoted are the shaft speeds relative to crankshaft speed.

cooling air is controlled manually or automatically. Pressurization raises the boiling point of the coolant and enables smaller radiators to be used.

Lubrication

Two pressure and two scavenge pumps of the gear type are driven from the wheelcase. The main pressure pump delivers oil to the relief valves unit which controls oil pressure in the high- and low-pressure system. The high-pressure oil feeds the crankshaft journal bearings, connecting-rod bearings, ignition timing relay unit and constant-speed unit. The oil for the latter is further increased in pressure by the unit for operation of the airscrew. High-pressure oil is also taken from the delivery side of the main pressure pump through a pressure pump of low capacity, to operate the change-speed mechanism of the supercharger drive.

The low-pressure system feeds oil to the camshaft and rocker mechanism, airscrew reduction gears, supercharger drive gears and various other bearings throughout the engine. Used oil drains back to the lower half of the crankcase from whence it passes through filters to two scavenge pumps and thence back to the aircraft tank through the oil cooler.

All service accessories are mounted on a separate gearbox on the aircraft bulkhead and driven by a shaft through universal joints from the top of the wheelcase. This gearbox has its own independent lubrication system. The combustion starter unit is bolted to the rear face of a housing integral with the reduction gear casing on the starboard side of the engine, and drives through dogs and a train of gears on to the gear wheel of the airscrew shaft. Fuel priming nozzles are provided in the induction system to ensure easy starting.

A Retrospect

In spite of many efficiency claims for other types of aero-engines the significant fact is that the Griffon is of fundamentally the same basic layout—that is a 12-cylinder upright 60-degree liquid-cooled—as the original Rolls-Royce design of 1914. The diagram reproduced above shows the shaft and drive layout of the Griffon, and an interesting point is that the Eagle and Falcon which made history in the last war also employed bevel-driven overhead camshafts and a geared airscrew drive, although the latter was by epicyclic gearing instead of the plain spur of the Griffon.

Thus, this classic design has stood not only the test of time but also the trial of two major wars, and may be said to have contributed more than perhaps any other factor in the struggle for air supremacy. There are even grounds for the belief that the inverted Daimler-Benz and Jumo 12-cylinder engines which were used on such a large scale by the Luftwaffe were inspired by a Rolls-Royce project for an inverted alternative and which was shown to the German Technical Mission between the wars.

Some comparative figures of one of the early Rolls-Royce piston engines and of one of the latest Griffons may be of interest to indicate the immense progress that can be made in the development of a single idea in aeronautical engineering.

	Eagle VIII	Griffon 65
Power per sq. in. of piston area	2.42	6.54
Maximum B.M.E.P.	130	286
Weight/power ratio lb./h.p. ...	2.58	.941

Much of this advance can be attributed to the introduction and perfection of high boost which has given the modern aeroplane a performance for take-off and at height which was not envisaged when Mr. F. H. Royce and his staff set out on their original project at St. Margaret's Bay, near Dover. Not all of this progress can be claimed by the development engineer, for the fuel technologists have contributed much in the form of anti-knock petrols for higher compression ratios. But these, in turn, have introduced further technical problems, such as the demand for improved materials to withstand higher stresses and temperatures. Rolls-Royce made a valuable contribution to the evolution of light alloys of considerably better metallurgical properties than those previously available from the normal sources of supply.

The sodium - cooled exhaust valve was an introduction that solved a problem which threatened at one time to jeopardize the future of the poppet-valve engine, that of burnt valves from high temperatures. More recently, the use of leaded fuels has introduced a new problem which also has been satisfactorily met so far as the high output power plant of poppet-valve design is concerned.

A further improvement which may be noted is the use of pressure cooling, which enables a smaller radiating surface to be employed and thereby reduces the specific weight and drag of the power plant installation. Liquid cooling can be justified on the grounds that it gives a better " heat capacity factor," a term coined by Air Commodore Banks in his recent lecture on " Power Unit Development.'

The performance and design data given with this article show that the Griffon is still progressing and there is every reason to believe that the basic design is capable of assimilating as much development as did that of its famous predecessor, the Merlin.