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# MERLIN II, III & V AERO-ENGINES

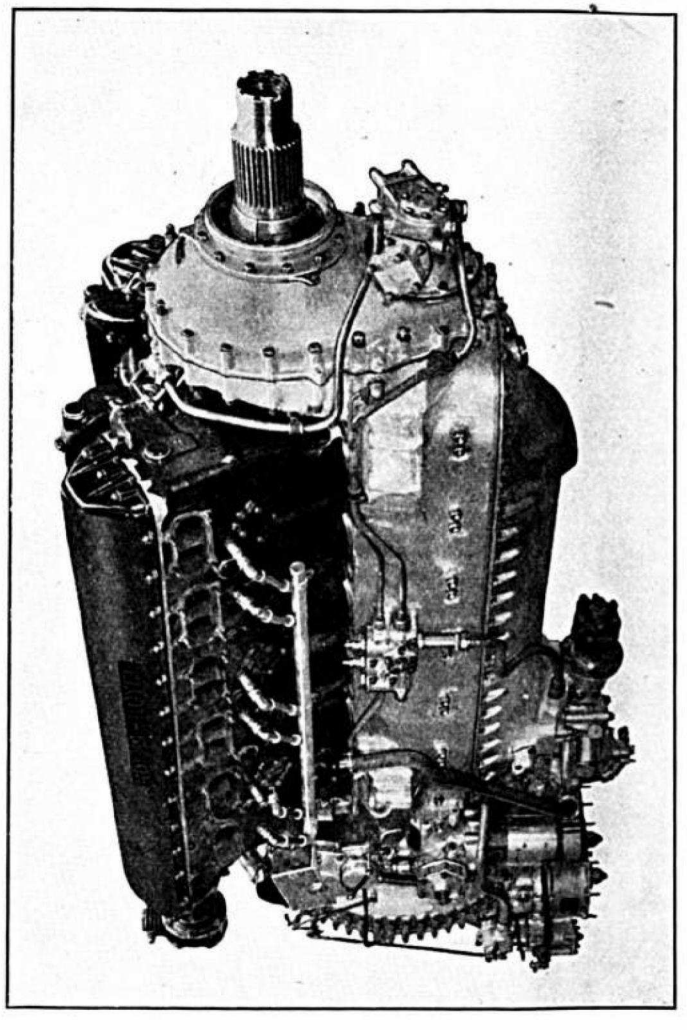
Prepared by direction of the Minister of Aircraft Production.

A. C. Rowlands.

Promulgated by Order of the Air Council.

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*Frontispiece* :—Three-quarter front view of Merlin III engine.

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**AIR PUBLICATION 1590B**
**Volume I,**
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# LEADING PARTICULARS

## (MERLIN II, III and V)

(1) *General*

| | |
|---|---|
| Type | Supercharged, geared, glycol-cooled V-engine. |
| Number of cylinders | 12. |
| Arrangement of cylinders | Two lines of six cylinders each with an inclined angle of 60°. |
| Bore | 5·4 in. |
| Stroke | 6 in. |
| Swept volume | 1,648 cu. in. |
| Compression ratio | 6 to 1. |
| Supercharger ratio | 8·588 to 1. |
| Airscrew reduction gear— | |
| Type | Spur layshaft, single reduction. |
| Ratio | 0·477 to 1. |
| Direction of rotation— | |
| Airscrew shaft | Right hand. |
| Crankshaft | Left hand. |
| Cylinder numbering (Airscrew) | 1A, 2A, 3A, 4A, 5A, 6A.<br>1B, 2B, 3B, 4B, 5B, 6B. |
| Weight of engine, nett dry, including ignition system, with bonding and screening, carburettors and induction systems, engine-driven fuel pump, water outlet collector pipes, hand turning gear, supercharger with necessary pipe-work and drives for accessories incorporated in engine, but excluding airscrew hub, exhaust manifolds or stub pipes, air intakes, connections from water outlets and water pump to radiator, oil and coolant. | 1,335 lb. |

(2) *Performance*

| | |
|---|---|
| (i) International power rating. | 950/990 b.h.p. at 2,600 r.p.m. at 12,250 ft. |
| (ii) Maximum power rating | 1,030 b.h.p. at 3,000 r.p.m. at 16,250 ft. |
| (iii) Maximum take-off power | 890 b.h.p. at 2,850 r.p.m. at sea level. |

(3) *Limiting operational conditions*

| | |
|---|---|
| (i) Maximum climbing | r.p.m., 2,600.<br>boost, + 6¼ lb. per sq. in.<br>coolant outlet temperature, 120°. |
| (ii) Maximum "all-out" level flight (5 minutes limitation). | r.p.m., 3,000.<br>boost, + 6¼ lb. per sq. in.<br>coolant outlet temperature 120°. |
| (iii) Maximum continuous cruising. | r.p.m., 2,600.<br>boost, + 4½ lb. per sq. in.<br>coolant outlet temperature, 95°. |

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(3) *Limiting operational conditions*—contd.

| | |
|---|---|
| (iv) Maximum take-off | r.p.m., 2,850.<br>boost, + 6¼ lb. per sq. in. |
| (v) Minimum take-off (full throttle). | r.p.m., 2,080. |
| (vi) Momentary maximum speed for T.V. dive. | r.p.m., 3,600. |
| (vii) Maximum continuous cruising mixture strength. | Automatic rich. |
| (viii) Economical cruising mixture strength. | Automatic weak. |
| (ix) Limiting conditions for economical cruising. | 2,600 r.p.m. at + 2¼ lb. per sq. in. boost. |

(4) *Fuel*

| | |
|---|---|
| Type | Specification D.T.D. 230. |
| Fuel consumptions— | |
| (i) At maximum climbing conditions at sea level (875 b.h.p. at 2,600 r.p.m.). | 71·5 gallons per hour. |
| (ii) At maximum cruising conditions at sea level (790 b.h.p. at 2,600 r.p.m.). | 0·595 pint per b.h.p. per hour. |
| (iii) At maximum take-off conditions at sea level (890 b.h.p. at 2,850 r.p.m.). | 78·5 gallons per hour. |
| (iv) At economical cruising mixture strength (automatic weak, 685 H.P. at 2,600 r.p.m. at + 2¼ lb. per sq. in. boost). | 0·53 pint per b.h.p. per hour. |

(5) *Oil*

| | |
|---|---|
| Type | Specification D.T.D. 109. |
| Oil consumption at maximum cruising conditions. | 10 to 18 pints per hour. |
| Oil pressure—high | 150 lb. per sq. in. |
| Oil pressure—main | (Normal) 60 lb. per sq. in. Emergency minimum (5 minutes limitation) 45 lb. per sq. in. |
| Oil pressure—auxiliary | (Normal) 6 lb. per sq. in. (Emergency minimum) 2 lb. per sq. in. |
| Inlet oil temperature— | |
| Minimum for opening up | 15°C. |
| Maximum for continuous cruising. | 90°C. |
| Maximum for climbing | 90°C. |
| Emergency maximum (5 minutes limitation). | 95°C. |

(6) *Ignition*

| | |
|---|---|
| Number and type of magnetos. | Two B.T.H. C1SE—12S. |
| Type of sparking plugs | See A.P. 1260. |



(6) *Ignition*—contd.

| | |
|---|---|
| Magneto timing—(fully advanced). | 45° before T.D.C. |
| Contact breaker gap | See A.P. 1374. |
| Sparking plug gap | See A.P. 1464A, Vol. I. |
| Firing order | 1A, 6B, 4A, 3B, 2A, 5B.<br>6A, 1B, 3A, 4B, 5A, 2B. |

(7) *Carburation*

| | |
|---|---|
| Fuel | Specification D.T.D. 230. |
| Maximum fuel demand | 88½ gallons per hour. |
| Carburettors | S.U., type Merlin A.V.T.32, duplex, double entry. |
| Feed pressure supply | 2 to 2¾ lb. per sq. in. |

(8) *Valves*

| | |
|---|---|
| Valve timing | Inlet opens 31° before T.D.C.<br>Inlet closes 52° after B.D.C.<br>Exhaust opens 72° before B.D.C.<br>Exhaust closes 12½° after T.D.C. |
| Valve clearances—<br>(Hot or cold) | 0·020 in. |

(9) *Coolant*

| | |
|---|---|
| Type | Treated ethylene-glycol: Specification D.T.D. 344. |
| Outlet temperatures— | |
| Minimum for take-off | 60° C. |
| Maximum for cruising | 95° C. |
| Maximum for climbing and level flight. | 120° C. |

(10) *Starting systems*

| | |
|---|---|
| Type | Hand and electric turning gear. |

(11) *Airscrews*

| | |
|---|---|
| Merlin II | Fixed pitch or two-position. (If modified, de Havilland constant speed can be used.) |
| Merlin III | Fixed pitch, two-position or constant speed (de Havilland or Rotol). |

## (MERLIN III AND V)

(1) *General*

| | |
|---|---|
| Type of engine | Supercharged, geared, ethylene glycol cooled. |
| Number of cylinders | 12. |
| Arrangement of cylinders | Two banks of six cylinders with an included angle of 60°, on the upper side of the crankcase. |
| Bore | 5·4 in. |
| Stroke | 6·0 in. |
| Swept volume | 1,648 cu. in. |
| Compression ratio | 6 to 1. |
| Supercharger— | |
| Degree of supercharge | High altitude. |
| Gear ratio | 8·588 to 1. |

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(1) *General*—contd.

| | |
|---|---|
| Airscrew reduction gear— | |
| Type .. .. .. | Spur layshaft, single reduction. |
| Ratio .. .. .. | 0·477 to 1. |
| Direction of rotation— | |
| Airscrew shaft .. .. | Right hand. |
| Crankshaft .. .. | Left hand. |
| Cylinder numbering Airscrew | 1A, 2A, 3A, 4A, 5A, 6A.<br>1B, 2B, 3B, 4B, 5B, 6B. |
| Weight (nett dry) .. .. | 1,335 lb. |
| Rated altitude .. .. | 12,250 ft. |

(2) *Performance*

| | |
|---|---|
| International power rating | 950/990 b.h.p. at 2,600 r.p.m. at 12,250 ft. at +6¼ lb. per sq. in boost. |
| Maximum power rating .. | 1,030 b.h.p. at 3,000 r.p.m. at 16,250 ft. and +6¼ lb. per sq. in boost. |
| Maximum take-off power | 890 b.h.p. at 3,000 r.p.m. at sea level and +6¼ lb. per sq. in. boost. |
| Minimum take-off power .. | 2,080 r.p.m. and +6¼ lb. per sq. in boost. |

(3) *Limiting operational conditions*

| | |
|---|---|
| (i) Maximum take-off (3 minutes or 1,000 ft.)— | |
| Maximum r.p.m. .. | 3,000. |
| Minimum r.p.m. .. | 2,080. |
| Boost .. .. | +6¼ lb. per sq. in. |
| (ii) Maximum climbing (30 minute limit)— | |
| r.p.m. .. .. | 2,600. |
| Boost .. .. | +6¼ lb. per sq. in. |
| (iii) Maximum level flight (5 minute limit)— | |
| r.p.m. .. .. | 3,000. |
| Boost .. .. | +6¼ lb. per sq. in. |
| (iv) Cruising (with automatic rich mixture)— | |
| r.p.m. .. .. | 2,600. |
| Boost .. .. | +4½ lb. per sq. in. |
| (v) Cruising (with automatic weak mixture)— | |
| r.p.m. .. .. | 2,600. |
| Boost .. .. | +2¼ lb. per sq. in. |
| (vi) Maximum for 30 minute emergency (1 engine stopped; multi-engined aeroplanes)— | |
| r.p.m. .. .. | 2,600. |
| Boost .. .. | +6¼ lb. per sq. in. |
| (vii) T.V. dive (20 seconds limit)— | |
| r.p.m. .. .. | 3,600. |
| Boost .. .. | +6¼ lb. per sq. in. |



(4) *Fuel*

| | |
|---|---|
| Type .. .. .. | Specification D.T.D.230 (Merlin III and V) or 100 octane (Merlin V). |
| Consumption (with 87 octane fuel)— | |
| (i) At maximum take-off conditions. | 78·5 gallons per hour (890 b.h.p. at 3,000 r.p.m. and +6¼ lb. per sq. in. boost at sea level). |
| (ii) At maximum climbing conditions. | 71·5 gallons per hour (875 b.h.p. at sea level at 2,600 r.p.m. and +6¼ lb. per sq. in. boost). |
| (iii) At maximum cruising (automatic rich) conditions. | 0·595 pint per b.h.p./hour (790 b.h.p. at sea level at 2,600 r.p.m. and +4½ lb. per sq. in. boost). |
| (iv) At economical cruising (automatic weak) conditions. | 0·53 pint per b.h.p./hour (685 b.h.p. at sea level at 2,600 r.p.m. and +2¼ lb. per sq. in. boost). |

(5) *Oil*

| | |
|---|---|
| Type .. .. .. | Specification D.T.D.109. |
| Consumption at maximum cruising conditions .. | 10 to 18 pints per hour. |
| Pressures— | |
| Main—Normal .. .. | 60 lb. per sq. in. |
| Emergency minimum .. | 45 lb. per sq. in. |
| Auxiliary—Normal .. | 6 lb. per sq. in. |
| Emergency minimum .. | 2 lb. per sq. in. |
| Inlet oil temperatures— | |
| Minimum for opening up | 15° C. |
| Maximum for continuous cruising .. .. | 90° C. |
| Maximum for climbing or 30 minute emergency (1 engine stopped; multi-engined aeroplanes) .. .. | 90° C. |
| Emergency maximum (5 minute limit) .. | 95° C. |

(6) *Ignition*

| | |
|---|---|
| Firing order .. .. | 1A, 6B, 4A, 3B, 2A, 5B.<br>6A, 1B, 3A, 4B, 5A, 2B. |
| Magnetos— | |
| Number .. .. | Two. |
| Type .. .. .. | B.T.H. C1SE–12S. |
| Direction of rotation .. | Starboard, clockwise; Port, counter-clockwise — Viewed from contact breaker end. |
| Speed of rotation .. | 1·5 engine speed. |
| Contact breaker gap .. | *See* A.P.1374. |
| Sparking-plugs .. .. | *See* A.P.1374, Vol. III. |
| Gap .. .. .. | 0·012 to 0·015 in. |



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(7) *Carburation*

| | |
|---|---|
| Carburettor .. .. | S.V. type Merlin A.V.T.32, duplex, double entry. |
| Maximum fuel demand .. | 88¼ gallons per hour. |
| Pump pressure to carburettor .. .. .. | 2 to 2¾ lb. per sq. in. |

(8) *Valves*

Valve timing—

| | |
|---|---|
| Inlet opens .. .. | 31° before T.D.C. |
| Inlet closes .. .. | 52° after B.D.C. |
| Exhaust opens .. .. | 72° before B.D.C. |
| Exhaust closes .. .. | 12½° after T.D.C. |

(9) *Coolant*

| | |
|---|---|
| Type .. .. .. | Treated ethylene glycol. Specification D.T.D.344. |

Outlet temperatures—

| | |
|---|---|
| Minimum for opening up | 60° C. |
| Maximum for cruising.. | 95° C. |
| Maximum for climbing and level flight (5 minute limit).. .. | 120° C. |
| Maximum for ½ hour emergency .. .. | 120° C. |

(10) *Starting system*

| | |
|---|---|
| Type .. .. .. | Hand and electric turning gear. |

(11) *Airscrew*

| | |
|---|---|
| Type .. .. .. | Fixed pitch, two-position or constant speed. Merlin III is fitted with universal type airscrew shaft. |



## INTRODUCTION

1. The Merlin II aero-engine is of the 12-cylinder V-type, its two integral blocks of six cylinders being inclined at 60°. It is glycol-cooled, geared and highly supercharged, and is fitted with a pneumatically operated (*i.e.*, directly by the boost pressure in the induction casing) boost control similar to that used on Kestrel aero-engines. Two mixture controls—one an atmospheric unit and the other a boost pressure controlled unit—are also used.

2. The two light-alloy monobloc non-detachable head, cylinder blocks are mounted on the top of the crankcase. The separate steel cylinder liners are of the wet type and are provided with shoulders at each end which abut against the crankcase and cylinder block respectively. Each cylinder has four valves—two inlet and two sodium cooled exhaust valves ; the heads and seats of the exhaust valves are surfaced with " Brightray " steel to resist corrosion and the stem tips of all valves are stellited to minimize wear. All valves of each cylinder block are operated from a single centrally disposed overhead camshaft through a system of individual tappet fingers.

3. The balanced six-throw crankshaft is supported within the crankcase in seven lead bronze main bearings. The connecting rods are H-section steel forgings and are of the plain type on the left hand or " A " side, and of the forked type on the right hand or " B " side. A divided steel bearing shell, lined inside and out with lead bronze, is bolted to the forked rod, the plain rod working on the outside and the inside of the shell bearing directly on the crankshaft. A floating phosphor-bronze bush is fitted in each small end. The light-alloy pistons are of the forged type and each carry three gas rings and two drilled scraper rings. A hardened steel gudgeon pin of the floating type is used.

4. Bolted to the front of the crankcase is the reduction gear case and mounted at the rear of the crankcase is the wheel case which houses the components transmitting the drive from the rear end of the crankshaft to the accessories and provides mountings for the upper and lower vertical drive units, the magnetos, the coolant pump, the idler gear which drives the oil pumps and the Lockheed pump, the fuel pumps and the generator drive. A hand and electric turning gear is also housed in the wheelcase.

5. The supercharger unit is attached to the wheelcase. The centrifugal type supercharger is driven from the rear end of the crankshaft through three centrifugally loaded clutch wheels which absorb the high inertia loading resulting



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from rapid acceleration and deceleration. Torsional fluctuations are absorbed by a spring drive shaft. Carburation is provided by two coolant-jacketed and oil heated carburettors which are integral with the supercharger casing cover.

6. Lubrication of the engine is of the dry sump type and one pressure pump and two scavenge pumps are employed. These three pumps form a unit which is attached to the rear end of the crankcase. A separate pressure oil circuit, operated from the pressure pump, is provided for the actuation of a two-position airscrew.

7. The Merlin III aero-engine is basically similar to early Merlin II engines except that it has an additional drive unit mounted on the reduction gear cover for the accommodation of a constant speed airscrew governor control unit and a vacuum pump. Later Merlin II engines will also be equipped with this unit, which will make them suitable for use with a de Havilland constant speed airscrew. The drive will take the control unit for operating constant speed airscrews of either the de Havilland or Rotol types. To accommodate all types of airscrews, a universal type of airscrew shaft, having a reduced diameter at its outer extremity, is also employed for Merlin III engines. The text describes the details of the Merlin III engine which differ from the basic Merlin II design.

7A. A modification to the boost control cut-out valve, limits the boost pressure to +12 lb. per sq. in. with the cut-out device in operation. This boost pressure may only be used for short periods under emergency conditions and necessitates the use of 100 octane fuel. The addition of slow-running cut-off valves to the carburettor enables the engine to be stopped positively without the risk of continued slow running by pre-ignition when the magneto switches are off.

The Merlin V aero-engine is basically similar to the Merlin III aero-engine, with the exception that, while its airscrew shaft is of the same general type, it is not universal in its ability to take all forms of airscrew.



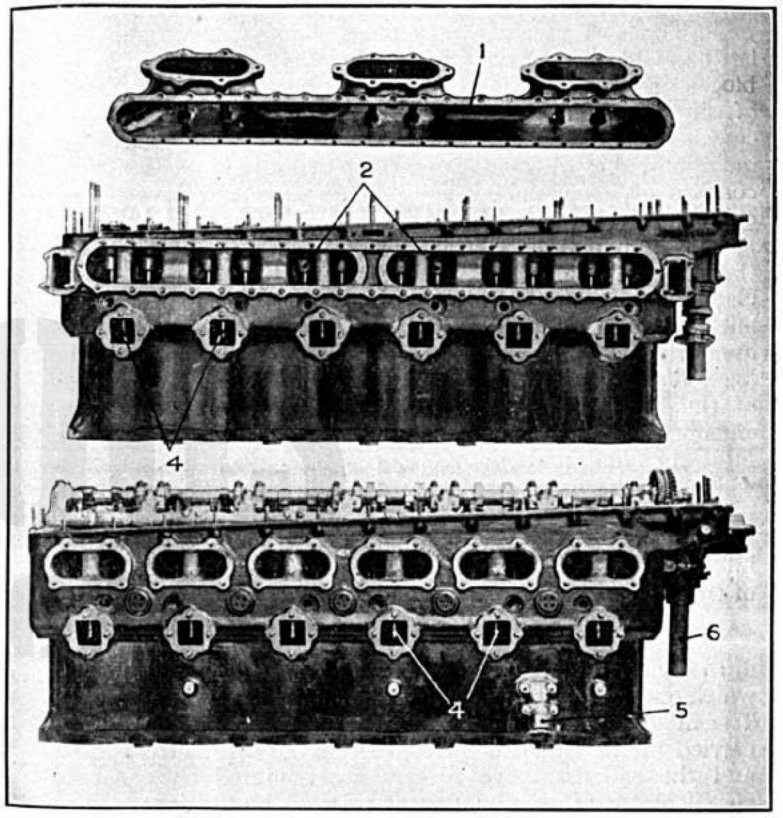



FIG. 1.—Cylinder blocks.

1. Induction manifold.
2. Inlet ports.
3. Exhaust ports.
4. Liner clamp studs.
5. Coolant inlet union.
6. Camshaft drive covers.

# CHAPTER 1

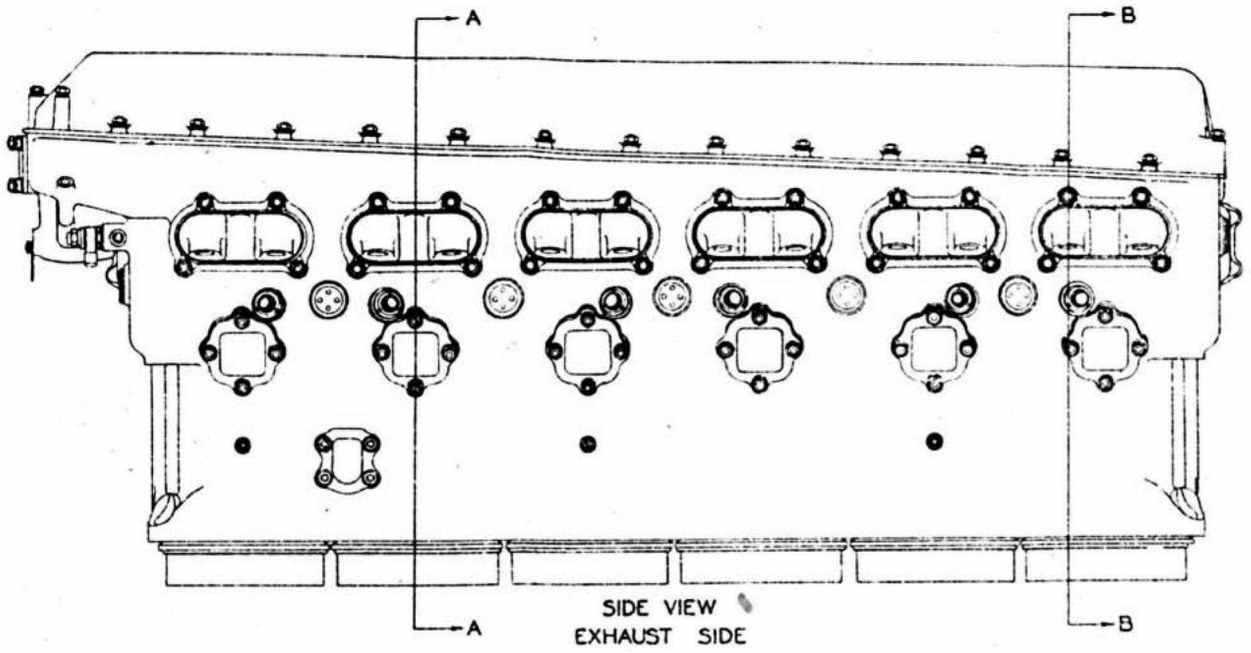
## CYLINDER ASSEMBLY

### CYLINDER UNIT

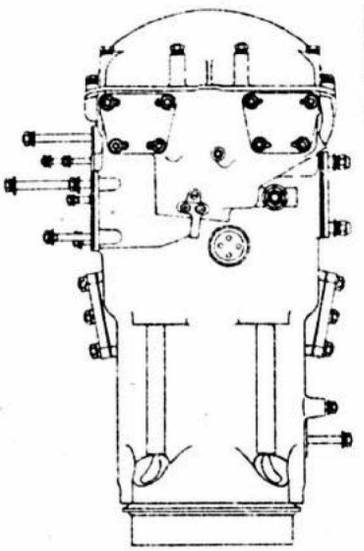
*General*

8. The two cylinder assemblies, namely the right and left-hand blocks known respectively as the "A" and "B" blocks are described in this chapter; each comprises a block of six cylinders, the upper camshaft drive unit and the camshaft and rocker mechanism which operates the valves incorporated in the cylinders. Each cylinder block (*see* fig. 1) consists of a common cast aluminium coolant jacket—the cylinder block proper—and six detachable wet steel liners. In addition to providing a coolant space around each liner, the cylinder block forms the roofs of the six combustion chambers in each of which two inlet and two exhaust valves and two sparking plugs are carried. Nuts at the upper ends of fourteen long studs screwed into the crankcase draw the bases of the combustion chambers down upon the upper ends of the liners and also draw the flanges around the lower ends of the liners on to the crankcase. The studs, therefore, fulfil the dual purpose of securing the cylinder unit as a whole to the crankcase and of rendering the head joints between the liners and cylinder block gas-tight. Additional tension is put upon each liner joint by two short studs screwed into the top of the head casting which hold the liner by means of two clamps.

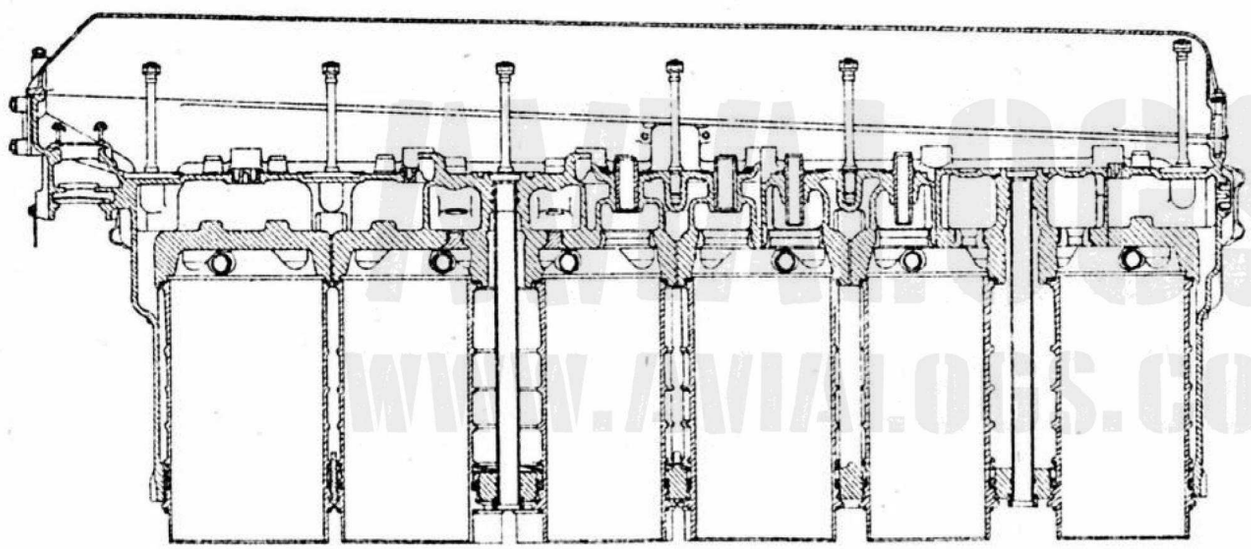
9. Seven brackets are mounted in line along the top of the cylinder block. They house the bearings for a camshaft which operates each valve through a separate cam and rocker. The inlet valve rockers are mounted on a common spindle carried in the exhaust valve sides of the camshaft brackets and the exhaust valve rockers are mounted on a second spindle carried in the inlet valve sides of the brackets. Each rocker is borne on near its free end by a cam, and operates a valve through an adjustable tappet. The spindles are extended rearwards to carry bushes upon which are mounted the driving wheels of the various auxiliaries carried by the rear ends of the cylinder castings. An R.A.E. compressor is mounted upon the faced end of the "B" block, and a B.T.H. compressor is mounted upon the faced end of the "A" block. A short spindle, known as the upper camshaft driving spindle which is mounted in the rear end of the cylinder block and drives the camshaft, is itself driven through a separate coupling shaft from the wheelcase (*see* para. 36).



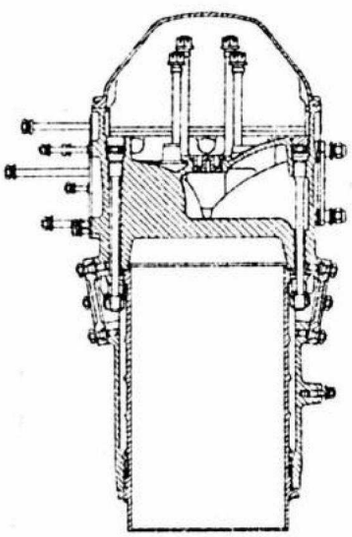

SIDE VIEW
EXHAUST SIDE



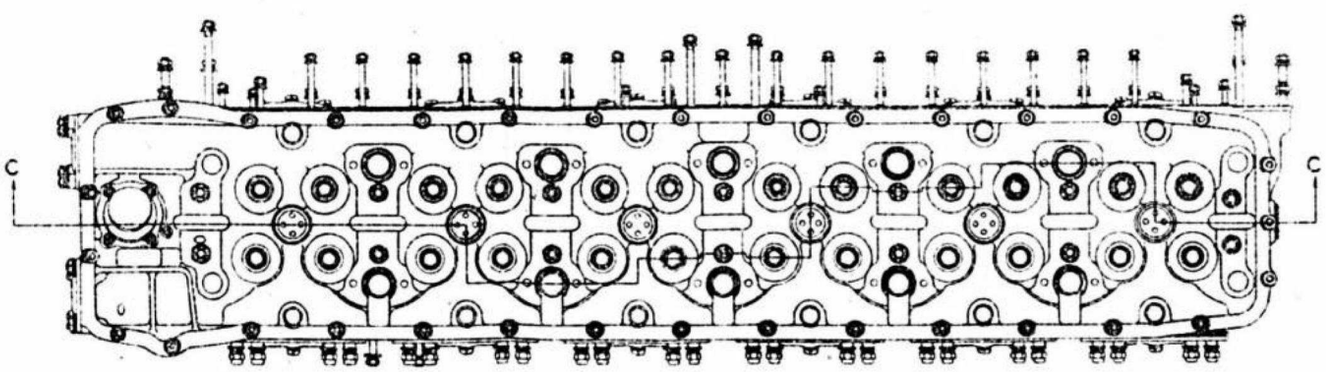
REAR END VIEW



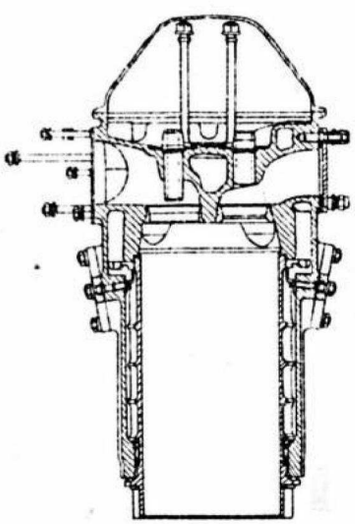
SECTION C-C



SECTION A-A




PLAN VIEW ROCKER COVER REMOVED



SECTION B-B

# FIG. 2. ARRANGEMENT OF CYLINDER BLOCK ("A" SIDE)

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10. A cast aluminium cover is fitted to the head of the cylinder block to enclose the camshaft and rocker mechanism. The cover for the " B " side cylinder block carries the engine-speed indicator drive.

*Cylinder block*

11. From the cross sectional view in fig. 2, it will be seen that the cylinder block casting receives nearly the whole length of the cylinder liners and that a coolant space is provided between the combustion chambers and the top of the block proper. The heads of the combustion chambers are flat and four gas passages lead upwards and outwards from each chamber to the sides of the block. The passages serving the inlet valves terminate at the inner face of the block in a common elongated port to which the branch of an induction manifold is attached. The exhaust valve passages are taken to the opposite or outer face of the block, and the two passages from each combustion chamber serve an individual port. A branch pipe of an exhaust manifold is attached to each of the six exhaust ports. The valve guides are carried in the bores of bosses cast between the tops of the cylinder blocks and each of the gas passages.

12. An aluminium-bronze valve seat is screwed and shrunk into the mouth of each inlet gas passage where the passage enters the combustion chamber; high silicon chromium steel is used for each exhaust valve seat. An aluminium bronze adaptor for a sparking plug is screwed and pinned into a boss cast between the inlet and exhaust sides of each combustion chamber and the sides of the cylinder block. The thickened portion between each combustion space has a lateral slot cut in the interests of even expansion and the minimizing of undue strain in these localities. The lower end of each combustion chamber is recessed to accommodate an aluminium-alloy joint washer carried on a shoulder at the upper end of the cylinder liner. There are six sockets in the base of each cylinder block to form coolant joints with spring-loaded rubber rings mounted in grooves towards the lower ends of the cylinder liners. (*See* fig. 3).

13. The fourteen studs by which the cylinder block is retained to the crankcase are arranged in seven pairs. The front and rear pairs are waisted and are for the greater part of their length outside the cylinder block but at their upper ends pass through bosses cast between the combustion heads of the end cylinders and the ends of the jackets. The remaining inner studs are not waisted and are of greater diameter; they pass through aluminium guard tubes taken through the coolant space between the cylinder liners. The ends of the guard tubes are a press fit in sockets in the upper

and lower ends of the cylinder block, and water-tight joints are made by two rubber rings at the top and one at the bottom compressed into grooves cut in the block to receive them. The top end of each tube is expanded to retain it in the block. A rubber sleeve pressed on to the lower end of each tube and spigoted into the block projects beyond the lower face of the cylinder block and makes an oil seal between it and the shallow socket in the crankcase. This construction enables oil from the camshaft and rocker mechanism to be drained to the crankcase through the guard tubes.

14. The upper ends of the retaining studs terminate a short distance above the top of the cylinder block. The end studs receive flat-based cap nuts which bear on the cylinder blocks. The remaining studs receive flat-based nuts which spigot into and bear upon bridge pieces provided with two diagonally opposed dowel pins which engage holes on either side of each stud hole. The bridge pieces on the exhaust side of the block span drain troughs into which the oil from the camshaft mechanism is evenly distributed by baffle ribs suitably cast between each pair of exhaust valves and each pair of stud holes. As very little of this drain oil passes down the tubes on the inlet side of the block there are no oil drain reservoirs or ribs on this side of it.

15. In addition to the main holding studs, the top end of each liner is provided with an additional means of attachment to the head by the use of two waisted studs which are threaded at both upper and lower ends. The upper ends of these screw into threaded sockets in the top of the head, and are provided with cone heads which seat upon similar faces in the casting and hexagon heads for the reception of a box spanner. The waisted portion of the stud extends through a vertical hole in the head and its lower end passes through a robust semi-circular clamp, which fits around and under a recessed lip cut in the liner to receive it, and screws into a tabwashered nut. The two studs are located one on each side of the cylinder to equalize the tension. After the studs are in position, the counterbored holes in the top of the head which receive the hexagon heads are sealed with light alloy plugs. In order to permit the clamps to be placed into position within the cylinder jackets, a faced port is provided adjacent to each ; after the clamps are in position, each port is sealed by a cover secured by four studs and nuts. Gaskets are used to make a water-tight joint.

16. The top of each cylinder block is slotted with seven central slots which engage tenons on the bottom faces of the camshaft brackets. A pair of studs, one on each side of a slot, anchor each bracket to the cylinder block. The rear



of each block is provided with an upper plain socket which receives the bearing housing of its respective upper camshaft driving spindle, and a lower threaded socket for a ring nut which retains the spindle assembly in the head. A recess is formed between the exhaust side of each socket and its adjacent ledge and is put into communication with the bore of the socket by a hole drilled diagonally through the ledge. It is through this hole that drain oil from the camshaft and rocker mechanism passes down into the wheelcase *via* the upper camshaft drive tube. The upper and lower flanged bushes carrying the upper spindle spigot into the two sockets and abut against faces formed in them.

17. Three facings at the front, middle and rear of the inlet side of the block and co-planar with the induction pipe facing are provided with studs for securing the coolant outlet connections to the block. Another studded facing on the rear bottom exhaust side of each block receives the coolant inlet connection for the block. (*See* para. 146).

18. A tapped hole in the rear face and on the exhaust side of the block receives an oil connection through which oil from the low pressure side of the pressure oil pump enters the block to lubricate the camshaft and rocker mechanism. A hole drilled at an angle to this connection and plugged at its drill-entry end intersects the hole for the union and a hole drilled vertically in the roof of the cylinder block between the pair of studs for the rearmost camshaft bracket. A second hole drilled in the head, conveys oil from the union to the upper bush supporting the upper camshaft driving spindle.

19. Three studs on the exhaust side of each block serve as anchoring points for the H.T. harness. A ledge around the top of the cylinder block is faced and studded for the reception of a jointing washer and the cover for the block. Numerous core holes are tapped and blanked by plugs screwed into the block by a peg spanner.

*Cylinder liner*

20. As may be seen from fig. 3, each cylinder liner is shouldered and spigoted at the upper end to receive the joint washer by which the gas-tight joint is made between it and the combustion chamber, and is provided with a flange towards the lower end for abutment on the crankcase to which it is drawn by the pressure of the cylinder holding-down studs. Flats are machined on these flanges to allow of interlocking of the flanges and therefore close assembly of adjacent cylinders. Two recesses are formed in the sleeve immediately under the upper seating flange to receive the clamps described

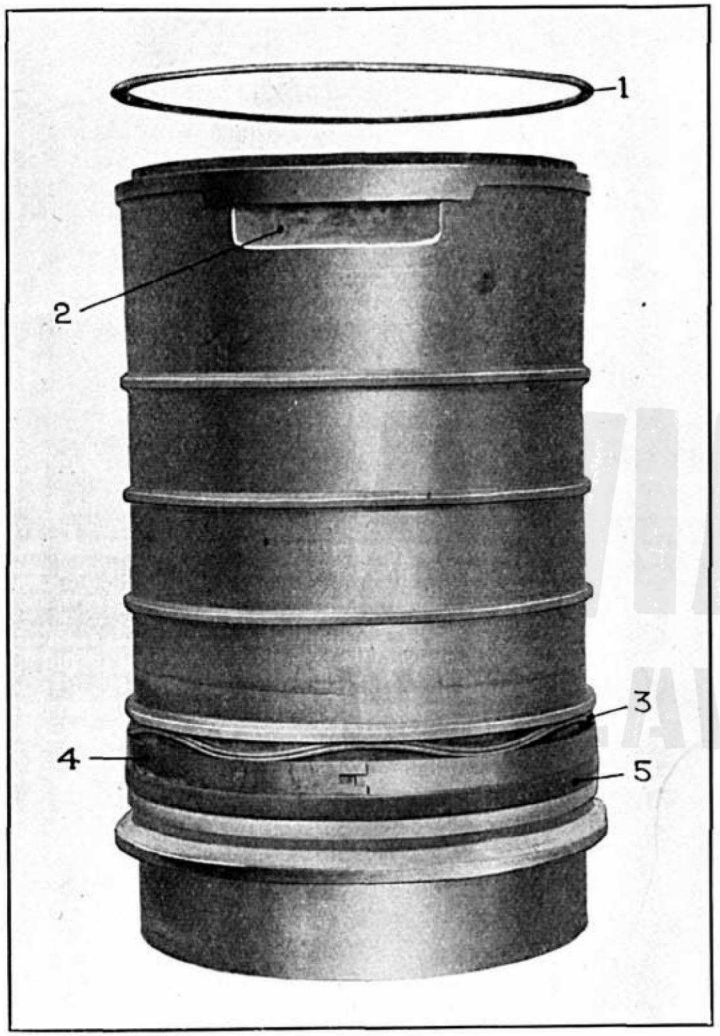



FIG. 3.—Cylinder liner.

1. Head joint ring.
2. Groove for liner clamp.
3. Spring ring.
4. Pressure ring.
5. Rubber sealing gland.



in para. 15. The lower of two grooves a short distance above the joint flange receives the rubber ring which makes the coolant joint with the cylinder block. Above this ring is a split stainless steel distance ring which is pressed downwards by a circular spring, which abuts against a flange formed on the sleeve. As the coolant jackets do not make contact with the crankcase, any leakage from these joints is carried outside the engine. The surface of the liner exposed in the coolant space is heavily nickel plated and provided with three concentric stiffening ribs.

*Cylinder block covers*

21. The covers are secured to their respective cylinder blocks by numerous studs and nuts, a jointing washer being inserted between the two contacting faces. The chief difference between the "A" and "B" block covers is that the latter incorporates the engine-speed indicator drive in its rear end (*see* para. 41) while the former is plain.

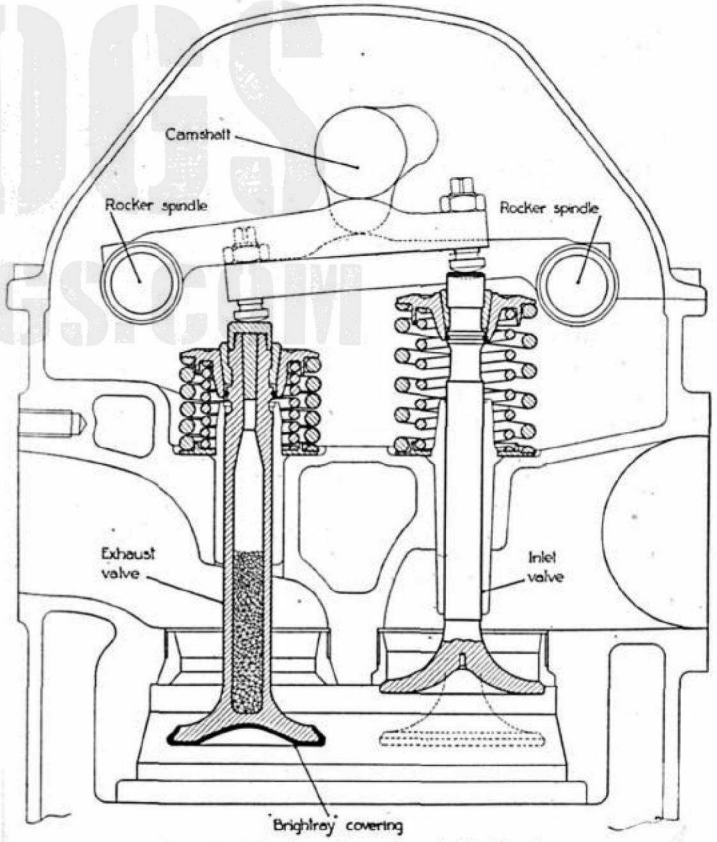



FIG. 4.—Section through cylinder head.

## VALVES.

*Valves and valve springs*

22. The inlet valves are not interchangeable with the exhaust valves. All valves are placed parallel with the centre line of the cylinder block. Both inlet and exhaust valves are of the trumpet type, and have stellited end caps; the inlet valves have solid stems, while the exhaust valves are sodium cooled and have seating faces and crowns surfaced with "Brightray" steel. A groove cut in the upper end of each valve stem provides attachment for a circlip which prevents the valve from falling into the cylinder in the event of spring failure. A pair of concentric coil springs returns each valve to its seat and is anchored to the stem by an upper spring retaining washer and split taper collet in the usual manner. Both top and bottom spring retaining washers are provided with concentric centralizing rings for the inner and outer springs as shown. (*See* figs. 4 and 5.)

*Valve guides*

23. The cast iron inlet valve guides are not interchangeable with the phosphor-bronze exhaust valve guides inasmuch as their shanks are tapered (1 in 20), while those for the exhaust valves are only slightly tapered (1 in 200); also they are smaller in the bore to suit the stem of the inlet valve which is smaller in diameter than the exhaust valve stem. Each guide is pressed into its respective bore in the cylinder block until a conical collar near its top end seats on and is flush with the roof of the cylinder block; the upper surface of the collar forms a flat seat for the base of the lower valve spring washer.

## CAMSHAFT AND ROCKER MECHANISM. CENTRE.

24. A single central camshaft mounted in seven pedestal brackets, which are fixed to the top of each cylinder block, operates both inlet and exhaust valves through rockers fitted with adjustable tappets. The rockers pivot on side shafts supported in arms projecting from each side of the pedestal brackets as shown in fig. 6. The camshafts which are similar for both blocks and rotate at half crankshaft speed in a clockwise direction, when viewed from the rear, are driven from the wheelcase by inclined shafts ending in bevel pinions which mesh with bevel wheels at the rear ends of the camshafts. Spigoted and bolted to each camshaft bevel wheel is a double spur gear which drives the auxiliaries mounted on the rear of the cylinder block. A ball thrust bearing is fitted in front of this bevel wheel to deal with thrust from the drive. Lubrication of the mechanism is effected from the low-pressure system by means of a port in the base seating for the rear pedestal bracket, the oil entering a duct in this bracket and being



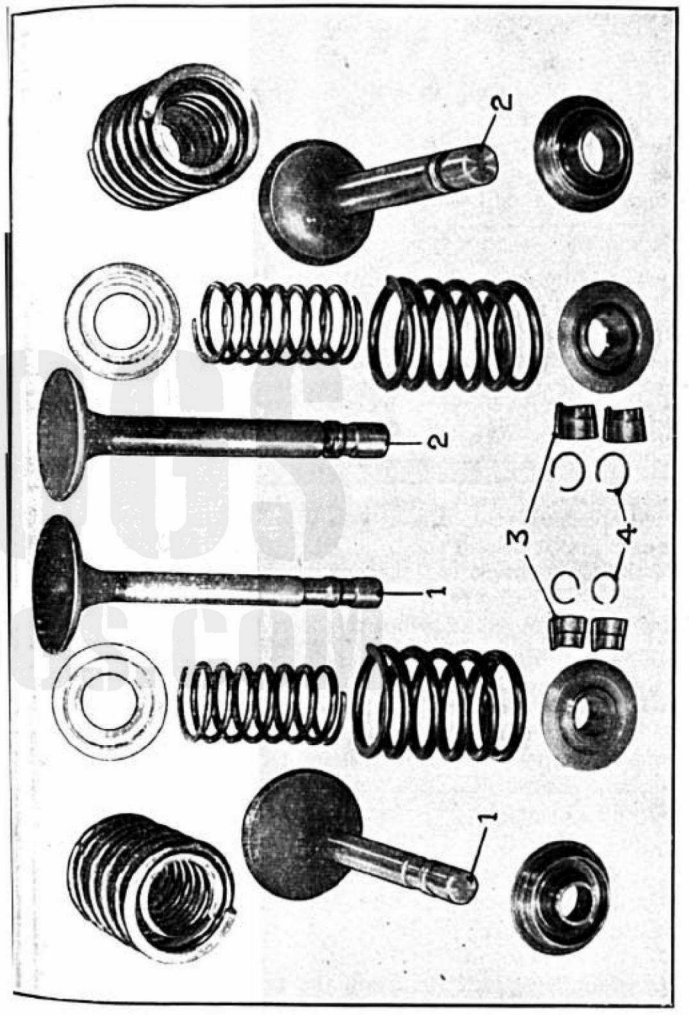



FIG. 5.—Valves and fittings.

1. Inlet valves.
2. Exhaust valves.
3. Valve stem cotters.
4. Valve stem circlips.

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distributed to the hollow camshaft to lubricate the camshaft bearings and to the two hollow side pivot shafts. Oil from these side shafts passes through holes in the rockers and emerges at the line of contact with the cams as shown. The rear end of the camshaft is furnished with a jet from which the oil is delivered to lubricate the bevel and auxiliary drives.

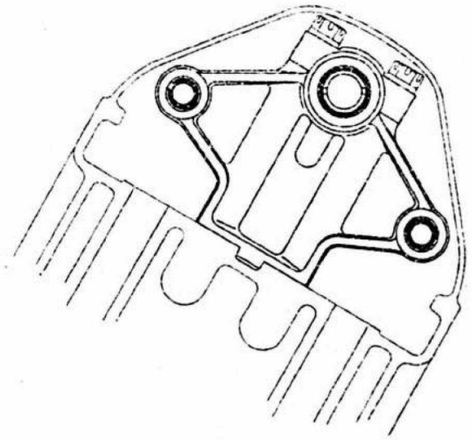
*Camshaft brackets*

25. The pedestal brackets, seven for each cylinder block, are aluminium alloy forgings and are each held to the cylinder head by a pair of studs and split-pinned nuts as shown. Each bracket has a longitudinal tenon in its base which spigots into a slot cut in the facing on the top of the cylinder block. The front brackets are smaller than the remainder and have the arms on the inlet sides offset obliquely forward; the rear brackets although made up from the same forgings are drilled to render them " handed " for the two blocks in order that they may register with the offset oil ports in the base joints. The intermediate brackets are similar for both blocks, but each of the seven brackets must be kept together as issued, as they are jig-reamed as a set. Front and intermediate brackets have the side extensions bored with parallel holes for the rocker pivot shafts; in the rear brackets these holes are taper-bored and keywayed. The rear brackets are drilled as shown. The intermediate and rear brackets are each drilled with four holes for bolts by which the bracket caps are secured; in the case of the front brackets the studs securing these brackets to the cylinder block also serve to retain the caps. With the caps in position the brackets are bored and reamed as a set to take the camshaft bushes. The bushes are keyed against rotation by hollow brass dowels let into taper sockets reamed in the centre of the brackets as shown; in the case of the rear bushes, the rear flanges of the bushes are notched to receive the tongue of a lockplate which is held to the bracket with a countersunk screw. The base flange of the front bracket is chamfered to clear the foremost exhaust valve spring washer.

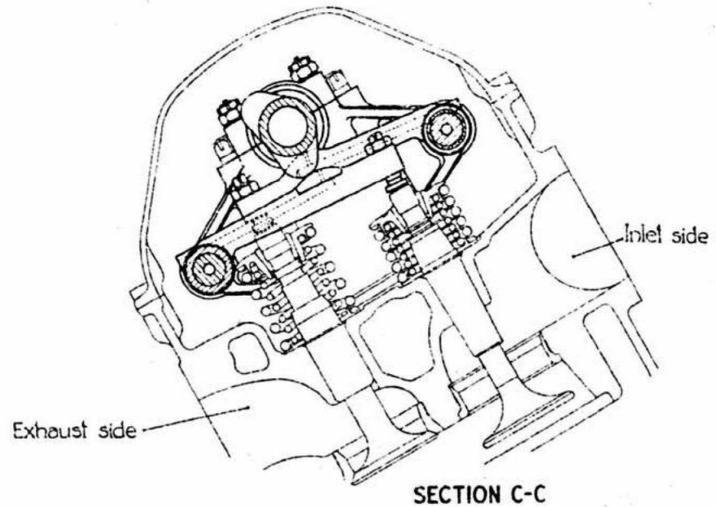
26. The bracket caps, of forged aluminium, have the bosses drilled with two large holes in the case of the front brackets and four smaller holes each in the remaining caps for the holding-down studs. In each of these four-holed caps, two holes which are diagonally opposed to each other in both cap and bracket are reamed to suit two fitting bolts which keep the bore of the bracket and cap in register.

*Camshaft bushes and bevel and auxiliary driving wheels*

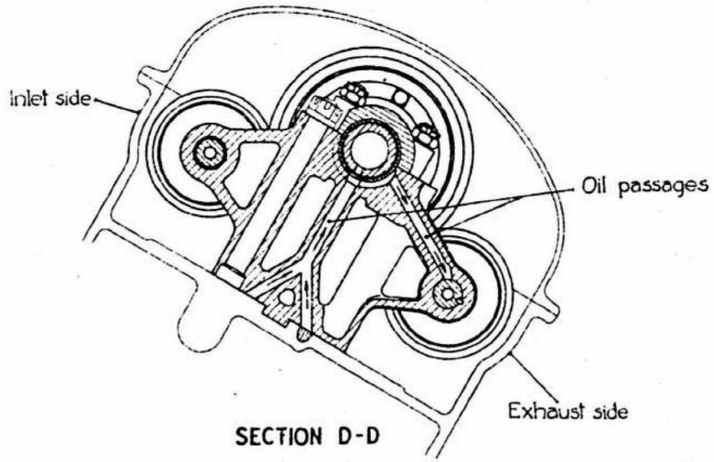
27. The camshaft bushes (*see* fig. 6) are flanged at both ends for location in the pedestal brackets. The rear end bushes have packing washers between their front and rear flanges and a shoulder on the camshaft and the front of the thrust bearing



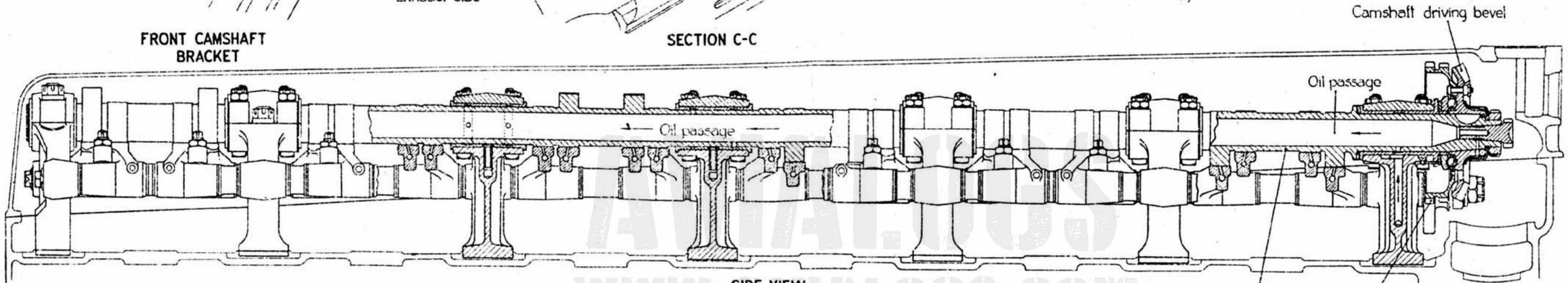
FRONT CAMSHAFT BRACKET



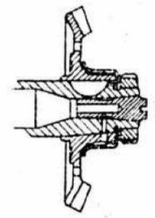

SECTION C-C



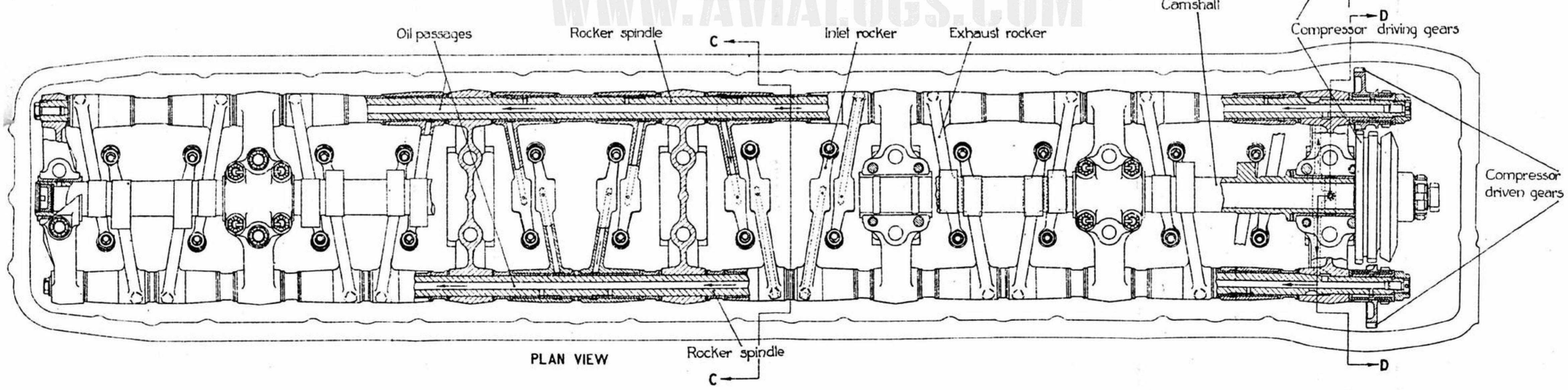

SECTION D-D




SIDE VIEW



REAR END 'A' SIDE CAMSHAFT




PLAN VIEW

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FIG.6. CAMSHAFT AND ROCKER MECHANISM ("B" SIDE)

in sets of four for each cylinder between its pair of pedestal brackets, the inlet cams occupying the two inner positions in each set. Each shaft (*see* fig. 6) is of nickel steel, case-hardened externally throughout except at the tapered rear end and the extreme front end. It is hollow and the bore forms a distributing channel for oil which is fed through radial holes in the camshaft to the various bearing bushes. The front end is counterbored to provide a shoulder against which is pressed a dished sealing washer by the pressure of a plug screwed into the camshaft to bear on the convex side of the washer. This plug is locked axially by a spring ring which is sprung into a groove near the mouth of the camshaft. Three radial slots are machined on the face of the washer extending from the outer edge inwards for about a third of the diameter. The bore at the rear end of the camshaft is tapered for the reception of the threaded shank of either a gear-wheel in the "B" side camshaft for driving the engine-speed indicator, or a sealing plug in the "A" side camshaft. The gear-wheel meshes with the engine-speed indicator drive spur gear. (*See* para. 41.)

31. Externally, the camshaft is tapered at the rear end to receive the bevel wheel and threaded for the retaining nut as already explained. A shoulder formed on the shaft in front of the rear pedestal bracket serves as an abutment face, together with the front face of the bevel wheel and the thrust bearing and various packing washers, by means of which the camshaft is located axially.

*Rocker fulcrum shafts*

32. The rocker fulcrum shafts (*see* fig. 6) are situated on the opposite sides of the block to the valves on which their rockers operate. Both shafts are hollow, the front ends being tapped and countersunk to receive a hexagon-headed screw which acts as a plug. The rear ends are tapered about two inches from the end and each is fitted with a Woodruff key so that the shafts can be drawn up into the taper sockets of the two arms of the rear pedestal bracket. The rear diminished diameter extremity of each shaft projects beyond the bracket to carry the bushes for the auxiliary driven gears, and it is threaded to take an end securing nut by means of which the tapered portion of the shaft is drawn up into the tapered bore of the socket. These nuts are locked by means of small bolts which screw into the rear bore of the shaft and provide an anchorage for a lockpin which passes through aligned holes in both nut and bolt head. Except for these tapered rear ends, the shafts are parallel sided throughout their length so that they can be threaded easily through the parallel holes in the pedestal brackets. The shafts are assembled in the rear brackets with



the keys horizontal and facing outward from the block so that the radial holes drilled to afford passage of oil from the bores of the shafts in way of each bearing bush are horizontal. A flat is formed on the shafts where each of these radial holes emerges, the purpose of which is to distribute oil along the length of the bearing bush.

*Valve rockers, rocker bushes and tappets*

33. The rockers (*see* fig. 6) are of two patterns, which are similar in shape and size, but to different hands. They are nickel-steel forgings with arms set obliquely to the bosses and to the pads which make contact with the cams. The ends remote from the bosses are tapped to receive the tappet screws, by which the clearances between cam bases and pads can be adjusted. The bosses are bored to receive the double bronze bearing bushes which are a press fit from each end in them. A groove formed in the bore of the boss is broken into by a tangential hole drilled along the arm to meet a hole drilled radially to the arc-shaped surface of the pad; the boss end of the hole is plugged at its drill-entry end with a plain plug. The groove and holes are for the passage of oil from the rocker bearings to the bearing surfaces of the rocker pads and cams. The bosses are milled tangentially as shown to clear the adjacent valve springs.

34. Both inlet and exhaust rockers are fitted with two bushes each one of which is plain and the other drilled through with a row of radial holes. Both bushes are flanged, the drilled bushes being fitted in the hub adjacent to the rocker. It will be seen from the illustration that the oil supply to the rockers is fed by a radial hole in the pivot shaft to the gap between the two bushes, and by the flat on the pivot shaft to the row of radial holes in the drilled bush whence by the passage in the rocker it finds its way to the rocker pad.

35. A flanged tubular distance piece of mild steel in conjunction with a washer separates each rocker from its respective adjacent pedestal, while the end clearance between each pair of flanged rocker bushes is reduced as required by means of mild steel washers which are available in varying thicknesses. The tappet screws of nickel steel, have flanged heads with spherical faces for bearing on the stellited valve ends. The top end of each screw is squared for manipulation in adjusting. The body of the screw is screwed into the bottom of the rocker and locked in position by a locknut.

*Upper camshaft drive unit*

36. The upper camshaft drive (*see* fig. 7) comprising a long hollow coupling shaft, a shorter length of hollow shaft, its bearing housing and an oil-tight guard tube, is fitted into the

double socket at the rear of the cylinder block. The long coupling shaft is splined at its bottom end to pick up the drive from the wheelcase, and is also splined at the top end to mesh with and drive the short shaft. These two sets of splines provide a vernier adjustment that is utilized for the purpose of timing the valves. A hardened thrust plug is inserted into the top bore of the long coupling shaft and secured by a taper pin. This plug abuts against a plate secured by two studs to the upper circular distance piece, and locates the shaft. The upper end of the short hollow shaft is formed with a bevel wheel to mesh with the camshaft bevel wheel. This shaft is borne at its top and bottom ends in separate flanged bushes. The upper bush is split and its flange is clamped along with a backlash adjusting washer to a shoulder in the top bearing housing by the circular distance piece mentioned above.

37. The lower housing is bossed suitably at its bottom end for the reception of the flanged lower bush which supports the bottom end of the driving spindle. This bush is pressed into the boss from the bottom of the housing and its flange imprisons a backlash adjusting washer. As will be seen from fig. 7, the short bevel shaft is formed with a broad double collar which forms a working contact for the lower end of the upper bush and the upper end of the lower bush. The two backlash adjusting washers already mentioned therefore have the effect of moving the upper camshaft drive assembly upwards or downwards and the bevel wheel into or out of mesh.

38. A downward extension of the lower bearing housing is bored and tapped to receive the threaded end of a circular sleeve. The latter is locked in position by a tabwasher whose two diametrically opposed tabs engage one of a series of slots cut on a shoulder near the centre of the sleeve and a slot cut on a threaded extension of the sleeve which takes a circular gland housing. Two conical rings in the gland housing contain a hollow gland of V cross-section which is compressed around the upper end of the guard tube by the pressure of a spring imprisoned between the lower ring, which cups the bottom surface of the gland, and an internal lip formed on the lower end of the gland housing. The gland housing is locked by the same tabwasher which secures the above-mentioned circular sleeve.

39. The guard tube consists of a short length of tube held at its top and bottom ends by the friction grip of the two spring-loaded glands. A shallow shoulder near its top end restricts the downward movement of the tube by engaging the internal lip of the gland housing; an internally lipped nut secures the spring-loaded gland in the lower gland housing. Upward movement of the tube is restricted by an internal lip at the bottom

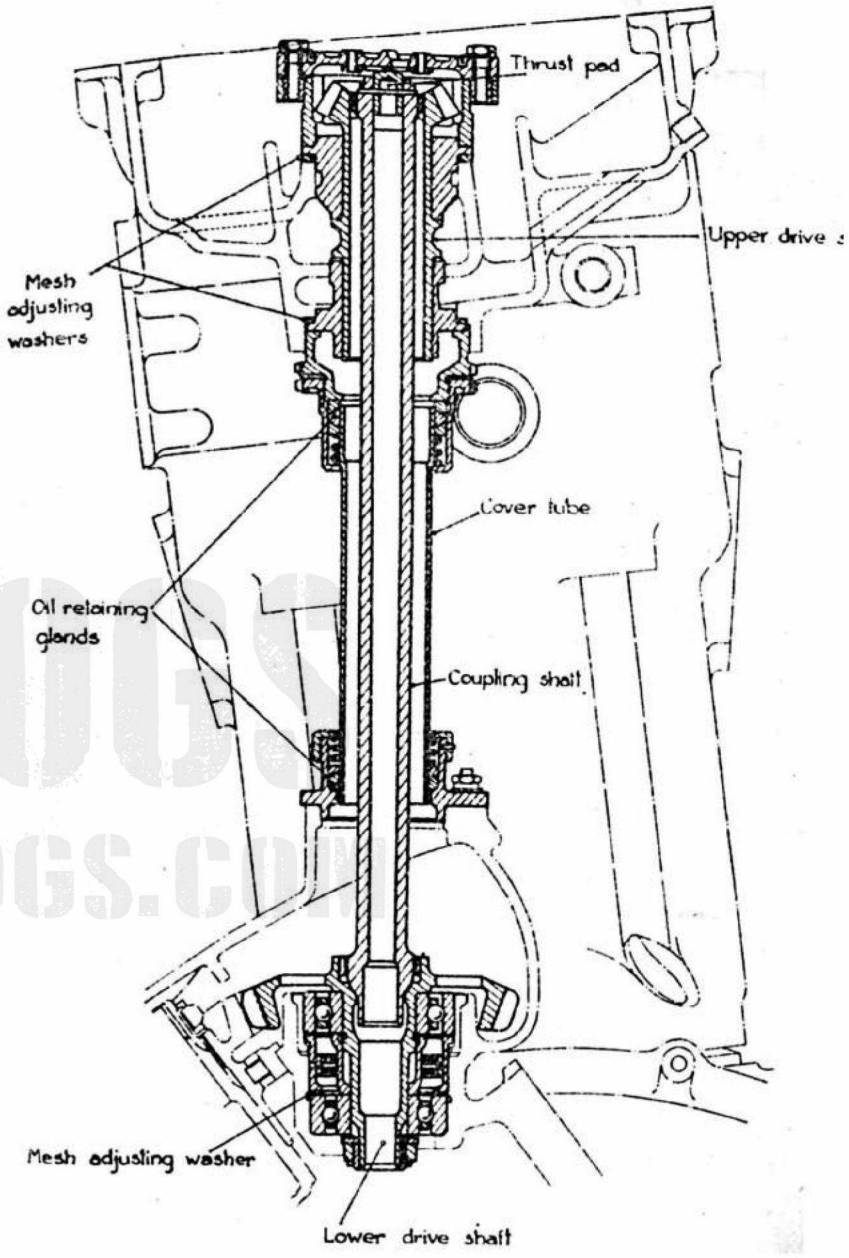



FIG. 7. ARRANGEMENT OF CAMSHAFT DRIVE

P.1210.

of the circular sleeve securing the lower bush mentioned in para. 38. For a description of the lower camshaft drive see para. 137 *et seq.*

40. The guard tube in addition to housing the coupling shaft acts as a conduit for drain oil from the camshaft and rocker mechanism to the wheelcase. A hole in the upper camshaft housing registers with a hole in the cylinder block which drains the oil that has accumulated in the well on the exhaust port side of the socket for the housing. From here this oil passes into the oil-tight guard tube. Low pressure lubrication of the bushes at the upper end of the camshaft driving spindle is effected by a hole drilled transversely

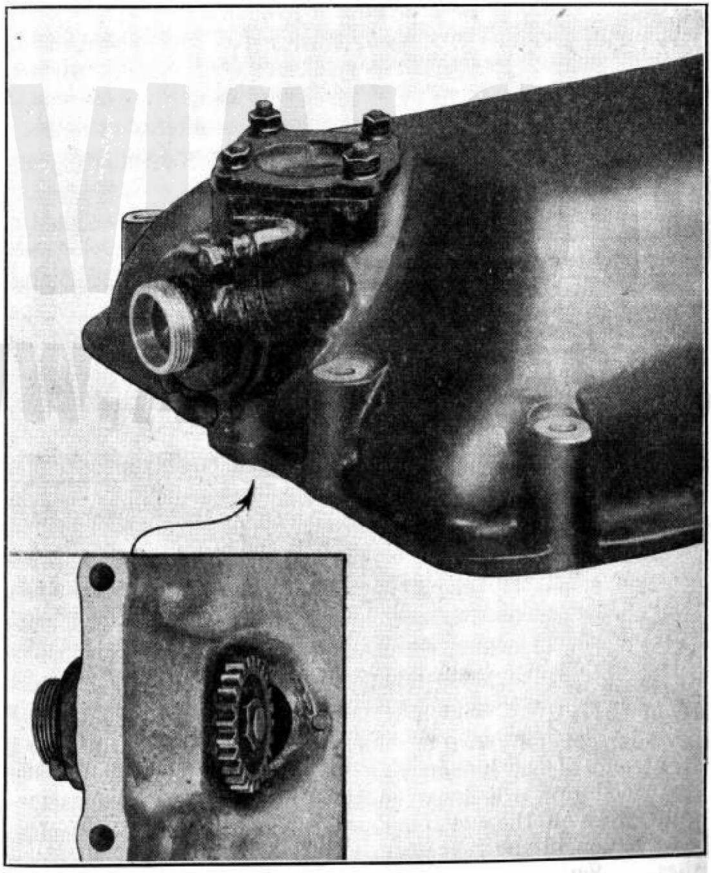


FIG. 8.—Engine-speed indicator drive.

through the boss for the bush and another hole drilled transversely through the bush to meet the former hole. The lower bush is lubricated by the oil passing through the drive casing.

### ENGINE SPEED INDICATOR DRIVE

41. The engine-speed indicator drive (*see* figs. 8 and 9) consists of a hollow layshaft carried in a duralumin bearing housing. A spur gear wheel secured positively to the front end of the layshaft meshes with the pinion at the rear end of the "B" side camshaft. The bore of the shaft is squared to engage the end of the engine-speed indicator flexible drive shaft, the sheath of which is secured by a nut to the threaded rear end of the bearing housing.

42. The bearing housing has a spherical shoulder near its centre which is held up into a hemispherical recess in the "B" side cylinder block cover by a coil spring imprisoned

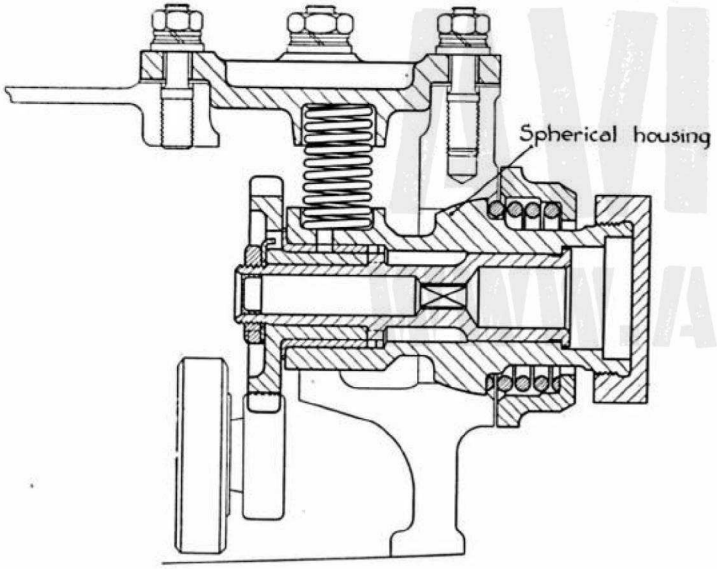



FIG. 9.—Arrangement of engine-speed indicator drive.

by a cover plate which is secured to the rear end of the cylinder cover by two studs and spring-washered nuts. The front end of the housing is squared and is capable of being displaced upwards between the inner faces of two parallel guide lugs in the cover should the teeth of the gear wheel and pinion in the rear end of the "B" side camshaft fail to mesh when the cover is being fitted. A coil spring shown in fig. 9 and secured between the top of the housing shank and



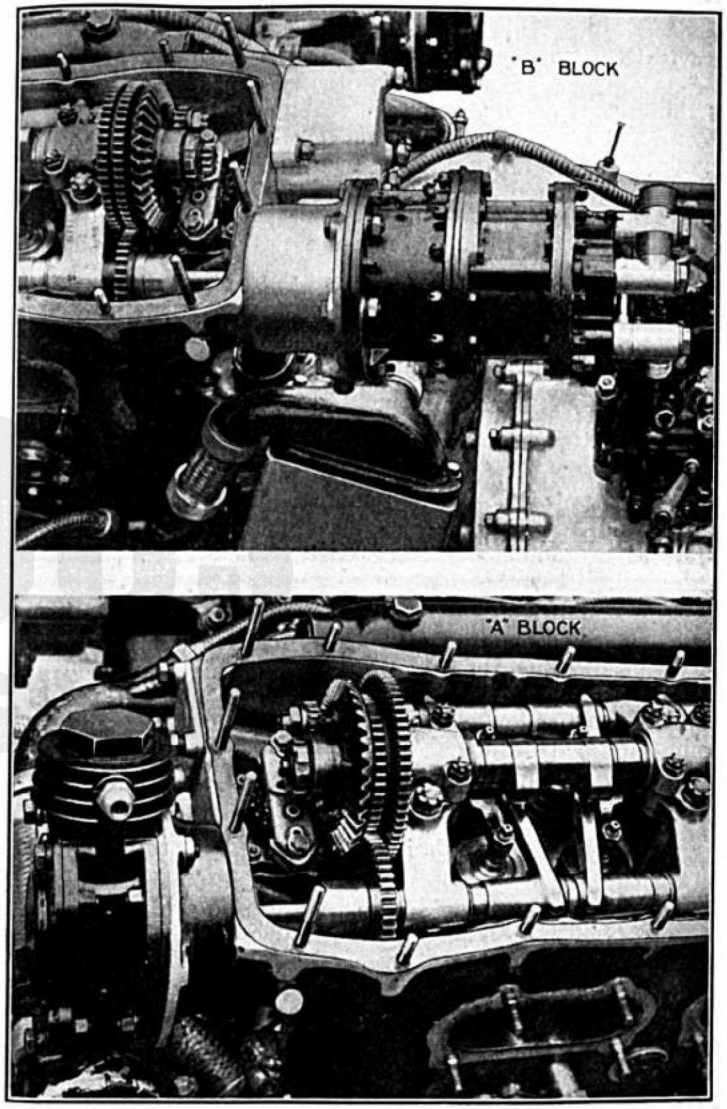



FIG. 10.—R.A.E. (top) and B.T.H. (bottom) compressor drives.

a detachable cover plate on top of the cover normally retains the front end of the housing upon the bridge piece in the cover, in which position the gears are correctly meshed.

43. A bush in the front end of the bearing housing provides the bearing for the shank of the layshaft gear wheel, while the housing itself provides the bearing for the rear end of the layshaft. The layshaft is machined to leave a slotted collar at its centre so as to engage dogs on the rear face of the shank of the gear wheel. The wheel is secured to the shaft by a tab-washered retaining nut. Two co-axial oil transfer holes are drilled in the front of the bearing housing and bush and an oil scroll is machined on the rear end of the layshaft.

**R.A.E. AND B.T.H. COMPRESSION DRIVES**

44. The R.A.E. and B.T.H. compressors, which are mounted respectively on the rear ends of the " B " and " A " cylinder blocks (*see* fig. 10) are each driven from one of the integral gear wheels attached to the camshaft driven bevel wheels mentioned in para. 29 through individual driven or idler gear wheels which are mounted upon the rear extensions of the outer or exhaust side rocker pivot shafts. The inner shafts also provide means for driving further auxiliaries but are not used by these engines; consequently, only one wheel of the double integral spur driving gear mounted on the camshaft bevels is used.

45. Each driven gear is integral with a comparatively long hub which has integral with its rear end a small pinion by means of which the drive to the compressor is transmitted through coupling shafts, which are splined internally at one end for connection with the pinion, and externally for connection with the compressor spindle at the other. A flanged bronze bush is pressed into each end of the hub. A flanged steel sleeve is mounted upon the rear extension of the shaft and serves as a bearing surface for the sleeve bushes; this sleeve is flanged at its rear end and is retained on the shaft by the pin-locked end nut mentioned in para. 32. It is drilled at its centre to align with an internal groove by means of which oil is passed from the hole in the shaft. The driven wheel abuts against a nickel steel washer at its forward end. These driven gear wheels are not interchangeable chiefly because they have specific numbers of teeth to provide for the individual speeds required by the compressors.

**EXHAUST MANIFOLDS**

46. The " A " and " B " exhaust manifolds are similar in design and construction except that they are handed to accommodate their respective positions on the cylinder blocks. They are built up from various sheet steel pressings and welded to form their individual components. Each manifold



is of blister form and is divided into forward, centre and rear sections, all of which are interconnected by tubular push fit extensions. The sliding fit of these interconnections absorb relative movement between the sections due to expansion. Each section has two flanged inlet pipes on its inner side which are secured to their respective outlet ports on the cylinder block by means of four studs and nuts. These pipes are increasingly lengthened from front to rear. A copper asbestos gasket is interposed between each pair of mating faces to form a gas-tight joint.

47. On its outer side, each section has two simple elongated outlet ports which exhaust directly to atmosphere. The outlet ports point downwards and so mask the exhaust flame from the pilot when operating at night. When in position on the installation, the outside half of each manifold protrudes unobtrusively through the contour of the cowling, thus providing an unobstructed outlet for the exhaust gases and a certain amount of cooling effect without marked increase of drag.

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CHAPTER 2

# PISTONS, CONNECTING RODS AND CRANKSHAFT ASSEMBLY

## GENERAL

48. The pistons are attached to the connecting rods by fully floating gudgeon pins. The connecting rods are of the forked and plain type, the forked rod being fitted to the " B " side of the engine. The big-end bearing or bearing block, is made separate from the forked rod, to which it is secured by four bolts. The bearing block is in two parts to enable it to be assembled to the crankshaft, the two parts being held together by the four bolts referred to above. The external surface of the bearing block is provided with a single lead-bronze track for the big-end of the plain rod, which is in two parts secured together by two bolts. The crankshaft is of the normal six-throw balanced type and provides drives for the reduction gear and wheelcase components through a built-up internally toothed flange at its front end and through internal splines at its rear end respectively.

## PISTON AND GUDGEON PIN

49. The pistons (*see* figs. 11 and 12), which are machined from light alloy forgings, are fitted with three compression rings and one grooved scraper ring above the gudgeon-pin axis and one grooved scraper ring at the bottom of the skirt. Segmental portions of the piston wall are inswept in the vicinity

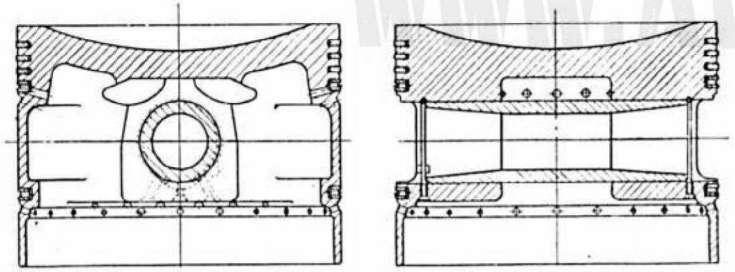


FIG. 11.—Arrangement of piston front view (left) and side view (right).

of the gudgeon-pin bosses which are each supported from the piston crown by a chordal web. The hollow gudgeon pins are of the floating type and are retained by spring wire circlips fitted into grooves in the bosses.

50. The piston crown is dished slightly to a spherical radius on the top side. The exterior of the piston walls is machined taper at the top and relieved eccentrically at the



ends of the gudgeon pin bores. The interior of the piston is cleaned up by milling, as are also the recesses in the exterior surface of the webs supporting the gudgeon-pin bosses. A pair of holes is drilled obliquely upwards and towards the centre to meet in the metal above each gudgeon-pin bore (as shown dotted in fig. 11) to assist in cooling the piston.

51. The grooves for the piston rings are deep and narrow with radiused bottoms and no stops are fitted so that the rings are free to rotate. The bore for the gudgeon pin is grooved to receive the spring steel retaining circlips ; these have plain

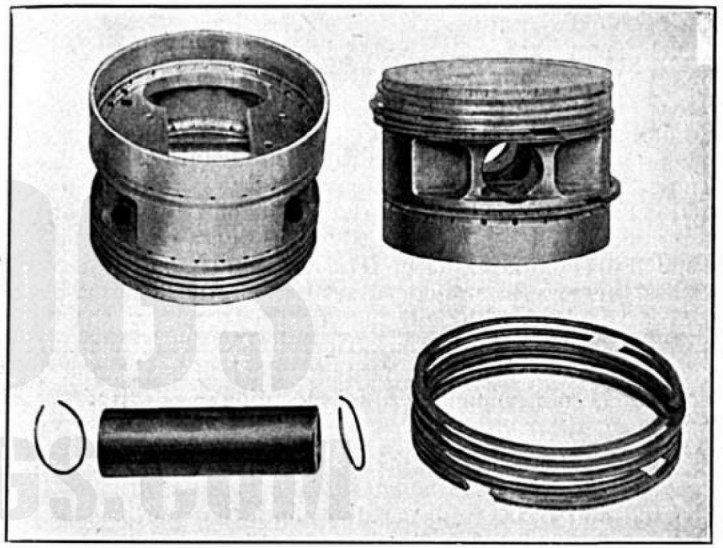


FIG. 12.—Pistons and accessories.

slightly outset ends which, in position, have a gap between them. This gap is filled by a mild steel countersunk headed screw which is screwed into place from the underside of the piston as shown. Cut radially across the groove is a slot by which the spring circlip may be levered out of its groove when necessary. The gudgeon pin is machined to the shape shown and highly polished on the bearing surface. The outer edges at the ends are finished with a concave radius to conform to the surface of the circlips.

52. The groove in the piston skirt for the upper scraper ring is put in communication with the bore of the piston by a series of radial holes drilled through the wall behind the ring as shown. Below the upper scraper ring groove is a shallow

interrupted radiused groove, which also has a series of holes through the piston wall connecting it to the interior of the piston. The groove for the lower scraper ring does not have these holes, but instead has located below it a shallow radiused groove which has a similar series of radial holes. The scraper rings are of the grooved type and have a series of radial holes drilled through them and they have oblique gaps ; the outer edges are chamfered and each ring is fitted with this edge towards the top of the piston. The gaps in these rings are diagonal.

## CONNECTING RODS

*Forked connecting rod*

53. The forked rods operate in the "B" cylinder block bores. Each rod is forged to the shape shown in fig. 13 and bored at the top end to take a floating bronze bush which forms the small-end bearing for the gudgeon pin. The bush has a series of radial oil holes drilled through it at mid-length. The small-end of the rod is grooved in the bore (mid-length) and is drilled through with a radial hole on either side of the top and also at mid-length ; by these holes oil is collected and led to the bearing bush. The lower end is bored centrally across the fork to provide a seating for the bearing block and is provided with four lugs drilled to receive the bolts securing the block to the rod. The top sides are faced into the contour of the rods to form seats for the bolt heads, and flats are formed on the inner sides for reception of the flats on the bolt heads described below.

54. The four bolts which secure the forked rod to the bearing block are of nickel steel and are a light drive fit into the rod and bearing blocks, the non-fitting portions of the length being waisted. The central fitting portion is tapered at the lower end to give it a lead into its socket in the bearing blocks. The heads are round on the external side and square on the internal side ; this square abuts against the corresponding square portion on the forked rod and prevents turning of the bolt when the nuts are being tightened up. The bolts are drawn up by nuts which are slotted across the corners instead of across the flats to receive closely fitting split-pins.

*Bearing block*

55. The two portions of the split bearing block are shown in fig. 13. The shape and extent of their lead-bronze bearing surfaces are clearly shown as is also the position of the radial holes through the block and the groove in the exterior lining. This latter groove links up the holes as shown and these form the oilways which are fed from the crankpin. The lower bearing block is provided with two strengthening ribs between



each pair of bolt holes, as is shown, and is machined with four lugs drilled to register with the bolt holes of the upper bearing block and faced to form seats for the bolt nuts.

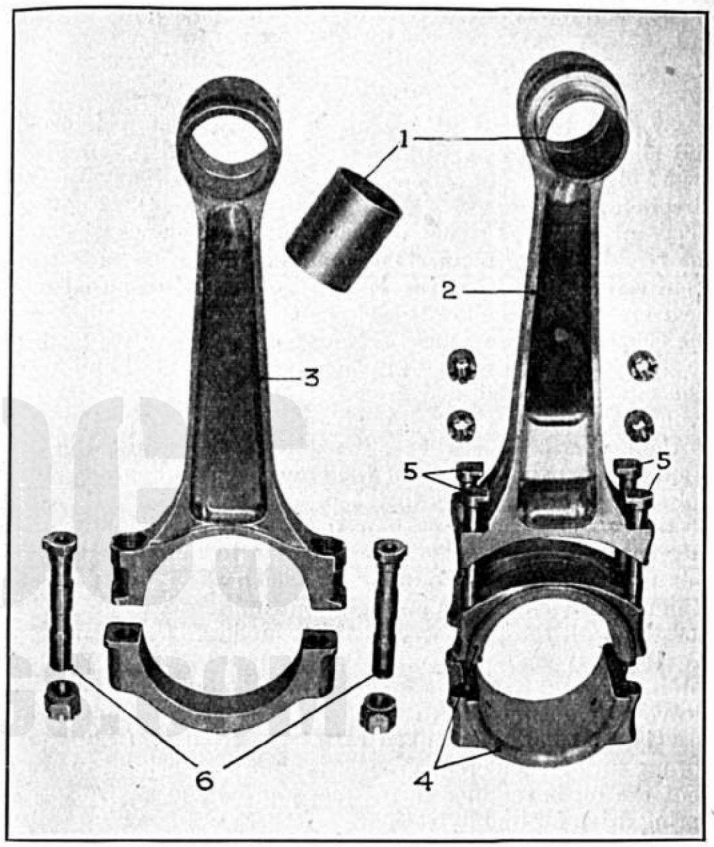



FIG. 13.—Connecting rods.

1. Floating gudgeon-pin bush.
2. Forked connecting rod.
3. Plain connecting rod.
4. Split bearing block.
5. Forked connecting rod bolts.
6. Plain connecting rod bolts.

*Plain connecting rod*

56. The plain rods operate in the "A" cylinder block bores. The plain rod is similar to the forked rod at the small-end and is fitted with a similar type of bush. The big-end is split diametrically to embrace the external surface of the bearing block, and the cap is held to the rod by two bolts as shown. These bolts are similar in pattern to those used in the forked

rod except that they are larger in diameter and have a key slot for the bolt head snug in the rod cut in the outer side instead of the flat side. Nuts slotted across the flats in normal manner and tight-fitting split-pins are fitted to the bolts. The bore of the plain rod is ungrooved but is chamfered slightly at each end.

### CRANKSHAFT

**57.** The balanced hollow crankshaft has seven journals and six throws. The throws are paired 1 and 6, 2 and 5, 3 and 4 in three directions 120° apart respectively in the direction of rotation of the crankshaft (*see* fig. 14). Eight of the crankwebs are extended to carry integral balance weights; the remainder are plain. The crankpins are numbered consecutively 1 to 6 from the forward end. Each journal and each crankpin is hollow; each bore, with the exception of the central and rear journals, are sealed by a pair of conical faced discs which are held in place by an axial stud and nuts. The chambers so formed are reservoirs for oil which is fed from the main bearings through radial holes in the journals to the hollow centres whence it passes by holes drilled in the crankwebs to the interior of the crankpins, and so by radial holes through these pins to the bearing surfaces for the connecting rods. The crankshaft has a flanged coupling with internal splineways, spigoted and bolted to the forward end; this meshes with the coupling by which the reduction gear pinion is driven. Valve and ignition timing marks are incorporated with the periphery of this coupling. (*See* para. 65.) At the rear end, the crankshaft journal bore is splined internally and counterbored to accommodate a coupling sleeve to transmit the drive to the spring drive unit; this rear journal bore is blanked off at the front end by a disc sprung into an undercut groove, the purpose being to ensure that the oil is retained in the rear journal and passed to the spring drive for its lubrication.

**58.** The extreme forward end of the shaft is shaped as a flange with a stout conical web. The outer edge is chamfered and the face is drilled for twelve bolts by which the reduction gear pinion driving flange is attached. These holes are equally spaced except for one, which is 2½° out of line with No. 1 crank, to facilitate correct alignment of the timing marks in relation to the crank throws. The flange has two flat faces on its forward side, the outer one for the driving flange abovementioned, and the inner one to act as a seating for a blanking disc which seals the forward end of the journal bore. The bore is formed with a step at the rear end in the plane of its adjacent web, which is chamfered where the bore opens into the crankpin way. This step and chamfer form the spigot



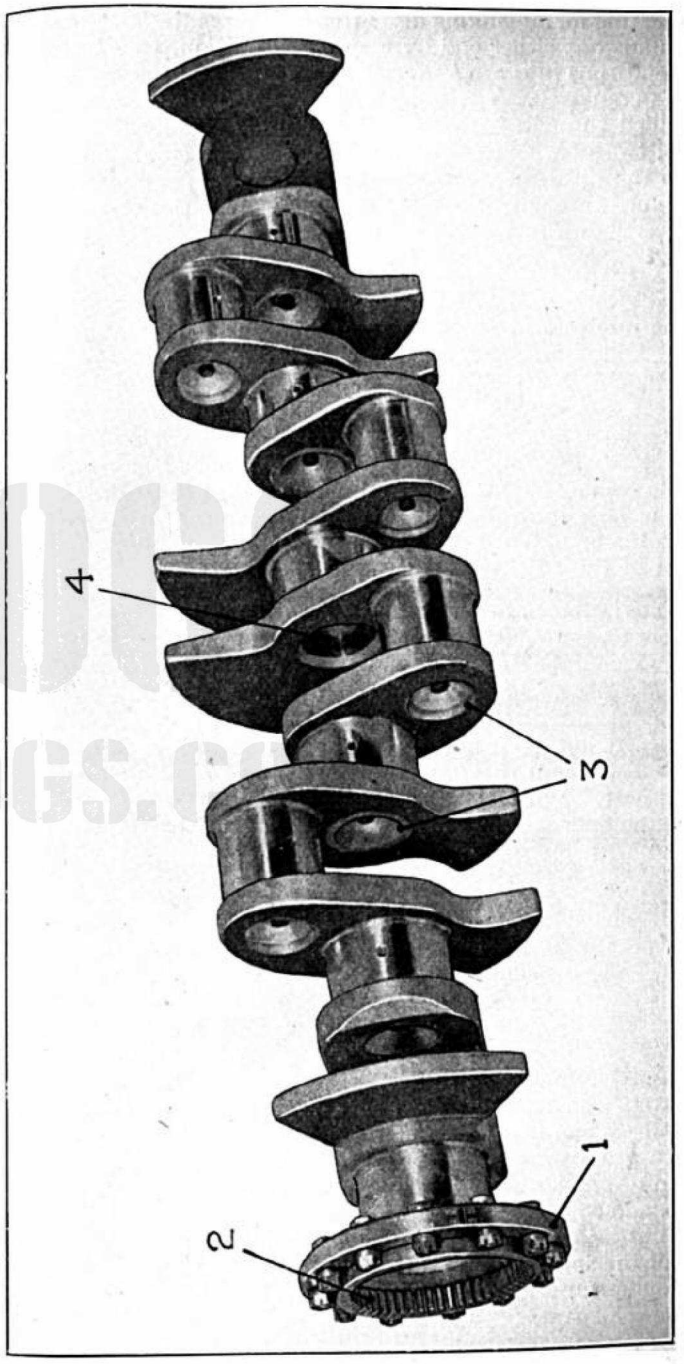



FIG. 14.—Crankshaft.

1. Timing marks.
2. Coupling flange.
3. Journal and crankpin end caps.
4. Open journal bore.

and seating for a blanking disc fitted at this point. The journal is bounded at either end by a radiused portion, which at the rear end runs into a boss formed as a facing on the front side of the crankweb. The journal bearing surface at mid-length is drilled through to the bore with three equally spaced oil holes, two of which are perpendicular to the crankshaft axis while the third, in the plane of the crankweb, is oblique and continued through the web to communicate with the crankpin bore as shown in fig. 56.

59. Eight of the crankwebs are extended beyond the journals to the opposite sides of their respective crankpins in the interests of accurate balancing. The webs are bored and counterbored on the shaft and pin axes to take the spigots and seats of the blanking discs, and the bearing surfaces are bounded by radii which run into facing bosses formed on the crankwebs. Each crankpin is drilled through radially to the bore at mid-length, the hole being started on the leading side of the crankpin as shown in fig. 56. The oblique hole by which oil from the respective journal bore is led to the crankpin bore, pierces the latter in the bore for the spigot of the adjacent blanking disc.

60. The bores of the intermediate journals are restricted slightly at the ends, and chamfered to form spigot and face seatings for the blanking discs by which they are sealed. The bore of the centre journal is formed in a similar manner but, as already mentioned, is not fitted with blanking discs. The centre journal is furnished with wide facings, as these have to deal with any thrust loads which may be imposed on the crankshaft. With the exception of the front, central and rear, the journals are drilled with two radial holes equally spaced with one oblique hole to the crankweb immediately behind.

61. The rear journal, which has its forward end bounded by a crankweb, has its plain exterior and interior surfaces finished off by slight chamfers at the rear end. The bore of this journal differs in arrangement from those of the other journals. The forward portion of the bore has longitudinal splineways cut in it to couple it, *via* the driving bush, to the spring drive inner shaft ; a master spline in line with No. 6 crankpin ensures correct positioning of this bush. The splined portion is counterbored at the front end and undercut with a groove into which a circular disc is pressed to act as a stop to prevent forward movement of the spring drive inner shaft, and as a seal to ensure that oil from the rear journal does not escape into the crankcase, but is used for the lubrication of the spring drive unit. This disc is circular and dished to a spherical radius before insertion into the grooved recess.



The rear end of the bore is counterbored to receive a flanged driving bush, which forms the coupling for the spring drive unit. This bush is a push fit in the crankshaft up to the full depth allowed by the stop flange at the rear end. Splines cut in its front end engage with those cut in the crankshaft bore. It is of nickel steel and is retained by a dowel which is inserted from the bore. An annular space is formed by it and the centre counterbore in the shaft which aligns with three equally spaced radial holes which are drilled through to the bore. The annular space lies in the plane of three equally spaced holes which pierce the rear journal radially and convey oil from the rear main bearing to the bore of the bush.

62. The blanking discs for all the crankpins are similar, each being in the form of a hollow frustum with a narrow flange mid-way along the exterior surface. The edges of these flanges form spigots which fit the crankpin bore, and the surface of the cone at the larger end forms the seat which beds in the conical seating of the crankweb. The disc is bored axially for the securing stud, which carries a washer and split-pinned nut. The stud which is waisted and shouldered as shown, has a plain nut riveted in place at one end and a pair of holes at right angles to each other but in different planes at the other end, so as to provide greater range of adjustment for the split-pin with a correspondingly smaller danger of buckling the blanking pieces when drawing up the stud.

63. The blanking discs for the intermediate journal bores are similar in pattern to those described above, which are used in the crankpin bores, except that they are larger and have a second spigot flange. These spigots are deeply grooved at mid-length and the inner flanges so formed have a series of semi-circular slots cut through to ensure that passage of oil from the crankshaft to the crankpin will not be blocked. The blanking disc for the front journal is of a different type. The one fitted at the rear end of the front journal is of similar pattern to that used in the intermediate journals, whilst that fitted in the front end is of thimble shape and has a flat seat as shown in the sectional view (fig. 66).

64. The flanged coupling, of case-hardened nickel steel, has a recessed face into which the flange at the forward end of the crankshaft spigots, and which is drilled to receive the bolts by which the coupling and crankshaft are held together ; the bolt holes in both components are reamed together to accept, with a push fit, the bolts which transmit the drive. The bore of the coupling flange is serrated to take the coupling shaft by which the driving pinion of the reduction gear is driven. The coupling bolts, which have flanged heads to fit against the rear face of the crankshaft flange, are secured by flanged split-pinned nuts.

*Timing ring and pointer plate*

65. The timing marks (*see* fig. 15) engraved upon the outer periphery of the coupling flange spigoted and bolted to the front end of the crankshaft comprise the following in clockwise sequence :—

| *Cylinder.* | *Markings.* | *Timing.* |
|---|---|---|
| B1 | MA | Magneto advance. |
| B1 | IO | Inlet open. |
| A6 | EC | Exhaust closed. |
| A6 | TDC | Top dead centre. |
| A6 | MA | Magneto advance. |
| A6 | IO | Inlet open. |
| B1 | IC | Inlet closed. |
| B1 | BDC | Bottom dead centre. |
| A6 | IC | Inlet closed. |
| A6 | BDC | Bottom dead centre. |
| A6 | EO | Exhaust open. |
| B1 | EC | Exhaust closed. |
| B1 | TDC | Top dead centre. |

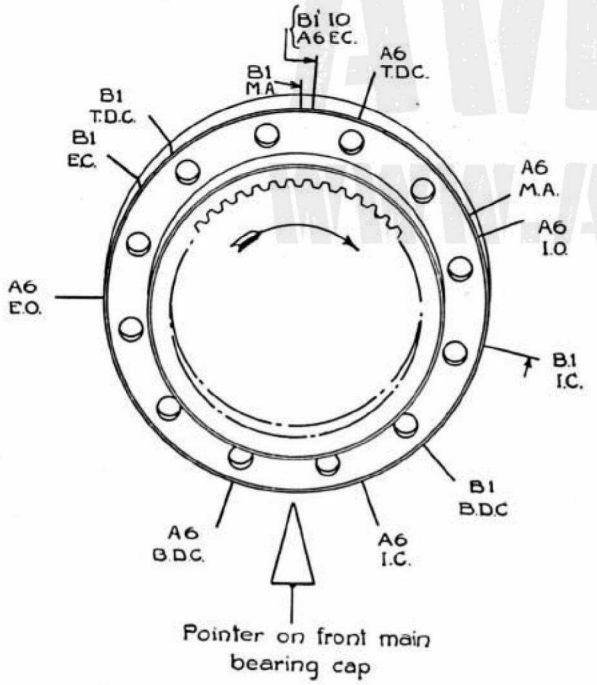



FIG. 15.—Crankshaft timing disc.



It will be observed that the timing operations are carried out solely with cylinders Nos. 1 and 6 of the "B" and "A" blocks respectively. During timing, the mark under consideration is aligned with a flat pointer attached to the front main bearing cap by means of two studs and nuts. The marks are visible through the inspection aperture located in the front end of the crankcase bottom half casting. With reference to fig. 15, it should be realized that the various timing marks shown are spread over a total rotation of 720°, i.e. two complete crankshaft revolutions; therefore, whichever particular mark is chosen as a datum, the sequence of the remaining marks should be considered individually since they will not necessarily follow in rotational order.

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# CHAPTER 3

## CRANKCASE ASSEMBLY

### GENERAL

66. The crankcase, which is in two portions bolted together, incorporates the rear half of the reduction gear housing at its front end and has a facing and spigot at the rear end to which is attached the wheelcase. The upper portion is of pentagonal cross-section, its two top faces being inclined to the horizontal at 30°, and each bored with six spigot sockets axially perpendicular to the faces to take the cylinder liners of each cylinder block ; the centre planes of the blocks are inclined to each other at 60°. The four engine feet, by which the engine is supported, are faced horizontally on the same plane as the crankshaft axis at the ends of box-formed arms which protrude one from each corner of the casting. The ends of the upper portion form webs across the casting, and five similar transverse webs span the interior and divide it into six compartments into each of which project two cylinders. The webs are bossed and bored above the crankshaft axis to take the bearing shells and beneath the axis rectangular studded housings are machined ; these take the bearing caps which, in addition to being drawn vertically upwards to hold the bearings, are each threaded by a pair of transverse bolts which emerge at both sides of the casting. The caps thus act as distance pieces across the mouths of each of the webs, and the bolts serve to stay these apertures and give support against lateral impulses of the crankshaft due to the inclinations of the cylinder blocks.

67. The lower portion of the crankcase forms a sump for oil and is drained by the scavenge pumps housed side by side on the depressed floor at the rear end of the casting. Two detachable filters are also fitted in this portion of the crankcase ; the forward filter casing has a pipe leading to the forward end of the casting to scavenge the front end, whilst the rear filter is in the scavenge circuit for the rear portion of the sump. The pressure oil pump is mounted beneath the rear scavenge pump on an external facing on the underside of the sump. The triple relief valves unit and the electric generator support bracket are mounted on facings on the right and left-hand sides of the crankcase respectively.

### UPPER PORTION OF CRANKCASE

68. The upper portion of the crankcase is an aluminium alloy casting of the shape shown in fig. 16. The forward end is extended outwards to form the rear half of the reduction



gear casing ; this is faced concentrically with the airscrew shaft axis to match up with the facing and spigot of the reduction gear casing. Four studs, anchored two in each side of the crankcase, are used, together with a series of bolts, to secure the two components together. The studs each have a collar which seats in a recess bored in the boss into which the stud is screwed and they are waisted ; the pair which are on the starboard side and are longer, have each a collar in the plane of the joint faces between the front and rear portions of the reduction gear casing.

69. Incorporated within the rear half of the reduction gear casing and integral with the crankcase are two separate and superimposed bearing housings contained in an inner transverse wall which is stiffened by means of radial ribs. The lower one is concentric with the crankshaft axis and houses the outer rear race of the reduction gear driving pinions, while the upper one is concentric with the airscrew shaft and houses the outer rear race of the airscrew shaft. Both housings have steel liners pressed into them and the races are retained by six clamps secured by studs and nuts. A second smaller blind housing having a broad face is machined in the crankcase casting immediately behind and concentrically with the airscrew shaft bearing housing ; this housing contains a spherically mounted oil gland which connects the high pressure airscrew pitch operating oil supply to the central tube in the airscrew shaft and is secured by means of studs and nuts. The rear end of this gland is fed with oil through a drilled passage in the crankcase which rises to the hollow boss on top of the rear cover into which is screwed the union connecting with the external pipe from the airscrew pitch operating valve in the relief valve body.

70. Attached to a face at the top rear side of the reduction gear cover by means of two waisted bolts and nuts, is the steel front slinging eye ; the eye has a flange which seats on the face on the outside of the casting. A boss on the right-hand side of the rear reduction gear case receives an oil jet which is connected externally to the front low pressure oil union on the relief valves body. Interconnection is made between this jet and a second jet screwed into the reduction gear front cover (*see* para. 92), and both jets direct oil upon the reduction gears. A breather is spigoted into a large diagonally positioned hollow boss on the exterior of the rear casing and retained by studs passing through a flange formed on its body. The breather body is a simple sleeve closed at the outer end and containing baffles in its bore. The lower end of the sleeve connects with the interior of the reduction gear case, while the upper end is closed and has a series of holes in it to permit breathing to atmosphere. A dished end cover is secured to

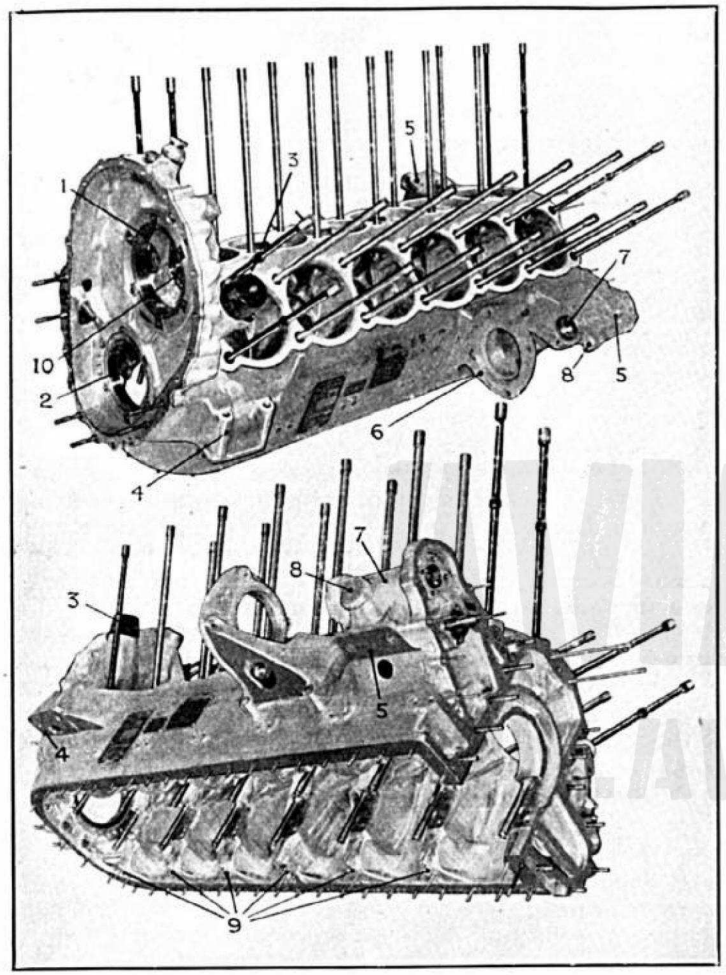



FIG. 16.—Crankcase, upper portion.

1. Airscrew shaft rear bearing housing.
2. Crankshaft front bearing housing.
3. Crankcase breather.
4. Front mounting foot.
5. Rear mounting foot.
6. Electric generator mounting bracket.
7. Electric generator drive shaft housing.
8. Slinging lug.
9. Facings for oil gallery.
10. Spherical oil seal.



the closed top end of the breather for the purpose of partially masking the breather holes and preventing undue dissemination of oil mist.

71. The top flanges of the crankcase are machined with inclined faces and bored to receive respectively the liner flanges and spigots of each cylinder block. The bores differ in diameter so that No. 3 cylinder spigot has a closer fit than the others. The cylinder block can thus expand endwise from No. 3 socket relative to the crankcase; No. 6 socket limits rotation of the block about No. 3 as axis, as it has a small clearance on an axis at right angles to the longitudinal one. Each bore is chamfered at its outer edge to receive the rubber joint ring around each cylinder liner spigot. Each facing for the cylinder block is drilled and tapped to receive fourteen studs; the four end ones have central collars and cap nuts whilst the others are plain and are provided with bridge pieces and open-ended nuts.

72. The cap nuts for the front and rear studs prevent oil from the camshaft covers escaping past the threads and down the studs to the outside of the engine. Each stud has a collar at the lower end which seats on a facing recessed into the crankcase facings. The recesses for the intermediate studs are counterbored to provide an annular space around the cylinder block guard tube ferrule into which spigots the rubber sleeve which forms an oil seal between the ferrule exterior and the crankcase. The annular space receives the oil which drains down the cylinder block guard tube from the camshaft casing. A hole drilled from the crankcase into this annular space forms a drain for the oil received from the crankshaft casing. Another hole is drilled from the crankcase into the lower end of each cylinder stud socket to release air which would be trapped and compressed when the stud was screwed into position.

73. The rear end of the crankcase has a part annular spigot concentric with the crankshaft axis upon which is centralized the wheelcase. In addition, there is an irregular composite face which mates with a similar face on the front of the wheelcase; this is in the form of a central rectangular face with rectangular extensions to right and left which are for the turning gear and generator drive casings respectively. Two oil return holes are incorporated in the lower edge (in the lower half of the crankcase) of the central facing for the purpose of returning oil to the crankcase from the wheelcase. The former is held to the latter by means of several studs and bolts, a paper gasket being used to form an oil-tight joint.

74. Immediately over the generator drive casing is a studded face with a hole in its centre for the reception of the

low pressure pipe extension provided for the lubrication of the generator drive. The hole in the facing connects with a long transverse passage drilled in the casing, and through this passage oil is taken to the idler and driving spindle bearing housings. A hole in the facing takes a proportion of this oil to a corresponding passage drilled in the wheelcase casting to other bearing housings in this component.

75. On the left-hand side of the crankcase is a rectangular facing with two horizontal tenon slots for the reception of the right-angled generator bracket casting, which is secured to it by means of four studs and nuts. Hollow horizontal bosses are formed integral with the rear mounting feet. The right-hand boss is pierced to permit the passage of the link-rod that actuates the airscrew pitch control valve; the rear end of the link-rod is hinged to an intermediate lever, the bracket of which is secured to a facing on the rear of the crankcase. The left-hand boss is a housing for the generator driving shaft and its bearings. A slinging lug is also formed on each of the rear mounting feet. On the right-hand side of the crankcase is a facing for the attachment of the relief valves body. Holes in the mating faces permit the passage of main pressure oil through the passages in the central crankcase web to the main bearing oil gallery (*see* para. 83) and the return of surplus low pressure oil from the body to the crankcase.

76. The engine feet are each bored vertically for two holding-down bolts; all the feet are faced horizontally on upper and lower sides. The front feet are bored with limited clearance for the bolts and thereby locate the engine on its mounting; the rear feet bolt holes have more ample clearance and so allow for longitudinal expansion of the engine relative to the bearers. Between the engine bearers and each engine foot is placed a packing strip, those under the front feet being of Ferodo and those under the rear feet being of hard rubber. The rear feet are also each surmounted with a further rubber packing strip and an aluminium alloy top plate. All these plates are drilled for the holding-down bolts. These are pulled down tightly for the front feet, but only moderately so for the rear feet, thus permitting longitudinal expansion of the engine.

77. The studs screwed vertically into the front rectangular bearing housing are of two varieties; one type, which is fitted to the starboard housings, has a deeper central shoulder than the type fitted to the remaining housings. The shoulders on the studs of the former type fit closely in the holes of their bearing caps while those on studs of the latter type fit their holes with considerable clearance. The remaining studs are also of two types; the right-hand ones have close



fitting shoulders which position the bearing caps, while the left-hand ones are plain. Each stud is fitted at its bottom end with a split-pinned nut.

78. The bosses formed on both sides of the crankcase near the joint face are drilled through horizontally across the bore of the crankcase to leave seven pairs of holes which house the fourteen bolts which pass through the main bearing caps to provide additional support. The bolts are passed through the crankcase from the starboard side, plain washers being inserted between the heads of each and the case. They are drawn up to the case by split-pinned nuts and plain washers on the port side of the case. These transverse stay bolts should be only lightly tightened after the vertical studs have been fully tightened; it will be appreciated that as the bolts are almost tangential to the crowns of the bearing caps any excessive pressure would draw the horns of the bearing caps inwards and so distort the bearing shells.

79. Three brass plates are attached by screws to the left side of the crankcase. The first is the engine data plate, the second gives the order of firing of the cylinders, and the third lists the patents embodied in the engine.

80. Studs are screwed up into the lower joint face of the upper portion of the crankcase to provide the means of attachment thereto for the lower portion, a vellumoid jointing washer being used between the joint faces of the two portions. Four of the stud sockets are deeply recessed, and with the lower half of the crankcase in position, are taper-reamed for the reception of flanged locating dowels.

*Bearing caps*

81. The bearing caps are arch-shaped aluminium alloy forgings whose side and top faces are machined and bedded to push fit into the rectangular housings in the crankcase webs. Each cap is drilled vertically for the two securing studs, the "A" side stud hole being counterbored to fit closely a collar on the "A" side stud; this feature ensures that the cap will be fitted the same way each time it is assembled and also serves to locate the cap endwise. The cap is also drilled vertically in the centre, counterbored and tapped at the lower end to receive an extractor screw, and reamed taper at the inner end to accept the dowel by which the bearing shells are prevented from rotating. These dowels are tapered externally from the socketing end, the other end being machined spherically and having two segmental portions cut away from opposite sides to leave the key portion which fits the slot in the bearing bush. The dowels are bored out axially, the outer ends being tapped to facilitate withdrawal when necessary. The caps,

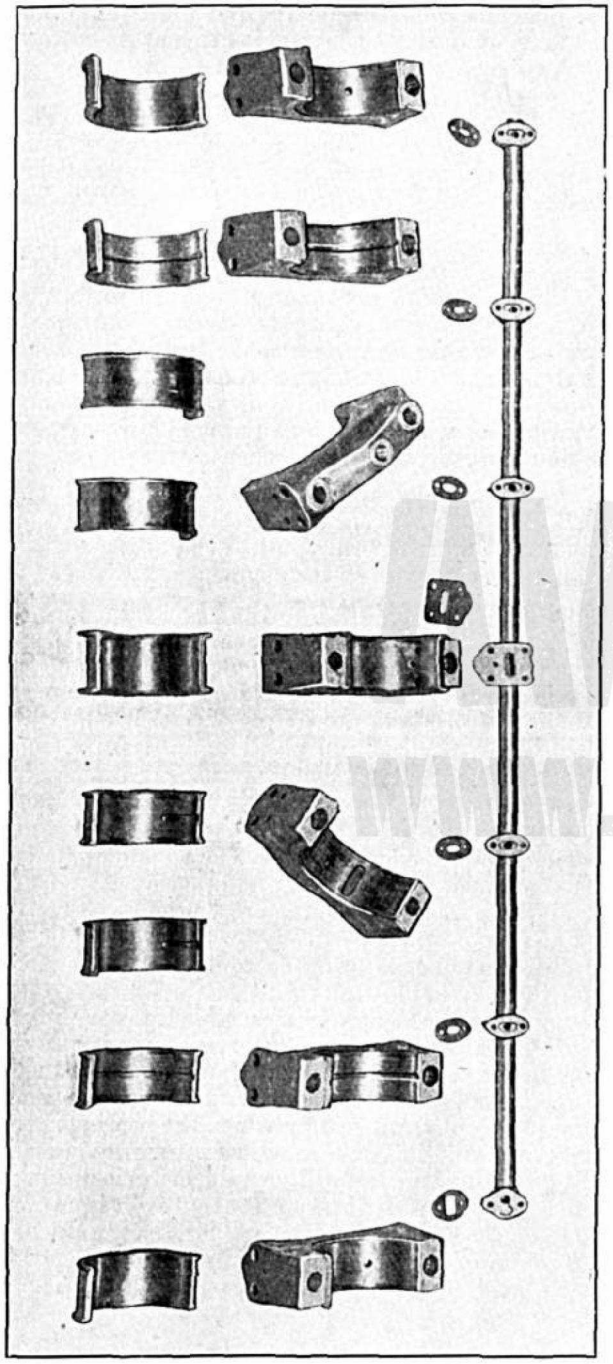


FIG. 17.—Main bearing caps, shells and oil gallery.



after being fitted into the crankcase, are bored and faced with the half-housings integral with the crankcase at one setting to take the bearing shells. Finally the cap is grooved and a pair of oblique holes is drilled to meet the oil inlet hole in the crankcase web and thus forming the necessary ducts for the passage of oil as shown in fig. 56. Two horizontal transverse holes are drilled through each bearing cap to clear the lateral bolts by which the crankcase is stiffened. A difference is noticeable between the cap for the centre bearing and those for the other bearings; the fore-and-aft faces of the former are plain whilst those of the latter are recessed to take the flanges of the bearing bushes and are of less width apart.

*Crankshaft bearings*

82. The crankshaft bearings (*see* fig. 17) are semi-circular flanged steel shells lined internally with lead-bronze, and fitted in pairs—upper and lower halves—in the housings formed by the crankcase and the bearing caps. Regarding them from the front end, bearings Nos. 1, 4 and 7 are not grooved, Nos. 3 and 5 have short grooves on each side, and Nos. 2 and 6 have complete single annular grooves. Two holes in each lower half are fed with oil from grooves in the cap, which are themselves connected by a horizontal hole in the cap with the main pressure supply passage in the crankcase casting. The centre bush is wider than the others and has deeper flanges which are faced with lead-bronze to deal with the crankshaft thrust.

*Main bearing oil gallery*

83. This is a pipe of light alloy tubing and acts as a distributor for the main pressure oil, which it receives through a central elongated slot from the two vertical passages drilled in the central crankcase web. The lower face of the central crankcase web has a slot cut in it for the purpose of leading the oil to the vertical supply passage in the web which joins at the top with a horizontal passage in the bearing cap mentioned in the last paragraph. This slot in the under face of the web is sealed by the large central oil pipe bracket which grips the oil pipe in a split bore tightened by a bolt. On either side of the elongated hole in the pipe are three equally spaced plain circular holes which, in conjunction with smaller split brackets attached to the respective underside faces of the crankcase webs, supply pressure oil to their respective main bearings through similar supply passages in web and cap as those employed in the central bearing. Both ends of the tube are sealed by means of a castellated screwed plug.

## LOWER PORTION OF CRANKCASE

84. This is a trough-shaped aluminium alloy casting (*see* fig. 18) having a rounded bottom between a shallow rectangular sump at the front end and a deep rectangular sump at the rear end. The rear end is faced for the wheelcase which is secured to it by bolts. This face incorporates, at its lower edge, two holes through which drain oil from the wheelcase returns to the crankcase. The top facings are flat and conform to the studded facings on the underside of the crankcase upper portion. Four hollow taper dowels fit round sockets in the two portions and ensure correct register of the end facings with their respective flanges.

85. The underside of the floor of the deep rectangular sump in the rear is faced in one plane to take, on the port side, the two scavenge filter caps which spigot into sockets in the casing and, in the centre, the pressure oil pump. The outlet union from the pressure pump connects by means of an external pipe with the inlet union on the underside of the relief valves body. Immediately in front is a faced circular housing which accommodates the drive for the Lockheed pump. On the upper side of the floor corresponding to these facings are, from port to starboard, two facings for the scavenge filter casings and a central facing on the same plane for the two scavenge pumps. The double-bushed hole in the centre of the floor receives the centre of the oil pumps driving shaft, while the smaller co-axial unbushed holes on either side of the casting are for the driven gears spindles for the pressure and rear scavenge pumps. The two holes in the centre of the case are the inlet ports to the two scavenge pumps. The front hole, which is the front scavenge pump inlet is served by a duct leading to the bore of the front filter housing, while the rear hole or rear scavenge pump inlet is served by a duct leading to the bore of the rear filter housing. Small oil ducts in the floor of the casting convey oil from the delivery passage in the pressure pump for the lubrication of various bushes of the pumps unit.

86. A second pair of holes, one bushed and the other unbushed, to the left of the rear scavenge pump position act as lower bearings for the lower ends of the front scavenge pump driving and driven spindle bearings respectively. A facing on the right-hand wall of the rear sump is for the attachment of a right-angled elbow, the inner end of which connects, by means of a short flanged tube, with the gland incorporated in the outlet port on the scavenge pumps body. The outer end of this elbow connects by means of an external pipe to the scavenge relieve valve body situated on the right hand side of the carburettor. The scavenge pumps body is attached to the floor of the crankcase sump by means of



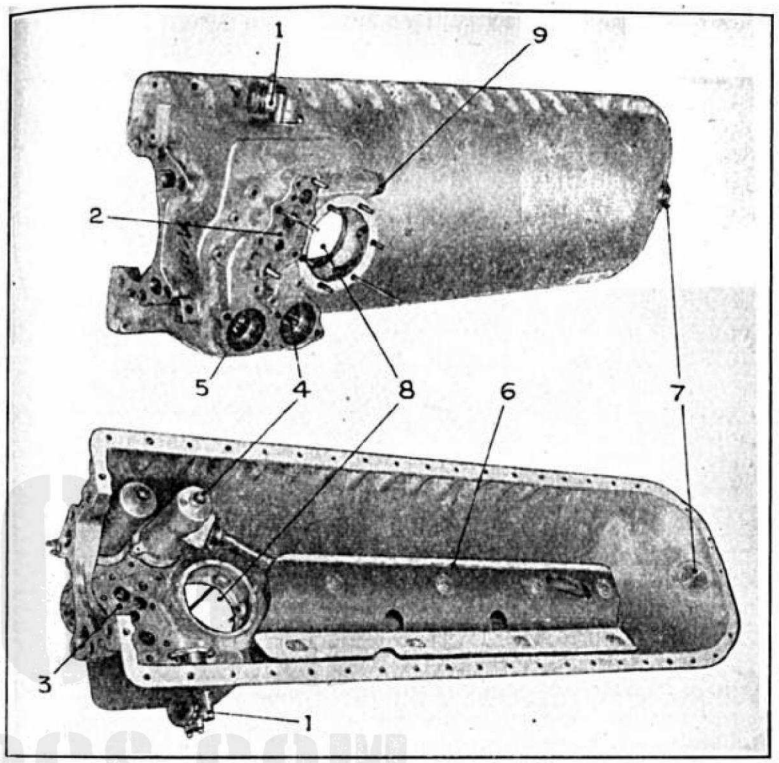



FIG. 18.—Crankcase, lower portion.

1. Scavenge oil outlet union.
2. Pressure pump mounting face.
3. Scavenge pumps mounting face.
4. Front filter.
5. Rear filter.
6. Baffle.
7. Timing inspection plug.
8. Lockheed pump mounting.
9. Pressure oil outlet union.

studs and bolts. The pressure pump is similarly attached to the underside of the casting and is also positioned by means of a steel dowel pinned in a boss integral with the mounting flange.

87. A baffle-plate, of sheet duralumin, is attached by eight bolts furnished with distance pieces to the top side of the casting forward of the rear sump. This baffle, by collecting much of the oil thrown off by the connecting rods, assists in the drainage of the oil to the sump. Mild steel washers are fitted under the heads of the bolts to prevent damage to the baffle and the bolt ends are lightly riveted over the nuts to lock them. The distance pieces on the side

walls are of aluminium while those in the trough are aluminium forgings which act as split clamps for the scavenge suction pipe leading from the forward sump to the forward filter casing. The pipe, of steel tubing, has a triangular flange brazed to its rear end for connection with studs, nuts and plain washers to a boss on the side of the front filter casing ; at its forward end it is belled and formed with a bend to enable it to dip into the forward sump.

**LOCKHEED HYDRAULIC PUMP DRIVE**

88. The Lockheed hydraulic pump is positioned in two separate drive housings attached to the underside of the crankcase lower half casting immediately in front of the pressure oil pump. It is driven through bevel gears from a separate vertical shaft having a spur wheel at its upper end which meshes with the second spur wheel of the composite gear wheel mounted on the oil pump driving spindle. This drive is incorporated in two separate castings, both of which are attached by superimposed flanges to the faced circular aperture in the crankcase lower half.

89. The hollow vertical driving spindle is carried in a hollow beehive shaped casting which spigots into the crankcase aperture. The lower wall of the casting incorporates an internally lipped housing for the reception of a ball bearing, which supports the lower end of the driving shaft. The outer race of this bearing is retained against the internal lip by means of an internally lipped and circlip-locked ring nut which screws on to the threaded portion of the bearing housing. The inner race abuts against a shoulder formed by the bevel integral with the lower end of the shaft, and is retained by a locknut which screws on to a threaded portion of the shaft and is locked by a split-pin. The upper end of the shaft is splined to receive the splined bore of a sleeve extension incorporated with the spur gear which meshes with the second gear on the oil pump driving shaft. The sleeve, and consequently the gear wheel, is retained to the shaft by means of a tab-washered nut. The inner race, containing a caged race of rollers, is fitted to a seating inclined at the apex of the beehive casting, and is retained against a shoulder in it by means of a circlip-locked nut screwed to a threaded extension of the casting. This extension, somewhat reduced in diameter, is continued right up inside the sleeve of the gear to prevent the escape of oil from the crankcase to the drive housings below. The outer race of this roller bearing is formed as an integral extension of the spur gear flange.

90. The horizontal driven shaft is housed in a separate casting which is attached by means of a horizontal face to the lower half of the crankcase in the manner already described,



and carries the Lockheed pump spigoted and bolted to a vertical facing. The driven spindle is hollow and has a bevel integral with its centre which meshes with the bevel on the driving shaft, and is splined internally at its rear end for engagement with the waisted coupling shaft, by means of which it is connected to the splined pump spindle. The rear end of the driven shaft is carried with no end location in the inner race of a ball bearing, the outer race of which is held in an internally lipped housing in the casting and retained against the lip by means of a screwed and circlip-locked end cap.

91. A partition is formed towards the front end of the casting. A circular aperture in this wall permits a flanged housing to spigot into it ; the housing is retained by means of studs and nuts. The outer race of a ball bearing is contained within the housing and abuts against an internal lip formed at its rear end ; the race is secured in the housing by means of a circlip-locked ring nut which screws into the threaded front end of the housing. The inner race carries the front end of the driven shaft ; a tab-washered locknut screwed to the front end of the shaft draws the race up against a shoulder formed on it. A mesh adjusting washer is interposed between this shoulder and the race. Lubrication of the gears and bearings described is performed by splash from a quantity of oil contained within the lower casting and supplied thereto by means of an oil nipple screwed into a boss at the side.

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# CHAPTER 4

## REDUCTION GEAR

### GENERAL

92. The reduction gear (*see* fig. 19) is of the single spur layshaft type and is housed partly in a casing bolted to the front end of the crankcase and partly in a complementary casing formed integrally with the front end of the crankcase. The former casing is located upon the latter by means of a spigot concentric with the airscrew shaft. The driving pinion is con-

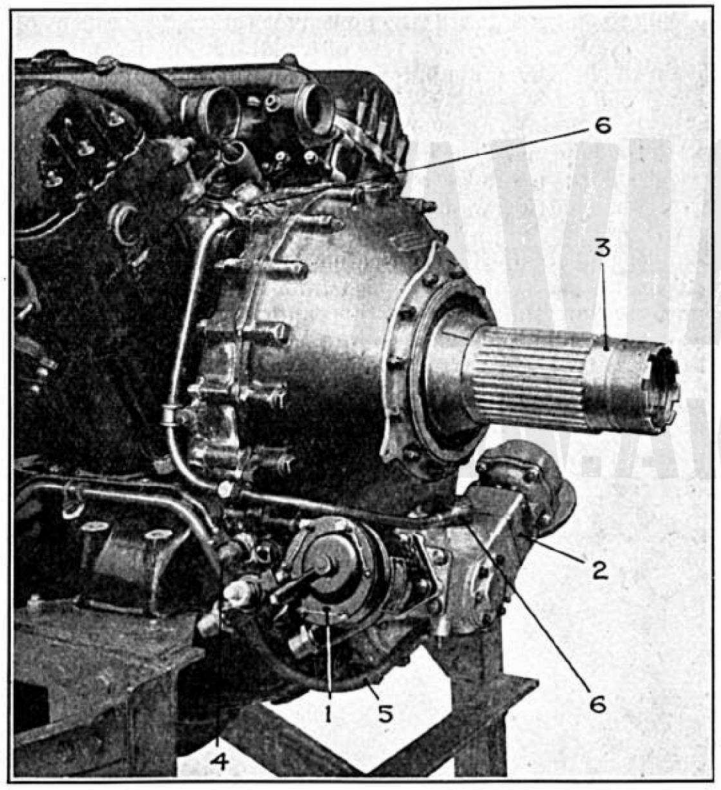



FIG. 19.—Reduction gear unit (modified Merlin II).

1. Vacuum pump.
2. Airscrew governor control unit.
3. Merlin II airscrew shaft (not suitable for Rotol constant speed airscrew).
4. Low-pressure feed pipe to reduction gear oil jets.
5. Main pressure feed pipe to airscrew governor control unit.
6. Delivery pipe to airscrew hub.



centric with, and is driven by, a short coupling shaft from the crankshaft ; the airscrew shaft, which is extended at the forward end to take the airscrew hub, is arranged above and parallel to it. Both shafts run in roller bearings, the airscrew shaft having also a thrust ball bearing enabling the engine to be used with tractor or pusher airscrews, and the driving pinion being located axially by a deep-groove ball bearing at the front end. A timing ring is arranged on the driving gear on the front flange of the crankcase and a pointer plate on the front main bearing cap ; the register of these items can be ascertained by removal of a screwed plug let into an oblique boss facing forward at the lower end of the crankcase lower half casting. Lubrication of the gears is through oil jets which are supplied from the low-pressure system of the engine ; the oil is directed on to the teeth as they come into mesh and the resulting distribution by splash serves to lubricate the bearings. Engines equipped to use constant speed type airscrews have an additional drive unit for the governor device as well as a vacuum pump mounted on the reduction gear cover.

### REDUCTION GEAR UNIT

*Coupling shaft*

93. The driving pinion is driven by a splined coupling shaft which fits the splined flange on the front end of the crankshaft and the splined bore of the forward end of the driving pinion. The coupling shaft is held concentric by the fitting of its splines in these parts, and it is free to float endwise between the flange of the crankshaft and the rear edge of the driving pinion. The coupling shaft is hollow and shaped as depicted in fig. 20 ; its rear end is furnished with 54 and its forward end with 30 hardened teeth. The rear end of the coupling shaft is extended and spigots into the thimble-shaped plug in the front end of the crankshaft for the purpose of centralizing and supporting the rear end. The front face of the rear or large gear is lipped internally for the purpose of catching oil, which is led to the meshed gear teeth through holes drilled in the gear flange.

*Driving pinion*

94. The driving pinion (*see* fig. 20) is hollow and has an inner roller bearing race formed at each end. The pinion is formed with 21 teeth. Just forward of a shoulder in front of the front face is a narrow spigot for a ring which is part of the inner race, and from the spigot to the extreme forward end of the pinion is provided a screwed portion to receive a hollow cap nut by which the outer race of a ball bearing, which determines the axial position of the pinion, is retained. The forward end of the pinion is splined (30 teeth) to mesh with the forward end of the coupling shaft.

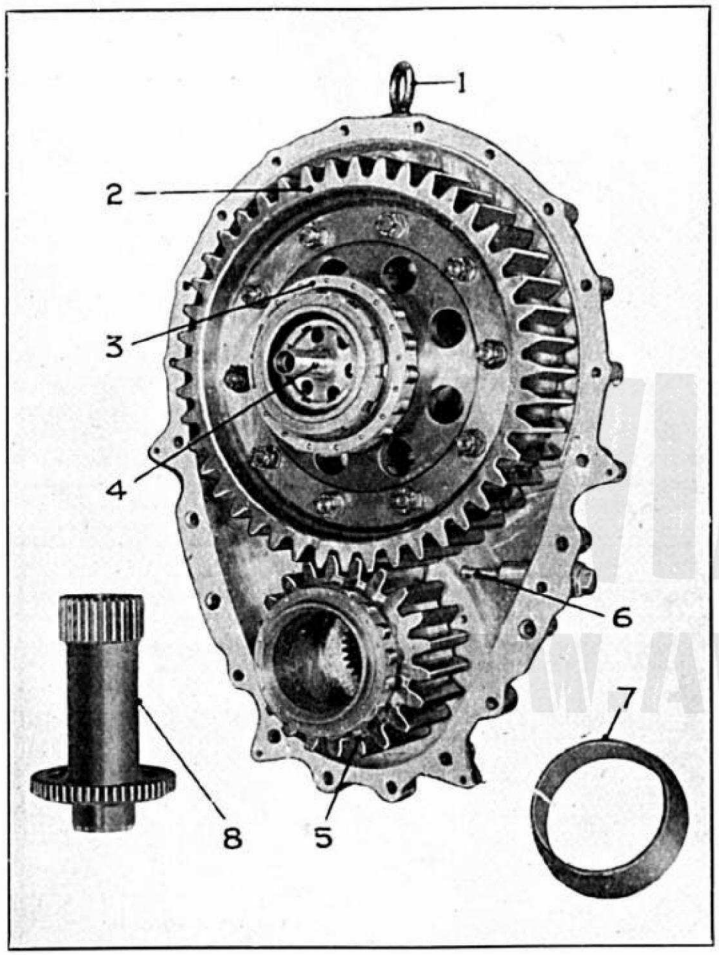



FIG. 20.—Reduction gears, rear view.

1. Reduction gear case slinging eye.
2. Airscrew shaft gear wheel.
3. Airscrew shaft rear roller race.
4. Oil tube for airscrew pitch control.
5. Driving pinion.
6. Oil jet.
7. Airscrew hub centring cone.
8. Coupling shaft.



95. Merlin III and modified Merlin II engines have the splined rear flange of an airscrew constant speed governor and vacuum pump drive coupling engaged with the front extremities of the splines in the bore of the driving pinion. This flange is retained by the internal lip of the cap nut screwed to the front end of the driving pinion hub. The splined front end of this coupling shaft engages the driving bevel housed in the drive unit mentioned (*see* para. 110).

*Gear casing*

96. The cast aluminium alloy reduction gear casing is spigoted to the front face of the crankcase and attached to it by means of numerous studs and bolts. It is elongated in form, having a broader section where it covers the airscrew shaft gear than where it covers the crankshaft gear. Concentric with the airscrew shaft axis is a large faced circular aperture for the reception of the housing containing the ball thrust and roller journal races for the airscrew shaft; this housing spigots into a circular aperture in the cover and is secured to it by means of several bolts which pass through a drilled flange integral with it. A small open compartment cast within the cover and situated at its top collects splash oil; this oil drains through a hole in the base of the compartment on to an aligning hole in the top of the bearing housing and situated midway between the ball thrust and roller journal races. At the top of the casting a bushed boss, normally blanked by a plug, provides attachment for a lifting eye as an aid to dismantling the gear unit.

97. A second open compartment is incorporated in the casting immediately beneath the airscrew thrust and journal race housing; the splash oil collected here is led through a short vertical and then a horizontal drilling; the latter breaks out of the face of the lower bearing housing where it aligns with passages in the end cover for the purpose of conveying oil to the driving pinion and coupling gear teeth. The roller bearing supporting the front end of the driving pinion hub is fitted to the lower circular housing in the casting; the outer race itself is carried in a flanged ring and another flange on the race spigots into a recess in the housing; the race is retained by means of a ring plate which is sandwiched between the face of the reduction gear cover and the end cover. The whole is secured by means of studs and spring-washered nuts. In Merlin III engines the end cover is replaced by the airscrew constant speed pitch and vacuum pump drive unit which is described in para. 110 *et seq*. As will be seen from fig. 21 the oil hole breaking through the face of the lower housing, aligns with the oil passage incorporated in the end cover; this passage terminates in a delivery spout which directs oil on to

the splines of the coupling shaft. In the case of the drive unit, internal passages in the drive casing lead the oil to the drive gears and bearings. The direction of rotation of the crankshaft is engraved on the end cover.

*Bearing housings and bearings*

98. The casings are bored to receive the steel housings for the driving pinion and airscrew shaft bearings. The pinion front bearing housing of mild steel is formed with an external flange at the forward end. The outer race has a spigot which locates the end cover or drive housing, whichever is used. The housing spigots tightly into the reduction gear casing from the front. The pinion rear bearing housing held in the crankcase is of mild steel and is of similar shape to the housing just described. The housing spigots from the front tightly into the crankcase half of the reduction gear casing to which it is secured, together with a cover, by means of studs and tab-washered nuts.

99. The rear roller bearing of the airscrew shaft has a plain housing which is held in the aperture by clamps secured to the forward face of the aperture by six studs and split-pinned nuts. The front roller bearing and the thrust bearing of the airscrew shaft have a common housing which spigots from the front into an aperture in the front casing, to which it is attached in addition to a flanged oil-retaining gland housing, by twelve square-headed bolts. The bolts are fitted with spring rings which prevent them being pushed inadvertently into the casing, and are drawn up by split-pinned nuts. The housing is of mild steel of the shape shown in fig. 66. The flange on the housing has three equally spaced tongues, which are drilled for reception of cowling attachments. All the bolt holes in the flange are evenly spaced except the two top ones; this arrangement is to ensure that the housing can be fitted in only one way and therefore that the oil collecting hole drilled radially through the wall of the housing will be uppermost and directly beneath an oil drain channel at the top of the casing. By this means oil is directed both to the thrust bearing and to the roller bearing.

100. The thrust bearing fits loosely into the housing against the flange at the rear end, followed by a grooved distance ring, the roller bearing outer race, an adjusting washer, and finally the retaining nut with its internal spring locking ring. The grooved distance ring of aluminium bronze, is of rectangular section with each flat side grooved radially at equiangular pitch, the grooves in one face being staggered in relation to the other; these grooves allow free passage of oil to the bearings on either side. The adjusting washer, of mild steel, is of rectangular section, ground on both faces,



and finished to enable the specified end clearance for the outer races of the bearings, when assembled in the housing, to be obtained. Contained within the bore of the retaining nut, secured at the rear by an internal lip and the front end by a spring circlip, is a Gits type oil seal, the inner or sealing portion of which bears upon a flanged sleeve clamped by means of an internal flange between the airscrew shaft nut and the airscrew hub rear cone.

101. In Merlin III engines, this retaining nut is not employed. Instead, a flanged end plate, containing the Gits type oil retaining gland, spigots into the front end of the bearing housing, the rear end of the spigot abutting against the distance ring. Moreover, the housing itself is not extended past its securing flange, which also has the three equally spaced ears for cowling attachment. Both bearing housing and oil gland end plate are retained by the same bolts and nuts as are used to secure the housing flange to the face on the cover casting. The front end of the cover plate is increased in diameter and grooved internally to form a seal with the Rotol airscrew hub for the purpose of providing a means of admitting pressure oil from the constant speed governor to the hub actuating mechanism.

102. The driving pinion bearings are of the caged roller type. The grooved inner races for the rollers are formed integrally with the driving pinion hub. The outer races are tight fits in their respective housings. The front outer race is grooved and has a spigot formed on its front end to receive the end cover casting. The airscrew shaft rear roller bearing has a plain outer race and an externally grooved inner race on which runs the caged roller bearing. The front roller bearing is similar in pattern but the front groove for the inner race has a detachable ring to allow the cage of rollers to be slid on to the hub of the gear. This ring seats in a recess and is retained by the cap nut. The airscrew shaft thrust ball bearing is of the deep groove, caged, single row, split outer race type. The inner race is a press fit on the airscrew shaft, but the two halves of the outer race have some clearance in the housing so that the bearing is not called upon to take any journal loads.

103. The airscrew shaft of nickel steel, is hollow throughout its length and furnished with a flange near its rear end on the forward face of which is bolted the reduction gearwheel. At the rear end is formed a shoulder and seating for the inner race of the rear roller bearing, and the shaft is screwed for the retaining nut and slotted longitudinally at two diametrically opposite points for the two internal tabs of a lockwasher. The flange is faced circumferentially and on its forward face

for the gearwheel which spigots into and is bolted to it with ten square-headed tapered shank bolts. Forward of the flange the shaft is machined to receive the thrust bearing, a shoulder being formed at the rear end of the machined portion to provide the abutment for the bearing. The shaft is again stepped down to suit the inner race of the front roller bearing and screwed for another retaining nut. Two diametrically opposite keyways are cut in this plain and screwed portion of the shaft to take the two internal tabs of a lockwasher by which the nut is locked after tightening up the above components against the forward face of the shoulder. Forward of the screwed portion, the shaft is slightly reduced in diameter to take the centring cone for the rear end of the airscrew hub. In front of this the shaft is parallel and splined to receive the airscrew hub, and reduced once more to a screwed portion at the front end which takes the hub retaining nut. In the case of the Merlin V engine, this reduction in diameter of the shaft extremity is more pronounced to enable a Rotol airscrew to be fitted. The Merlin III is fitted with a universal type airscrew shaft (*see* para. 104A).

104. The shaft is bored out as shown in fig. 66, and the forward end is plugged by means of a conical end piece, which is retained by means of a distance ring and a lock ring screwed into the bore of the shaft and secured by a spring circlip. This plug has a central sleeve integral with it to which is welded a pipe which runs inside the shaft bore and protrudes for some distance from its rear end. This pipe is supported in the centre of the bore by means of a flanged web, the centre of which is welded to the pipe, the outer flange being borne in a thickened parallel portion of the bore. A second taper plug, with similar means of retention, is positioned within the rear of the shaft bore ; the rear of the pipe slides through a central sleeve which is itself received in the spherical spring-loaded gland located within its own housing in the rear wall of the crankcase half of the reduction gear casing. This arrangement permits oil under high pressure to be admitted directly from the outlet union on the relief valves body, to the rear end of the tube contained within the shaft and thence to the front end of the shaft for the purpose of actuating the pitch operating mechanism of the airscrew. The spherically mounted gland at the rear end of the tube prevents loss of oil at this point and yet permits the tube to rotate freely with the airscrew shaft.

104A. The airscrew shaft fitted to the Merlin III aero-engine is of the universal type which is suitable for use with all types of existing airscrews. The chief difference between this shaft and the shaft fitted to the Merlin V engine, as described in para. 104, is that the reduction in diameter of



the shaft extremity is longer and that the front plug is a plain spigot to which the central pipe is secured by means of a lock-nut.

105. In Merlin III and V and modified Merlin II engines employing de Havilland constant speed airscrews, the high pressure oil supply is taken to the inlet union of the constant speed governor unit mounted on the reduction gear cover ; the outlet union of this unit is connected to the inlet union on top of the crankcase. Some Merlin III and V engines employing Rotol constant speed airscrews have a pipe from the outlet union on the airscrew governor unit connecting with the large circular oil gland mentioned in para. 101. The central oil tube is, therefore, unnecessary with this arrangement and also in the case of engines using fixed pitch airscrews. A blanking disc is, therefore, fitted into the front end of the airscrew shaft and retained by a circlip-secured ring nut.

106. The gearwheel is bored and faced to spigot and seat on the edge and forward face of the airscrew shaft flange, to which it is bolted. It has 44 teeth of special stub form, and meshing with the pinion, which has 21 teeth, gives the airscrew shaft a reduced speed ratio of 0·477 relative to the crankshaft. The bolts by which the gearwheel is held to the flange of the airscrew shaft are of nickel steel and are square-headed, taper shanked and hollowed to half length from the head end. They are drawn up by flanged split-pinned nuts.

107. The aluminium-bronze distance washer which fits on to the airscrew shaft between the inner races of the thrust and front bearings is of rectangular cross section. The faces are grooved to collect oil and to minimize wear if creeping of the adjacent races should occur.

108. The retaining nut is of the splined ring type and is cut with a right-hand thread to fit the airscrew shaft and to secure the inner races of the front and thrust bearings in position. The forward end of the body of the nut has a right-hand thread cut on it, and as this portion of the nut rotates with small clearance in the bore of the nut of the front bearing housing, these threads tend to prevent the escape of oil from the housing. The nut is locked by a washer of sheet steel, which has two tabs which are bent rearwards to fit the two grooves in the airscrew shaft, and two tabs bent forward to fit the splineways of the nut. The aluminium-bronze nut is engraved with an arrow and the word OFF on its front face to indicate that it has a right-hand thread.

109. The split centring cone is a phosphor-bronze ring bored to fit the airscrew shaft and tapered down towards the front end to centralize the airscrew hub and shaft on their splines. The rear face of the conical ring bears against the forward face of the thrust bearing retaining nut.

## AIRSCREW PITCH GOVERNOR AND VACUUM PUMP DRIVE UNIT

110. The additional drive unit fitted to the lower part of the reduction gear cover on Merlin III and V and some modified Merlin II engines (*see* figs. 21 and 22) provides for the mounting and actuation of a governor unit for use in conjunction with constant speed airscrews of either the de Havilland or Rotol types, and a vacuum pump (Pesco A.C. type B.3, model 207), for the operation of certain navigation instruments. This unit is self-contained and is driven from the front end of the reduction gear driving pinion through the coupling mentioned in para. 95. Lubrication of the gears is achieved by splash oil obtained through special ducts from the reduction gear casing, while the driven spindles and bushes are lubricated through other transverse ducts in the casting directly from the high pressure inlet supply to the governor. Drain oil passes through holes in the rear wall of the casting. In the event of the drive unit being used on a basic Merlin II layout, that is, with the high pressure pipe C (*see* fig. 54) going directly to the reduction gear instead of the drive housing, separate lubrication for the drive unit must be arranged from the pressure gauge connection (main pressure) on the relief valves body through the additional pipe M (*see* fig. 54). If this is not done, the drive unit will be unlubricated and damage will ensue. (*See* para. 277.)

111. The body which houses the drive is a light alloy casting, having a central portion which includes two diagonally positioned and square sectioned faced bosses into which spigot, and are secured to by four studs and spring-washered nuts, the driven spindle housings. Incorporated at the rear is a large flange by means of which the whole unit is spigoted and secured to the lower or driving pinion housing in the lower part of the reduction gear cover. A small end cover is spigoted to the front of the body and secured to it by studs and spring-washered nuts. Bosses for an inlet and an outlet union are provided on the bottom and top of the left-hand square sectioned mounting boss to provide attachments for the inlet high pressure oil from the relief valves body and the outlet to the union on top of the crankcase reduction gear casing respectively. An oil channel is contained within the thickened rib on top of the central portion of the body; the top end of this channel aligns with the hole in the mounting face on the crankcase and receives splash oil collected in the compartment situated immediately under the airscrew thrust bearing housing, while the lower end of the channel delivers it, through a short connecting passage in the small front cover, into the front housing containing the ball bearing which supports the front end of the driving spindle. A transverse oil passage drilled through a rib incorporated in the under

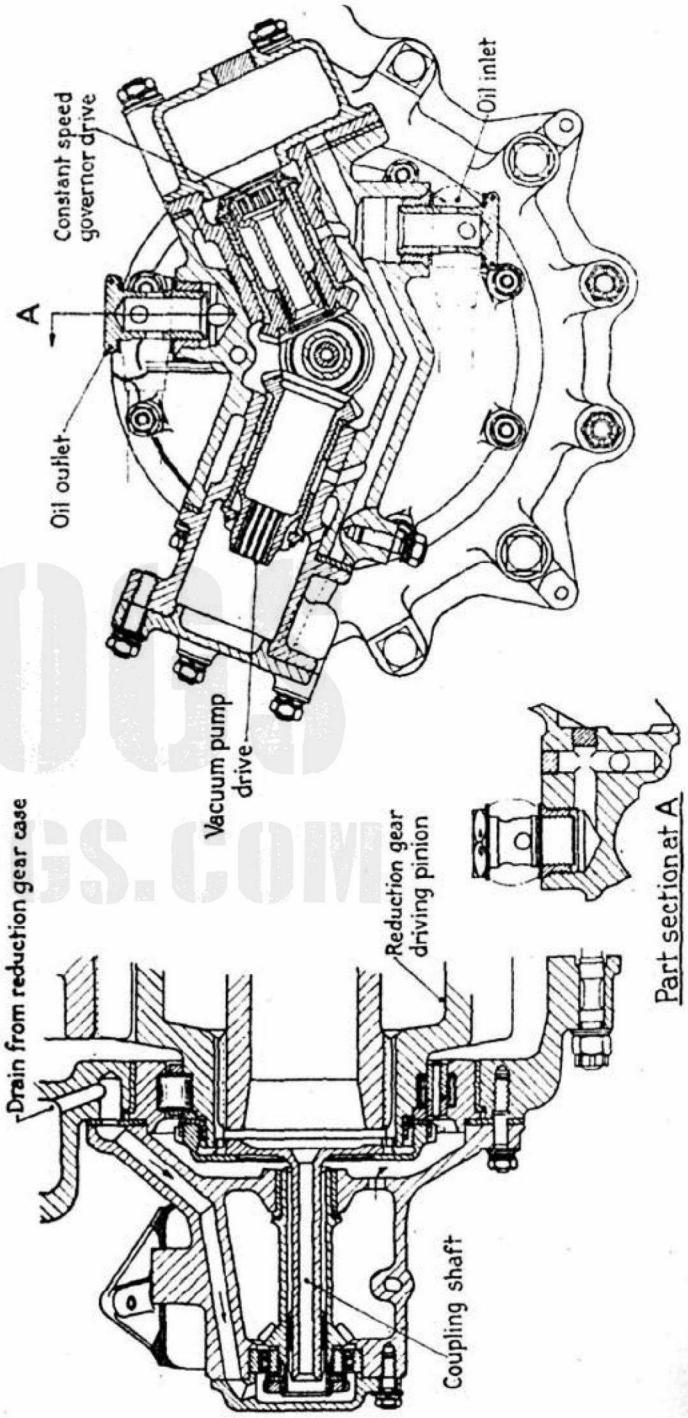



FIG. 21. ARRANGEMENT OF CONSTANT SPEED GOVERNOR AND VACUUM PUMP DRIVE UNIT

side of the body supplies high pressure oil from the inlet union to the driven spindle bushes.

112. The front interior portion of the body is bored to receive the outer race of a ball bearing which supports the front end of the driving spindle. This race is gripped between an internal lip in rear and the spigot of the small front cover in front. A wall is incorporated with the rear of the body and contains in its centre a hollow boss into which is pressed a flanged phosphor-bronze bush from the front end. This bush supports the rear end of the driving spindle.

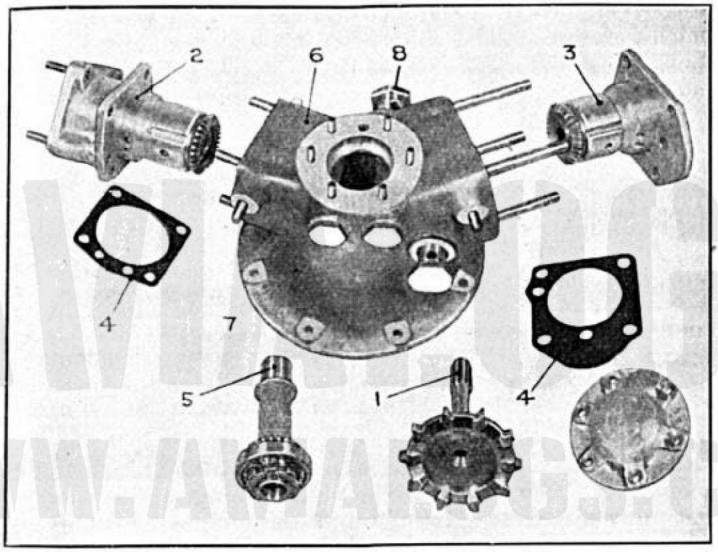



FIG. 22.—Constant speed governor and vacuum pump drive unit.

1. Coupling shaft.
2. Vacuum pump drive.
3. Constant speed governor drive.
4. Mesh adjusting shim.
5. Driving shaft.
6. Casing.
7. Oil inlet from pump.
8. Oil outlet to airscrew hub.

113. The driving spindle, supported in the ball bearing and bush already described, is concentric with the crankshaft axis. It is hollow, its bore being plain at the rear end and splined at the front end. The splined coupling extension mentioned in para. 85, which is itself dogged to the splines in the bore of the reduction gear pinion, meshes with these internal splines and transmits the drive to the spindle. A bevel gear is formed integrally at the middle of the spindle and meshes with the driven bevels formed on the lower ends of the two driven spindles. A shoulder at the rear end abuts against the flange of the bush, while the inner race of the ball bearing

at the front end is mounted on a thickened portion of the spindle and abuts at the rear against the shoulder formed by the bevel wheel. A mesh adjusting washer is interposed between inner race and shoulder. A locknut, secured by a tab-washer, screws on to the threaded front portion of the spindle and retains the inner race upon it. The spindle is thus positioned endwise by the ball bearing.

114. The separate light alloy housings which contain the hollow driven spindles and which have mounted upon them their respective governor and pump units are generally similar but are not interchangeable. Each spigots into its respective housing on the body and is secured thereto by a flange through which pass four studs; interposed between flange and body housing is a washer which controls the mesh of the driving and driven bevel wheels. The inner portion of each housing bore has pressed into each end a flanged phosphor-bronze bush, thus forming an annular space in the middle which connects with a hole in the housing and permits pressure oil from the lower transverse passage to enter for the lubrication of the bushes. Each driven spindle is hollow with a bevel gear formed integrally at its inner end; the outer end has two grooves for reception of a square sectioned circlip and end ring by means of which it is retained in its pair of bushes. The left-hand or governor driving spindle has internal splines formed at the inner end of its bore, while the pump spindle is internally splined at its outer end. The drive to the governor is transmitted from the former driven spindle through an externally and internally splined coupling rod which meshes with the splines in the driven spindle and on the governor unit spindle respectively. The splines in the right-hand or vacuum pump driven spindle are at the outer end and the splines on the pump spindle mesh directly, instead of using an intermediary coupling. The governor unit is retained by the same studs and nuts as are used for its driven spindle housing flange, but the pump unit is retained by separate studs screwed into the outer flange of its driven spindle housing.

**AIRSCREW HUB**

115. The rear flange and barrel of the airscrew hub used with wooden airscrews are integral. The hub is of nickel-chromium steel and is of the section shown in fig. 23. Its bore at the rear end is coned to fit the split bronze centring cone on the airscrew shaft, while in the centre it is splined to mesh with the driving shaft. The front shoulder formed by the internal splines is chamfered to provide a seating for the front centring cone. Externally, the flange formed at the rear end has a concentric spigot adjacent to the bolt holes, which engages a flat on each of the twelve bolt heads to prevent the bolts from rotating when the nuts are being turned. Twelve



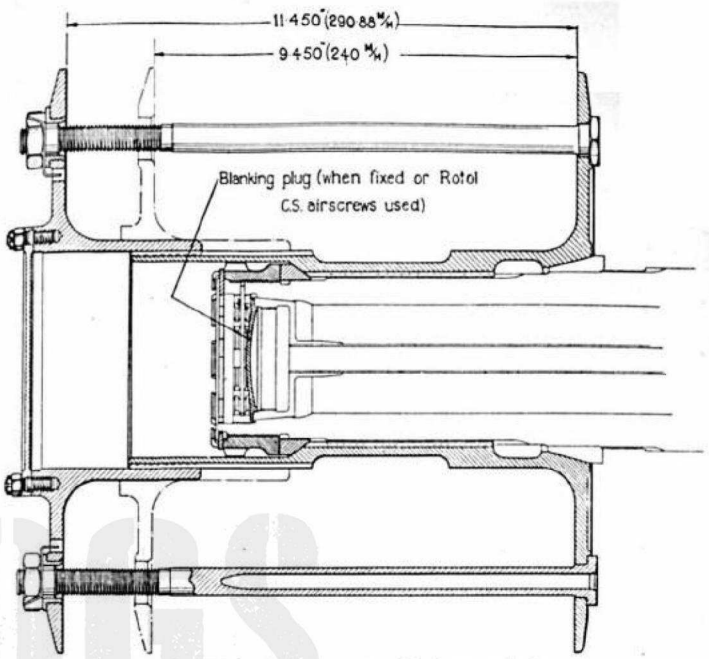



FIG. 23.—Arrangement of airscrew hub.

lightening holes are drilled on a smaller pitch circle than the bolt holes. The hub, which is cylindrical, merges into the flange with a large radius; the forward end of the hub is counterbored up to the shoulder formed by the front end of the internal splines to accommodate the airscrew shaft nut. This nut is locked by means of an internally and externally serrated plate retained by a spring circlip. It should be particularly noted that since Merlin III and V engines use airscrew shafts which are of smaller diameter at their front extremity than those employed with Merlin II engines, it will be necessary in this case to use a suitable airscrew shaft nut and accessories.

116. The nave plate is an aluminium alloy forging; it is serrated in the bore to fit the airscrew hub and suitably drilled for the twelve bolts so that these can be aligned with the bolt holes in the hub flange. Twelve lightening holes are drilled through the flange. The bolt holes are each fitted with a flanged mild steel bush which is pressed into the forward face of the flange and expanded into the chamfer of the bolt hole on the rear face. A ring of six evenly spaced holes are drilled in the flange which are tapped and fitted with studs which receive a plain end cover. The twelve spigoted nickel-steel hub bolts pass through both rear and front flanges of the hub and are fitted with spigoted tab-washered nuts at their front ends. The bolts are bored from the rear end for lightness for most of their length.

CHAPTER 5

## WHEELCASE ASSEMBLY

### GENERAL

117. The wheelcase, which forms a detachable unit, is bolted to the rear end of the crankcase and carries the magnetos, the coolant pump, the generator drive, the crankcase breather, the hand and electric turning gear and the fuel pumps unit. It houses the spring drive unit and certain shafts through which the magnetos, camshafts, fuel, oil and coolant pumps, and the electric generator are driven. Its rear portion houses part of the impellor drive, and the supercharger casing is attached to its rear face. The spring drive unit is a torsionally flexible shaft through which the various shafts and wheels in the case are driven. Its front end is splined into the driving bush positioned in the rear end of the crankshaft from which it transmits the drive to a bevel wheel mounted near its centre, and a spur wheel mounted on its rear end. The bevel wheel meshes with other bevel wheels at the ends of co-axial vertical drive shafts carried, one in the upper portion of the casing and one in the lower, while the spur gear meshes with the three supercharger layshaft pinions. The hand and electric turning gear drives, and the electric generator is driven, through individual supercharger layshafts by means of separate trains of gears incorporated in the left and right-hand sides of the wheelcase respectively. The fuel pump unit is mounted on the lower left-hand side of the wheelcase and is driven through a pair of spiral gears from the lower vertical shaft.

118. The upper vertical drive shaft has a bevel wheel splined to its upper end to drive two short inclined shafts detachably mounted in the upper end of the casing. The inclined shafts are coupled through long coupling shafts to the camshaft driving spindles contained in the cylinder block and are known as the lower camshaft drives. The transverse shaft, which is known as the magneto shaft, is fitted with a serrated coupling at each end to drive the two magnetos. The lower vertical drive shaft drives the coolant pump, which is below it, through a co-axial coupling shaft and carries a spur and a skew gear wheel near its lower end. The spur gear meshes with an idler wheel through which the oil and Lockheed pumps are driven and the skew gearwheel meshes with the skew gear on the horizontal fuel pump spindle.

119. The hand and electric turning gear consists of (*a*) a bevel gear box incorporating a freewheel device for protecting the operator from backfires, (*b*) a composite electric turning shaft and gear box incorporating a double epicyclic reduction



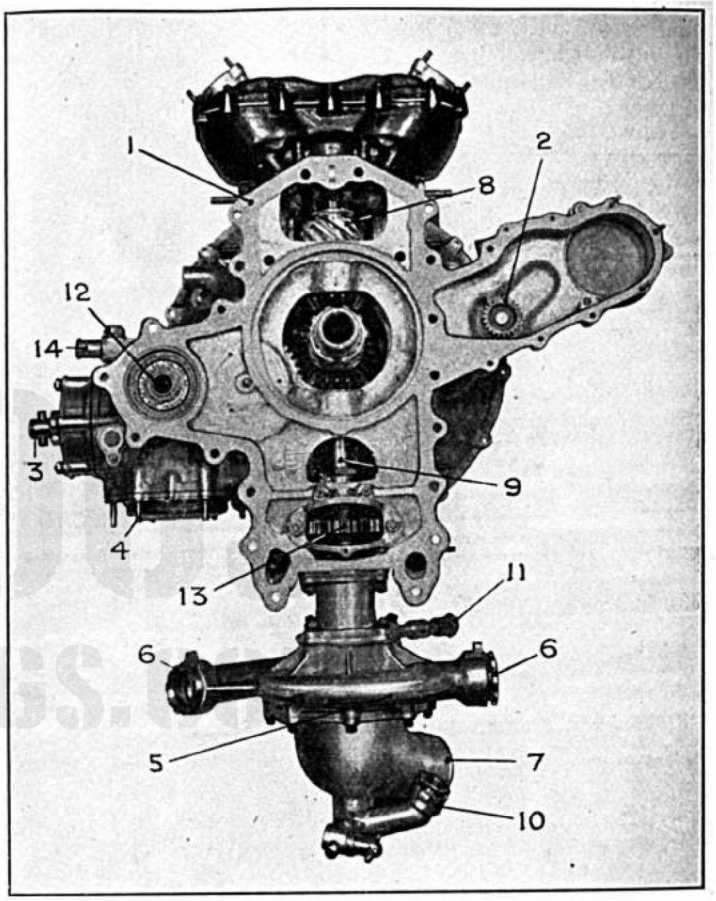



FIG. 24.—Wheelcase and gears, front view.

1. Wheelcase.
2. Generator drive intermediate gear.
3. Hand starter shaft.
4. Attachment for electric turning gear motor.
5. Coolant pump.
6. Coolant pump outlet.
7. Coolant pump inlet.
8. Upper vertical drive shaft.
9. Lower vertical drive shaft.
10. Inlet from coolant jackets on carburettor.
11. Coolant pump spindle lubricator.
12. Turning gear idler shaft.
13. Oil pumps idler gear.
14. Wheelcase relief valve.

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gear and a spring-loaded ratchet which isolates the epicyclic electric turning gear when the hand turning shaft is operated, (*c*) a layshaft, and (*d*) a driving shaft which carries a sliding dog for engagement with its respective similarly dogged supercharger layshaft, a small plate clutch for moving the sliding dog into engagement and a large plate clutch for isolating the electric turning epicyclic gear train from damage in the event of a backfire. The electric generator is driven from a pinion on

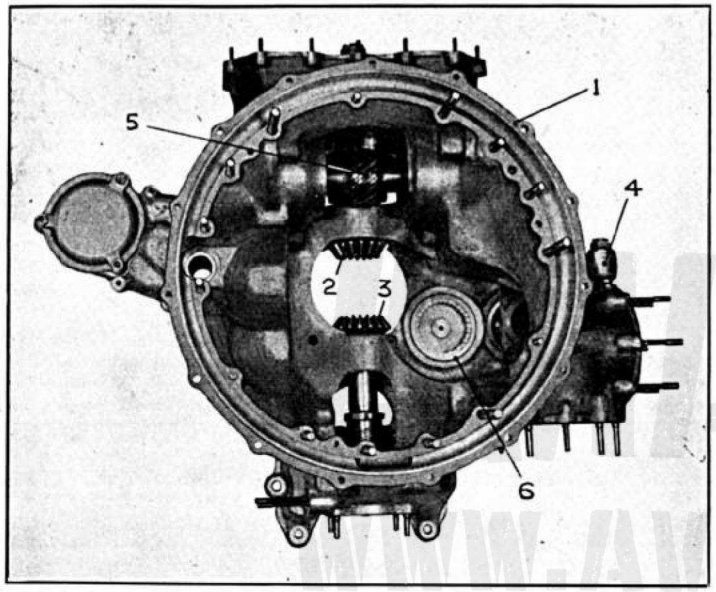



FIG. 25.—Wheelcase, rear view.

1. Wheelcase.
2. Upper vertical drive shaft bevel.
3. Lower vertical drive shaft bevel.
4. Wheelcase relief valve.
5. Magneto cross drive shaft.
6. Timing gear idler shaft front roller bearing.

its respective supercharger layshaft through an idler gear, a lay spindle, a second idler gear and a long external driving spindle. Coupling is made to the generator spindle from this latter shaft by means of a Cardan shaft with a Hardy type flexible coupling at each end. The wheelcase and the aforementioned drives are described in the following paragraphs.

## WHEELCASE UNIT

*Wheelcase*

120. The wheelcase is an aluminium casting of the shape shown in figs. 24 and 25. It spigots and is bolted to the rear of the crankcase. The facing around the large inner circular



aperture at the back of the casing receives the support plate for the rear end of the spring drive unit and also the dished casing which supports the rear ends of the supercharger drive layshafts. The larger outer facing provides attachment for the supercharger casing. The tubular extension beneath the casing forms a spigoted mounting for the coolant pump, while the facing low down on the port side of the casing receives the fuel pump. A horizontal faced circular housing on the starboard side secures the hand turning free-wheel device, while another similar facing under it provides attachment for the electric motor and epicyclic driving gear. A crankcase breather and union are attached by means of two studs to the upper of these two housings.

121. The two faced apertures opposite to each other in the sides of the casing receive the magnetos and house the bearings for the magneto shaft. The two inclined hollow bosses at the top of the case receive the two lower camshaft drive units, while the studded facing around them receives a cover in which are glands which secure the lower ends of the camshaft drive cover tubes. On the port side of the wheelcase there is a long hollow horizontal boss which houses the generator drive lay spindle, and a lateral gear case extension which forms an enclosed casing with a similar extension on the rear of the crankcase for the remainder of the generator drive. Immediately behind the starboard magneto housing is a hollow boss by means of which low pressure oil through an external pipe is taken to the three impellor layshaft bearings and sprayers (*see* para. 190).

*Spring drive shaft*

122. The spring drive shaft (*see* fig. 66) is a torsionally resilient coupling shaft which transmits the drive from the crankshaft to the supercharger and the auxiliary drives contained within the wheelcase. It comprises an inner torsionally resilient shaft and a stiff outer shaft, both of which are coupled by means of the driving bush in the rear end of the crankshaft at their front ends and to the auxiliaries driving bevel and the impellor driving spur gear at their rear ends. Owing to a considerable clearance between the engaging coupling element of the outer shaft and the crankshaft driving bush sleeve, torsional oscillations of the inner shaft will be possible over a limited range. The bevel wheel which drives the upper and lower vertical drives is splined to the centre, while the impellor driving spur gear is spigoted and bolted to a flange formed at the rear end of the shaft. The rear end of the spring drive unit is borne in a ball bearing contained in a housing which is secured to a diaphragm plate, while the front

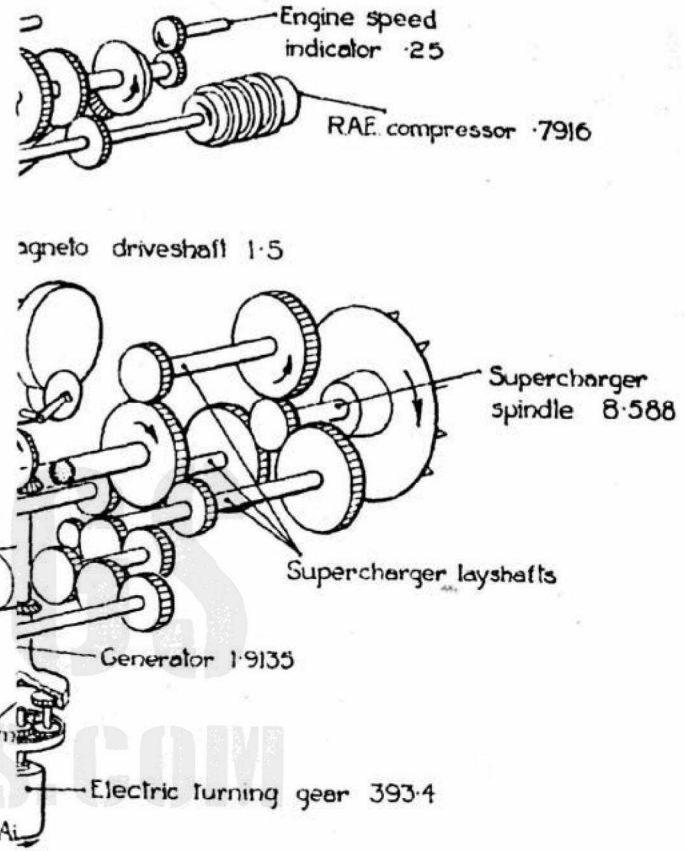
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end is carried by the crankshaft driving bush. This plate spigots into and is secured to the inner facing within the rear of the wheelcase.

123. The inner shaft is the torsion spring member of the spring drive unit. It is of nickel steel and has a flange at the forward end which is splined (30 serrations) round the edge to fit the internal splineways in the driving bush in the crankshaft rear journal bore. A master spline is formed in the same plane as No. 6 crankpin ; the shaft can thus be fitted in only one position relative to the crankshaft. Six oil transfer holes are drilled in this flange. The central portion of the shaft is waisted to give the necessary torsional flexibility, and the rear end is furnished with a splined (18 serrations) shoulder which meshes with the internally splined hub of the supercharger driving spur gear on the rear end of the hollow spring drive shaft. A master spline is also provided at the rear end.

124. The outer steel shaft is hollow and is borne at its forward end within a bush pressed into the centre of the bore of the crankshaft driving bush, and at its rear end in a ball bearing retained within a housing in the centre of the end plate attached to the inner facing within the rear of the wheelcase. The inner torsional shaft passes through this outer shaft. A drilled flange at its rear end has spigoted and bolted to it the spur gear which meshes with and drives the supercharger layshaft pinions. The inner race of the rear ball bearing is held upon a reduced diameter of the shaft and, mounted on the shaft, and abutting against the inner race so that it is pressed against a shoulder in rear, are a bevel wheel mesh adjusting washer, a long distance sleeve and the hub of the auxiliaries driving bevel wheel. This latter wheel hub is internally splined and meshes with splines formed to receive it in the centre of the shaft. A second washer is positioned in front of the bevel and the whole assembly is drawn up against the afore-mentioned shoulder by a tab-washered locknut.

125. At the forward end, the shaft is again splined on a reduced diameter to receive the internally splined hub of a coupling pinion, which connects the outer shaft with the internally toothed rear end of the crankshaft driving bush ; a tab-washered locknut retains the pinion on the shaft and draws it up against a shoulder. The clearance between the teeth of the pinion and the internal teeth of the crankshaft driving bush permits the outer shaft to rotate through 6° in relation to the crankshaft before the drive is transmitted through the outer shaft. This occurs only during shock loads, and normally the drive to both the supercharger and the auxiliaries associated with the wheelcase is taken entirely through the central torsion




CRANKSHAFT

shaft which deals effectively with normal torque fluctuations. Should the inner torsion shaft break, the outer shaft would of course drive the bevel and spur gears directly.

*Upper vertical drive shaft*

126. The upper vertical drive shaft (*see* fig. 66) consists of a hollow shaft which is driven at its bottom end by the main driving bevel wheel in the centre of the wheelcase and transmits its drive to the magneto drive shaft and the lower camshaft drives by a skew and a bevel gear respectively, both of which are secured directly to the shaft. The shaft is borne in a ball bearing at its lower end and a roller bearing at its upper end. The outer race of the lower ball bearing is clamped to a shoulder in the wheelcase by a nut which is locked to the casing by a circlip whose hooked end passes through holes in the casing and the nut. Interposed between the inner race and a shoulder immediately above the ring of bevel teeth is a backlash adjusting washer. Between the top of the inner race of the lower ball bearing and the skew gearwheel is a distance sleeve. Keyed to the shaft by a pair of diametrically opposed Woodruff keys, the phosphor-bronze skew gear is located axially by a castellated nut which bears directly on its upper surface and is locked by a split-pin. Splined to the top end of the shaft is a sleeve on whose upper end is machined another ring of bevel teeth. The wheel is secured to the upper end of the shaft by a tab-washered nut. The grooved inner race of the top roller bearing is formed integral with the extended hub of the bevel gear ; mesh adjusting shims are interposed between the lower end of the hub and a shallow shoulder in the upper mid-position of the shaft. The flanged outer race of this bearing is spigoted and studded to a facing provided in the top of the wheelcase.

*Lower vertical drive shaft*

127. The lower vertical drive shaft (*see* fig. 66) consists of a hollow shaft which is driven at its top end by the main driving bevel wheel in the centre of the wheelcase and transmits the drive to the fuel pump spindle and to the idler gear by a skew and a spur gear respectively ; the skew gear is secured to the spur gear which in turn is secured to the shaft. The shaft also transmits the torque to the coolant pump rotor through an internal concentric coupling shaft which is secured at its top end to the vertical drive shaft and at its bottom end to the universally coupled coolant pump rotor spindle.

128. The shaft is borne in two ball bearings, one near each end. The outer race of the topmost bearing is housed in a detachable housing which spigots into the bottom of an aperture in the wheelcase. This housing is provided with a

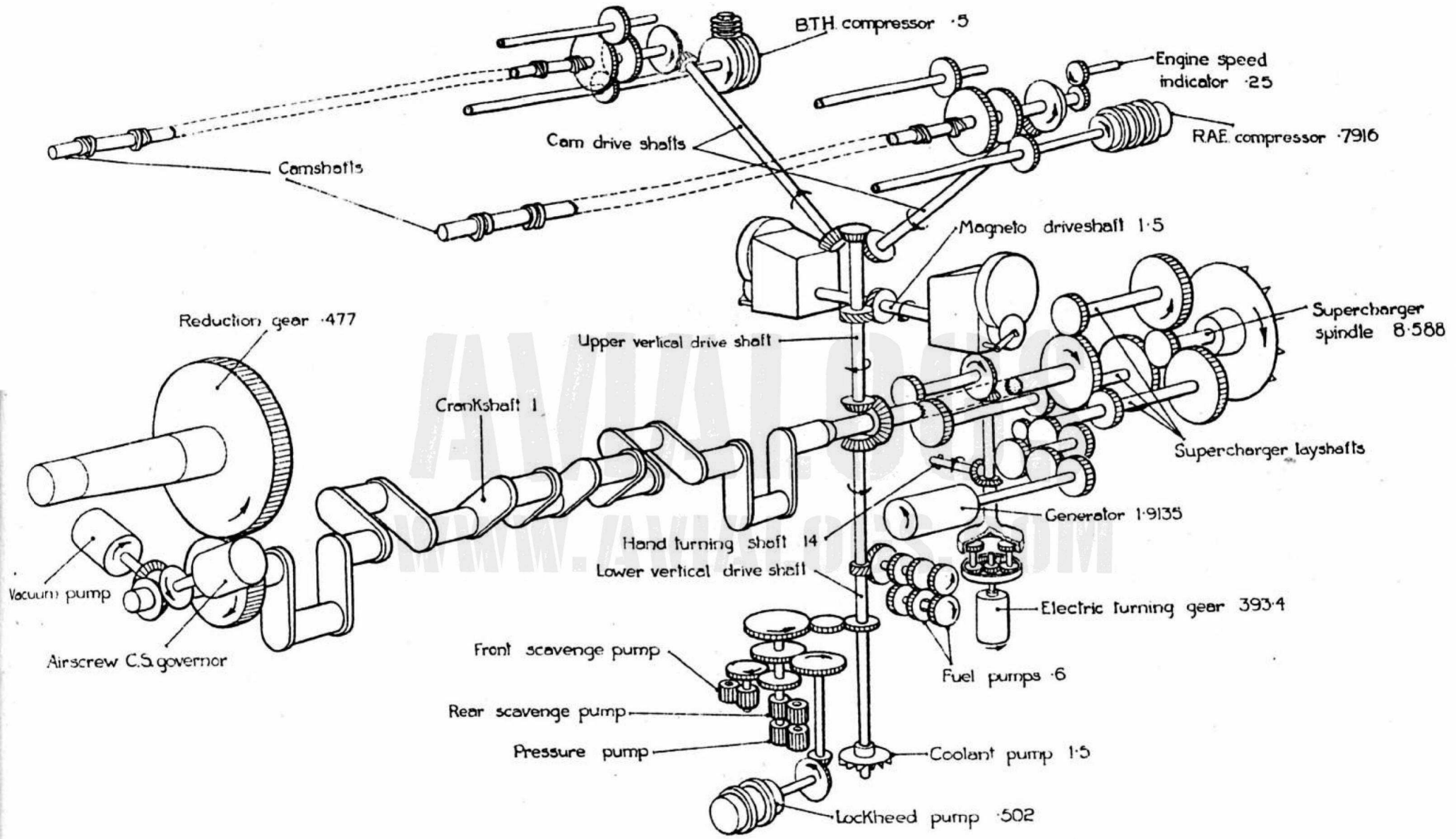



FIG. 26. AUXILIARY SHAFTS SPEEDS RELATIVE TO CRANKSHAFT

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lip at its topmost end against which are retained successively, a backlash adjusting washer and the outer race of the ball bearing by a ring nut whose top face bears on the outer race and which is locked to the wheelcase by a circlip sprung into an internal groove in the nut and having its hooked end engaged in holes in the nut and casing. A tab-washered retaining nut screwed to the bottom of the shaft retains successively, the inner race of the lower ball bearing, a backlash adjusting washer, the hub of the spur gearwheel, a distance sleeve and the inner race of the top ball bearing to a shoulder beneath the ring of bevel teeth at the top of the shaft. The outer race of the lower ball bearing is received in the bore at the top of a housing which is spigoted and studded to the bottom of the wheelcase; a jointing washer is interposed between the housing flange and the wheelcase.

129. This housing is provided with a downward extension to which is bolted the coolant pump. The housing is tapped internally at its upper end to receive a circlip-locked ring nut which retains the flange of a long baffle sleeve and a joint washer to an internal shoulder in the housing. The baffle sleeve is concentric with the lower drive shaft. A continuous spiral groove is cut on its outer surface as a deterrent against oil from the wheelcase creeping up it and leaking through its bore. It spigots at its bottom end into the housing and enshrouds the coolant pump driving shaft for nearly the whole of its length and is surrounded at its top end by a short length of tube pinned to the top end of the coupling shaft. These two tubes baffle the drainage of oil from the wheelcase into the coolant pump.

130. The dished spur gearwheel is internally serrated to engage with the shaft. It meshes with the idler wheel and thereby drives the oil and Lockheed pumps. Its hub is also externally serrated to engage with a sleeve machined with a ring of skew gear teeth which drive the fuel pumps spindle. This sleeve is centralized on the spur gear hub by a cylindrical ring which fits its bore at the top end and is prevented from rotating by a small tang which is integral with the tab-washer that locks the nut that clamps the sleeve to a shoulder on the spur gear hub.

131. The internal concentric coupling shaft which transmits the torque from the lower drive shaft to the coolant pump, is splined to the shaft and located axially by a circlip-locked ring nut which is screwed into the top of the shaft. Pinned to a shoulder near the top of the shaft is the short length of sleeve which has already been described. A collar at the bottom of the shaft is serrated to engage with the universal coupling at the top of the coolant pump spindle. Another



shoulder at the top end of the shaft is chamfered to provide a seating on the mating surface in the bore of the lower drive shaft. This assists in preventing oil drainage from the top of the lower drive shaft into the coolant pump.

*Magneto drive*

132. The magneto drive (*see* fig. 27) consists of a hollow transverse shaft driven at 1·5 times engine speed by a central skew gear from the upper vertical drive shaft of the wheelcase, two hollow serrated coupling shafts transmitting the drive to two serrated couplings, one on each magneto. The serrations at the ends of the coupling shafts are so arranged as to form verniers whereby a minimum variation of 1·8° of the timing may be obtained.

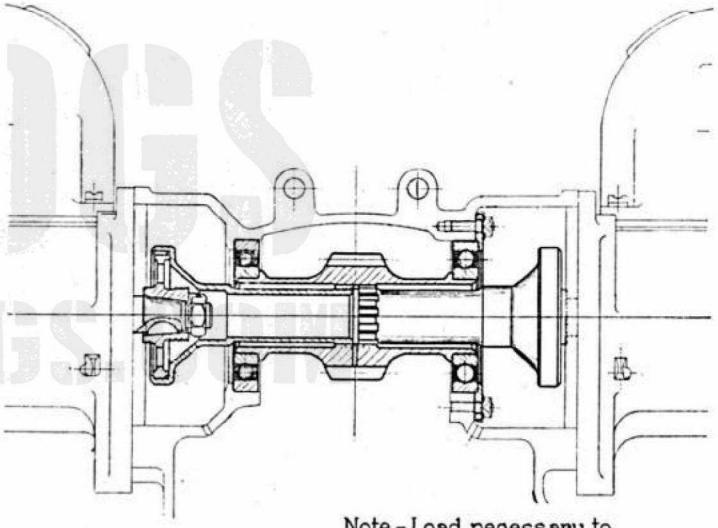



FIG. 27.—Magneto drive.

133. The shaft, of case-hardened nickel steel, is hollow and symmetrical about its mid-length plane. The bore is splined (11 teeth) centrally and chamfered at the ends. At the centre of the shaft is formed a ring of left-hand skew gear teeth for meshing at 90° with the upper vertical drive shaft in the wheelcase. The ends are finished with slight shoulders and spigots for the inner races of the ball bearings in which the shaft runs. A radial hole is drilled through between two teeth at mid-length to form a passage for lubrication.

134. The ball bearings are of the light single row type, the inner races of which fit up to the shoulders on the shaft and the outer races fitting into housings machined in the wheelcase. The housing on the starboard side has a stop shoulder and that on the port side, which is plain, has a retaining plate, secured by studs and nuts, which holds the outer race of the ball bearing.

135. The magneto couplings, of nickel steel, are machined to the section shown. The bore of the central boss is tapered and has a keyway cut in it to fit the spindle and Woodruff key of the magneto armature spindle. Externally, at the small end of the taper, the boss is screwed for an extractor to enable the coupling to be withdrawn from the armature spindle. The web of the coupling is lightened by six holes and the rim is plined (12 teeth) to suit the magneto drive coupling. The rim of the coupling is extended slightly inwards to form a thrust edge for the magneto drive coupling. A tab-washered locknut is employed to secure the coupling to the magneto spindle. The lock washer has a plain tab which is turned in to fit the keyway in the coupling and a V-notched tab which is bent back against the nut when the latter is tightened up.

136. The magneto drive coupling of nickel steel is a hollow sleeve which fits into the drive shaft; it is enlarged and internally serrated at its outer end to receive the serrated coupling plate on the magneto spindle. The inner end is serrated externally (11 teeth) to fit the serrations in the drive shaft, and the dished outer end is provided with 12 internal serrations to fit the serrations of the magneto coupling. The couplings assemble as shown and are located axially by the thrust edges of the coupling plates on the magneto spindles. As previously stated, the magneto drive couplings form vernier adjustments for the magneto timing. As the magneto shaft rotates at 1·5 times crankshaft speed, one turn of the magneto shaft is equivalent to 240° of crankshaft rotation. Therefore, if the magneto and coupling are unmeshed from the serrations in the centre of the shaft and remeshed one serration forward, i.e. $\frac{1}{11} \times 240°$, and then the magneto is unmeshed from the serrations in the end of the coupling and remeshed one serration backwards, i.e. $\frac{1}{12} \times 240°$, the net forward movement of the magneto will be

$$\left(\frac{1}{11} - \frac{1}{12}\right) 240° = \left(\frac{1}{132}\right) 240°$$
$$= \frac{20°}{11}$$
$$= 1{\cdot}8° \quad \text{(crankshaft)}.$$



*Lower camshaft drive*

137. The lower camshaft drive unit (*see* fig. 7) comprises a short hollow spindle which transmits the drive from the wheelcase to the upper camshaft drive, and a composite bearing housing which bears the spindle and is secured to the wheelcase.

138. The spindle has formed integrally at its top end a large bevel wheel, having lightening holes in its flange, which meshes with and receives its drive from the bevel wheel splined to the upper end of the upper vertical drive shaft. A shallow internally serrated hub is formed on the upper surface of the bevel and the top of the shaft bore is spherical; the lower end of the long hollow coupling shaft is similarly formed so that it may mesh with the serrations and seat upon the spherical face. The inner race of the top ball bearing slides on to the shaft and abuts against a shoulder formed under the bevel; a groove is cut in the shaft to receive a square spring ring which retains the inner race on the shaft. The outer race is held in a housing which spigots into the wheelcase; this housing is flanged at the top end and has an internal lip formed at the lower end which engages a flange of the locknut which screws into the wheelcase and secures the outer race of the lower ball bearing in its housing. A mesh adjusting washer is interposed between race and locknut, and the nut is locked by an internal spring circlip, the end of which passes through a hole in the nut and into an aligning hole in the wheelcase.

139. The lower end of the shaft is threaded to receive a tab-washered nut which retains in sequence a washer, the inner race of the lower ball bearing and a counterbored distance sleeve and the inner race of the top ball bearing. All these components are pulled up against the shoulder formed under the bevel by the afore-mentioned nut on the lower end of the shaft.

## COOLANT PUMP

*General*

140. The coolant pump is of the bottom fed centrifugal type and serves each cylinder block from a separate outlet (*see* fig. 29). The sixteen-bladed forged brass alloy rotor of the pump is screwed and pinned to a steel spindle, which is driven from the lower vertical drive shaft in the wheelcase. The spindle and rotor are borne in a coolant-tight housing contained in an extension of the pump outlet casing; this latter casing is secured to the wheelcase by means of an adaptor casting. Spigoted into the bottom of this casing and secured to it by studs and spring-washered nuts is the

pump inlet casing. Lubrication of the spindle is by grease supplied from a grease lubricator which is housed in a boss in the pump outlet casing. Descriptions of the two main components of the pump unit, viz., the inlet casing and the outlet casing, are given in the following paragraphs (*see* fig. 28).

*Inlet casing*

141. This consists primarily of a stub pipe which is suitably flanged and spigoted for its union with the bell-shaped outlet casing and is machined so as to clear the bottom face of the rotor by a fine limit. It is provided with a boss co-axial

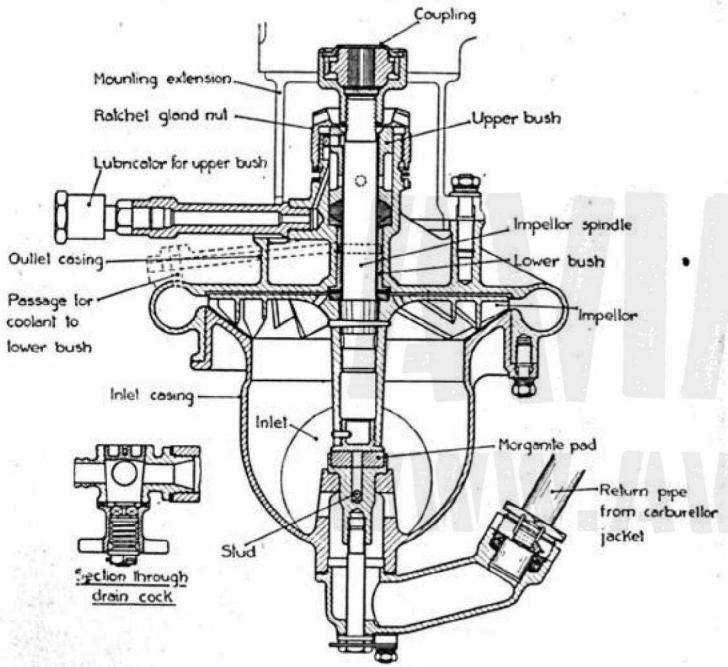



FIG. 28.—Arrangement of coolant pump.

with the rotor spindle and drilled to receive the shank of a flanged and cupped stud whose flange bears on the top of the boss and contains a self-lubricating button of morganite which acts as a foot-step bearing for the lower end of the rotor spindle. This stud, in conjunction with a bolt, also secures a lower cover, which houses a drain-pipe connection, to another facing co-axial with the rotor spindle and below the foot-step bearing boss. This cover spigots into the casing and is clamped, with a joint washer on its upper face, to the casing by the bolt which screws into the stud; the shank of the bolt spigots into a hole drilled centrally in the cover.



The bolt is locked by a cranked plate which is anchored to a stud in the casing at one end and at the other end is slotted to engage the hexagonal head of the bolt. The cover is provided with a bossed hollow extension into which is screwed a drain-pipe connection, which contains a compressed rubber ring type sealing gland. This connection is attached to a pipe which drains each carburettor of its coolant. The bossed extension has a subsidiary boss which contains a drain cock, by means of which the coolant may be withdrawn. A spring clip normally keeps the cock closed. Holes drilled in the web surrounding the foot-step bearing boss pass this drain coolant into the suction side of the pump.

142. The coupling connecting the tubular end of the inlet casing with the coolant supply pipe from the radiator consists of a rubber tube whose forward end is clamped against a small semi-circular shoulder on the casing by the pressure of a Jubilee type hose clip; the rear end is clamped in a similar way to the supply pipe from the radiator.

*Rotor and spindle*

143. The stainless steel rotor spindle is borne in two lead-bronze lined steel bushes in the centre of an extended housing integral with the top of the pump outlet casing. The lower of these two bushes is pressed from the bottom into the casing until its flange, which enters a recess, is flush with the surrounding metal. The upper bush is pressed down upon a V-section ring of packing inserted between its flanged lower end and a chamfered washer situated at the upper end of the lower bush by the lip of a threaded cap nut screwed on to the top of the housing. This cap nut is locked by a coil spring whose hooked top end engages one of a number of ratchet grooves cut on the lower face of the nut and whose hooked bottom end engages a slot cut in the rim of the facing. Axial movement of the upper bush is prevented by a square-headed grub-screw which engages a slot machined in the bore of the housing. This bush is waisted on either side of a centre shoulder to form, with the housing bore, an annulus which acts as a grease reservoir. This annulus is served by a passage in the housing which registers with a grease entry hole in the pump outlet casing. Lubrication of the lower bush is effected by the coolant which is led to it through another passage in the casting.

144. The rotor spindle consists of a solid shaft of stainless steel which is splined at its top end for engagement with the hub of a flexible coupling and is tapered and threaded at its bottom end for the reception of the hub of the rotor. The coupling comprises a sleeve, a central driving element and a cupped washer. The driving element is splined

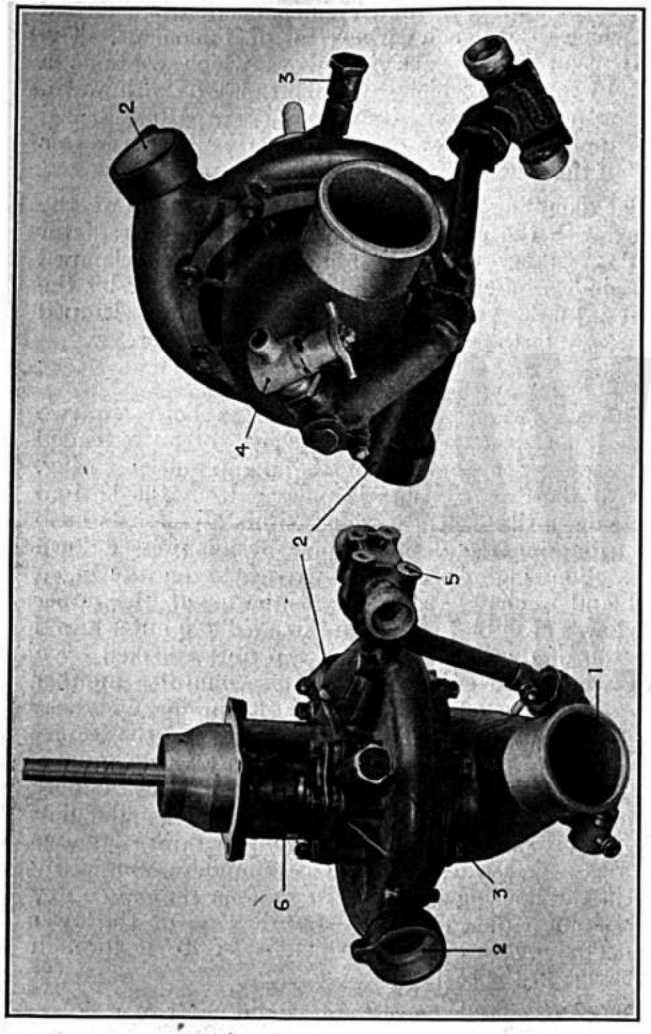



FIG. 29.—Coolant pump.

1. Coolant inlet.
2. Coolant outlets.
3. Pump spindle lubricator.
4. Drain cock.
5. Return union from carburettor coolant jackets.
6. Ratchet for adjusting pump spindle gland.



internally, for engagement with the lower end of the coupling shaft from the wheelcase, and externally for meshing with the splines in the interior of the sleeve in which it has a small degree of universal movement by virtue of its spherically shaped top and bottom faces. The cupped washer is clamped to a shoulder in the top of the driving element by the peened-over rim of the latter. The hub of the sleeve is splined internally for coupling with the upper end of the pump spindle. Sweated in the bore of the driving element on the top of its splines is a location washer which restricts the downward movement of the element by bearing on the top of the rotor spindle.

145. The brass rotor has sixteen vanes and a single shroud. The hub is screwed on to the spindle which is tapered for a short distance inside the threads to form a seating for a similar tapered portion of the bore of the hub. The hub is secured to the bottom of the spindle by a taper pin whose smaller end is peened over. A steel plug is screwed and pinned to the bottom of the hub to form a hard bearing surface for working contact with the morganite button in the inlet casing stud. The top face of the rotor is recessed to receive a steel washer which provides a hard bearing surface on the lead-bronze faced bottom of the lower bush.

*Outlet casing*

146. The outlet casing of the pump consists of a central volute chamber which feeds two diametrically opposed integral branch pipes connecting respectively by external pipes with the "A" and "B" cylinder jackets (*see* para. 17). The bottom of the casing spigots into the inlet casing and is attached to it by eight studs and spring-washered nuts, while the top of the casing is secured to the bottom of the coolant pump adaptor casting by studs and spring-washered nuts. Screwed into the central boss in the casing is a grease lubricator which lubricates the upper bush. A hollow rib in the top of the casting conveys coolant from the pressure side of the pump to the lower bush. Each end of the branch pipe is enlarged and threaded for the reception of a ring nut which compresses an aluminium washer on to a rubber joint ring against a shoulder in the pipe. Each ring nut is locked by a plate mounted in a lug formed on the pipe.

## IDLER GEAR UNIT

147. The idler gear unit (*see* fig. 66) comprises a spur gear which is free to rotate on a hollow vertical spindle pinned to a bracket which is secured to the lower front face of the wheelcase by two studs fitted with spring-washered nuts. The spindle is entered into the bracket from the top end to fit the tapered bore in the bottom of the bracket to which it

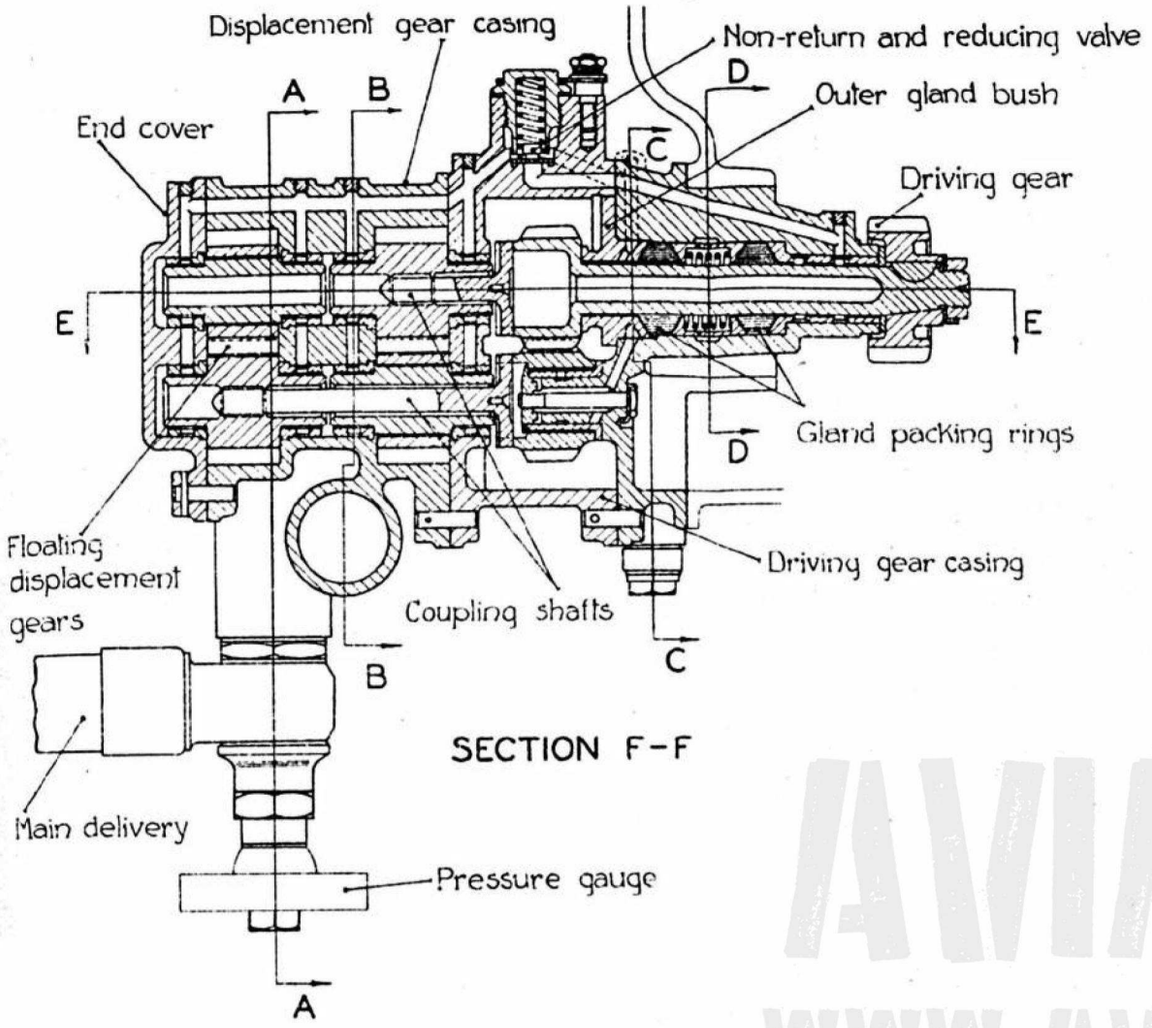
is locked by a taper pin driven in from the rear of the bracket. It is drilled radially near its centre with two holes to lubricate the bush of the spur gear. The outside of the spindle also has a shallow longitudinal slot cut in it which connects with one of these holes for the purpose of distributing the oil over the whole length of the bush. This bush, of phosphor-bronze, is pressed into the bore of the spur gear hub until its flange abuts against the bottom face of the hub. A steel thrust washer is interposed between the bush and the bottom of the idler gear bracket. The idler gear meshes at the rear with the spur gear on the bottom of the lower vertical drive shaft and in front with the upper or largest gear of the composite oil pump driving gear.

**FUEL PUMPS UNIT**

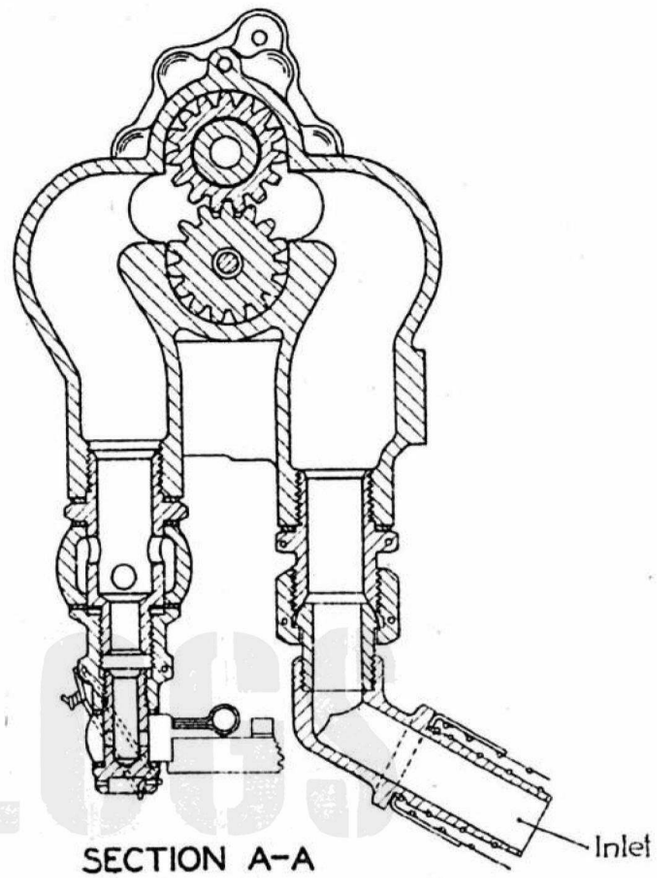
148. The fuel pumps unit (*see* fig. 31), mounted upon the facing of the left-hand side of the wheelcase, consists of two separate pumps operating in parallel. Each pump is capable of operating independently of the other, and each is of sufficient capacity to supply more than the maximum volume of the fuel required by the engine. Each pump is driven separately by means of a thin coupling shaft ; in the event of one pump seizing, its respective coupling shaft will shear and so automatically isolate it from the drive without causing damage to the other unit. As stated in para. 130, the fuel pump driving shaft is coupled directly to the lower vertical drive shaft by means of a pair of spiral gears.

149. The pump unit comprises four separate castings (*see* figs. 30 and 31), namely—the inner housing which carries the driving shaft and a spring-loaded double sealing gland; the driving gear casing which encloses a two-spur gear by means of which each pump is operated independently ; the main pump casing which carries the two pumps, the spring-loaded relief valve and the inlet and outlet union ; and an end cover. Lubrication of the various spindles and bushes is effected by oil from the high pressure circuit, metered to a limited supply and delivered through a small spring-loaded reducing valve and a system of aligning passages incorporated in the different castings. The whole unit is mounted on the wheelcase facing by means of four studs which pass through a flange integral with the gear housing ; these studs also retain the gear case housing and permit the fuel pump body to be quickly removed for inspection without disturbing the drive. All bushes are of phosphor-bronze with whitemetal linings.

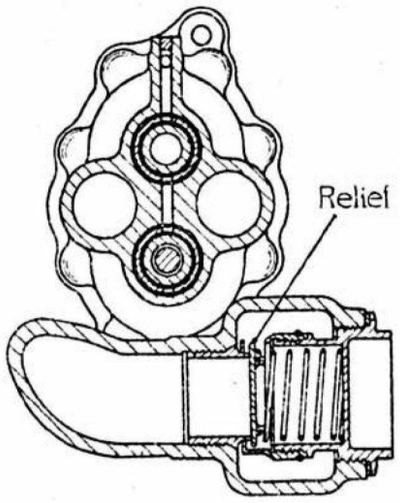
150. The flanged inner housing, by means of which the whole unit is attached to the wheelcase, has a large central boss which is bored and counterbored for the reception of the driving spindle bushes and the double oil retaining gland.




SECTION F-F

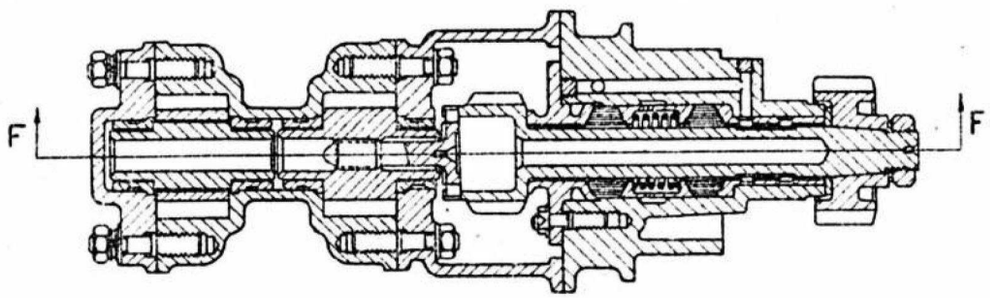



SECTION A-A

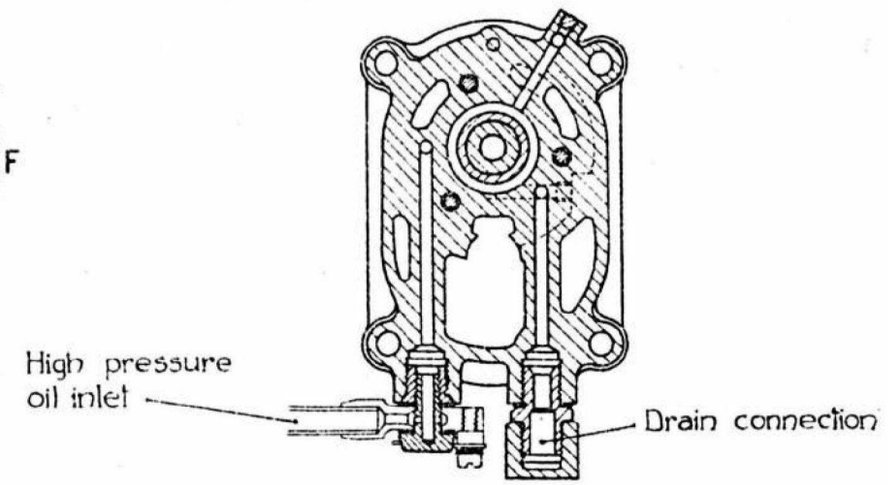



SECTION B-B

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SECTION E-E




SECTION C-C



SECTION D-D

FIG. 30, ARRANGEMENT OF FUEL PUMPS UNIT

The inner bush is pressed into the smaller diameter bore from the interior of the counterbore and has a cone-shaped flange on its inner face to accommodate the inner V-sectioned asbestos packing gland. The outer bush is similarly shaped on its end face to accommodate the outer packing gland, and is pressed into the end of the counterbore and retained by bolts which pass through a flange formed on it into the casting. An annular groove is cut around the spigot of the bush for the purpose of directing oil from an exterior passage leading from the oil reducing valve that connects with it to its own bearing surface and also, by means of a further duct, to the hollow interior of a boss immediately below. Between these two chamfer-ended bushes and loaded by means of a coil spring interposed between them are the two asbestos packing glands; the ends of the spring bear upon cone-shaped washers which abut against the inner ends of the packing glands, thus continually forcing them against the bush flanges and rendering the gland self adjusting.

151. The driving shaft has a spur gear formed integrally at its outer end and has keyed to its inner tapered end a spiral gear which is retained by a tab-washered nut. A steel thrust ring is interposed between the flange of this gear and the end of the spindle boss. The spiral gear meshes directly with the corresponding spiral gear splined to the lower vertical drive shaft in the wheelcase. The outer integral spur gear is hollow and its rim is extended and castellated to receive the dogged flange of the short thin coupling shaft through which the inner pump is independently driven. Formed on the outer face of the inner housing wall is a hollow parallel boss upon which a flanged bronze bush which is whitemetal lined internally is mounted. The idler driving gearwheel through which the outer pump is driven and which is also provided with castellations on its rim for engagement with the dogs of the long coupling shaft is mounted upon this bush and meshed with the spur gear integral with the driving shaft. The idler gear which is whitemetal lined internally is retained upon the bushed boss by means of an end cap which spigots into the bush and is retained by a bolt passing through the casing flange and screwing into its centre. The bush is lubricated from the hollow boss, as mentioned in para. 150. The two meshed driving gears are lubricated by slight oil and fuel leaks which collect in the gear drive casing.

152. On the lower side of the inner housing are two bosses into which are screwed unions. One union provides a connection for an external pipe bringing oil from the high pressure system; it proceeds thence through internal passages in the casting to the inner or smaller diameter bush. The oil is then

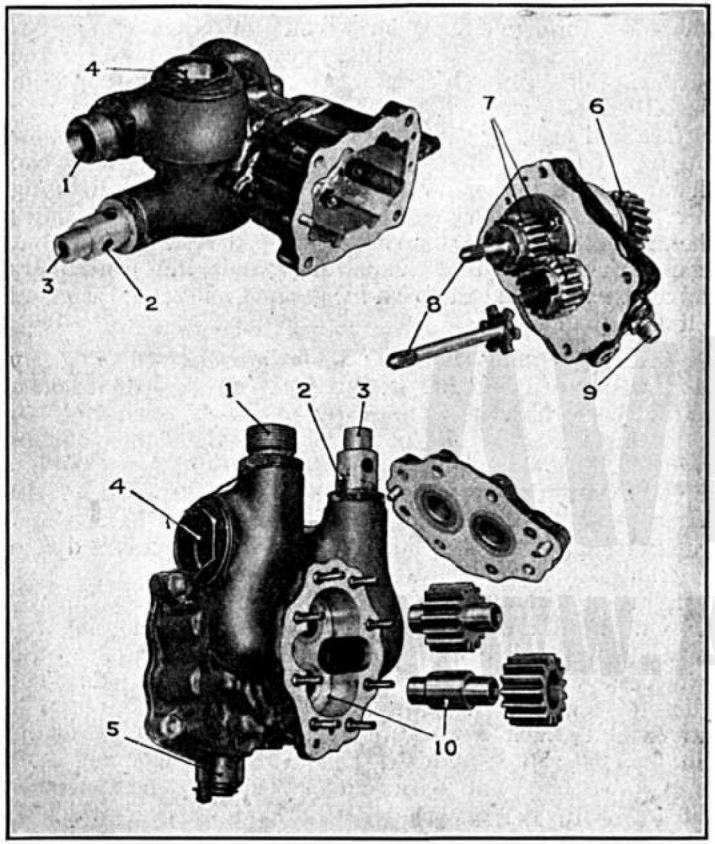



FIG. 31.—Fuel pumps unit.

1. Inlet union.
2. Outlet union attachment.
3. Pressure gauge union attachment.
4. Relief valve.
5. Non-return reducing valve.
6. Driven spiral gear.
7. Pump coupling gears.
8. Coupling shafts.
9. High pressure oil inlet union.
10. Pump unit and displacement gears.



metered past this bush to another delivery passage, which leads to the oil reducing and non-return valve ; this metering action is performed by means of a flat cut upon the spindle which registers first with the inlet passage and then with the outlet passage, thus permitting a certain quantity (about 15 drops a minute) to pass.

153. After passing through the reducing and non-return valve, the oil is led through the aligning and inter-connecting passages in the various castings already mentioned, to the several bushes which support the driving shaft and the driving and driven pump spindles.

154. The second union provides connection for a drain from the space between the two bushes for the oil that has leaked past the glands. The main pump casting has a thick central wall, into either side of which are pressed two flanged bushes in which run the inner ends of the four pump pinion spindles. Each pair of meshed pinions is enclosed in a specially shaped housing machined in each side of the casting. The outer ends of the pairs of pinion spindles are borne in pairs of bushes carried respectively in the wall of the drive casing and the end cover. The pump casting incorporates large hollow bosses into which are screwed the inlet and outlet unions, the latter union incorporates a connection for a fuel pressure gauge pipe.

155. Fuel is led to and from each pump unit by means of common inlet and outlet passages incorporated in the casting. The spring-loaded disc type relief valve is embodied in the inlet passage and in the event of an excessive pressure being generated permits the excess fuel from the delivery side to return to the inlet side. The stainless steel seating is secured into the boss in the casting, while the disc type valve is pressed against it by means of a coil spring retained by a screwed hexagon-headed cap which screws into the boss.

156. Each stainless steel driving pinion of the pump units has its hollow spindle formed integrally with it and is splined internally for meshing with the splined end of the coupling shaft. The phosphor-bronze driven pinions have whitemetal lined bores and separate spindles upon which they float. The end cover is a simple casting embodying two blind bosses into each of which is pressed a flanged bush which supports the outer end of one of the outer pump spindles. It is attached to the outer face of the main pump casting by means of studs and nuts. All four castings are aligned with one another by means of dowels ; the end cover and main pump casting are attached as a unit to the drive casing by means of eight long bolts. Paper joints are inserted between the faces of the

main pump casting; the inner drive housing and the wheelcase mounting; while the remaining faces are made by means of suitable jointing compound.

### ELECTRIC GENERATOR DRIVE

157. The Rotax 500-watt, 12-volt. electric generator is mounted upon a cast light alloy right-angled bracket which is located on a face situated on the left-hand side of the crankcase by means of a tenon slot and four studs and spring-washered nuts. The generator is driven from a small overhung spur wheel formed on an extension of the left-hand supercharged layshaft, through a gear-train contained partly within the wheelcase and partly within a lateral extension of the crankcase (*see* fig. 32). This gear-train consists of (*a*) an idler wheel, (*b*) an intermediate lay spindle, (*c*) a second idler wheel, and (*d*) a driving shaft. All the wheels and spindles mentioned are carried in plain bushes which are lubricated by means of passages drilled in the castings concerned and supplied to a hole in the left-hand side of the crankcase from the low pressure oil system by means of an external pipe leading from the double union, which is bolted to a face incorporated with the rear side of the camshaft drive cover.

158. The idler wheel (*a*) which meshes with the pinion of the supercharger lay spindle has a flanged phosphor-bronze bush pressed into each end of its hub and is mounted upon a hollow flanged spindle which spigots into a housing provided for it in the supercharger casing and is attached by studs and nuts. The outer extremity of this hollow spindle is reduced slightly in diameter for the reception of a flanged end cap which retains the wheel upon the spindle. The end cap is merely a push-fit on the spindle and is secured by a taper pin.

159. The idler wheel meshes with a small pinion which is mounted upon the tapered rear end of the intermediate lay spindle (*b*) and is keyed to it by means of a Woodruff key; this pinion is retained by means of a tab-washered nut screwed to the threaded end of the spindle. Integral with the front end of the spindle is a second pinion. The spindle is carried in two long flanged bushes pressed into each end of a long housing incorporated in the wheelcase casting; these bushes are grooved internally for purposes of lubrication, and low pressure oil is supplied to the grooves through the passages in the casting referred to in para. 315. The spindle is positioned axially in these two bushes by means of flanges which abut against the shoulder formed by the integral pinion at the front end and a loose thrust washer at the rear end.

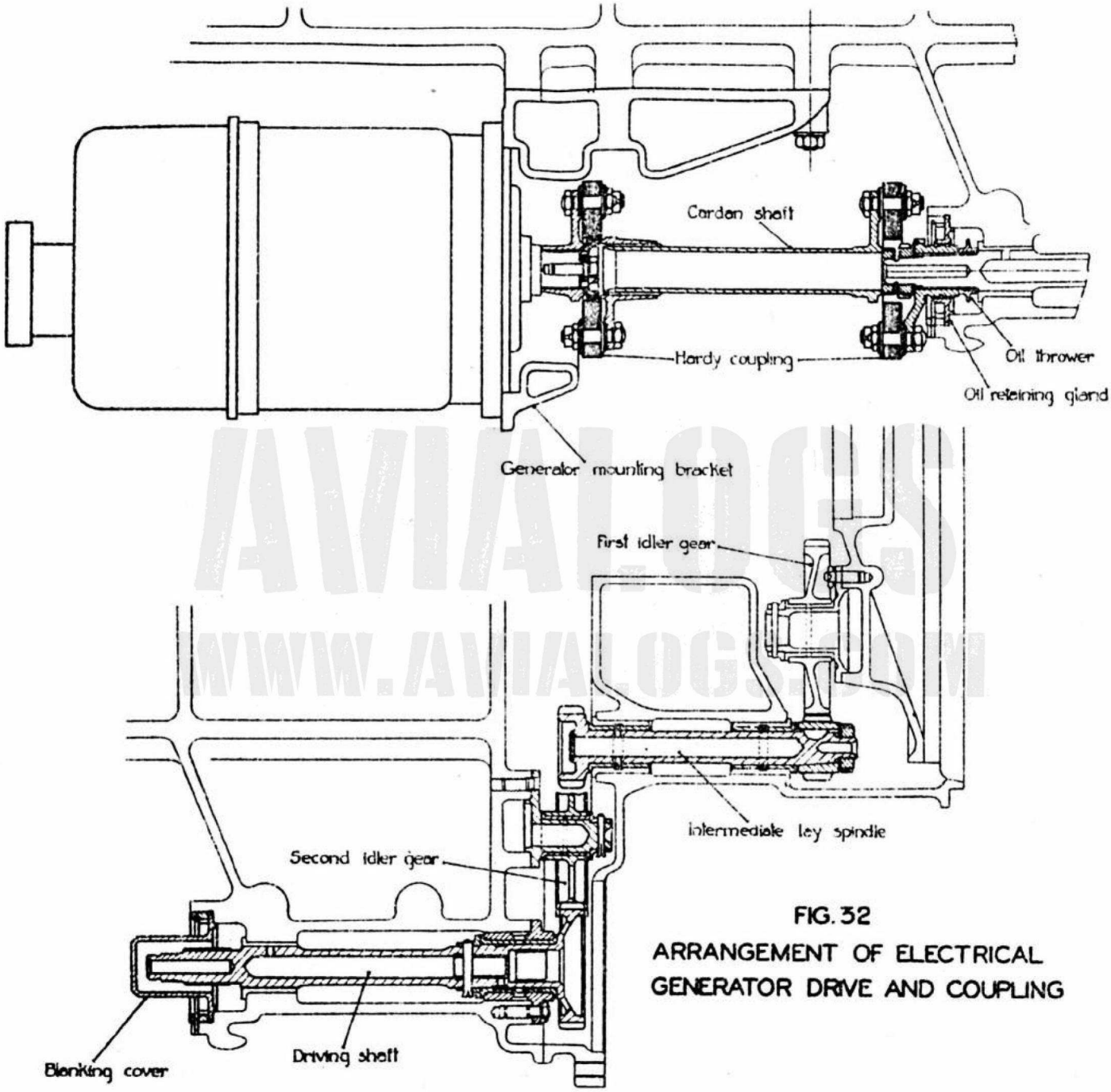



FIG. 32
ARRANGEMENT OF ELECTRICAL GENERATOR DRIVE AND COUPLING

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160. The pinion at the front end of the intermediate lay spindle described in the preceding paragraph meshes with the second idler wheel (*c*), which is similar in construction to the idler wheel (*a*) already described, except that its flanged spindle is spigoted into a faced housing incorporated in the crankcase casting. This second idler wheel meshes with a pinion formed integrally on the rear end of the generator driving shaft. The rear end of this shaft is carried in two flanged bushes which are pressed into opposite ends of a flanged housing spigoted into the bore of the tubular casing in the casting and retained by means of studs and nuts. The flange of the rear gearwheel abuts against the flange of the rear bush, while a flanged unthreaded retaining sleeve is passed over the front end of the shaft and is secured to it by means of a taper pin. The shaft is thus positioned axially between the two flanges of the composite rear bush. Incorporated in the rear bore of the shaft, and secured by the taper pin already mentioned, is an oil-retaining plug which retains the oil entering through the groove and the radial hole in the rear end of the shaft from a longitudinal groove in the rear composite bush for the purpose of lubricating the front bush through the radial hole in the front end of the shaft.

161. The driving shaft is waisted in its centre portion and then thickened towards the front end to form a bearing surface for the front bush which is pressed into the front end of the casting. The radial hole mentioned in the preceding paragraph is drilled through this thickened portion and permits oil from the interior of the shaft to reach the bearing surface. The front end of the shaft is splined for the reception of a driving spider which forms one of the components of the rear of the two Hardy type flexible couplings incorporated with the Cardan shaft through which the generator is driven.

162. The exterior of the hub of this spider has oil-retaining grooves cut in it ; these grooves, acting in conjunction with a close fitting sleeve incorporated with an end cap, which spigots into the casting and is retained by a circlip retained locknut, form an oil gland at this point. In the event of an electric generator not being used, this gland-forming end cap is replaced by a blanking cap, which is retained by the same locknut. When the generator is fitted, an oil flinger is located upon the splines of the shaft immediately in rear of the spider hub. The spider is retained upon the splined forward end of the shaft by means of a tab-washered locknut. The Cardan shaft incorporating a Hardy type flexible coupling at either end has an integral spider at the rear end and is splined at the front end for engagement with the splined hub of the spider associated with the generator shaft.

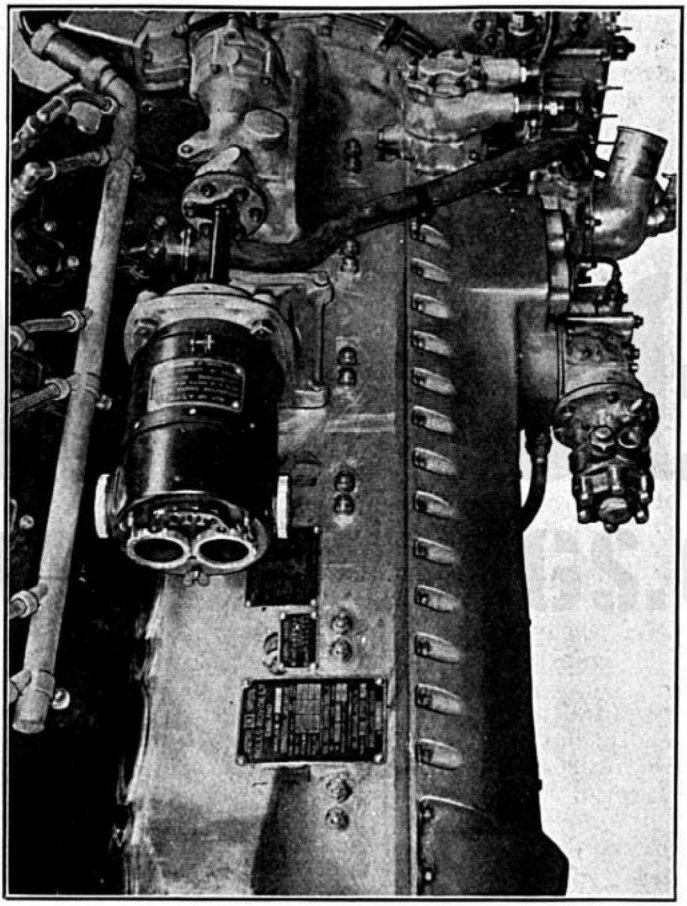
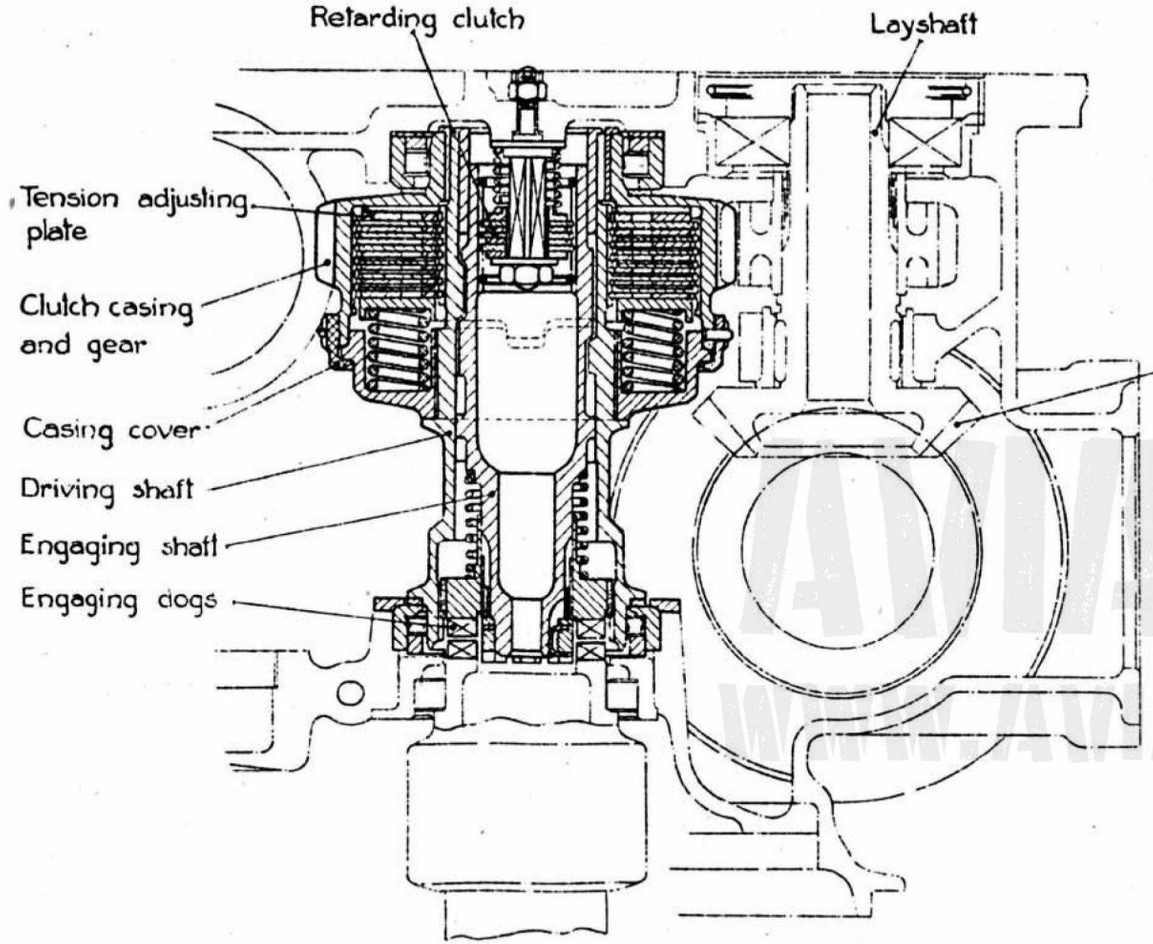
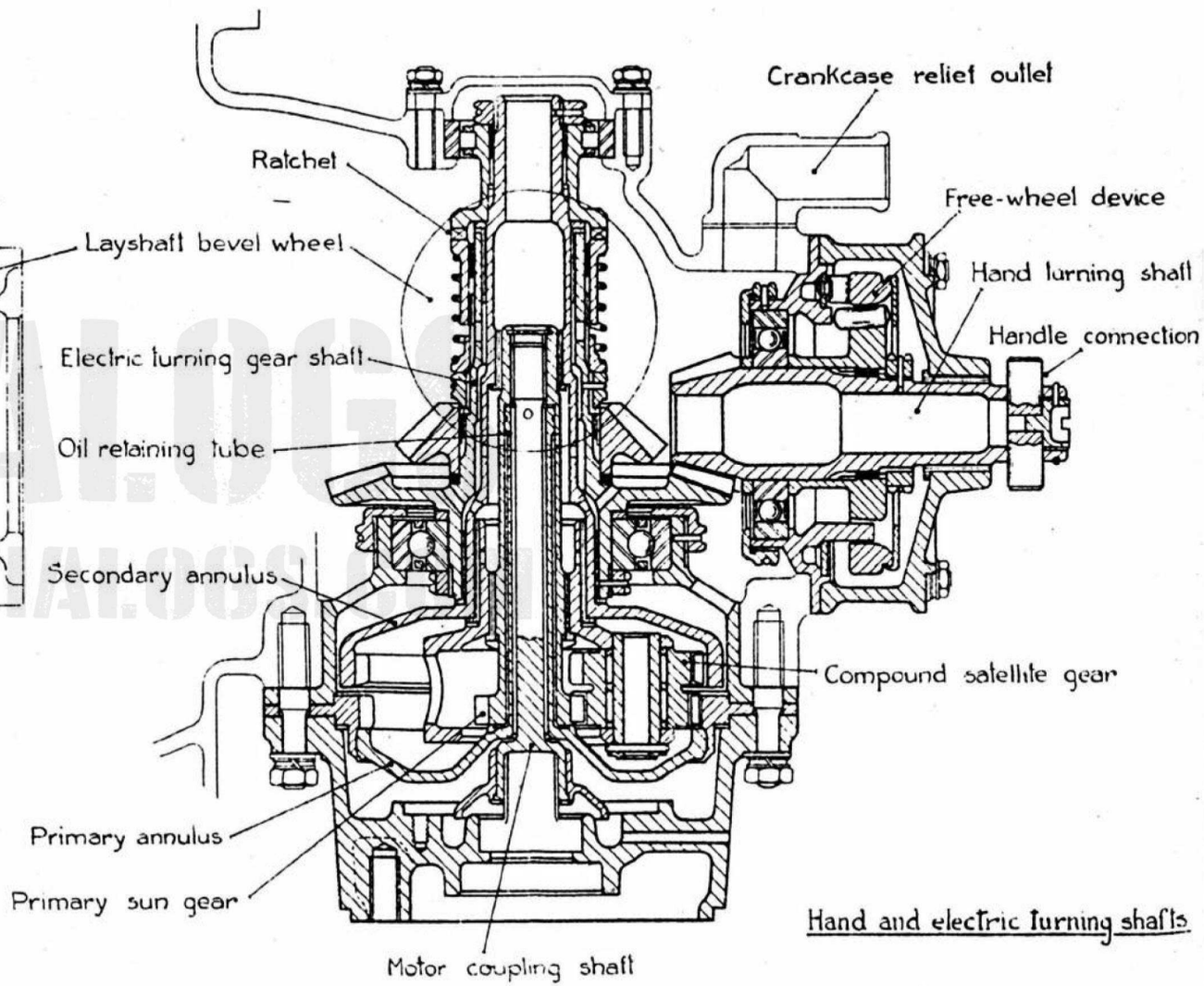


FIG. 33.—Electrical generator, pressure oil, fuel, and coolant pumps and Lockheed pump drives.




Turning gear engaging claw and slipping clutch




Hand and electric turning shafts

# FIG.34. ARRANGEMENT OF HAND AND ELECTRIC TURNING GEAR MECHANISM

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## HAND AND ELECTRIC TURNING GEAR

163. The mechanism by means of which the engine may be turned either by hand or by an electric motor for starting purposes is located within the right-hand side of the wheelcase in special housings which are incorporated with the main casting. The starter dog by means of which the turning effort is communicated to the rear end of the crankshaft through the spring drive shaft, engages with a dogged extension formed on the right-hand supercharger layshaft; the pinion on this layshaft meshes with the main driving gear on the rear end of the spring drive shaft and so completes the connection. The turning mechanism (*see* fig. 34) comprises four separate shaft groups as follows:—

(i) Hand turning gear which provides an external coupling for the hand cranking handle and incorporates a freewheel device of the "roller jamming" type which, in conjunction with the large slipping clutch mentioned in (iv) below, isolates the hand cranking shaft and prevents injury to the operator in the event of a backfire.

(ii) Electric turning gear assembly which incorporates a double epicyclic reduction gear (ratio 90 to 1), known as a crypto gear, through which the electric motor operates and a spring-loaded ratchet which isolates the electric turning gear when the hand turning gear is being used. The latter gear drives through a large bevel wheel incorporated with this assembly, while a smaller bevel transmits the drive from both hand and electric turning shafts to a layshaft.

(iii) The layshaft couples at one end with a small bevel wheel on the electric turning shaft and a large spur gear on the engaging mechanism and safety clutch shaft.

(iv) The engaging mechanism and safety clutch driving shaft has incorporated with it a large multiple plate clutch (having a slip loading torque of 3,500 in./lb.) which will safely transmit normal turning efforts but will slip if abnormal loading due to a backfire is imposed upon it. Its particular function is, in conjunction with the "freewheel" device, to protect the high ratio reduction gear of the electric turning mechanism and also the hand turning operator from injury. The shaft also contains the dogged shaft which, when the turning gear is in operation, rides rearward along internally formed spiral grooves in the shaft into engagement with the complementary dogs formed on the right-hand supercharger layshaft. A small multi-plate clutch, (having a slip loading torque of 5 in./lb.), holds the lugs on the dogged shaft against the spiral grooves during

the initial turning motion and so causes it to ride along and into engagement with the dogged layshaft ; as soon as the two dogged ends are locked together, this small clutch slips. The hand and electric turning gears have reduction gear ratios in regard to the crankshaft of 14 to 1 and 393 to 1 respectively. A 12-volt (or 24-volt., according to the aeroplane concerned) B.T.H. starter motor, type C.A. 4125, form F.E.3 is used. These various mechanisms are described in the following paragraphs.

*Hand turning gear*

164. The hand turning gear is a separate unit enclosed in a casing which is spigoted into and secured by means of studs and nuts to a faced circular aperture in the right-hand side of the wheelcase. The steel body has a bronze bush pressed into a boss in its outer wall and has spigoted to its inner open end a steel cover which contains a ball bearing, the outer race of which is retained against an internal lip by a circlip-pinned locknut.

165. The hand turning shaft has a bevel integral with its inner end which meshes with the large horizontal bevel mounted on the electric turning gear shaft. A stout pin is pressed through a transverse hole at its outer end for engagement with the claw on the turning handle. The shaft is carried by the ball bearing and bush at its inner and outer ends respectively. The inner race of the former abuts against a mesh adjusting washer which itself abuts against a shoulder formed by the bevel teeth and is pressed against it by the hub of the inner member of the freewheel which is splined to the centre of the shaft ; the assembly is retained by a circlip-pinned locknut which is screwed to a threaded portion of the shaft. The outer end of the shaft is blanked by a screwed plug which is locked by a circlip. This plug has a central projection which spigots into a hole in the centre of the pin.

166. The circular outer member of the freewheel is fixed to the casing cover. A series of rollers are interposed and retained by an end plate between the mating faces of the inner and outer members and are arranged in a cage integral with the end cover so that they are axially inclined with the centre line of the shaft. This arrangement ensures that when the shaft is turned normally by the operator the rollers will ride free of the two opposing faces, but when the relative rotation is reversed due to a backfire, they will ride into engagement and jam, thus preventing the shaft from rotating and transmitting the shock to the operator. When the shaft is thus held, the large clutch, described later, will slip and so absorb the shock loading.



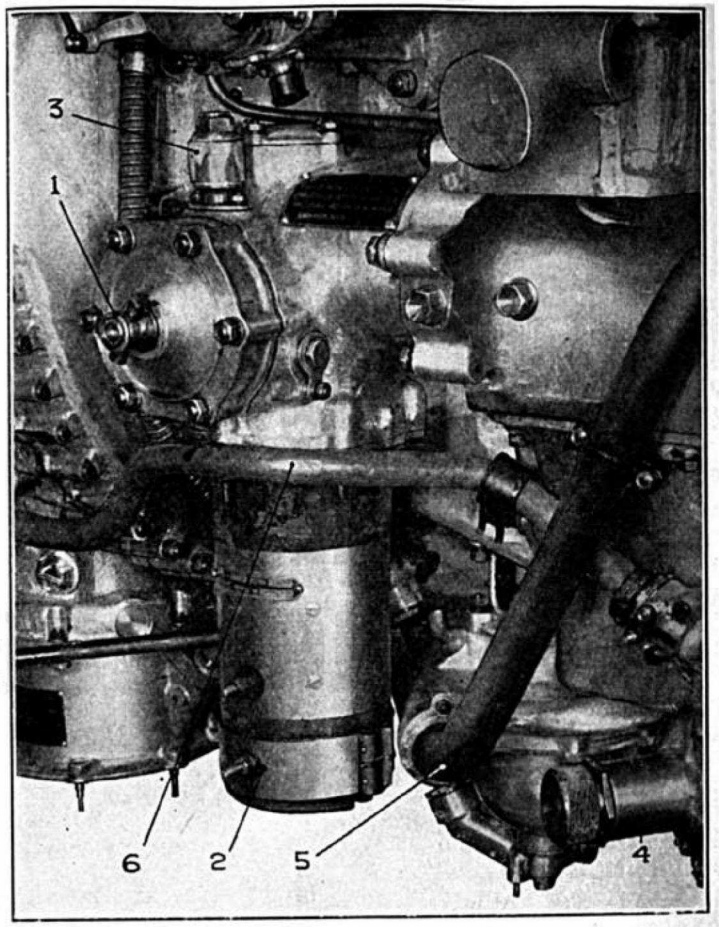



FIG. 35.—Hand and electric turning gear.

1. Hand turning gear shaft.
2. Electric turning gear motor.
3. Wheelcase relief valve.
4. Inlet union on pressure oil pump.
5. Coolant delivery pipe to "A" block.
6. Scavenge oil return pipe.

*Electric turning gear*

167. The electric motor drives the vertical electric turning gear shaft through a double epicyclic gear enclosed in a housing which is spigoted into a faced circular aperture in the wheelcase and attached to it by studs and nuts, which also secure the flange of the starting motor. Connection is made between the splined motor spindle and the top end of the shaft of the primary sun gear by means of a long splined coupling shaft. The primary annulus gear is fixed to the casing and the double satellite gears are mounted on needle rollers. The mechanism comprises several concentric shafts which, with the exception of the central solid driving shaft, are carried one upon the other by various bushes incorporated with them. The shafts are drilled radially to permit splash oil from the wheelcase to reach the various bearing surfaces. These shafts, in order from the centre, comprise: driving shaft, stationary oil-retaining tube fixed to the primary annulus gear, primary sun gear shaft to which is splined the driving shaft, satellite carrier stub shaft, secondary annulus shaft and the outer shaft which carries the horizontal bevel wheels.

168. The hollow spindle of the secondary annulus gear has mounted concentric with it another shaft which bears the composite large and small horizontal bevels, the former of which is coupled to the hand-turning gear bevel. This gear floats on bushes on the shaft and is connected to it in one direction only by means of a spring-loaded ratchet already referred to. The bevel wheel shaft is borne at its lower end in a ball bearing housed in the inner wall of the epicyclic gear casing; mesh adjusting washers are interposed between the two bevel wheels and their abutments, and the inner race of the bearing is retained on the shaft by a circlip-locked nut. The upper end of the shaft is borne in a roller bearing, the outer race of which is housed in an internally lipped aperture in the top of the wheelcase and retained by an external cover secured by studs and nuts. The inner race is formed integrally with the upper ratchet sleeve, which is splined to the top end of the secondary annulus shaft and secured to it by a circlip-locked nut.

*Layshaft*

169. The hollow layshaft, which transmits the drive from the hand and electric turning gear to the dogged driving shaft, has an integral bevel wheel on its rear end which meshes with the smaller horizontal bevel wheel on the electric turning gear shaft, and a spur gear splined to its centre which meshes with the teeth formed on the clutch housing mounted on the driving shaft. At its rear end it is carried by uncaged needle rollers which run in a flanged outer race pressed into an aperture machined for it in the wheelcase; the inner track is formed



as a broad shallow groove in the shaft. The rear end is carried in a ball bearing, the outer race of which is carried in an internally lipped housing pressed into an aperture in the crankcase rear wall and retained by a circlip-locked ring nut. The inner race and the spur gear, with a mesh adjusting washer interposed between them, are drawn up against a shoulder on the shaft by a tab-washered nut.

*Driving shaft*

170. The driving shaft is hollow and has cut in its bore a right-hand spiral thread or groove which engages a similar quick thread formed on the engaging shaft carried within it, The rear end of the outer or driving shaft forms an inner race for a set of rollers upon which it is supported; the internally lipped outer race is pressed into a housing provided for it in the wheelcase casting. A shoulder in the shaft incorporating a thrust ring bears against the internal lip of the outer race. In the centre of the shaft is a thickened parallel portion and a shoulder which receive the central bore of the clutch spring retaining cover, which is thus freely mounted upon the shaft. In front of this smooth central portion, the shaft is splined for engagement with the internally serrated steel clutch plates. The front end is plain to receive the bush pressed into the central hub formed on the clutch housing, which thus is freely mounted upon the shaft.

171. The engaging shaft has, as already mentioned, a quick thread formed on it which engages with the spiral groove cut in the interior of the outer driving shaft for the purpose of forcing the former backwards into engagement with the dogs on the supercharger layshaft. The front bore of this inner shaft is splined to engage the outer serrations on the plates of a small retarding clutch mounted on a square-sectioned spindle anchored by a nut to the crankcase wall. When the turning movement is applied, this small clutch maintains the thread on the inner shaft in contact with the spiral groove of the outer shaft and so causes the former to advance through the latter. When the dogs eventually engage, the clutch slips as the rotation of the shaft continues. The engaging dogs, which have a 10° taper on their trailing sides to facilitate engagement, are formed on a flanged hub which is freely mounted on splines on the rear of the inner shaft; it is urged rearwards into engagement by a coil spring and retained on the shaft by a thrust ring and a castellated nut. The drive is transmitted to it from the outer driving shaft by four lugs on its periphery which float endwise within splines formed in the rear bore of the outer or driving shaft. The spring loading of the freely mounted engaging dog, together with the inclined sides already mentioned, ensures effective engagement of the dogs and prevents jamming.

172. The clutch housing, mounted freely on the front end of the driving shaft, is internally splined to engage the serrations on the outer edges of the light alloy clutch plates which are arranged alternately with the internally serrated steel plates already mentioned. The front steel plate can be obtained in different thicknesses and thus provides a means for varying the clutch tension. The plates are pressed together by ten stout coil springs imprisoned between the recessed pressure end plate, which bears against the rearmost clutch plate, and the housing end cover which spigots into the clutch housing and is retained to it by an integral flange and an internally lipped lock ring secured by a circlip. A large spur gear, which meshes with the spur gear on the turning gear layshaft, is cut on the periphery of the clutch case. It will be appreciated from this description that the turning movement is transmitted from the layshaft to the driving shaft entirely through the binding effect of the externally and internally serrated clutch plates, and that if the point at which the clutch is set to slip is exceeded due to a backfire, the drive will be discontinued.



# CHAPTER 6

## SUPERCHARGER ASSEMBLY

### GENERAL

173. The supercharger is of the high-speed centrifugal type embodying a single semi-shrouded impellor which is driven from the rear end of the crankshaft at 8·588 times crankshaft speed through the spring drive and a speed increasing gear train comprising three lay driving spindles each incorporating a centrifugally loaded clutch. The calculated impellor speed at the normal engine r.p.m. of 2,600 is thus 22,330 r.p.m. The light alloy impellor is co-axial with the crankshaft and is enclosed within two large light alloy castings known respectively as the supercharger induction casing and cover; these two halves are bolted together and are mounted as a unit to the larger or outer spigot face at the rear end of the wheelcase. The front or induction casing half houses the ball bearing in which the front end of the impellor spindle is borne, while the rear or induction casing cover half incorporates in its centre a double floating bush which carries the rear end of the spindle.

174. As described in Chapter 7, the induction casing cover has integral with its lower side, the top half of the twin choke carburettor and incorporates the choke housings and intake passages, the butterfly throttles, the scavenge oil relief valve and the top cover for the float chamber and altitude and induction chamber pressure governed mixture control capsule compartments. For details of these carburettor components Chapter 7 should be consulted. The two intake ducts are merged at the centre over the central area of the impellor. On its front face, the casing cover is shaped to conform with a fine clearance to the contour of the rear side of the impellor blades, and a diffuser guide vane ring is countersunk within a broad concentric groove. At this locality, the rear face of the induction casing is bevelled to provide the annular venturi passage within which the speed of the gases flung off tangentially from the impellor vanes is reduced and so converted into pressure within the induction volute formed jointly at the periphery of the casing and cover.

175. The three clutch lay spindles and their respective driving gears which mesh with the pinion on the front end of the impellor spindle are carried within two smaller light alloy castings which are bolted together and form a unit. These halves are known respectively as the supercharger gear casing and cover, the former being to the rear. Both halves carry

roller bearing housings for the support of the rear and front ends of the clutch lay spindles; in addition, the casing cover incorporates at its centre, the ball bearing which bears the rear end of the spring drive shaft, and adjacent to the upper spindle a housing for attachment of the spindle which carries the first idler gear in the generator drive train. The two lower clutch lay spindles are extended rearwards to provide connections for the generator and turning gear drive respectively. The complete unit is spigoted into the smaller or inner facing at the rear end of the wheelcase. Lubrication of the components is provided for by an extension of the low-pressure system. The general arrangement of the supercharger and its drive is shown in fig. 66, and its chief components are described in the following paragraphs.

## INDUCTION CASING ASSEMBLY

*Induction casing*

176. The induction casing is a dished and flanged light alloy casting of the shape shown in fig. 36. It is circular in form and has the front half of a volute passage incorporated with its periphery and a flanged facing on its front side by means of which it is spigoted and secured by studs and nuts to the larger or outer facing on the rear of the wheelcase casting. The large central boss receives an internally flanged steel housing for the outer race of the impellor spindle front ball bearing. A castellated cap nut screwed to the threaded exterior of the boss and secured by a tongued lock plate and stud, retains the race against a shoulder in the rear of the housing and the stepped rear end of the housing against a shoulder in the boss. A number of oil holes put the inner bore of the housing into communication with an annular oil space formed by its stepped rear end. This annular space communicates by means of a short hole with a vertical duct in the front wall of the induction casing which connects with atmospheric pressure for the purpose of preventing the oil being sucked from the bearing by the depression caused by the rotation of the supercharger (*see* para. 197). A second annular space formed by an internal flanged lip in the casting affords an additional isolation locality.

177. The shape of the volute chamber and the front of the rotor chamber as incorporated in the induction casing is illustrated in fig. 36. A cast drain elbow is fitted at the lower end of the front of the induction casing and is connected to prevailing atmospheric pressure outside the cowling by an external pipe; this elbow connects with the duct in the front wall of the casing mentioned in the last paragraph and has screwed into its open outer end a flanged sleeve holding two



superimposed banjo unions. One union connects with an external atmospheric balance pipe from the inside end of the double floating bush of the impellor spindle which prevents oil from being sucked from the bush by the supercharger depression, while the other provides atmospheric pressure through

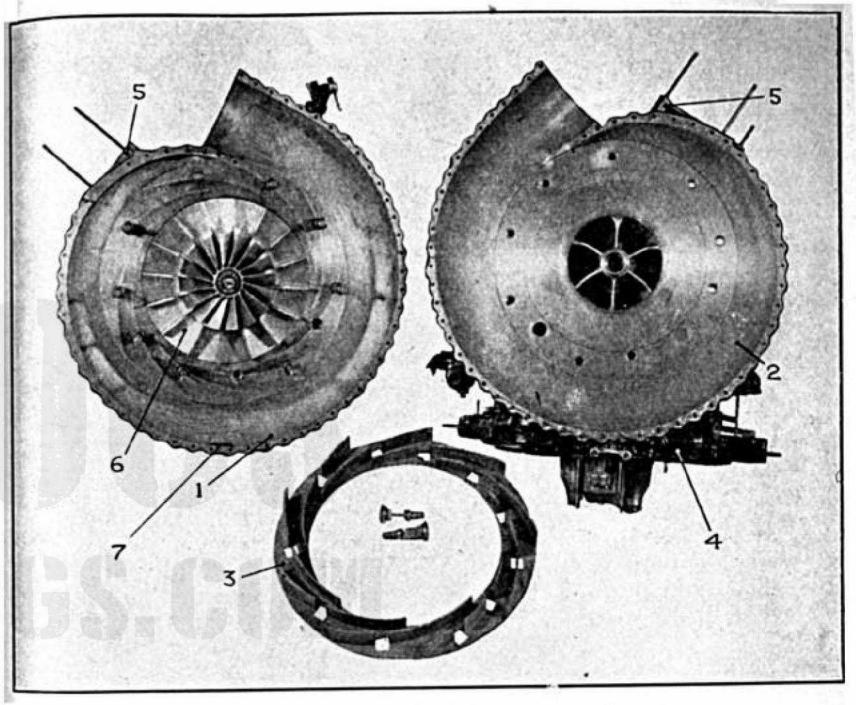



FIG. 36.—Supercharger induction casing and cover.

1. Supercharger induction casing.
2. Supercharger induction casing cover.
3. Diffuser vane ring.
4. Top half of carburettor.
5. Mounting for boost control unit.
6. Impellor.
7. Fuel sump.

an external pipe to the change-over valve on the boost control unit (*see* para. 241). Secured by studs and spring-washered nuts to a facing at the lowest point of the front side of the casing is the cast T-union through which is passed the coolant from the carburettor choke jackets to the inlet side of the coolant pump through the external pipes described in para. 282 (iv) and (v).

178. The rear or inner face of the induction casing has a concentric groove in which rotates a concentric square-sectioned rib formed on the front face of the impeller; this

arrangement provides an additional air seal between the impellor compartment and the impellor spindle ball bearing. Beyond this groove, the wall of the induction casing is slightly concave to accommodate the shape of the front of the rotor. Beyond this again, the face is bevelled to form the annular venturi area, while around the periphery is formed the front half of the annular volute passage. This volute passage, which is completed by the complementary rear half in the casing cover, terminates on top of the casting in a large flanged outlet port which is connected to the central induction manifold located between the cylinders by the right-angled induction elbow. To the left of this port is a facing upon which, in conjunction with the complementary facing on the supercharger casing cover, is mounted the boost control unit by means of studs. Three ports, two of which connect with the pressure and one with the suction sides of the supercharger, are drilled in the facing for the operation of the boost control unit.

179. The rear face of the induction casing is faced and flanged to receive the corresponding front face of the induction casing cover. The flange has numerous evenly spaced drilled bosses to accommodate the waisted holding bolts to the rear ends of which are screwed spring-washered nuts. Bosses are incorporated in the wall of the casing to receive the thin sectioned feathered holding studs which also help to secure the cover to the casing. A small shallow fuel sump is formed in the bottom of the casing which connects by means of aligning holes in the casing and cover with the small venturi incorporated in the right-hand choke housing for the purpose described in paras. 215 and 271.

*Induction casing cover*

180. The light alloy induction casing cover is shown in fig. 36. It is dished and is shaped at its periphery to mate with the rear face of the induction casing and has numerous equally spaced drilled bosses to accommodate the waisted attachment bolts which hold the halves of the complete supercharger casing together. The dished portion at the periphery of the induction casing cover forms the rear half of the delivery volute. The inlets to the intake volutes project from the back of the cover and terminate at the lower end in the upper half of the carburettor which is integral with the induction casing cover as already mentioned (*see* Chapter 7). The upper end of the intake volute terminates in the divided annular space integral with the centre of the rear wall of the casting; this space leads through the circular aperture in the wall to the impellor entry and combined strengthening ribs and diffuser vanes are incorporated in the opening.



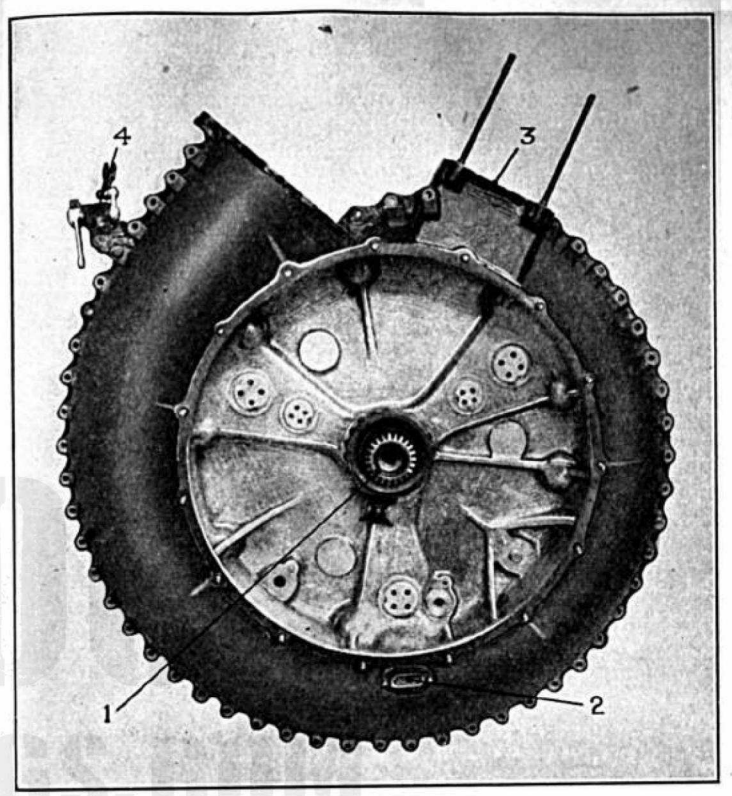



FIG. 37.—Supercharger induction casing, front view.
1. Impellor spindle gear.
2. Atmospheric air inlet and union face.
3. Boost control unit mounting face.
4. "A" side magneto control lever.

181. The face of the front wall of the induction casing cover forms the back of the rotor chamber and the broad concentric groove incorporated in it receives the ring of tangential diffuser vanes through which the mixture passes on its way from the rotor chamber to the induction volute. A stout flanged boss is incorporated in the centre of the wall to receive the double floating bush flanged housing which supports the rear end of the impellor spindle. The housing spigots into the hollow boss from the rear and is secured by a flange and three studs and spring-washered nuts. The housing has a swivelling type union screwed into its rear end to provide an inlet for the external low-pressure oil pipe which supplies oil to the bushes. A second smaller offset boss receives another banjo union

which provides attachment for another external pipe which delivers atmospheric pressure through a duct in the casting to the inner end of the bushes to prevent the oil being sucked from the bearing surfaces by the supercharger depression. An adaptor, having a screwed taper hole, is fitted in the right-hand intake volute and therefore connects with the depression side of the supercharger ; this connection may be used for the operation of blind flying instruments or blanked off by a plug if not required. The halves of the facing that form the mounting for the boost control on the upper side of the two castings have three air holes, two of which communicate with the delivery or pressure side and one with the intake or suction side of the supercharger (*see* para. 243). The boost control unit is attached by means of five studs. An elongated facing is provided just above the intake volute for the control shaft mounting brackets, which are attached to it by bolts. Radial stiffening ribs are formed on the rear wall and large blanking plugs permit access to some of the feathered bolts mentioned in para. 179.

*Diffuser vane ring*

182. The ring of nine tangentially disposed diffuser or guide vanes shown in fig. 36 is machined from a circular steel forging. The flat ring itself is housed flush in the broad concentric groove cut in the front wall of the induction casing cover. The square apertures around the ring afford clearances for the inner ring of flat-sectioned studs which help to retain the cover to the supercharger casing. Flats are machined on the studs where they pass through the vanes so that they may be feathered with the vanes and so avoid interruption of the vane surfaces. The studs are secured with the flats in line with their respective vanes by rectangular shoulders above the flats which engage with the rectangular apertures in the ring already mentioned. The passage of the mixture between the vanes ensures that it enters and flows around the delivery volute with the minimum of turbulence, and assists efficient diffusion and distribution of the mixture.

*Impellor and spindle*

183. The impellor spindle is bored and counterbored from its front end for somewhat more than half its length and is borne in a ball bearing and a double floating bush at its front and rear ends respectively. The front ball bearing determines the end location of the spindle. An integral spur pinion, formed at its front end, meshes with the three concentrically arranged clutch driving gears. The centre portion of the spindle is splined to receive the impellor and separate ring of entry blades, while the rear end is reduced in diameter and threaded some distance in front of the rear end for the impellor



retaining nut. The solid rear extremity is parallel and smooth and forms a journal for the double floating bush contained in the housing held in the centre of the wall of the supercharger casing.

184. The outer race of the front ball bearing is held in the stepped housing and located within the central boss in the supercharger casing wall as described in para. 176. The inner race is mounted on the front end of the impellor spindle and abuts against the shoulder formed by the spindle pinion. An impellor clearance adjusting washer is interposed between the shoulder and the race ; different thicknesses permit the impellor to be moved longitudinally in relation to the walls of the impellor compartment and so adjust this critical clearance. At the rear of the inner race there is mounted upon the spindle respectively : an oil thrower, a distance piece which is bevelled at its rear end, the impellor, the hub upon which the inducer or entry blades are formed, a centring cone, a tab-washer and a second impellor clearance washer. All these components are pulled up against the shoulder at the front end of the spindle by means of a locknut which screws on to the threaded portion at the rear end of the spindle.

185. The double floating rear tail bearing bush comprises a flanged sleeve type phosphor-bronze housing which spigots from the rear into the boss in the centre of the supercharger casing cover and is secured by means of three studs and spring-washered nuts which pass through an integral flange. As mentioned in para. 181, this housing has a rear projection into which is screwed a swivelling type oil union. An external pipe conveying low pressure oil connects with this union, while a duct, formed in the cover boss and connected by means of a second external pipe, establishes atmospheric pressure at the inner end of the bush for purposes mentioned in para. 177. Within the sleeve of the housing are located two close-fitting concentric bushes, the larger of which is of steel and the smaller of phosphor-bronze. They are closed at their rear ends, except for a central hole which allows oil from the inlet union to enter the bushes and find its way on to their bearing surfaces through spiral grooves formed upon their exteriors. The particular function of this double floating bush is to reduce the relative rubbing speed between the surfaces and so enhance the operational safety factor.

186. The impellor is a light alloy forging having its vanes formed radially upon a single shrouding. A concentric rib is machined upon the front face of this shrouding and runs within the concentric groove machined in the rear face of the supercharger casing, as mentioned in para. 178. This arrangement forms an air seal and helps to isolate the front ball bearing

from the interior of the impellor compartments. A stout boss in the centre of the impellor is bored and splined for mounting upon the splined central portion of the spindle. The front end of this boss projects and is bevelled to form a mating face with the rear bevelled end of the distance piece mounted upon the spindle. A second smaller set of curved impellor blades, machined from a steel forging and designed to assist the entry of the gases to the impellor, is also splined to the centre of the spindle; the front of its boss projects and spigots into the rear end of the main impellor boss, while the rear end is bevelled for the reception of the rear centring cone.

## GEAR CASING ASSEMBLY

187. The halves of the supercharger driving gear casing which contain the three driving clutch gears and their lay spindles are illustrated in fig. 38. The front portion of the casing, known as the cover, is spigoted together with the cover itself to the smaller or inner facing at the rear end of the wheelcase and secured by studs. Provision for low pressure lubrication of the lay driving gears, clutches and bearings is made by means of ducts drilled through ribs incorporated in the two castings.

*Gear casing*

188. The gear casing is a circular light alloy casting which is dished, the periphery of the dished portion being equidistantly interrupted to allow the insertion of the three driving clutch gears. The front faces of these three dished portions, which actually take the form of three large hollow triangular lugs, form the combined mating face upon which seats the rear face of the casing cover. The wall of the casing has three blind housings into which are spigoted the flanged outer races containing the roller bearings upon which the rear ends of the lay spindles are supported. Each outer race for these rollers is grooved, and the housings themselves are retained by means of three tab-washered bolts screwed into them through hollow bosses from the rear face of the casing. The blind portion or rear wall of each lower housing has a circular recessed slot machined in it to allow low pressure oil from the respective connecting oil duct in the casting to enter the rear open end of the flanged floating steel spindle pushed into the rear bore of the lay driving spindle, while the upper housing has two such circular slots which intersect and so also serve to pass on the oil to the left-hand lower housing.

189. At the centre of the wall is formed a plain flanged aperture which fits over the housing in the supercharger casing which contains the impellor spindle front ball bearing. The interconnecting oil ducts mentioned in the last paragraph are



drilled in three ribs on the casting arranged symmetrically in triangular form. The top horizontal rib is bored for most of its length and connects at either end with the two other ducts which are only bored for half their length, i.e., sufficiently to allow them to connect with their respective centrally disposed

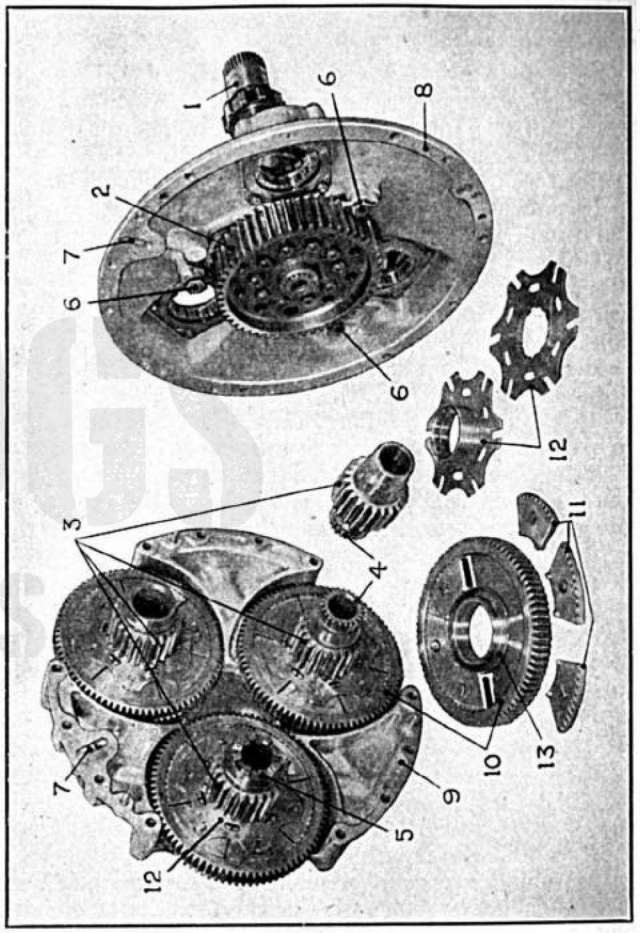



FIG. 38.—Supercharger gear casing and clutch driving gears and spindles.

1. Spring drive.
2. Spring drive driving gear.
3. Lay driving spindles and pinions.
4. Generator driving gear.
5. Hand and electric turning gear dogs.
6. Oil jets.
7. Oil feed.
8. Front cover.
9. Rear cover.
10. Clutch driving gears.
11. Clutch pads and driving dogs.
12. Clutch side plates.
13. Spring circlip.

housings. At the right-hand side, the top horizontal duct also connects with the flanged port in the front facing which aligns with the complementary port in the casing cover and supplies the duct system described with low pressure oil from the inlet union on the right-hand side of the wheelcase. This union connects with the port in the face of the casing cover through a short right-angled duct in the inner facing at the rear end of the wheelcase.

*Gear casing cover*

190. The gear casing cover which holds, at its centre, the outer race of the spring drive ball bearing, is secured by a flange to the inner facing at the rear end of the wheelcase. The outer race of the bearing is held against a shoulder in the bore of the central housing by an internally castellated and flanged circular nut which is locked by means of an internal circlip, the end of which passes through aligning holes in nut and housing. The three equally disposed sockets in the wall of the casing cover hold the flanged outer races for the roller bearing cages upon which are supported the front ends of the clutch driving lay spindles. These outer races spigot into the apertures in the cover from the rear end and are each secured in position by means of four studs and tab-washered nuts which pass through holes in the integral flange. The right-hand socket is extended at the front end to form a housing for the outer race of the roller bearing which supports the rear end of the turning gear driving shaft (*see* para. 170). Arranged adjacent to these three bearing housings are three bosses which have screwed into them combined jets and swivelling unions. The jets are so arranged that oil issuing from them impinges upon an individual clutch driving wheel; correct orientation of the jets is provided for by dowels. Oil is delivered to these unions through ducts drilled within integral ribs formed in the wall of the cover and supplied in the manner already described from the low pressure oil pipe which connects with the inlet union on the right-hand side of the wheelcase. Connection from the wheelcase duct to the gear casing ducts is made through aligning holes and slots in the mating faces of the various castings.

191. A smaller faced blind housing is incorporated in the casting immediately above the socket for the left-hand lay driving spindle front roller bearing. The spindle, upon which is mounted the first idler gear in the generator drive, is spigoted into this housing and secured to it by means of four studs and spring-washered nuts, the former passing through an integral flange. The left-hand combined jet union connects through its hollow stem screwed into the casting with the blind housing and so supplies oil to the hollow idler gear spindle for the purpose of lubricating the idler gear bush.



*Clutch driving wheels and lay spindles*

192. Each of the three clutch driving wheels consists of a short counterbored spindle which has formed integrally upon it at its front end a pinion which meshes with the spur driving gear on the rear end of the spring drive shaft. A frictionally driven spur driving gearwheel which meshes with the pinion on the front end of the impellor spindle is freely mounted upon the hub of a large driving flange; this flange, together with a secondary flange, is splined to the central portion of the lay spindle while the driving gear hub is phosphor-bronze bushed. The gearwheel is driven through two sets of six bronze friction pads which rotate solidly with the spindle and are forced under centrifugal load into grooves beneath the rim of the wheel. The pads themselves are driven through flat-sided dogs riveted to them and the dogs engaging in radial slots around the edges of the flanged sleeve on the front side and the secondary flange on the rear side, which are splined to the spindle. The driving slots in the flanges are slightly inclined to assist the outward thrust on the clutch pads. A pair of lugs formed on the inner periphery of each pad project through elongated slots in the driving flange; this arrangement gives an indication of the radial wear of the clutch faces by the visual clearance between lug and elongated slot, and also prevents the pads from rocking.

193. A spring circlip is engaged in the groove around the inner edge of each set of pads and holds them up close to the faces of the grooves in the gearwheel when the engine is stationary, and also imposes a slight initial loading. The clutch gearwheel is bushed and floats upon the shank of the flanged sleeve in the manner already described. A nut secures the various components mentioned above against the rear shoulder of the pinion. The front end of the upper spindle is plain, while the left and right-hand lower spindles have formed integrally with them a small spur gearwheel for meshing with the generator drive (*see* para. 157) and a ring of driving dogs for engagement with the corresponding dogs on the turning gear shaft (*see* para. 163).

194. Each clutch driving lay spindle is located axially in the forward direction by the flanged inner and outer races of the front roller bearing and in the rearward direction by the flange of a large steel flanged bush, which floats within an aluminium bush within the bore of the spindle, the flange being held within the blind housing which holds the rear roller bearing. The inner flanged bush is freely mounted, except that its flange is held within the housing in the casing for the rear roller bearing. It is hollow except at its front end, which is sealed by a partition so that oil entering its open rear

bore from the low pressure source described in para. 197 passes out through a hole and so lubricates the aluminium bush which floats upon it. Both spindle and bush are grooved for the better distribution of the oil over their respective bearing surfaces. The bush also has a radial hole which allows the oil to reach the grooves on its outer surfaces and the bore of the lay spindle itself. From here, the oil passes outwards through a hole in the lay spindle to another hole in the hub of the flanged driving plate to the bronze bush in the hub of the clutch driving wheel.

195. It will be seen therefore that the drive from the rear end of the crankshaft through the spring drive unit can only be transmitted to the impellor spindle by means of the binding effect of the clutch pads. The value of this binding effect is determined so that normal maximum loading will be safely transmitted, but high inertia loading, resulting from rapid acceleration or deceleration of the clutch driving gear, will cause the driving clutches to slip and thus safely absorb what would otherwise prove to be a destructive force. In addition, torsional fluctuations in the drive are absorbed by the normal functioning of the spring drive itself.

**LUBRICATION OF THE SUPERCHARGER ASSEMBLY**

196. All ball and roller bearings used in the supercharger assembly are lubricated by oil splash and spray. Low pressure oil is fed through external pipes to a point on the right-hand side of the wheelcase and from there an extension is taken to the double bush in the supercharger casing cover which bears the rear end of the impellor spindle. Holes and spiral grooves direct the oil to the various bearing surfaces of the concentric floating bushes and impellor spindle. As described in para. 190, the connection on the right-hand side of the wheelcase supplies oil to the three clutch driving wheel jets and also the rear roller bearings in the casing through various ducts and aligned ports incorporated in the three castings concerned. In addition, the hollow intermediate spindle in the electric generator drive is also lubricated from one of the oil jet unions; a radial hole in the spindle permits oil to issue from the interior of the spindle to the bearing surfaces of bush and spindle.

197. Ducts and oilways are arranged to lead oil to each of the three hollow flanged floating steel spindles and their aluminium bushes which project into the rear end of each clutch driving lay spindle. Oil from the ducts in the casing is then conducted by means of holes and annular grooves in spindle and bush, and then through further holes in the lay spindle and hub of the driving flange to the floating driving gear hub. The gearwheels and clutch pads, are lubricated by



the oil jets and also by spray thrown off from the hubs of the gearwheels. The pads have crossed grooves in their bevelled friction and inner bearing surfaces to improve the distribution of the oil over them. A small escape hole is drilled through the gear rim between two pairs of teeth of each gearwheel to permit oil trapped in the circular groove in the rim to escape and so avoid the possibility of the clutch pads seating imperfectly due to an oil lock at this point. The oil, having issued through the holes, assists in lubricating the gear teeth. Oil mist condensing in the housing for the impellor spindle front ball bearing is drained therefrom through the vertical duct cored in the front wall of the supercharger casing and thence through the atmospheric balance pipe.

198. Drain oil from the supercharger assembly falls to the bottom of the front wall of the supercharger casing and then drains into the wheelcase, whence eventually it enters the rear end of the crankcase.

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# CHAPTER 7

## CARBURATION SYSTEM

### GENERAL

199. The S.U. twin-choke, vertical type Merlin A.V.T.32 carburettor fitted to the Merlin II and III engines is, with the exception of the separate boost control, entirely self-contained and is arranged to be fully automatic in its functioning, with the result that the responsibilities of the pilot are reduced to their simplest form and the danger of engine damage resulting from incorrect setting is obviated. The various features and their functions of this carburettor unit which achieve this may be summarized as follows :—

(i) A normal diffuser system whereby the fuel is drawn through the main jet, emulsified by air from the pressure balance chamber impinging upon it and drawn out of the top of the diffuser into the choke tube where, after mixing with the air in the choke tube, it becomes a suitably carburetted mixture.

(ii) A pressure balance system ensures that air pressure in the air intake and within the sealed float chamber is balanced. This is necessary to prevent any unequality of pressure between these two localities upsetting the mixture.

(iii) An automatically operated mixture control enables the mixture to be weakened to suit the requirements of the reduced weight of air at altitude.

(iv) A slow-running jet provides a suitable mixture when the throttle is in the closed position and works in conjunction with a device which takes the form of a multiple jet to obviate flat spots when the throttle is opened.

(v) A single accelerator pump which provides an immediate discharge of additional fuel into the induction system simultaneously with the opening of the throttle.

200. In addition to the normal functions outlined in the preceding paragraphs, there are two further accessories which are essentially associated with the requirements of supercharged engines. These are as follows :—

(i) A pneumatic type variable datum boost control, which is operated directly by the induction chamber pressure, prevents the individual induction pressures from rising above the specific values respectively employed for take-off, climbing and cruising at all altitudes below the rated altitude. It consists of a device which provides a



super-imposed and progressive control over the hand-operated throttle, thereby relieving the pilot of the need for close observation of the boost gauge to maintain any particular boost pressure within the permitted limits. The variable datum feature of the control eliminates lost motion between the throttle lever and butterfly valve, so that the former is always proportional to the latter, and a steady rise in induction pressure is obtained from ground level to rated altitude. Early engines were fitted with a fixed datum type of boost control unit.

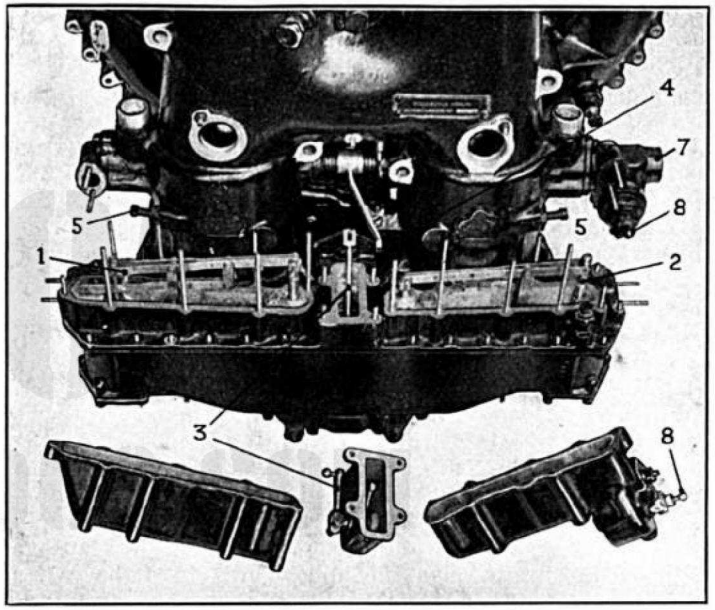



FIG. 39.—Carburettor, S.U. type Merlin A.V.T.32.

1. Atmospherically controlled mixture control.
2. Induction pressure controlled mixture control.
3. Accelerator pump and actuating lever.
4. Throttle lever.
5. Slow-running adjustment.
6. Scavenge oil relief valve.
7. Scavenge oil return to tank.
8. " Rich–Weak " mixture control lever.

(ii) A second mixture control, automatically operated by the induction chamber pressure, which increases the mixture strength when the throttle is opened to that extent at which the engine develops its higher ranges of power output. This arrangement permits the mixture in the intermediate stages of power output to be reduced to economical proportions, whilst automatically providing

the normal strength required for the higher ranges, together with the additional enriching necessitated for maximum boost under take-off and maximum climbing and all-out level flight conditions.

## CARBURETTOR

201. The S.U., Type Merlin A.V.T.32 carburettor (*see* fig. 39) is of the twin-choke vertical type and embodies two complete carburettors in one unit. The flow of fuel through the right-hand carburettor main jet is directly controlled by the induction pressure controlled mixture control, while the left-hand main jet is directly controlled by the atmospherically operated mixture control. Both these mixture controls are automatically operated through linkwork and controlled by separate aneroid capsules incorporated in each end of the carburettor body. The top of the carburettor unit is formed integral with the blower casing, each carburettor feeding into the central impellor intake through individual vertical intake passages. The lower face of the supercharger cover provides attachment for the lower half casting of the carburettor to which it is secured by means of studs and spring-washered nuts, a large specially shaped gasket being interposed at the joint faces to effect a gas and fuel tight joint. The separate throttle barrels are coolant jacketed and the jackets are included in the coolant return from the "A" cylinder block to the inlet side of the coolant pump. The pneumatically operated variable datum boost control is attached to the top left-hand side of the blower casing by means of studs and nuts, and controls the throttle opening through a differential gear incorporated in the control shaft, which is also mounted upon the blower casing. A system of oil heated throttle valves is also included to prevent freezing, and provides for a proportion of the scavenge oil being directed through the hollow interior of the valves before it is returned to the oil tank.

*Upper half casting*

202. Both the upper and lower halves of the carburettor body are cast in light alloy and are divided into two main sections which meet on the horizontal centre line in a faced flanged joint. The lower section incorporates a third section in the form of a combined detachable main jet and float chamber base cover. The upper casting (*see* fig. 40), which is integral with the blower casing, comprises the double delivery passages to the supercharger impellor, the slow-running adjustment screws and their necessary fuel and air passages and delivery nozzles, the choke tubes, the hollow oil heated butterfly throttles and their common operating spindle, the pressure balance chambers and connecting air ducts to the diffusers and float chamber, and the delivery ducts for the



accelerator pump. The top half also contains the two mixture control operating linkages and attachment for the choke delivery tubes, the diffusers and the slow-running jets. The two separate linkage systems are enclosed and within separate covers, and in the centre of the casting and immediately between the two covers is a third smaller cover bearing a cam spindle, which is operated externally by a lever for the actua-

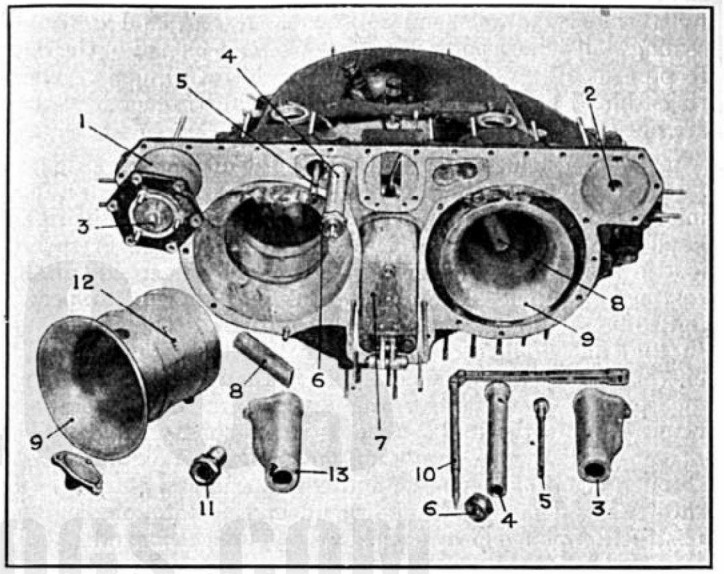



FIG. 40.—Carburettor, top half.

1. Atmospherically controlled mixture control.
2. Induction pressure controlled mixture control.
3. Mixture control adjustment.
4. Diffuser.
5. Slow-running jet.
6. Main jet.
7. Float.
8. Choke delivery tube.
9. Choke.
10. Mixture control needle and actuating arm.
11. Choke fixing screw.
12. Accelerator pump delivery orifices.
13. Diffuser cover.

tion of the accelerator pump. Incorporated with the right-hand linkage cover is another externally operated spindle which carries a cam for the actuation of the "Rich-Weak" automatic positions of the induction chamber pressure governed mixture control or enrichment capsule.

203. The common steel throttle spindle is positioned laterally across the two choke passages and is carried by four long flanged phosphor-bronze bushes, which are pressed into bosses incorporated in the main casting. The external ends

of the two central bushes are bevelled to accommodate V-sectioned packing rings which are each compressed by means of a separate spring abutting against the sleeve of the throttle lever which is clamped on the centre of the spindle. The external flanged end of each of the two outer bushes is square for the abutment of a capsule type sealing gland which is incorporated in a counterbored boss included in the main casting. Each light alloy throttle valve is fixed to the spindle by a transverse bolt and tab-washered nut, and a rubber sealing ring is incorporated in a groove in each end of the bore to prevent oil leaking from the inside of the throttle. These rings should be used once only and should be renewed if they are once disturbed.

204. The right-hand gland boss in the main casting is faced for the reception of the small relief valve casting which has an inlet passage for the supply of the scavenge oil to the right-hand side of the hollow throttle valve spindle. A spring-loaded relief valve is incorporated on the under side of this casting and provides for a back pressure of some 25 lb. per sq. in., to be set up against the direct return of the scavenge oil to the tank. Oil passing directly through the relief valve enters the outlet passage embodied in the valve ; this passage incorporates a union for the attachment of the external return pipe to the tank. The back pressure, created by the scavenge relief valve, causes a proportion of the oil to be forced through the hollow spindle and the interiors of the butterfly throttles and out at the left-hand end of the spindle. An obstruction plug is placed within the bore of the spindle at the centre of each throttle valve which, in co-operation with inlet and outlet holes in the spindle, forces the oil to circulate through the hollow interior of each throttle valve. A cast outlet elbow is attached to the faced housing on the left-hand side of the main casting and provides attachment for an external return pipe which connects at its right-hand end with the outlet side of the oil return passage in the relief valve body.

205. The two separate integral coolant jackets around the chokes each have a vertical inlet union connecting with the exterior pipes which supply heated coolant directly from the "A" cylinder block jacket (*see* para. 282). Incorporated in the lower outside end of each jacket is a faced outlet port for the reception of a faced connection which provides for the return of the coolant through an external pipe to a common union located immediately under the supercharger and in front of the carburettor. From here the coolant is returned through a cast T-piece to another external pipe for return to the intake side of the coolant pump. A bleed cock is incorporated in each outlet elbow connection mounted on the carburettor for the purpose of obviating air locks when filling the cooling system.



206. The air supply to each diffuser, for the purpose of emulsifying the fuel from the main and slow-running jets, passes directly to each diffuser housing by a separate passage which connects with the annular pressure balance chamber formed by the flared portion of the lower end of each choke tube in conjunction with the intake chamber integral with the carburettor itself. The two pressure balance chambers are also connected by means of drillings in the upper casting, and a connection is taken from this passage to the roof of the float chamber, for the purpose mentioned in para. 224.

207. The horizontal portion of the upper half of the carburettor body provides attachment for the two diffusers which are fitted from the top into counterbored vertical holes in the casting. The diffusers themselves are flanged at the top for seating in the housing and stepped down so that they form, with the counterbored hole, an annular space. This space is connected to its individual pressure balance chamber by means of a large bored drilling in the casting, mentioned in the last paragraph. The diffuser delivery tube is secured in a horizontal bore in the choke passage ; this joins a short vertical passage which breaks through the under-side of the casting. When the diffuser cover is in position on the under-face of the casting, the lower extremity of the diffuser passes through a bore at the lower end of this cover. The lower end of the diffuser is threaded for the reception of the disc type main jet which screws on to the threaded portion extending through the cover ; the main jet thus incidentally holds the cover in position. A depression in the choke therefore will be communicated to the upper space in the diffuser cover and will cause air from the pressure balance chamber to enter the diffuser *via* the annular space and two large holes in the top of the diffuser which coincide with it. This diffuser air issuing, under the influence of the suction, through the series of small holes in the centre of the diffuser, will cause an emulsified stream of air and fuel (i.e. a rich mixture) to pass into the choke passage *via* the delivery tube. The main intake air supply in the choke tube then combines with the rich mixture to form a normally combustible mixture for delivery to the supercharger. Flow of fuel to the interior of the diffuser cover and consequently the diffuser, is governed by the disc type jet, through which the mixture control needle protrudes and which is incorporated in the diffuser locknut.

208. Situated alongside the diffuser housing in the top half of the carburettor, is a smaller housing for the reception of the slow-running jet tube. This tube has a flanged head which seats upon the casting when the jet is in position. The threaded portion on the tube by means of which it is screwed into the casting, is located a little distance below the head.

Between the head and this threaded portion is a waisted portion which has two holes in it communicating with the interior of the tube. This waisted portion and the two holes align with a counterbored hole in the casting, with the result that when the tube is in position an annular space is formed around the hole. The slow-running jet orifice itself is incorporated in a plug located in the lower middle of the bore of the tube, while during slow running the lower end of the tube is submerged in the fuel contained within the diffuser cover. An air-bleed hole is drilled in the tube above the jet orifice for the purpose of emulsifying the fuel in the tube.

209. When the throttle valves are in the slow-running position and the depression is thereby transferred from the main jet delivery tubes to the slow-running delivery orifices adjacent to the valves, the depression is transmitted to the slow running jet *via* the slow running passage drilled in the choke housing, the lower end of which connects with the annular space formed round the top of the tube. Partially emulsified fuel is consequently drawn up the tube, through the slow-running jet, to the annular space and thence through the slow-running passages to the delivery orifices in the choke tube housing. Incorporated in the passages in the choke tube housings are separate slow-running adjustment screws, the coned inner ends of which break into the passage and permit either more or less rich mixture to pass, as the case may be. After adjustment, these screws are locked with nuts (*see* para. 223).

210. Incorporated in the front left-hand side of the upper half casting is a large boss into which is screwed the fuel inlet union. This boss connects, by means of an internal passage, with the top of the combined float valve housing and seat which screws into the casting. It is possible to adjust the fuel level in the float chamber by varying the thickness of the tabwasher which secures the housing. The whole of the float mechanism is incorporated in the valve housing, and is therefore suspended from the upper half of the carburettor.

211. At either side of the top half casting are the actuating linkages for the automatic mixture controls which operate needles contained within the diffuser tubes. The linkage mechanism is attached by means of studs and nuts to suitable facings incorporated with the main casting, while a boss on each side houses a bushing in which slides the capsule rod. The right-hand or enrichment capsule has a union for connecting the capsule compartment contained in the lower half to the induction chamber pressure by means of an external pipe connecting with the supercharger casing. This union incorporates a spring-loaded disc type safety valve to protect the capsule from sudden and excessive pressures such as may



result from backfires. The disc valve has a $\frac{1}{16}$ in. cushioning by-pass hole drilled in its centre. The two linkage covers are attached to machined facings on the casting by means of studs and nuts. A third and smaller cover is situated on a facing in between the two larger casings ; this cover incorporates the accelerator pump operating lever and spindle.

*Lower half casting*

212. The greater portion of the lower half casting (*see* fig. 41) is occupied by the central float chamber and the accelerator pump barrel and the two mixture control capsule compartments. The central float chamber is isolated from the two capsule compartments by means of partitions, while the accelerator pump barrel is located immediately behind the float chamber. Attachment of the top machined face of the lower half to the bottom machined face of the upper half is made by means of numerous studs and spring-washered nuts ; a large specially shaped gasket is used to preserve an air and fuel tight joint over the whole surface.

213. When the lower half is in position, it will be seen that the diffuser covers containing the main jets, diffusers and slow-running tubes project into the float chamber and become submerged in the fuel contained therein. A third casting comprising a combined float chamber base, main diffuser inspection cover and accelerator pump base in which is incorporated a non-return delivery valve, is attached to the machined face on the under-side of the lower half and retained thereto by means of studs and spring-washered nuts ; a gasket is interposed between the faces to effect a fuel tight joint.

214. Each capsule compartment is open on its underside and a cover, to which is fixed the capsule and its adjusting device, is attached to a face around this aperture. As has already been mentioned, the right-hand or enrichment capsule is controlled by the boost pressure which is transmitted from the lower casting *via* an external pipe and a safety return valve, while the left-hand or altitude control capsule is controlled by atmospheric pressure, and consequently a plain hole is drilled in the front wall of this capsule chamber, which connects with the left-hand air-intake passage.

215. The intakes to the choke tubes are formed on either side of the lower casting and in front of the capsule compartments. They are circular in shape ; their upper ends receive the flared portion of the lower ends of the choke tubes and consequently their upper ends help to form the pressure balance chambers as described in para. 224. The right-hand passage incorporates at its front a diagonal boss which breaks through from the outside into the intake passage. This boss houses a venturi union which is connected by an external flexible pipe to the slow-running suction system incorporated with the

priming pipes (*see* para. 271). Surplus fuel which collects in the small sump of the supercharger casing during slow running, is led to an annular space in this union through connecting passages drilled in the supercharger and carburettor castings. The annular space connects, by means of holes, with the area of maximum depression in the venturi ; the fuel is consequently emulsified by the air entering the union from the intake and the resulting rich mixture and is delivered through the external pipes mentioned above to the four delivery orifices in the induction manifolds (*see* fig. 51).

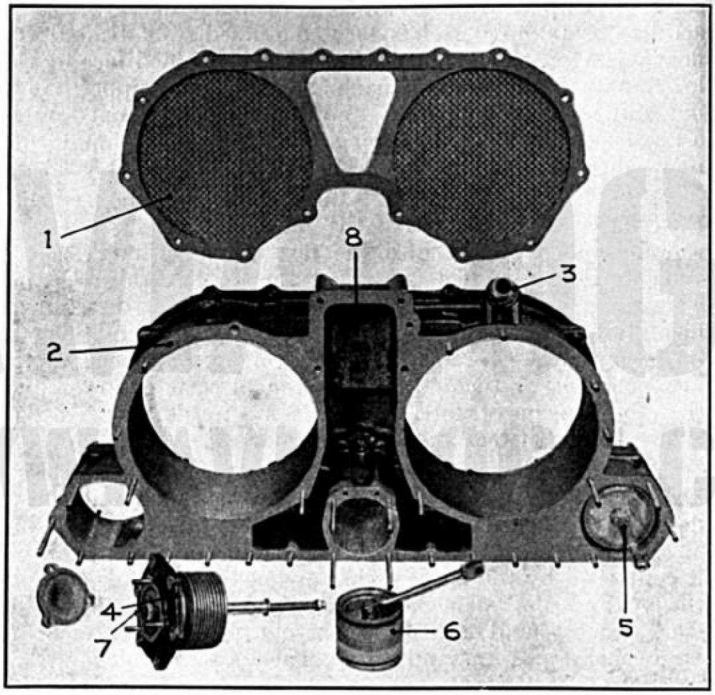
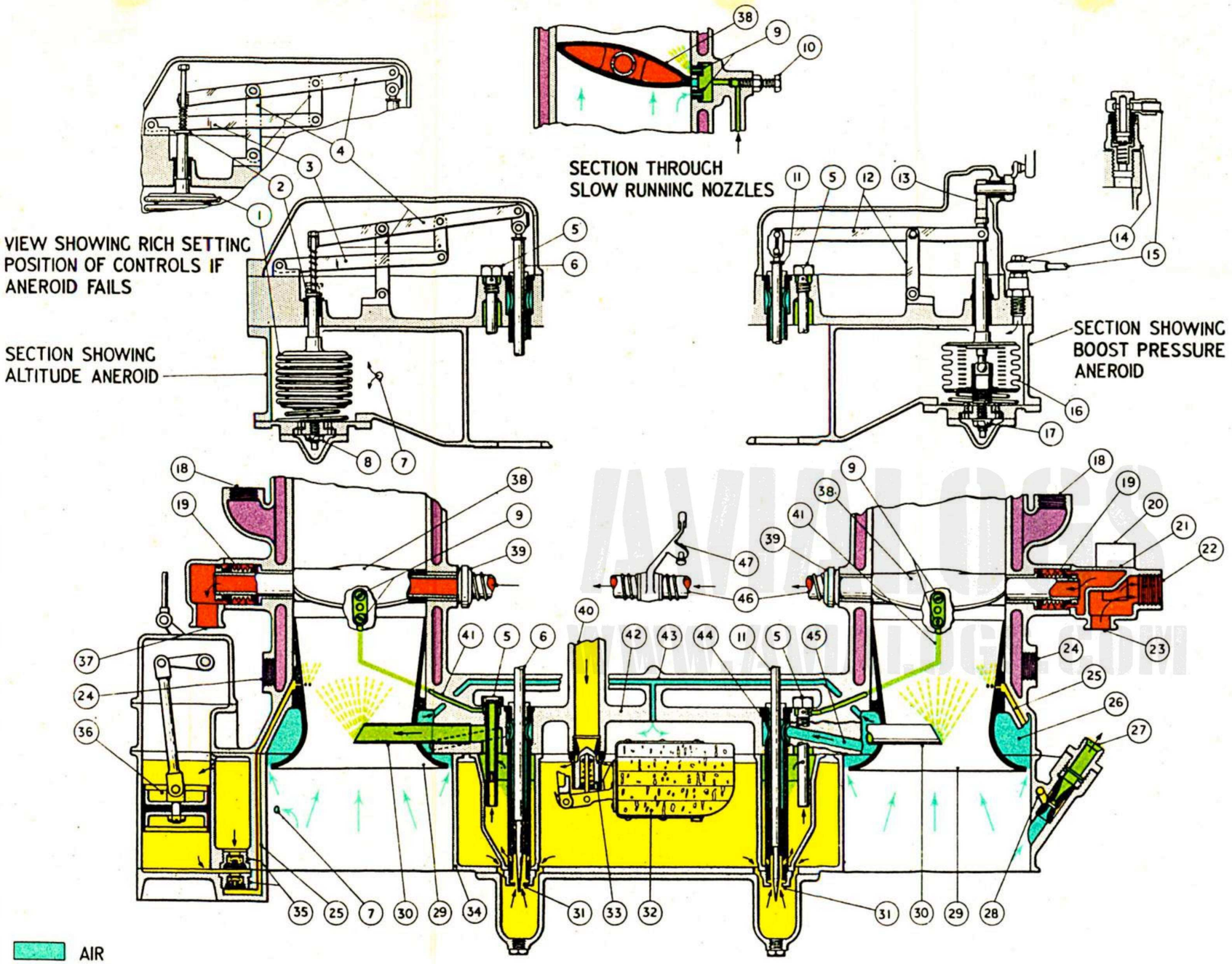



FIG. 41.—Carburettor, bottom half.

1. Intake gauze and gaskets.
2. Body.
3. Slow-running suction venturi.
4. Mixture control capsule assembly.
5. Enrichment capsule assembly.
6. Accelerator pump piston.
7. Adjusting screw.
8. Float chamber.

216. The front under-side of the lower half casting which forms the entry into the choke passages is faced and bossed to retain the air intake. A composite gauze, secured in a framework, together with two gaskets, are interposed between the carburettor and air-intake jointing faces.




1 ALTITUDE ANEROID FOR MIXTURE CONTROL
2 WASHER FOR OPERATING LINKS 3
3 LINKS FOR RETURNING NEEDLE TO FULL RICH POSITION IF ANEROID FAILS
4 LINKS FOR NORMAL OPERATION OF NEEDLE
5 SLOW RUNNING JET
6 NEEDLE FOR MAIN JET, ALTITUDE GOVERNED
7 VENT TO ATMOSPHERE
8 ALTITUDE ANEROID ADJUSTMENT
9 SLOW RUNNING NOZZLES
10 SLOW RUNNING ADJUSTMENT
11 NEEDLE FOR MAIN JET, BOOST PRESSURE GOVERNED
12 OPERATING LINKS
13 HAND OPERATED CAM FOR 'RICH-WEAK' AUTOMATIC SETTINGS
14 SAFETY VALVE
15 BOOST PRESSURE INLET CONNECTION
16 BOOST PRESSURE ANEROID FOR MIXTURE CONTROL
17 BOOST PRESSURE ANEROID ADJUSTMENT
18 ENGINE COOLANT INLET
19 OIL SEALS
20 SCAVENGE OIL INLET
21 RELIEF VALVE BODY
22 SCAVENGE OIL RETURN TO TANK
23 OIL RETURN FROM THROTTLES
24 ENGINE COOLANT OUTLET
25 ACCELERATOR PUMP DELIVERY DUCT
26 PRESSURE BALANCE CHAMBER
27 VENTURI OUTLET TO INDUCTION MANIFOLD
28 FUEL DRAIN FROM SUPERCHARGER CASING
29 CHOKE
30 DIFFUSER DELIVERY TUBE
31 MAIN JET
32 FLOAT
33 FUEL INLET VALVE TO FLOAT CHAMBER
34 CARBURETTOR BODY BOTTOM HALF
35 NON-RETURN VALVES FOR 36
36 ACCELERATOR PUMP
37 OIL OUTLET FROM THROTTLES VIA 23
38 THROTTLES
39 AIR SEALS
40 FUEL INLET
41 SLOW RUNNING DUCT
42 SUPERCHARGER CASING
43 FLOAT CHAMBER AIR VENT
44 DIFFUSER TUBE
45 AIR DUCT TO DIFFUSER
46 THROTTLE SPINDLE
47 THROTTLE LEVER AND STOP

# FIG. 42. DIAGRAMMATIC ARRANGEMENT SHOWING FLOWS THROUGH CARBURETTOR

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*Diffuser*

217. The diffuser body is a simple parallel bored sleeve which is threaded at its lower end for the purpose of receiving the main jet nut. The flange at the top end abuts against the main casting and is countersunk within the top counterbored portion of the diffuser housing. A flanged bush is pressed into the diffuser bore at the top end to provide a bearing surface for the mixture control needle which extends right through the diffuser. The lower portion of the bore is decreased in diameter and provides a guide for the lower end of the needle, which is a good fit to prevent fuel reaching the diffuser through the guide and thus upsetting the calibration of the diffuser holes in the body of the diffuser. The lower end of the diffuser is counterbored for some distance and a series of diagonal holes drilled in it here, permit fuel, after passing through the orifice of the needle controlled main jet, to issue from the float chamber to the interior of the diffuser cover. The lower end of the diffuser is supported by the lower end of the cover and protrudes from it sufficiently to allow the main jet nut to be screwed into position.

218. The upper end of the diffuser is provided with two large diametrically opposed holes which, when the body is in position, aligns with the annular space, mentioned in para. 207, formed between the carburettor body and the diffuser. As already explained, this annular space is connected to its respective pressure balance chamber and draws air therefrom for the emulsification of the fuel. In the middle of the diffuser there are a series of small holes which are submerged beneath the normal fuel level in the diffuser cover.

219. The operation of the diffuser (*see* fig. 42) is in accordance with the usual practice for this type. The fuel issuing from the float chamber through the main jet into the diffuser cover reaches a level which submerges the series of small diffuser holes. When the engine is running with the throttle in the closed position, no depression is created at the choke delivery tube, but the whole of the depression is concentrated at the edges of the throttle, causing the mixture to be withdrawn from the slow-running jet tubes only. As the throttle is opened a depression is established in the choke tube, which is communicated to the top space of the diffuser cover by way of the choke delivery tube, and sets up a depression in the bore of the diffuser. The depression is relieved by air which enters from the pressure balance passage and, passing into the diffuser through the large holes at the top end and out of the small submerged holes in the middle, takes up the fuel and emulsifies it to form a homogeneous mixture which enters the choke tube by way of the choke delivery tube. As the throttle is opened further, the level of the fuel in the diffuser

sinks, owing to the restrictive action of the needle controlled main jet, and as the level sinks so more of the air holes in the diffuser wall are uncovered and admit more air, which reduces the depression in the bore of the diffuser and thereby produces the necessary compensation whereby a proportioned mixture strength is maintained. At all operational throttle openings, there is no actual fuel level within the diffuser cover, i.e., it becomes a straight-through passage. When the throttle is opened to a point at which the engine attains maximum permissible boost and power output at ground level, the mixture delivered by the diffuser becomes too weak to maintain satisfactorily normal power output, and it is here that the right-hand or enrichment mixture control enlarges the right-hand jet by withdrawing the needle, in order to augment the fuel supply. On the other hand, a weakening effect is brought about in the left-hand or atmospherically controlled mixture control as the aeroplane continues to climb.

*Slow-running system*

220. Details of the slow-running jet (*see* fig. 42) itself, together with its operating passages, are given in para. 208. The slow-running jet and its subsidiary delivery orifices not only provide a suitable mixture for running at the closed throttle position, but also obviate the flat spot which would otherwise occur when the throttle is being opened and the change-over from the slow running to the main jet is taking place.

221. The side of the streamline throttle adjacent to the slow-running delivery orifices in the choke tube is thickened slightly to extend the locality of depression caused when the throttle is in the nearly closed position. When this is happening, the depression is concentrated just above this point with the result that the depression so created is transferred to the slow-running jet through the slow-running passages described.

222. The cover sealed pocket on the rear of the throttle housing is formed with a vertical row of three holes which open into the choke and are threaded to receive small brass delivery nozzles. When the throttle is in the slow-running position with a very small clearance between its edges and the walls of its housing, the lower end of the transfer passage is approximately opposite to the middle one of the three holes and a powerful suction is imposed upon the upper hole. The nozzle pocket, which is fed by the rich mixture from the slow-running jet, receives almost undiluted fuel from the slow-running jet, the mixture being so rich as to be altogether too strong for slow-running purposes. The lowest nozzle, which is just outside the zone of low pressure prevailing at the throttle edge,



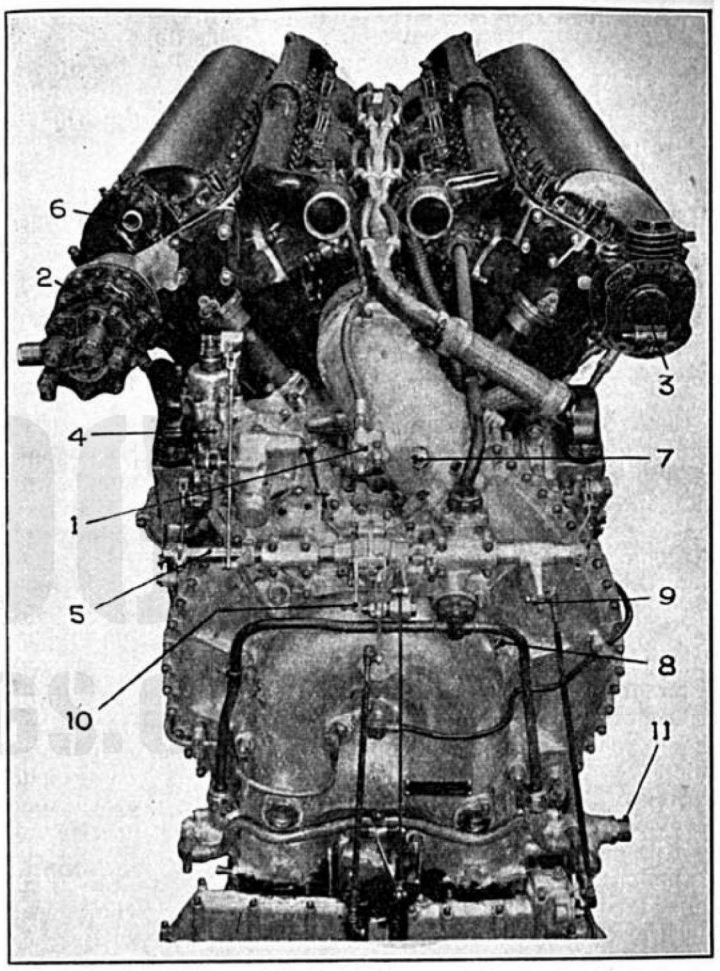



FIG. 43.—Rear view of engine.

1. Priming connection.
2. R.A.E. compressor.
3. B.T.H. compressor.
4. Variable datum boost control unit.
5. Control shaft assembly.
6. Engine-speed indicator drive.
7. Boost gauge connection.
8. Vacuum pipe connection.
9. Mixture control connection.
10. Throttle control connection.
11. Scavenge oil return to tank.

partly relieves the depression within the pocket by admitting a generous supply of air to it, thereby considerably diluting the rich mixture within the pocket. As soon as the throttle commences to open, the thickened edge comes opposite to the nozzle in the lowest hole, whereupon the air bleed flow through this nozzle is retarded. The middle hole, as well as the upper orifice, is now within the high depression prevailing above the throttle, and there being a reduced air supply to the pocket through the lower hole due to masking action by the throttle, a strong mixture is drawn off which is of sufficient strength to overcome the flat spot that occurs in the transition stage of passing from the slow running to the main jet supply. As the throttle continues to open, so the holes and the transfer passage progressively go out of action until, when the lower edge of the throttle is below the lower hole, only the normal throttle chamber depression is prevailing at the mouth of the holes.

*Slow-running cut-off*

222A. In order to eliminate the risk of continued slow running due to pre-ignition, a cockpit-operated device has been fitted in modified engines (Mod. Merlin 97) for breaking down the depression which exists at the slow-running delivery orifices by admitting air to the orifices and thus positively cutting off the slow-running mixture. The device is fitted over the slow-running delivery orifices of both chokes, after the blanking covers have been removed and both cut-off valves are actuated simultaneously by means of a link-rod which connects their operating levers. The aluminium bodies, which are handed to suit the tapped holes by which they are attached but are otherwise identical, are each secured to the facing on the supercharger casing (*see* fig. 43A) around the slow-running orifices by two plain and spring-washered hexagon-headed setscrews. Above the flange face is the housing in which the valve operates ; the housing is connected by a neck incorporating a passage through which air from the cut-off valve passes to the orifices. The hollow cylindrical valve rotates in a bronze bush secured by a countersunk grub screw ; holes are drilled in the bush to admit air from a transverse port in the valve. Atmospheric air passes to the valve from a cylindrical gauze filter contained in a horizontal barrel-shaped portion of the body, the filter being secured by a wire-locked nut. A cover secured to two studs by spring-washered nuts spigots into the casing and holds the valve in position, whilst over an extended sleeve portion, and anchored by the lower nut, is a square-sectioned spring which normally retains the valve in the closed position. The outer end of the spring engages the operating lever which is secured to the valve stem by a pinch bolt. The starboard lever is a bell crank and has its

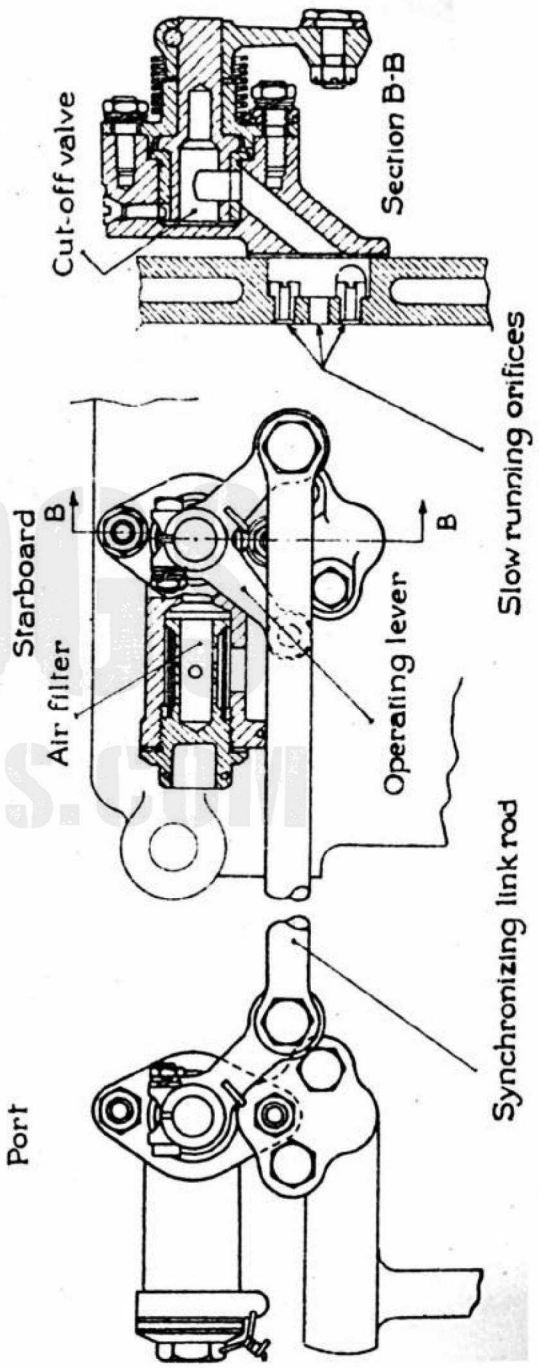



FIG. 43A. ARRANGEMENT OF SLOW RUNNING CUT-OFF VALVES

left-hand arm connected to the cockpit control, the other being attached by means of a synchronizing link-rod to the port cut-off control lever.

*Slow-running adjustment*

223. As has already been mentioned in para. 209, the top horizontal delivery passage drilled in the carburettor body has incorporated with its outer end a device for increasing or decreasing its effective area. This is achieved by providing a cone-ended screw which screws into a boss incorporated in the main casting. By screwing in the screw the cone end intrudes upon the passage and reduces its effective area, thus permitting a smaller volume of slow-running fuel to pass; conversely, screwing out the screw increases the effective area and permits a greater quantity of fuel to pass. A weaker or richer slow-running mixture may thus be obtained as desired. After adjustment, the screw is secured by a locknut. In practice, these adjusting screws are set in the fully open position and correct slow-running adjustment is obtained by varying the sizes of the delivery orifices in the choke tube.

*Pressure balance system*

224. The normal function of the pressure balance system is to provide equality of pressure between the air intakes and the float chamber, in order to prevent disturbance of the mixture supplied by a change of pressure affecting the one without the other. To provide for this, the central float chamber is placed in direct communication, by means of the special passages incorporated in the top half of the carburettor body already mentioned, with the air intake and, except for this communication, the top of the float chamber is sealed. The opposite ends of the pressure balance passage to that which opens into the float chamber is situated within the annular space formed between the main casting and the flared lower ends of the chokes. These annular spaces are in direct communication with the intake pressure and therefore any change of pressure in this locality is simultaneously communicated to the float chamber. In this carburettor, in addition to maintaining a balance of pressure between the float chamber and the air intake, the annular space also provides air through separate passages to the main diffusers for emulsifying the fuel (*see* para. 206) passing through them for delivery to the choke tubes.

225. The depression created in the choke tube and communicated to the diffuser by the choke delivery tube is responded to by air drawn from the pressure balance chamber and passages and passed into the interior of the diffusers. The pressure balance passage is always subject to a depression when the engine is running (except with the throttle in the slow-running position) but it will be seen from the foregoing

that this depression varies relatively with the throttle opening by reasons of the depression created by the air supplied to the diffusers.

**MIXTURE CONTROL**

226. This carburettor incorporates two automatically operated mixture controls by means of which (*a*) the mixture is strengthened for high power running and (*b*) weakened to correct for the effect of the changed atmospheric density at altitude upon the carburettor characteristics (*see* fig. 42.)

227. It has already been explained that the right-hand mixture control capsule is subjected directly to the boost pressure and consequently reacts to this influence. It can be re-set manually by the pilot to give either an " automatic weak " or " automatic rich " position ; the former condition is permitted only for weak mixture cruising, and the latter is required for all other phases of operation. The actual automatic weakening or enriching is effected by decreasing or enlarging the orifice of the right-hand main jet only ; the mixture correction for altitude is similarly effected through the left-hand main jet under the direct influence of atmospheric pressure.

228. The control capsules used in the left and right-hand compartments are basically similar in construction and means of mechanical operation. The single corrugated aneroid is attached at top and bottom to two bossed end plates. The interior of the capsule is exhausted to a high degree and hermetically sealed. The exterior of the lower end cap has a hollow central extension into which is screwed an adjusting screw by means of which the relative position of the capsule, and therefore the precise setting of the needle in relation to the main jet, may be accurately adjusted. This adjusting screw is held in a central threaded bush attached to the bottom cover which seals the aneroid compartment. After adjustment, the screw is secured by a locknut and the head of the screw is enclosed in a second smaller cover which is secured by studs to the first cover. Interposed between the lower capsule end plate and the compartment cover is a tapered coil spring which maintains the lower end cover in a fixed position after it has been adjusted by means of the screw described.

229. The aneroid is a single corrugated cylinder held together by the two end plates already mentioned ; a flat sectioned coil spring is imprisoned between the two end covers and located by means of spigots formed on the end plates. The aneroid is supported against its normal operating pressure by this flat sectioned coil spring contained within it ; the capsules are not interchangeable, since among other things,



the enrichment capsule has a stronger spring than the altitude capsule. The lower end cover has a central integral sleeve which forms a guide for the ball ended extension integral with the upper end cover. The upper aneroid end cover is also provided with a central extended boss into which is screwed a connecting rod which, when the aneroid expands or retracts, slides within a close fitting bush pressed into the main casting. The connecting rod has a series of concentric grooves which form, with the bush, an air tight seal ; it also has an extension of reduced diameter, the top end of which is threaded and passes through the pivot in the horizontal actuating arm. The threaded top end of this rod receives a securing nut ; a small coil spring transmits the upwards thrust of the rod and retains the actuating arm against the securing nut under normal circumstances (*see* para. 231).

230. The induction pressure operated right-hand or enrichment capsule may be depressed a specific amount by a separate manual control which operates a cam positioned directly over the top of the connecting rod. Depressing the capsule provides " automatic-rich," and permitting it to return to its normal position provides " automatic-weak " settings respectively. The horizontal operating arm for this control is attached at its outer end to a pivoted fulcrum, which is itself anchored to the main casting, at approximately its centre, while its inner end is connected through a short radius link directly to the eye of the needle contained within the right-hand diffuser. The lower end of this needle is of special shape and should not be confused with the more gradual taper of the left-hand needle. In the event of the setting being left in the automatic weak position and the throttle inadvertently opened beyond the economical cruising position, then the increased boost will compress the capsule and so withdraw the needle from the jet, thus enriching the mixture strength and avoiding the detonation that would otherwise occur. The arrangement thus also acts as a safety device that guards against the dangerous effects resulting from incorrect operation of the mixture control lever.

231. The left-hand or atmospherically controlled capsule does not incorporate a manual control ; the needle contained within the left-hand diffuser is operated as before through a single operating arm, but in addition, a secondary arm is included which comes into action in the event of the capsule being rendered inoperative through damage. In this event the capsule would expand because of the loss of vacuum and also under the action of the spring contained within it, with the result that the needle would be moved downwards and the mixture consequently weakened to its maximum extent. This would be a dangerous condition which might

result in complete engine failure. A collar on the capsule connecting rod is therefore arranged to engage the secondary arm when the faulty capsule is pushed upwards to its full extent and so carry the arm with it, with the result that the needle is raised to the fully rich (i.e. ground level) position (*see* fig. 42). The top arm is hinged as before at its approximate centre to a fulcrum fixed at its lower end to the main casting, while the lower or secondary arm is hinged at its outer end to a lug secured to the main casting.

232. The action of the left-hand or atmospherically controlled mixture control capsule unit is as follows. Since the compartment within which it is contained is open to atmosphere through the hole already mentioned, a decrease in atmospheric pressure will cause the capsule to expand upwards with the result that the inner end of the operating arm will push the needle downwards and so cause the taper on the lower end of the needle to ride further into the main jet orifice. This will have the effect of reducing the fuel flow through the main jet to accommodate the decrease in volume of air passing into the intakes at altitude.

233. In the normal "automatic-rich" position, i.e., with the right-hand capsule nut depressed by means of the extra manual control, any increase in induction pressure will cause the capsule to contract downwards, which motion will cause the needle to move upwards, thus withdrawing its lower tapered end from the main jet orifice. This action will thus permit a larger quantity of fuel to flow through the main jet and so enrich the mixture to permit the higher boost pressures to be safely used. When the capsule is depressed by means of the manually operated cam, the range of capsule control is re-set without depriving it of its automatic function, with the result that the needle is withdrawn from the main jet to a greater extent than obtains with the undepressed or weak mixture cruising setting, thus providing a richer mixture to be used for the higher power conditions. A collar on the needle limits its downwards travel and prevents the mixture from being weakened below that required for economic cruising.

**ACCELERATOR PUMP**

234. The function of the accelerator pump is to provide additional fuel at the instant of opening the throttle, and the pump crank is accordingly connected by a linkrod directly to the throttle operating shaft so that discharge will coincide with the throttle movement. The additional fuel provided by the pump is necessary to make up for the deficiency caused by the time lag that occurs upon acceleration between the instant of the change in depression in the induction system,



caused by opening the throttle, and the response of the main jet with the greater quantities of fuel required for the increased volume of air that is entering the carburettor.

235. The accelerator pump is of the single or instantaneous type and is illustrated in fig. 42. The pump barrel is unlined and communicates at its lower end with the float chamber through an inlet disc type suction non-return valve. As already mentioned, the lower end of the pump barrel is sealed by the combined cover mentioned in para. 213, and incorporated with this cover, is a delivery disc type non-return valve which permits the fuel to pass out from the lower end of the cylinder, when the position is depressed, into the two delivery passages formed in the main castings which eventually lead up to and break through the sides of the chokes. At this point, the wall of each choke is provided with a horizontal slot for the purpose of delivering the fuel to the five small radial delivery holes drilled in the choke tube which coincide with this slot. This arrangement assists the atomization of the fuel delivered into the chokes.

236. The accelerator piston is composed of two similar cap-shaped pressings placed end to end with a distance washer in between. Incorporated with each half is a chrome leather washer moulded to conform with the outer shape of each pressing; each pressing is kept in position by a disc and the whole assembly is retained together by means of a central bolt and split-pinned nut. The top end of this bolt is formed with an eyelet to which is hinged the operating connecting rod. The upper end of this rod is hinged in its turn to the lever on the accelerator pump operating spindle, which is mounted in bushes contained within a separate cover, attached to the centre of the upper main casting. The lever attached to the outer end of this spindle is connected by means of the long linkrod already mentioned, to its individual operating lever on the operating shaft. Each pressing is provided with a series of radial holes and a diagonal hole breaks through the top end of the barrel to permit fuel to flow from the float chamber to the upper side of the piston. This arrangement of holes is to ensure that the chrome leather washers are kept moist and efficient. A second hole ($\frac{1}{16}$ in. dia.) is also drilled through the top wall of the cylinder and connects with the float chamber for the purpose of relieving the displaced air on top of the piston when it is being drawn up.

*Float, needle valve and seating*

237. Fuel is supplied to the central float chamber in the lower portion of the carburettor body through a union screwed into a boss on the right-hand forward side of the

upper half of the body. The internal passage in the upper half connects this inlet union with the top bore of a hollow boss formed in the upper half casting. A seat for the top feed needle valve is screwed into the lower end of the boss; the seat consists of a union screwed at its top end and formed below the seat proper into a tubular guide for the body of the needle valve. The union is locked in position by means of a tabwasher which may be varied in thickness to adjust the fuel level in the float chamber (*see* para. 377). Radial holes are drilled around the central portion of the guide extension to admit fuel to the float chamber. The valve is of the shape shown in fig. 42, and has a specially shaped conical seat and a thickened circular body which slides within the guide sleeve. The valve is operated through a short connecting rod which is hinged midway to the float arm; the float arm is pivoted at its rear end to a pillar attached to the underside of the top half casting. The connecting rod protrudes within the hollow valve and when the fuel level in the float chamber rises, the action of the float raises the valve and so seals the orifice. The connecting rod has a return spring incorporated with it to prevent damage when the float is not supported by fuel. The cork float is rendered fuel tight by several coats of special varnish and is riveted to a brass bracket on the end of the arm.

*Choke tube*

238. The choke tube is of the section shown in figs. 40 and 42. It is retained within the intake passages by a large grub screw and locknut carried in a large boss in the upper portion of the carburettor body. The central and upper portions of the choke are each provided with an outer flange for the purpose of holding it securely within the intake passage. Five small radial holes are arranged within a horizontal groove which aligns with the accelerator pump delivery passage as described in para. 235 to provide the outlet from the pump. The lower end of the choke has a large radial hole through which is passed the diffuser delivery tube which is secured within the main casting by means of a tab-washered grub screw. The lower extremity of the choke is flared and is of considerably greater diameter than the top end. This shape, in conjunction with the counter-bored portion of the intake passage in the carburettor casting, forms an annular space known as the pressure balance chamber. The chamber is put into communication with the incoming air by means of apertures in the periphery of the lower end of the choke for the purpose of supplying air for the pressure balance, main diffuser and slow-running jet systems.



## AUTOMATIC BOOST CONTROL

*General*

239. All Merlin III and the majority of Merlin II engines are fitted with the variable datum (or progressive) type of automatic boost control unit. Early Merlin II engines were fitted with the fixed datum type of boost control, but these will eventually be replaced by the variable datum unit.

240. The variable datum automatic boost control prevents the boost pressure from arising above normal boost at all altitudes below and up to rated altitude. It consists of a device which provides a superimposed control over the hand-operated throttle, thereby relieving the pilot of the need for constant observation of the boost gauge to maintain the boost pressure within the permitted limits. With the fixed datum type of automatic unit for which the control has been set, maximum permissible boost is obtained soon after the throttle is opened past the slow-running position. In consequence of this, below rated height and particularly near ground level, it

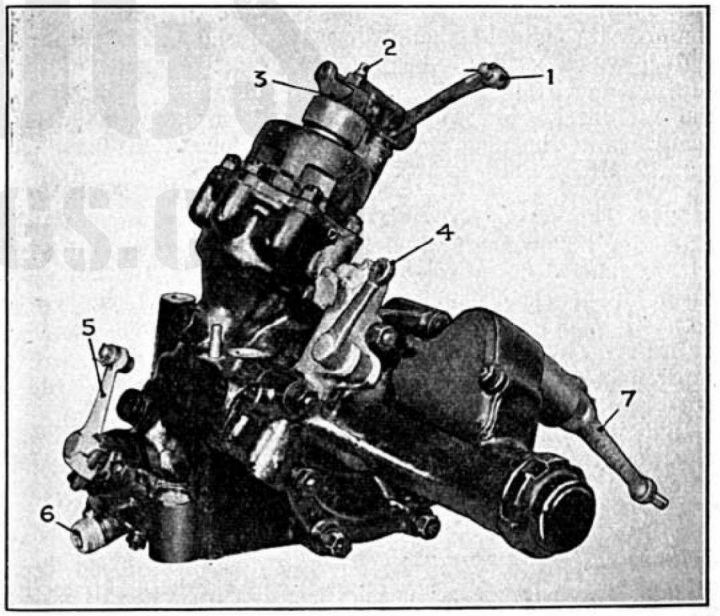



FIG. 44.—Variable datum automatic boost control unit.

1. Variable datum cam actuating lever.
2. Variable datum cam pad adjustment.
3. Variable datum cam.
4. Cut-out valve lever.
5. Change-over valve.
6. Atmospheric pipe union.
7. Throttle actuating lever.

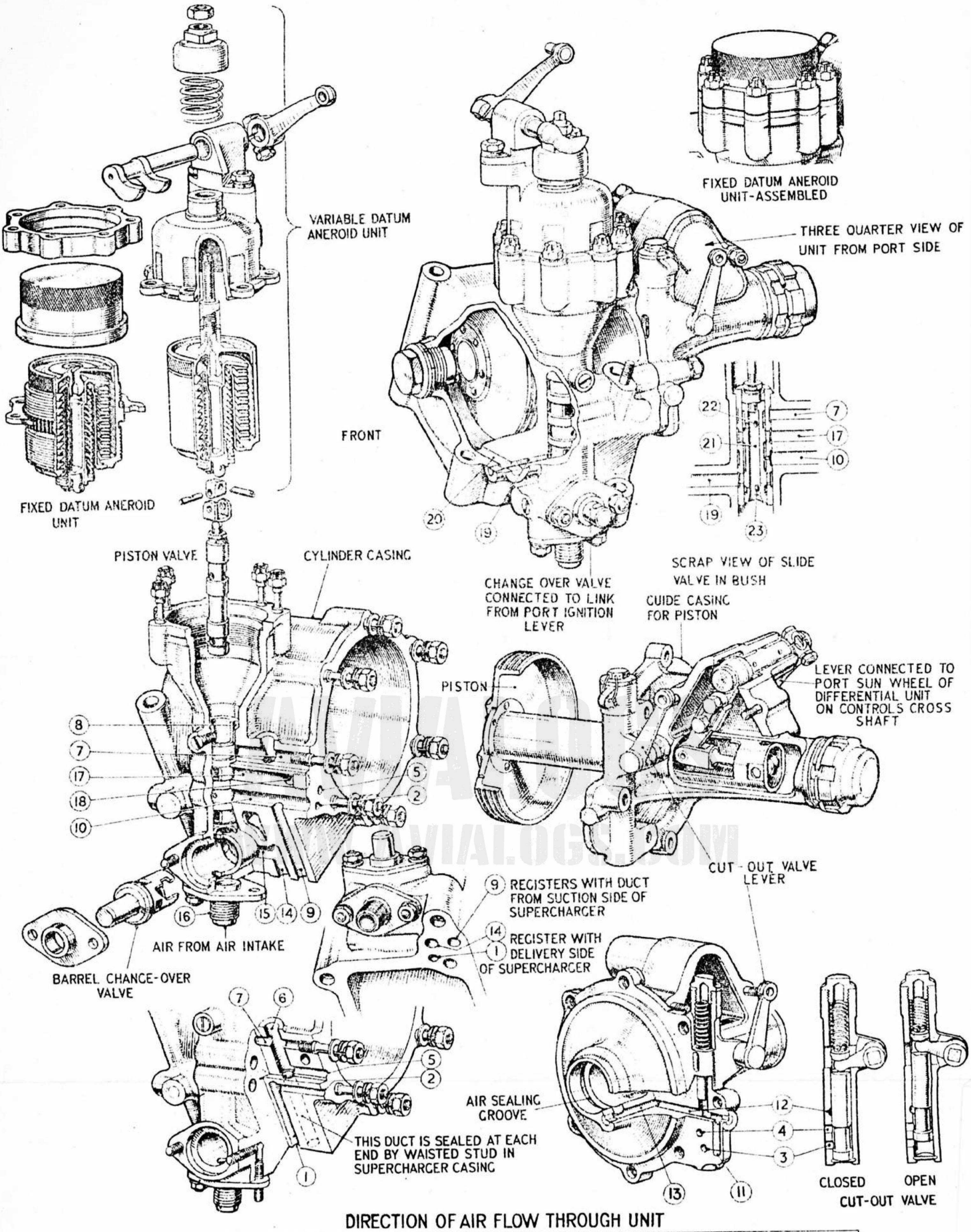
is only possible to open the throttle a small amount with the result that a considerable degree of lost motion in the cockpit throttle operating lever occurs. With the variable datum type of automatic unit the variation in boost pressure is proportional to the throttle opening, so that the lost motion between throttle lever and butterfly valve is eliminated and the movement of the pilot's throttle lever is a definite indication of the boost pressure obtained ; moreover, up to rated altitude, any given position of the pilot's throttle lever will always give the same boost pressure.

241. The automatic boost control unit is attached to the oblique facing on the top port side of the supercharger casing. It comprises a pneumatically operated servo piston, the motion of which is transmitted to the carburettor throttle valves through suitable linkages connected to the port and starboard hubs of the differential unit described in para. 263. The piston works horizontally in a cylinder incorporated in a casing which also contains an aneroid-operated piston valve, internal air ducts necessary for the functioning of the unit and a barrel type of change-over valve. The operating medium for the piston is air which enters the piston valve chamber through the change-over valve and passes through a duct which leads to the pressure or delivery side of the supercharger. The change-over valve admits air either from the air intake or from the delivery side of the supercharger into the piston valve chamber for reasons given in para. 254.

242. The servo piston has riveted to it a rearwardly extending hollow shaft which is borne in a long boss integral with a flanged cover spigoted into the rear of the cylinder casing. The casing houses a cut-out valve which, when actuated in an emergency, puts the boost control out of action by interrupting the flow of air from the delivery side of the supercharger to the aneroid chamber and at the same time puts air from the suction side of the supercharger into communication with the aneroid chamber. Figs. 44, 45 and 46 illustrate the boost control. It should be noted that the bracketed indication numbers appearing in paras. 243 to 257 inclusive refer only to fig. 45.

*Cylinder casing*

243. The cylinder casing is of the shape shown in fig. 45. The large cylinder, the opening of which is at the rear of the casing, receives the boost control servo piston ; the end cover spigots into the cylinder and is secured by studs and nuts. The hollow vertical boss on the port side of the casing houses in its top compartment the aneroid unit. In the case of the




## DIRECTION OF AIR FLOW THROUGH UNIT

| | CONDITIONS | DIRECTION OF AIR FLOW |
|---|---|---|
| 1 | BOOST PRESSURE LESS THAN -- ½ lb PER SQ INCH, CHANGE-OVER VALVE OPEN TO AIR FROM AIR INTAKE ONLY | THROUGH 9-10-19-20 TO FRONT OF PISTON<br>" 16-21-22-17-18 TO REAR OF PISTON |
| 2 | BOOST PRESSURE LESS THAN + ½ lb PER SQ INCH, CHANGE-OVER VALVE OPEN TO GAS FROM DELIVERY SIDE OF BLOWER ONLY | THROUGH 9-10-19-20 TO FRONT OF PISTON<br>" 14-15-21-22-17-18 TO REAR OF PISTON |
| 3 | BOOST PRESSURE MORE THAN + ½ lb PER SQ. INCH, CHANGE-OVER VALVE OPEN TO GAS FROM DELIVERY SIDE OF BLOWER ONLY | THROUGH 9-10-17-18 TO REAR OF PISTON<br>" 14-15-21-23-19-20 TO FRONT OF PISTON |
| 4 | CUT-OUT VALVE CLOSED | THROUGH 1-2-3-4-5-6-7-8 INTO ANEROID CHAMBER |
| 5 | CUT-OUT VALVE OPEN | THROUGH 9-10-11-12-4-5-6-7-8 INTO ANEROID CHAMBER |

# FIG. 45. SECTIONAL PERSPECTIVE VIEWS OF AUTOMATIC BOOST CONTROL

variable datum unit (*see* para. 253) the bore of this compartment is faced and spigoted for the reception of the aneroid housing. Seven studs screwed into the facing around the top of the boss serve to secure the flange of the cover of the aneroid unit to the cylinder casing. Beneath the compartment for the aneroid unit is housed a bush for the piston valve. This bush is located axially near its top end, by a setscrew, and is machined with a slot at this end to form a duct (*see* (8) of fig. 45), which registers with duct (7). It is through this slot that the aneroid unit receives its air supply for actuating the piston valve. At its bottom end the slot runs into the topmost of four circumferential grooves cut on the exterior of the bush ; this groove registers with duct (7) of fig. 45. The second and fourth grooved portions of the bush are each machined with two diametrically opposed transfer slots and they register respectively with ducts (17) and (19). The third grooved portion of the bush is drilled with two radial transfer holes, and it registers with duct (10) through which flows air from the suction side of the supercharger.

244. Beneath the chamber for the slide valve bush is housed the change-over valve in a hollow horizontal boss. Into this boss is pressed a bush, secured by a setscrew, in which rotates the body of the change-over valve. The bush is drilled with three large air transfer holes, two of which are in one longitudinal plane and are diametrically opposed to the third (*see* fig. 45). When the bush is in position the two former holes are on top and register with the lower bore of the slide valve bush ; the third hole registers with a hole at the bottom of the casing, into which is spigoted a flanged plate which has a screwed boss for a union integral with it. It is through this connection that air at atmospheric pressure enters the change-over valve chamber (*see* para. 177).

245. The change-over valve is shaped as shown in fig. 45. It is located axially in the cylinder casing by a cover plate which spigots into and is secured by two studs to the casing. The stem of the valve protrudes through a hole in the plate and is secured to a lever which is linked to the centre of the port magneto control lever on the control shaft. The body of the valve is hollow and is divided into two compartments by a small brass plug riveted in and bearing against a shoulder in the centre of the bore of the valve body. The inner compartment is provided with one air transfer slot which is in the same plane as the innermost of the two holes in the top of the valve bush. The other compartment is machined with two air transfer slots, circumferentially co-planar with each other and with their centre lines about 138° apart. These slots are in the same circumferential plane as the outer one of the two holes in the top of the bush and the hole in the bottom of the

bush. They are staggered in respect to the slot in the inner compartment. When the two slots in the outer compartment register with their respective holes in the valve bush, atmospheric air enters the piston valve chamber. When the single slot in the inner compartment registers with its respective hole in the valve bush, air from the delivery side of the supercharger enters the slide valve chamber. For positions of the pilot's throttle lever from fully closed to slightly open, i.e. just when the depression is being transferred from the slow-running to the main jets, the change-over valve admits only atmospheric air to enter the interior of the piston valve. This air, which is at a higher pressure than that obtaining in the suction side of the supercharger during slow running, is admitted to the rear of the piston, through the aneroid-operated piston valve, and keeps the piston positively at the forward end of its stroke. It is essential that the piston should move away from this position toward the rear only when the boost pressure exceeds — ½ lb. per sq. in. Should it move to the rear simultaneously with opening of the throttle (as would occur at small throttle openings when the compression ratio of the supercharger is practically 1, and when air from the delivery side of the supercharger is the sole operating medium for the piston), then the effective working stroke of the piston would be shortened with the result that the boost control would control the boost pressure only up to some altitude intermediate between sea level and the specified rated altitude of the engine.

246. The supply of atmospheric air to the servo cylinder, therefore, is cut off by the change-over valve when the pilot's throttle lever is just being opened and air from the delivery side of the supercharger is substituted. Beyond this position of the throttle lever, i.e. only a few degrees open, the boost pressure begins to exceed — ½ lb. per sq. in. and the piston commences its boost controlling function (*see* para. 254).

247. Screwed into the front of the cylinder body concentrically with the piston is a stop plug, the depth of entry of which is dependent upon the thickness of an adjusting washer interposed between the casing and a shoulder on the plug. This washer is supplied in various thicknesses. This arrangement provides means of adjusting the relative travel of the servo piston in respect of throttle opening when initially setting the boost control, and it should not normally require re-adjustment.

248. As mentioned above, the cylinder body houses most of the air ducts necessary for the operation of the boost control. These ducts are illustrated in fig. 45 where also the circuits under various conditions of boost are tabulated. Duct (14) registers with the larger of the two holes in the delivery side



of the supercharger (*see* para. 178) and passes air at supercharger delivery pressure into the barrel change-over valve chamber *via* duct (15). The drill-entry end for duct (15) is closed by a screwed plug. Duct (1) registers with the small hole in the delivery side of the supercharger and passes air as supercharger delivery pressure into the aneroid chamber successively through duct (2), the ducts (3) and (4) in the piston guide casing, (when the cut-out valve is closed), ducts (5), (6) and (7) and the slot (8) in the piston valve bush. Duct (6) is the bore for one of the five bolts which secure the cylinder body to the supercharger casing. This bolt is waisted and does not hinder the air supply from duct (5) to duct (7). Duct (7) is sealed at its drill-entry end by one of the studs securing the piston guide casing to the cylinder casing.

249. Duct (9) registers with the hole leading to the suction side of the supercharger (*see* para. 178). It passes air at supercharger intake pressure into the piston valve chamber through duct (10). This latter duct is open at its drill-entry end and registers with the slot (11) in the piston guide casing. This slot communicates with the deep circumferential groove in the bore of the servo piston guide boss in the end cover (*see* para. 257). When the cut-out valve is opened, air at supercharger intake pressure is deviated from the ducts to this groove into the aneroid chamber, as described in para. 261.

250. Ducts (17) and (18) put the piston valve chamber into communication with the rear of the piston while ducts (19) and (20) link this chamber with the front of the piston. Ducts (17), (19) and (20) are each closed at their drill-entry ends with screwed plugs.

*Aneroid unit and piston valve*

251. The aneroid unit and piston valve are illustrated in fig. 45. The aneroid consists of a single corrugated capsule which is soldered at its top end to the flange of a concentric spindle and at its bottom end to the bottom of a cylindrical housing. Spigoted and soldered into the top of the housing is a cover plate. The air between the aneroid and its housing is exhausted to an absolute pressure of ½ lb. per sq. in. through a hole in the centre of the cover plate; when the specified pressure is obtained this hole is sealed by a pinned plug as shown. Movements of the aneroid due to varying boost pressures are transmitted, through the aneroid spindle and a universal coupling, to a small eyebolt screwed into the top end of the piston valve. The details of this universal coupling are clearly shown in fig. 45. The eyebolt is screwed into the top of the piston valve and locked by a tabwashered nut. The top pin of the universal coupling is slotted at each end as shown, so as to retain a spring retaining collar in position.

A spring, housed between a lip at the top of a guide and a washer superimposed on the aforementioned collar, ensures that, in the event of the aneroid becoming punctured, the piston valve will be pushed down and so admit air from either the atmospheric source or from the delivery side of the supercharger, (depending upon the position of the change-over valve, *see* para. 254) to the rear of the piston. This will cause the piston to be pushed to the forward end of its stroke. The piston, therefore, in its motion to the forward end of its stroke, would open the carburettor throttles fully ; the throttle valves can then be operated directly by the pilot without any interference from the boost control. It should be noted however that in this case over-boosting is possible and care should be taken to avoid this.

252. In the fixed datum unit, the aneroid housing is screwed into, while in the variable datum unit the housing is spigoted into, the vertical boss on the port side of the cylinder body (*see* fig. 45). At mid-depth it is provided, in the former case, with a belt of serrations which engage with the internal splines of a lock-plate. This lock-plate is anchored to the seven studs which secure the aneroid housing to the cylinder casing. Screwed on to another threaded portion above the serrations is a knurled cap nut which covers the top of the aneriod unit and is locked by a clamp plate. This plate beds on a shoulder around the bottom of the nut and is retained by the seven afore-mentioned studs to the cylinder casing.

253. In the variable datum unit, the aneroid housing is spigoted into the vertical boss on the port side of the cylinder body and retained by the seven studs and nuts. Screwed to a projection on the aneroid cover plate is a guide rod which is borne in a bush pressed into a hollow boss, formed in the top of the aneroid housing. Screwed on to a stud projection of this guide rod is a cap plate which imprisons a spring between itself and the top of the housing and is locked upon the stud extension by means of a nut. This arrangement provides means of initial adjustment of the aneroid setting. A face on the aneroid housing provides attachment for a bracket which carries a double cam spindle and is operated through a linkrod directly from the control shaft (*see* fig. 47). This double cam, bearing upon the top of the cap plate, depresses the aneroid and consequently the piston valve proportionally to throttle opening and so provides a progressive increase in boost pressure.

254. The piston valve is of the shape shown in fig. 45. Its hollow bore is open at its bottom end and sealed at its top end by the shank of the eyebolt mentioned in para. 251. It is machined externally with three circumferential grooves,



the top and bottom ones of which each communicate with the bore of the valve by a pair of radial holes as shown, while the central groove communicates with the duct (10) through the transfer hole which breaks into the third circumferential groove from the top of the valve bush. The position of the valve relative to its bush and subsequently to ducts (17), (10) and (19) depends upon the boost pressure of the engine. When the boost is — ½ lb. per sq. in. the ports in the bush leading to (17) and (19) are covered by the shoulders between the topmost and central and the central and lowermost grooves respectively, with the result that there is no air flow to either side of the piston. When the boost is less than — ½ lb. per sq. in. the valve moves down, uncovering the ports leading to ducts (17) and (19). Air from the change-over valve passes to the duct (17) *via* duct (21) and the pair of transfer holes (22) in the topmost groove of the piston valve. This duct (17) leads air to the rear of the piston. At the same time air at atmospheric pressure from the pipe mentioned in para. 177 passes into duct (19) which leads to the front of the piston. When the boost exceeds — ½ lb. per sq. in. the piston valve is lifted by the aneroid so that it again uncovers the ports in the bush leading to ducts (17) and (19). This time, however, air from the change-over valve enters duct (17) (to the front of the piston) through duct (21) and the pair of transfer holes (23) in the bottommost groove in the piston valve, while air from the intake side of the supercharger passes into duct (19) to the rear of the piston.

*Piston, piston guide casing and cut-out valve*

255. The servo piston is shaped as illustrated in fig. 45. Riveted to it is its rearwardly extending rod which is located in the bore of the guide integral with the end cover. The rear end of this guide bore is sealed by a domed cap nut which is locked to the casing by a circlip as shown. Connected by a small gudgeon pin to the end of the rod is the eye of a connecting rod. The gudgeon pin is not fully floating as it is secured to the lever by a split-pin which is inserted through one of two diametrically opposed holes at right-angles to the holes for the pin. The rod and the guide casing are slotted for the passage of another lever, the lower end of which is hinged to the forked end of the small connecting rod attached to the end of the rod. The upper end of the former lever is secured by two bolts to the shank of a lever connected by a linkrod to the left-hand bevel wheel of the differential (*see* para. 263).

256. The piston guide casing consists of a cover with a rearwardly projecting sleeve concentric with the cylinder casing. It spigots into and is secured to the rear of the cylinder body by seven studs. A vertical boss on the port side of the casing is drilled to receive the cut-out valve. The

bottom of this hole is sealed by a disc which is peened in position. The boss is machined at mid-depth with two clearance slots in the rear one of which works a lever which is designed to operate the cut-out valve. The ball end of this lever engages with a rectangular sectioned slot in the cut-out valve while its eye end engages the square portion of the fulcrum pin of another lever which is connected to the cockpit. The pin of this latter lever is borne in two lugs one on each side of the aforementioned slot in the boss. It is located axially by a collar and split-pin fitted on its inner end.

257. Screwed into the top of the boss for the cut-out valve is a wire-locked cap nut between the bottom of which and the top of the cut-out valve, is fitted a spring by which the valve is loaded. The cut-out valve consists of a plunger which is machined near its bottom end with a circumfereutial groove and near its top end with the rectangular slot which has been dealt with in the preceding paragraphs. The groove near the bottom of the valve, links holes (3) and (4) in the piston guide casing when the cut-out valve is closed, so that the circuit of supercharger delivery air to the aneroid chamber is not interrupted. When, however, the valve is opened, hole (3) is covered by the shoulder beneath the groove, while hole (12) is put into communication with hole (4) with the result that the former air circuit is interrupted and in its place is substituted air from the intake side of the supercharger. This latter circuit is as tabulated in fig. 45, the guide casing providing the slot (11) and ducts (12) and (13). The drill-entry hole for ducts (12) and (13) are each blanked by screwed plugs. The groove in the bore of the guide casing minimizes air leaks past the piston rod, the air being pumped back into the duct (13) by the reciprocating motion of the piston. Four circumferential grooves in the piston also minimize air leaks.

257A. In its unmodified condition, the boost control cut-out valve permitted the boost pressure to rise very consider-ably. Mod. Merlin 154, however, limits the pressure to +12 lb. per sq. in. for use under emergency conditions (*see* para. 359A *et seq.*). This modification consists in drilling a 0·093-in. hole right through the cut-out valve in the middle of the waisted portion and in line with the slot into which the inner end of the actuating bell crank lever fits. Since the valve is hollow, this action results in two radial bleed holes which permit the boost pressure to exert a limited effect on the aneroid capsule.

### ACTION OF BOOST CONTROL

258. The bracketed indication numbers in paras. 258 to 261 inclusive refer only to fig. 46. As soon as the engine starts, with the throttle just open, a depression will be transmitted to the aneroid chamber (16), which will cause the piston valve (4) to be lowered and to admit the depression by passage and



port (9) to the front end of the cylinder (5), atmospheric pressure being admitted to the other end through valve (13) and port (8).

259. With the relay piston in this position, the throttle (12) will be opened as the hand-lever (1) is opened, up to a position which gives + 6¼ lb. per sq. in. boost, before the control comes into action to restrict throttle opening. It will be seen that the change-over valve (13) is about to cause boost pressure by passage (7) to be substituted for atmospheric pressure for relay operation purposes. At the same time the pressure in chamber (2) (i.e. the boost pressure) will have increased, causing the piston valve (4) to be raised so that it is on the point of admitting boost pressure to the front of the cylinder (5), and suction pressure to the rear. If the hand throttle lever be opened sufficiently to cause this to occur, then the relay plunger will be moved to the rear and will close the throttle through the differential gear (11), until a state of equilibrium is reached.

260. If the hand throttle lever be moved to the full open position at ground level, the throttle will not open further than that necessary to give + 6¼ lb. per sq. in. boost, the relay piston being then approximately at the rear end of the cylinder, but as the aeroplane rises this boost will be maintained by the control up to the rated altitude. When the rated altitude has been reached, the relay piston will be at the front end of its cylinder and the throttle will be wide open. The effect of this is to establish (with the fixed type of boost control) a dead period in the closing of the throttle from the fully open position, during which period the engine does not respond to the throttle control movement. This dead period is at a maximum at ground level and vanishes at rated altitude and above. The dead period, therefore, corresponds to the cockpit throttle control movement necessary to bring the relay piston of the boost control to the forward end of its stroke. This dead period is eliminated in the variable datum type of boost control since, by means of the cam (18) and the actuating lever (19), which are coupled directly to the control shaft and move in step with the cockpit throttle lever, the boost is increased progressively with the movement of the cockpit throttle lever.

261. Operation of the cut-out valve (14) substitutes suction for boost pressure in the aneroid chamber (2). This has the effect of rendering the control virtually inoperative, as the relay piston is held in the forward position, enabling the throttle to be fully opened by the hand lever at any altitude. When Mod. Merlin 154 has been applied, however, the boost control is still subjected to a qualified pressure from the pressure side of the supercharger, with the result that the boost pressure is limited to +12 lb. per sq. in. for emergency purposes. (*See* para. 257A.)

FIG. 46.—Diagram of boost control (variable datum type).

1. Pilot's control lever.
2. Boost chamber.
3. Metallic aneroid (capsule).
4. Piston valve.
5. Servo cylinder.
6. Suction passage.
7. Delivery passage.
8. Rear control port.
9. Front control port.
10. Servo piston.
11. Differential.
12. Throttle valve.
13. Change-over valve.
14. Cut-out valve.
15. Ports for cut-out valve.
16. Aneroid chamber.
17. Aneroid spring.
18. Variable datum cam.
19. Cam control lever.
20. Return spring for aneroid unit.
21. Adjustment for initial boost setting.
22. Locknut for aneroid valve adjustment.
23. Throttle stop on controls.
24. Return passage for leakage.
25. Cam clearance at slow running position (0·087 in.).
26. Cap clearance at take-off position (0·030 in.).

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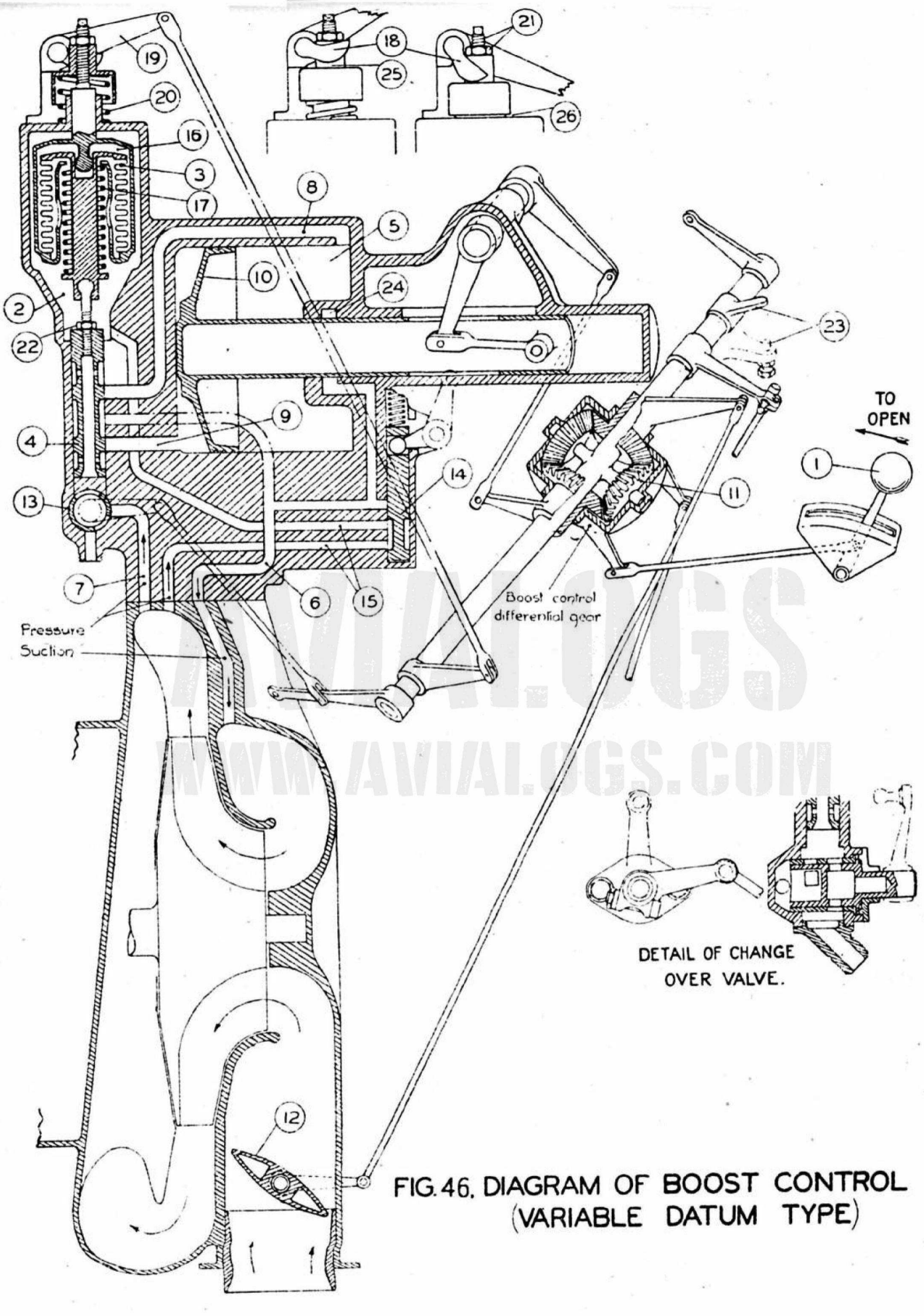



FIG. 46. DIAGRAM OF BOOST CONTROL (VARIABLE DATUM TYPE)

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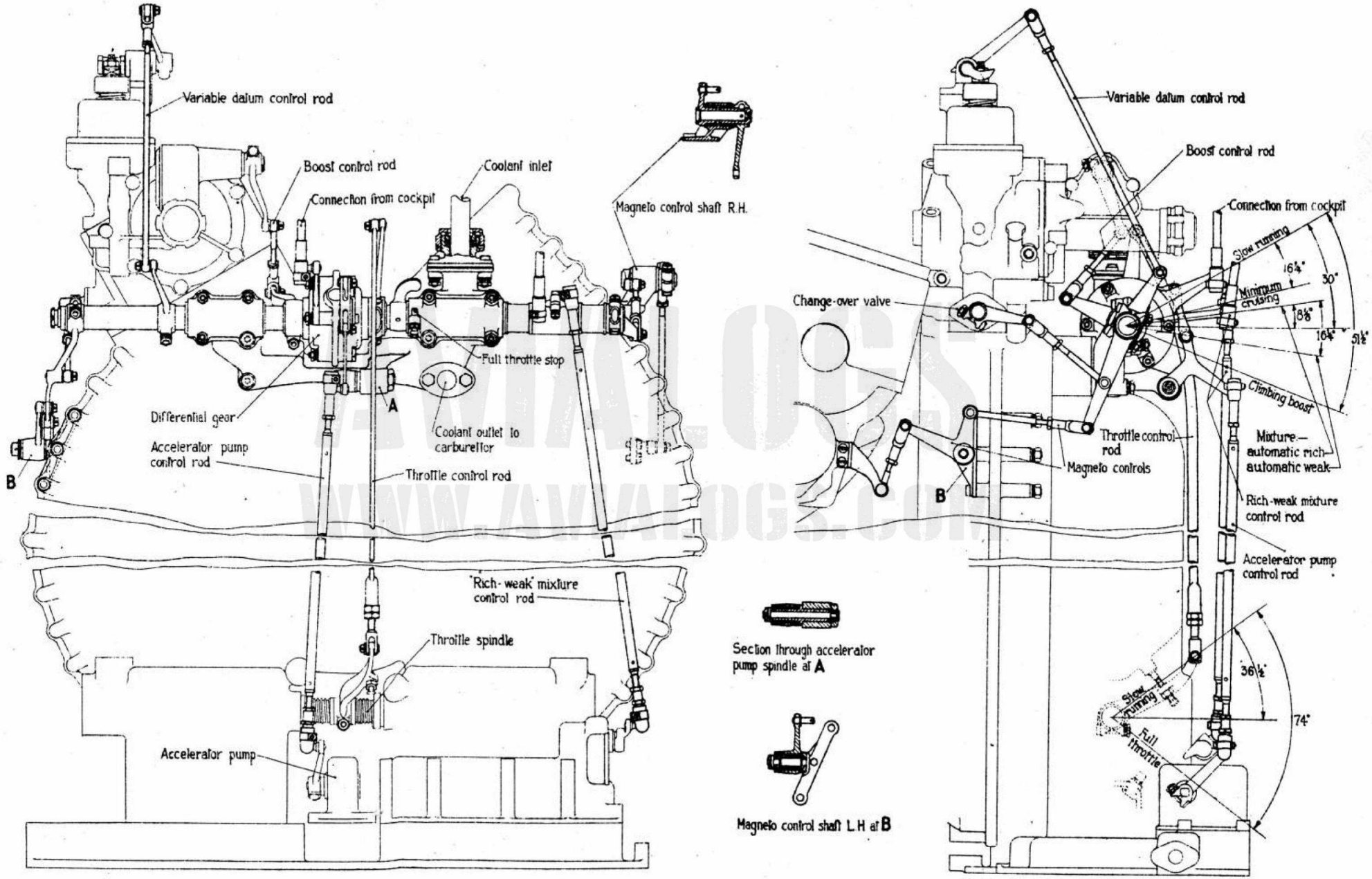



FIG.47. CARBURETTOR, BOOST AND MAGNETO CONTROLS

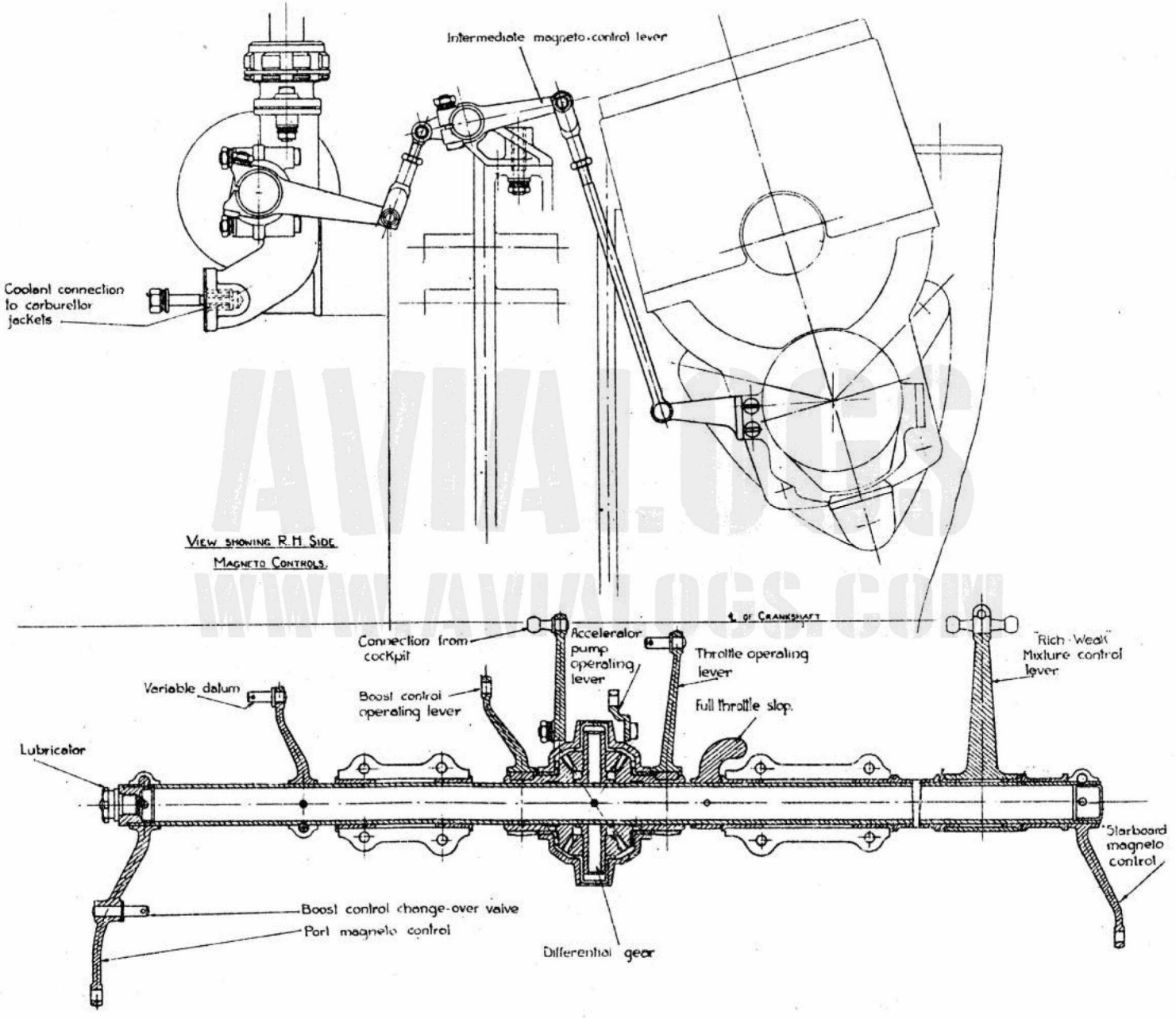



FIG. 48. ARRANGEMENT OF CARBURETTOR, BOOST AND MAGNETO CONTROL SHAFT

*Control shaft*

262. The common control shaft (*see* figs. 47 and 48) whereby throttle, accelerator pump, boost controlled mixture control and magnetos are actuated, is mounted in two double bushed split housings attached to facings on the upper rear side of the blower cover. The hollow control shaft itself is sealed by means of a plug at its right-hand end and incorporates an oiling nipple at its left-hand end. The oil (Specification D.T.D.44B) so injected into its bore finds its way out through various holes in the shaft which are aligned to convey the lubricant to the bushes of the various shafts and the differential gear mounted thereon.

263. Pinned to the centre of the shaft is a spider for carrying the bevel wheels of a small differential gear which permits the boost control to operate the throttle valves independently of the cockpit control. The two larger bevel wheels which mesh with the smaller bevel wheels mounted upon the spider have long unbushed hubs by means of which they are mounted freely upon the shaft. The left-hand larger pinion is connected by means of an arm and link-rod to the boost control operating arm, while the right-hand pinion is provided with an arm which connects through a long vertical link-rod to the throttle lever mounted in the middle of the throttle spindle. The whole assembly of gearwheels is enclosed within a split light alloy casing secured in position by series of bolts and nuts. The left-hand side of this casing has a ball joint lever to which is attached the cockpit control rod. Attached to the right-hand side of the casing is the accelerator pump operating lever which operates the accelerator pump in the manner already mentioned through an intermediate Y-lever and appropriate link-rods.

264. Attached to either end of the shaft are arms for operating the magneto cams; both these controls operate through an intermediate bell-crank lever hinged to the blower casing. In addition, the left-hand magneto operating arm has an intermediate attachment to which is pivoted the link-rod controlling the boost control change-over cock. Situated just inside the right-hand end of the shaft is a bushed lever which merely floats upon it; this lever is provided with two ball joints, one for connecting to the cockpit mixture control and the other to the long vertical link-rod connecting with the "weak-rich" control cam of the right-hand or induction pressure governed mixture control. The lever on the shaft adjacent to the left-hand supporting bracket connects, by means of a link rod, with the variable datum cam lever; the cam therefore is moved directly by the movement of the shaft.

## INDUCTION SYSTEM

*General*

265. The mixture supplied from the supercharger is delivered through an induction elbow which joins a central delivery tube through an intermediary connection. This central delivery tube is situated along the top of the crankcase and within the V of the cylinder blocks. The tube has six faced outlets by means of which the three faced inlets of each manifold are attached to it. The induction system also incorporates the priming and slow-running suction system described in paras. 270 and 271.

*Induction manifolds*

266. Each induction manifold (*see* figs. 49 and 50) is a single light alloy casting and both manifolds are substantially identical in practically all features except that they are " handed " to accommodate the right and left-hand cylinder blocks. In general form each manifold is an elongated cover faced to seat upon the combined elongated inlet port on the cylinder block. The manifold is attached to the cylinder block by means of numerous studs which pass through bosses integral with the manifold ; a gasket is provided to form a gas-tight joint between the faces.

267. Incorporated on the upper side of each manifold are three faced bosses, situated at each end and in the middle respectively. These bosses provide seatings for the priming and slow-running suction piping system described in para. 270, *et seq*. The outer bosses have a large hole drilled through them for the reception of the atomizer nozzles, and a second smaller hole for connection with the slow-running suction pipes. The central boss has two diagonally positioned holes which, as mentioned in para. 270, are connected to their corresponding holes in the other manifold through separate drilled passages in the thickened webs incorporated in the manifolds and in the central portion of the central delivery tube.

*Induction trunk*

268. The induction trunk is a simple tapering tubular light alloy casting sealed at its front end with a plug and having at its rear end a spigot for the reception of the short connecting tube and its gas-tight gland. Situated at both ends and in the middle respectively are three pairs of faced and bossed outlet ports which are attached, in the manner already described, to the short curved intake elbows of the two manifolds. The short connecting tube slides into the rear spigoted end of the central tube and a circular rubber ring is compressed within the enlarged spigot by a cone-ended locknut which screws into the threaded bore of the spigot. A connecting bracket is attached to the short connecting tube for electrical bonding purposes.

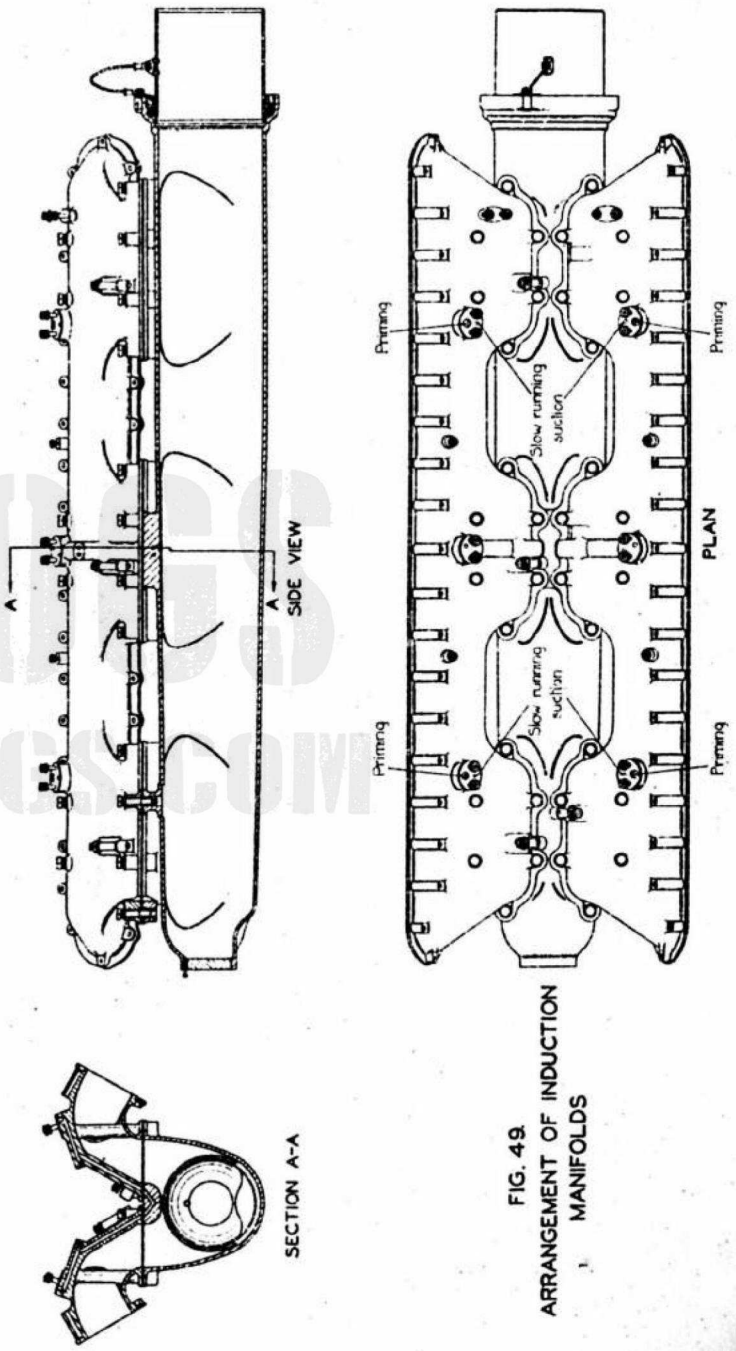



FIG. 49.
ARRANGEMENT OF INDUCTION MANIFOLDS

P.1210.

*Induction elbow*

269. The induction elbow is a light alloy casting curved so that the faces of its two ends are at right-angles to each other. Its rear end is flanged and bossed for attachment to the outlet facing on the top of the blower casing. Its front end is enlarged to form a spigot and a housing for the sealing gland by means of which it is connected to the rear end of the short connection tube already described. The gland comprises a circular rubber ring compressed within the spigot by means of a cone-ended lock ring which screws into the threaded portion of the large spigot. In the middle of the elbow is a hollow facing to which is attached by studs and nuts, the primer filter

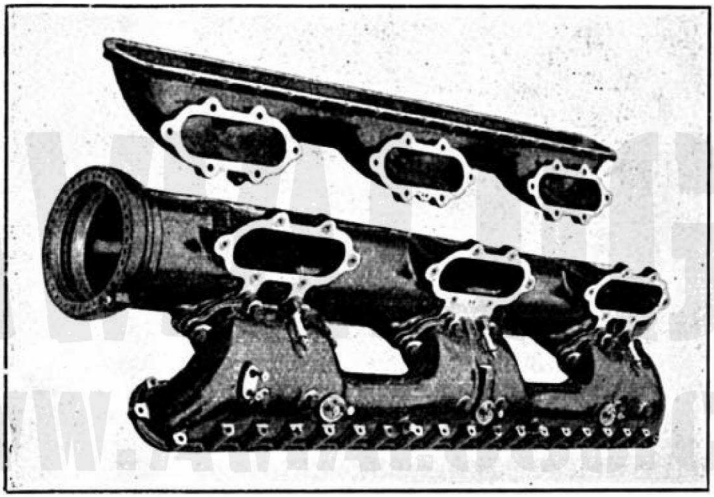


FIG. 50.—Induction manifolds and central delivery trunk.

and union casting. A priming atomizer body screws into the threaded hollow portion of this facing. To the right of this facing is a hollow circular boss for the reception of the boost pressure pipe union.

**PRIMING AND SLOW-RUNNING SUCTION SYSTEMS**

270. An external piping system (*see* fig. 51) provides for injecting atomized fuel into the central inlet elbow and also both branches of each induction manifold from the priming pump in the aeroplane. For this purpose a spiral atomizing device is incorporated in the rear end of the induction elbow. This device is contained within a bushing having a small delivery orifice, which is screwed into a faced boss on the

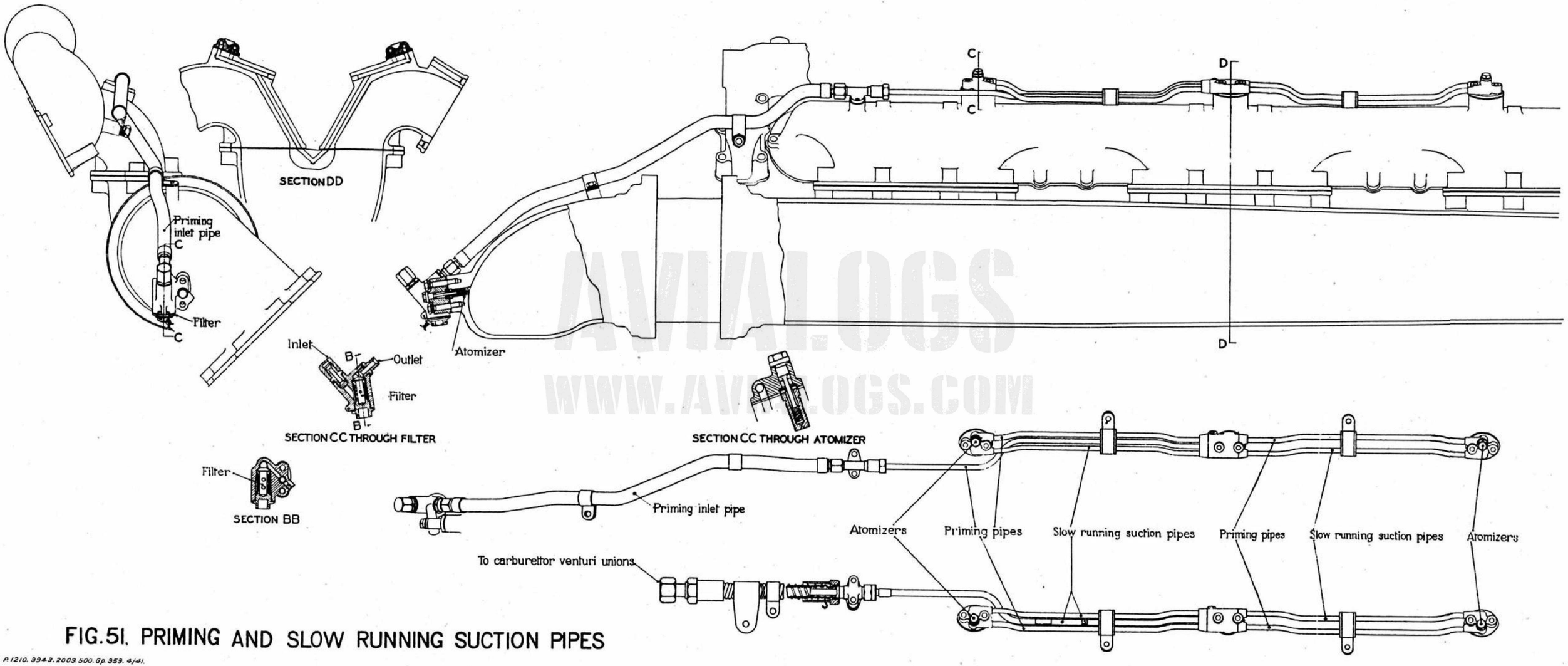



FIG.51. PRIMING AND SLOW RUNNING SUCTION PIPES

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elbow. Attached to this facing by means of studs and nuts is a small casting which incorporates an inlet union by means of which fuel is admitted from the priming pump, a detachable filter, and an outlet union to which is attached the flexible pipe supplying the separate manifold priming points. This pipe runs from the induction elbow forward to a union connector secured to a boss at the rear end of the left-hand induction manifold by means of studs and nuts. Connected to the forward end of this connector is a copper pipe which is brazed into a distributor block mounted on a facing in the middle of the left-hand induction manifold. From this central distributor the fuel is directed through two separate external copper pipes which carry it to separate atomizers located at the front and rear ends of the left-hand manifold. In addition, a connection is taken from this central distributor through passages drilled respectively in thickened portions of the left-hand manifold, central induction tube and right-hand manifold to a similar central distributor, which also has external copper pipes running fore and aft to individual atomizers located in the front and rear ends of the right-hand manifold. It will be seen therefore that this arrangement provides priming at five different points in the induction system.

271. The two external pipelines mounted upon the induction manifolds already described are duplicated and also interconnected through the castings in a precisely similar manner. The four inlets to the manifolds are, however, merely plain holes and do not incorporate atomizers. A connection is taken from this suction system from the right-hand central distributor, which is connected by means of a copper pipe, a union connector and an external flexible pipe to the venturi union connecting with the right-hand carburettor intake and also to a small sump situated at the bottom of the blower casing mentioned in para. 215. This system is for the purpose of sucking up any liquid fuel that may collect within the blower casing after prolonged periods of slow running. The suction in the manifolds withdraws any liquid fuel that may have collected in the sump and also mixes it with air from the venturi union, thus forming an emulsified fuel for delivery to the induction manifolds during slow running.

# CHAPTER 8

## IGNITION SYSTEM

### GENERAL

272. The sparking plugs of both cylinder blocks are served by two B.T.H. magnetos, type CISE–12S, which are mounted on the "A" and " B " sides of the wheelcase. The " A " side magneto serves the plugs on the inlet valve side of both cylinder blocks, the " B " side magneto the exhaust plugs. The magnetos are spigot mounted on the side of the wheelcase, each being retained by three studs and spring-washered nuts. They are each driven by the magneto drive shaft in the wheelcase through a separate coupling shaft (*see* paras. 132 to 136). An operating lever is carried on the contact breaker cover of each magneto and is connected through a bell-crank lever pivoted on a lug on the super-charger casing to a lever pinned and clamped to one end of the throttle control shaft. This causes the timing to be advanced as the throttles are opened and retarded as the throttles are closed, a slight retardation from the fully advanced position being effected at full throttle. The amount of this retardation is equivalent to approximately 3° of crankshaft movement.

### IGNITION CABLES AND FITTINGS

273. Each shielded magneto distributor cover has twelve sockets from which emerge the metal braided high-tension cables to the sparking plugs. The cables from the starboard or "A" side magneto serve the sparking plugs on the inlet sides of the cylinders, and those from the port or " B " side magneto the exhaust side sparking plugs (*see* fig. 53). The cables are, for the most part, contained within three metal conduits, one placed between the cylinder blocks and one on the outside of each block (*see* fig. 52). These conduits are supported throughout their lengths to the blocks by means of suitable brackets welded to them. Metal covers are fitted over the distributors and the cables are carried from them in short flexible tubes, which are coupled by means of screwed flanged connectors to the rear ends of the conduits.

274. The distributor end of each cable has an insulated sleeve pressed over it, and the wire itself is brought through an inner partition and connected electrically with a spring-loaded connector thimble which protrudes from the end of the sleeve. When the sleeve is in position in the distributor cover, the thimble presses upon its own particular stud in the magneto. All studs are marked. Each cable, enclosed in a screened metallic braiding, is led through a separate outlet tube incorporated with the conduit at a point adjacent to the

plug it serves; these outlet tubes have screwed to them screw caps which grip the screened sheathing and hold it securely at this point.

275. Special sparking plugs, having hollow threaded extensions, are used to accommodate the quickly detachable cable adaptors. These adaptors are obtuse angled for the outer or exhaust side plugs and straight for the inner or inlet

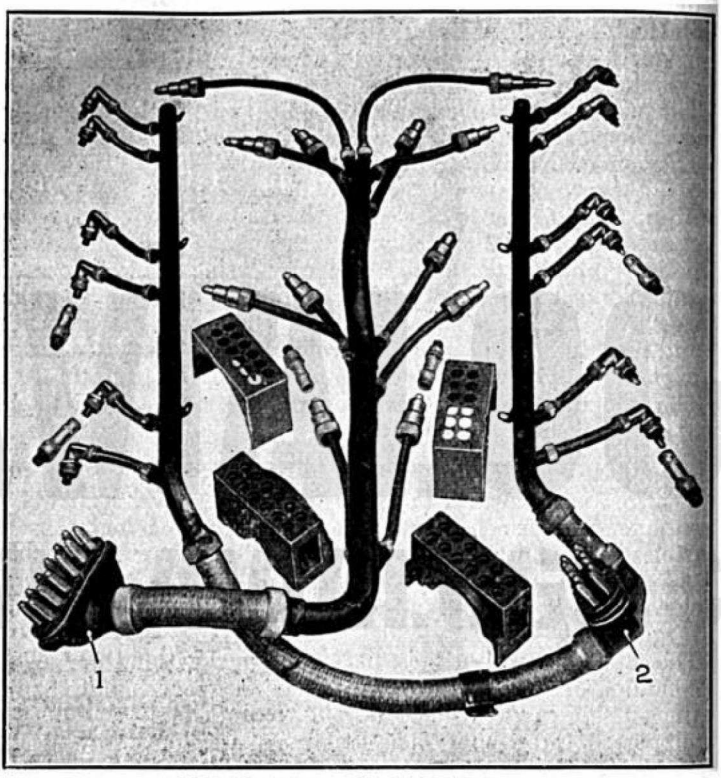
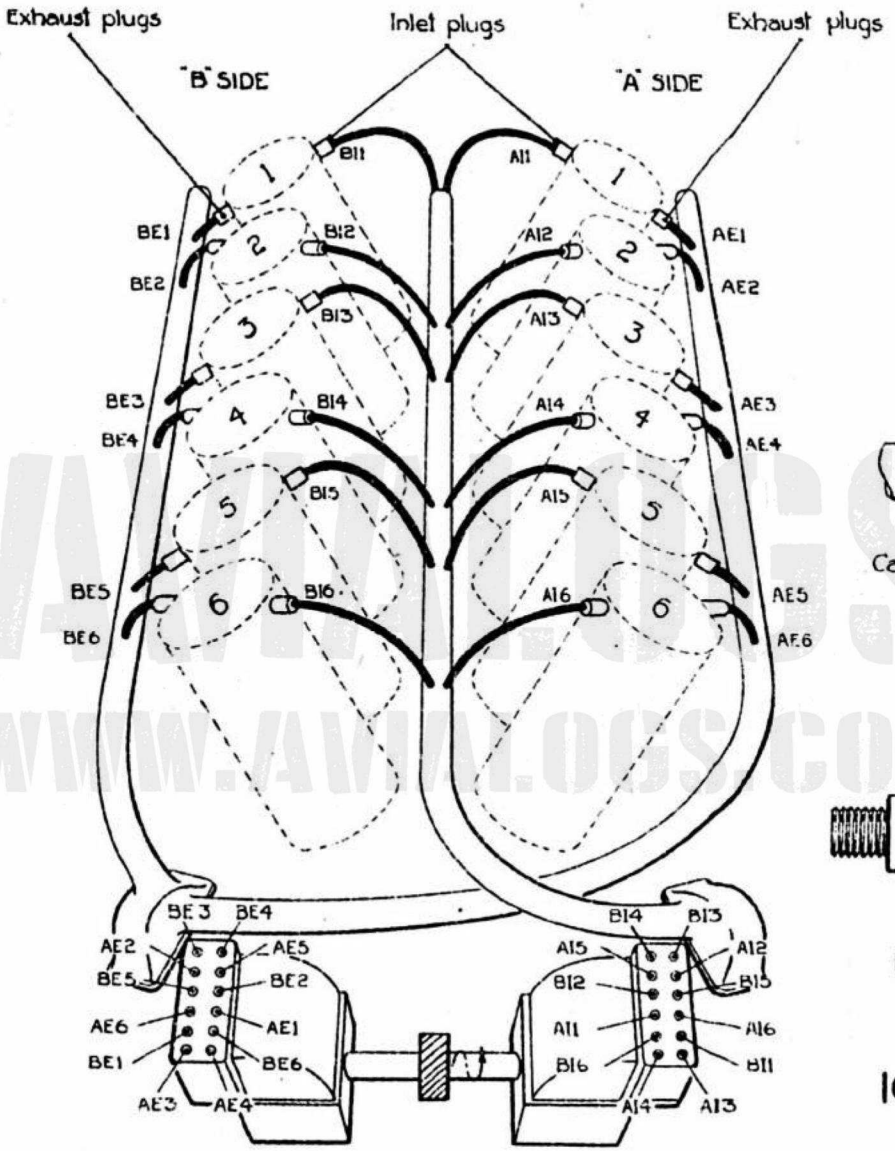
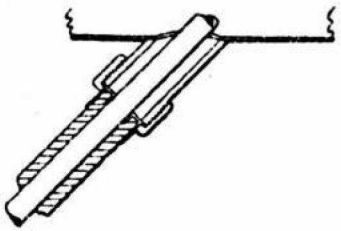


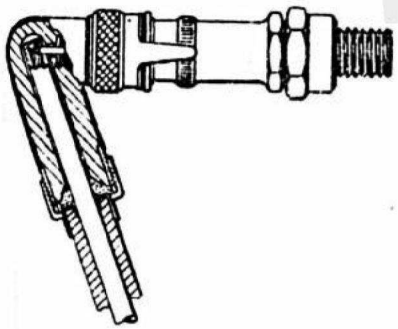

FIG. 52.—Screened ignition harness.
1. "A" side magneto distributor block. 2. "B" side magneto distributor block.

side plugs. Each adaptor comprises generally an internally threaded sleeve which screws on to the threaded end of the sparking plug extension and is locked in position by two spring extension arms, the extremities of which engage a ring of serrations cut in the middle of the plug extension. Each adaptor contains a spring-loaded plunger which, when it is screwed on to the plug, bears upon and connects with the outer end of the central electrode. The cable end is gripped in the outer end of the adaptor by an internal sleeve.

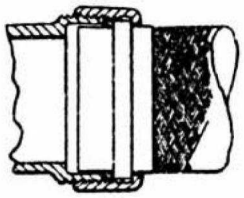


Cable outlet



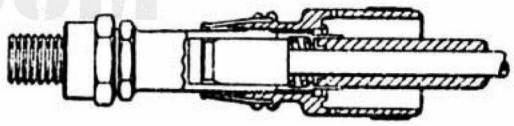
Exhaust plug connector



Conduit joints



Cable magneto end inlet and exhaust
(Scale 2/1)



Inlet plug connector

# FIG. 53
# IGNITION WIRING DIAGRAM

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# CHAPTER 9

## PIPING SYSTEMS

### GENERAL

276. The piping systems dealt with in this chapter comprise all external pipes and fittings supplied with the engine. They fall under the headings of oil, air and coolant pipes and are described in the following paragraphs.

### OIL PIPES

277. Fig 54 shows the arrangement of pipes which convey the high and low pressure and scavenge oil to various points of the engine. Each is of steel and has brazed-on fittings. These latter fittings, of steel, comprise nipple and banjo type unions and flanged type connectors. All main pressure connections are internal and comprise ducts, with the exception of the distributor gallery which conveys the main pressure oil supply to the main journal and big-end bearings (*see* para. 83), and the additional pipe (*see* fig. 54) for supplying oil to the vacuum pump and constant speed drive unit in the event of this unit being used with a basic Merlin II layout (*see* para. 110).

*High pressure pipes*

278. The high pressure pipes comprise the following :—

(i) A large bore pipe A from the outlet union on the pressure pump to the long inlet union on the underside of the relief valves body. This pipe delivers the whole of the oil used in the lubrication of the engine proper (*see* para. 298).

(ii) A small bore pipe B leading high pressure oil from a union in the pressure pump outlet passage to the inlet union on the fuel pumps unit (*see* para. 152).

(iii) A medium bore pipe C leading high pressure oil (after it has passed through the airscrew pitch operating valve), to the union on top of the crankcase half of the reduction gear casing, in the case of early Merlin II engines (*see* para. 103), or to the inlet union on the underside of the governor drive unit on the front of the reduction gear cover, in the case of Merlin III and modified Merlin II engines (*see* para. 111). In the latter case, the additional pipe $C_1$ is required to connect the outlet union on the top of the governor drive unit to the inlet union on the crankcase half of the reduction gear cover.

*Low pressure pipes*

279. The low pressure pipes comprise the following :—

(i) A small bore pipe D from the front of the relief valves body to the reduction gears oil jets (*see* para. 70).

(ii) A small bore pipe E from the rear of the relief valves body to a T-connection fixed to the rear right-hand side of the crankcase (*see* para. 121). This pipe supplies a series of pipes at the rear of the engine (*see* paras. 18, 157 and 185).

(iii) A small bore pipe F from the T-connection in (ii) to the union on the right-hand side of the wheelcase for supplying the three supercharger layshaft oil jets (*see* para. 189).

(iv) A small bore pipe G from the wheelcase union in (iii) to the rear supercharger bush housing (*see* para. 185).

(v) A small bore pipe H from the T-connection in (ii) to a four-way connector mounted on the rear of the crankcase ; the three outlets from the connector supply oil through separate pipes ($H_1$ and $H_2$) to the unions on the "A" and " B " cylinder blocks through which the camshaft drives are lubricated (*see* para. 18), and through a pipe $H_3$ to a flanged connector on the left-hand side of the wheelcase which supplies oil to the various bearings of the generator drive (*see* para. 157).

*Scavenge pipes*

280. The scavenge pipes comprise the following :—

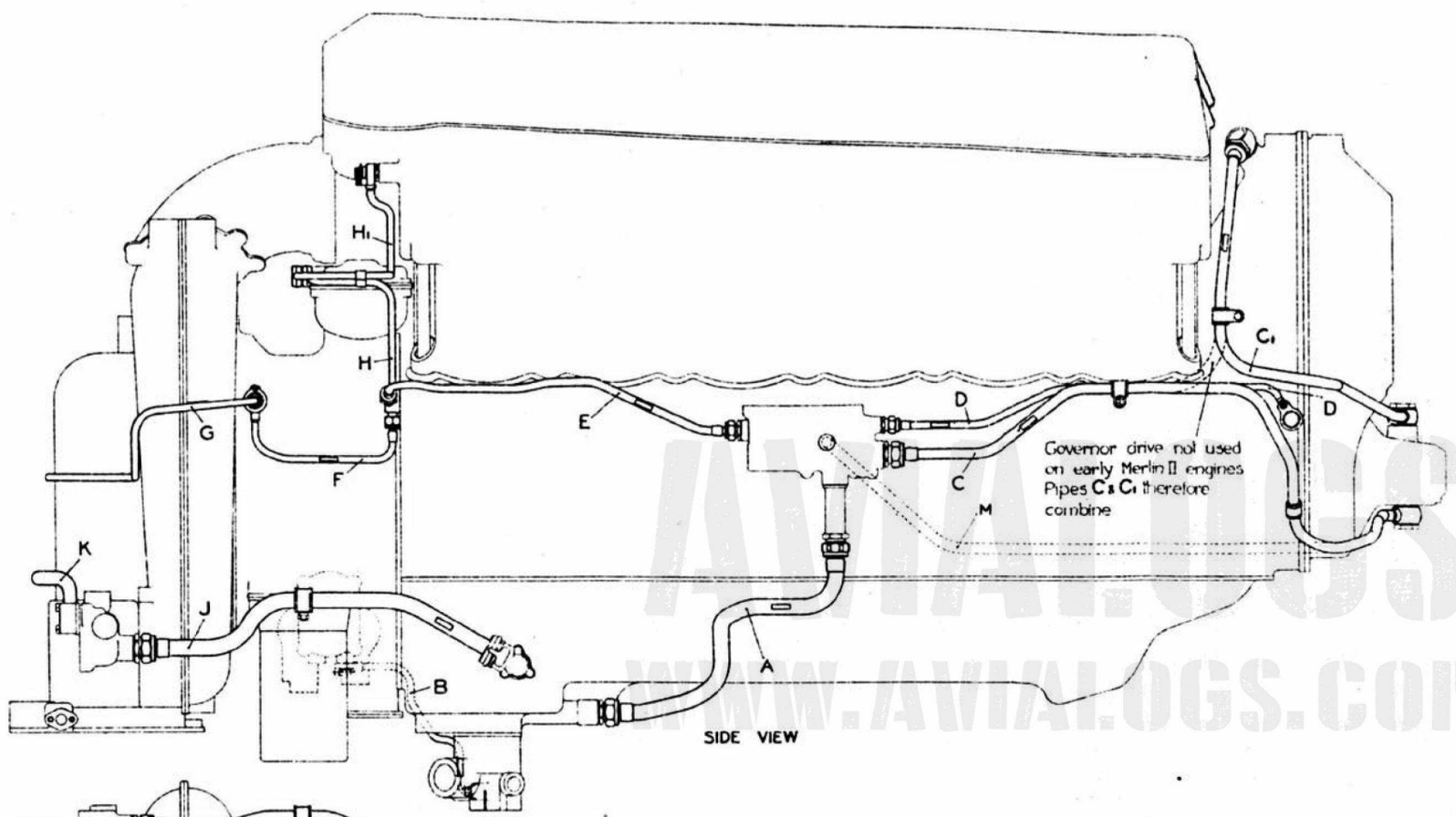
(i) A large bore pipe J from the right-angled scavenge outlet in the rear right-hand side of the crankcase sump to the inlet union on the scavenge relief valve body (*see* para. 204) situated on the right-hand side of the supercharger casing cover. This pipe carries the whole of the scavenge oil passing from the engine back to the tank.

(ii) A large bore pipe K connecting the left-hand end of the hollow carburettor throttle spindle to the scavenge relief valve body. This pipe returns the oil passed through the spindle and butterfly throttle valves to the outlet union for return to the tank, together with the remaining scavenge oil which has been by-passed by the scavenge relief valve (*see* para. 204).

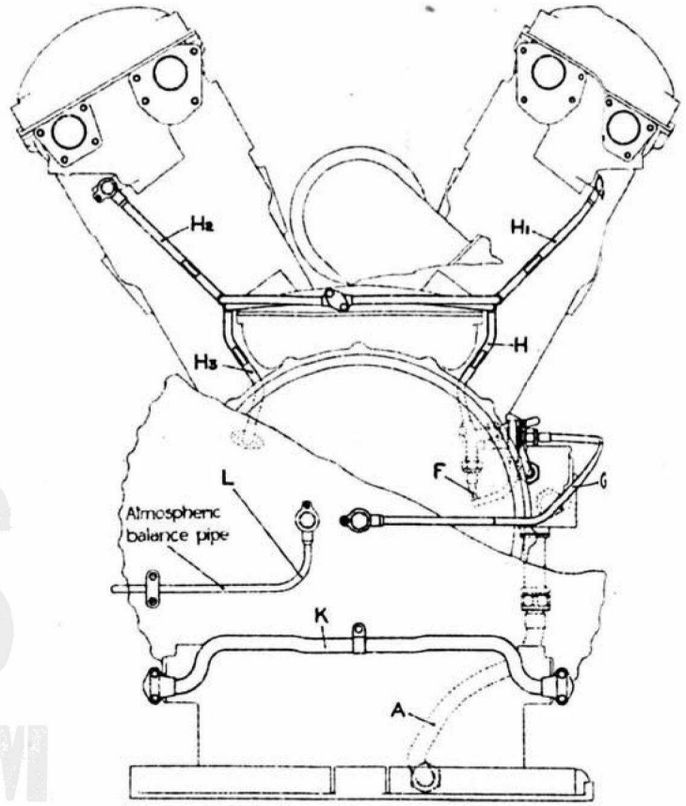
**AIR PIPES**

281. The arrangement of air pipes on the engine is shown in fig. 54 and comprises :—

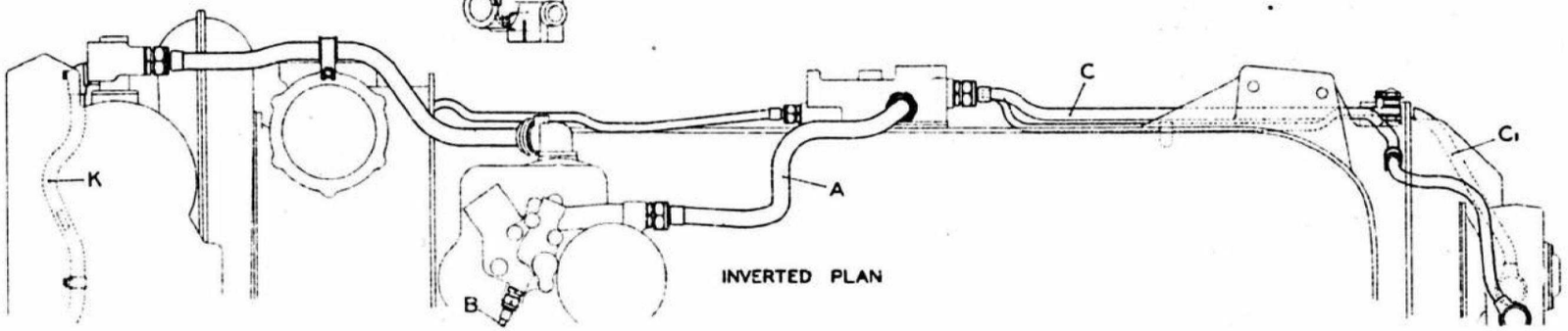
(i) A small bore pipe L from an offset boss in the supercharger casing through which is communicated atmospheric pressure to the inner side of the supercharger



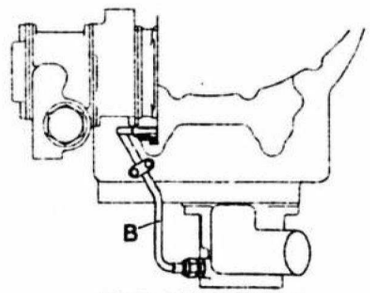

SIDE VIEW




END VIEW



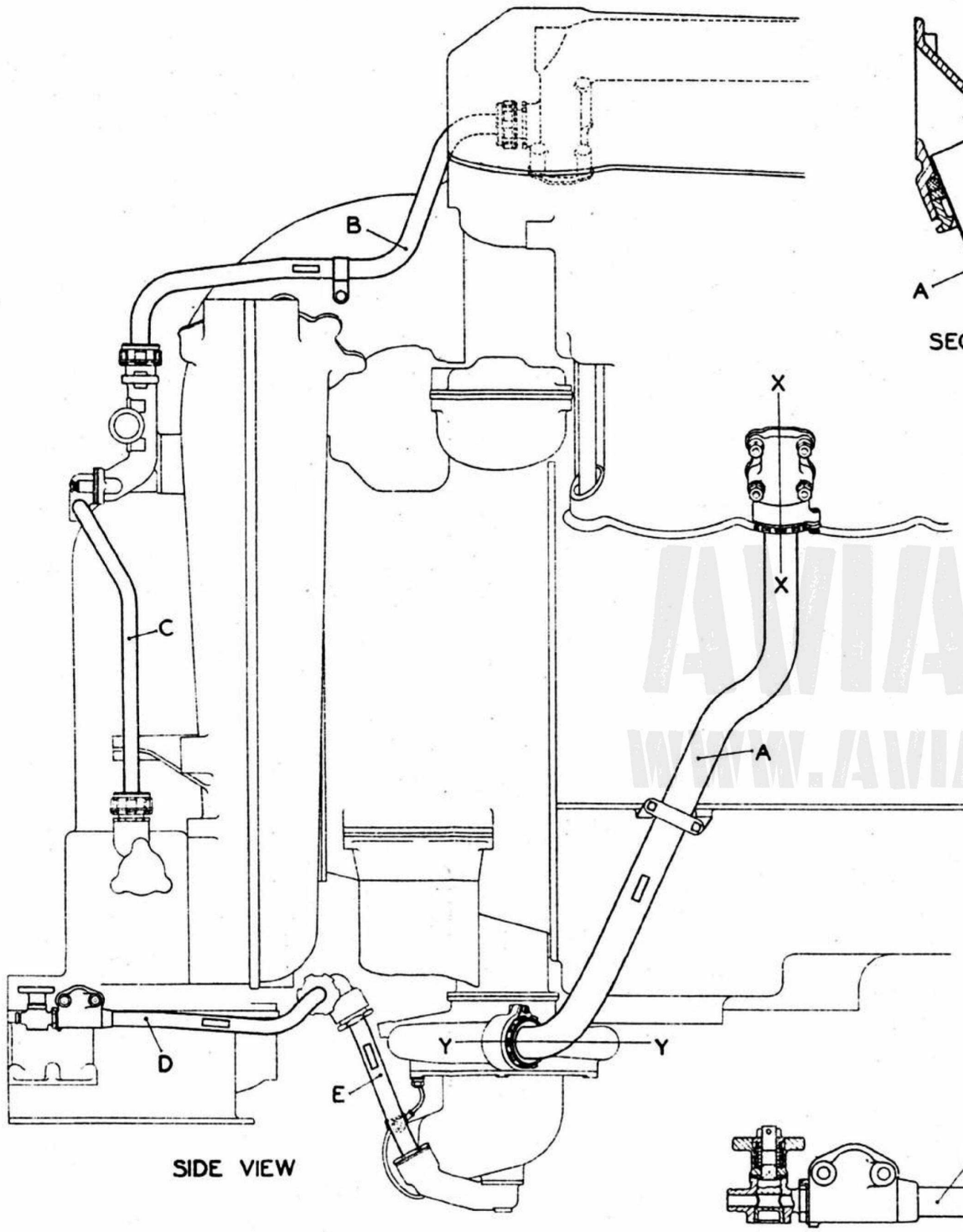

INVERTED PLAN



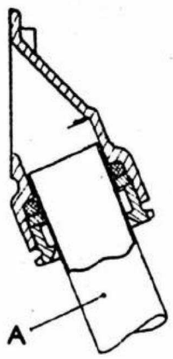

REAR VIEW OF SUMP

FIG.54. ARRANGEMENT OF OIL PIPES

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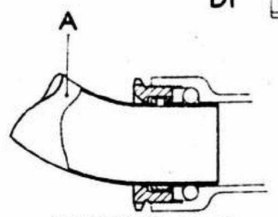

SIDE VIEW




SECTION X-X




SECTION THROUGH DRAIN COCK




SECTION Y-Y




END VIEW

FIG. 55. ARRANGEMENT OF COOLANT CONNECTIONS

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spindle rear bearing bush from a junction union mounted at the front lower side of the supercharger casing (*see* para. 185). A subsidiary pipe connects by means of a banjo union to this pipe and is open to atmosphere. It should be noted that this junction union is hollow and also connects with the inner side of the supercharger front ball bearing through a passage in the casting.

(ii) A small bore pipe (*see* fig. 46) from the change-over valve on the boost control to the atmospheric union on the supercharger casing mentioned in (i) (*see* para. 254).

**COOLANT PIPES**

282. The arrangement of coolant pipes on the engine is illustrated in fig. 55. All the coolant pipes described here, with the exception of (i), are for the purpose of leading hot coolant from the " A " cylinder jacket through the carburettor choke jackets and back to the inlet side of the pump. They are of steel and comprise the following items :—

(i) Two large bore pipes A and $A_1$ conveying coolant from the pump to the cylinder coolant jackets each connect to a cast elbow situated low down on the outside of the block, covering an inlet port adjacent to No. 5 cylinder (*see* paras. 17 and 146). The pipes are bent at right-angles at the lower ends and each has a retaining ring brazed to it which is used in conjunction with the ring nut and rubber sealing gland incorporated in the pump outlet. The upper end of each pipe is plain but a similar ring nut and rubber gland is incorporated in the elbow on the cylinder.

(ii) A medium bore pipe B from the outlet sealing union gland at the rear end of the " A " side coolant outlet manifold to a similar inlet union on the right-hand carburettor control shaft bracket (*see* para. 205).

(iii) A medium bore pipe C, bent to a U-shape and having a face union in its right centre which is attached to the faced lower end of the short passage in the bracket casting mentioned in (ii). The two lower ends of the pipe connect with the inlet unions situated on each side of the carburettor coolant jackets (*see* para. 205).

(iv) Two small bore pipes D and $D_1$ attached at their rear ends to faced unions which are connected to the carburettor jacket outlet ports situated on each side of the top half of the carburettor. Each of these faced unions has a drainage cock incorporated with it. The front ends of these two pipes curve round the front of the carburettor to a central cast T-connection to which they connect by means of ring nuts and rubber glands (*see* para. 205).

(v) A short medium bore pipe E leading from the central outlet union in the T-connection mentioned in (iv) to the inlet elbow secured to the underside of the coolant pump. Coolant diverted from the "A" side cylinder outlet manifold through the pipes described is returned to the inlet side of the pump through pipe E (*see* para. 205).

### FUEL PIPES

283. The only external fuel pipes incorporated with the engine are the short connection between the fuel pump outlet union and the carburettor float chamber inlet union and the combined system of priming and slow-running suction pipes described in paras. 270 and 271.

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## CHAPTER 10

## LUBRICATION SYSTEM

### GENERAL

284. There are five oil circuits (*see* fig. 56) in the lubrication system of the Merlin II engine, as follows :—

(i) The high pressure feed circuit.
(ii) The main pressure feed circuit.
(iii) The low pressure feed circuit.
(iv) The front sump scavenge circuit.
(v) The rear sump scavenge circuit.

In the Merlin III engine (i) above is deleted.

285. The high, main and low pressure feed circuits are served by a pressure pump and suitable relief valves, while each scavenge circuit is served by a scavenge pump. These three pumps are described in detail below as are the relief valves and the oil filters. Following these descriptions are given an explanation of the oil flow through the five circuits and descriptions of the lubrication of individual components of the engine.

### OIL PUMPS

*General*

286. The oil pumps (*see* figs. 57, 58 and 59) are of the gear type and comprise a pair of separate scavenge pumps fitted on the floor of the rear sump of the crankcase, and beneath this floor a pressure pump. The deliveries of the two scavenge pumps are arranged in parallel. The pressure and rear scavenge pumps are driven at approximately three quarters crankshaft speed from a vertical shaft which is geared through an idler gear to a pinion on the lower vertical shaft in the wheelcase, while the front scavenge pump is driven from an individual pinion on the former shaft.

*Scavenge pumps*

287. Each of the two scavenge pumps consists of a pair of gears in its casing, the two casings being integral and held down to the floor of the crankcase rear sump by studs anchored in the crankcase. The driving gear of the rear scavenge pump is integral with the driving shaft, which, by means of splines, also drives the driving gear of the pressure pump. The spindle is borne at its centre in two flanged bronze bushes which are pressed into the crankcase sump, and at its upper end in two flanged bronze bushes which are pressed into a deep boss in the top of the rear scavenge pump casing. Each

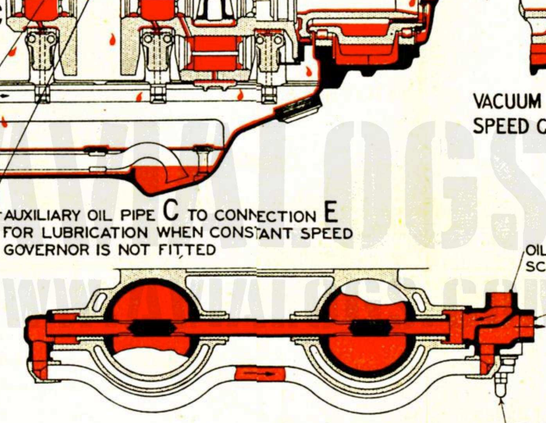
of these pairs of bushes form an annulus in the centre of the particular boss in which they are held; oil is fed to both annuli through small ducts in the crankcase and pump body from the delivery side of the pressure pump for their lubrication. Mounted on a taper and splined to the top of the oil pumps spindle are three integral gearwheels which are retained by a tab-washered locknut. The shaft is hollow except at its top end; the lower end is splined to receive the driving pinion of the pressure pump and the lower extremity is plain for operation in the flanged bronze bush pressed into the pressure pump casing. This bush has an annular groove which is fed with oil from a small hole in the casting connecting with the delivery side of the pressure pump.

288. The composite driving gear on the rear scavenge pump shaft (*see* figs. 57 and 58) is splined at its top end and tapered at its lower end, and is a push-fit on the driving shaft. The idler gears of both pressure and scavenge pumps have plain bushed bores and the gears and bushes are drilled between two teeth with a radial hole for oil. The pressure idler gear has a plain long bronze bush pressed into its bore, while the scavenge pump idler gears each have a short flanged bronze bush pressed into each end, forming an annulus in the middle. The radial oil hole between the two teeth already mentioned aligns with its respective annulus and permits oil to pass to the bearing surfaces. The idler gears of each pump rotate on a hollow nickel-steel spindle one end of which is closed and which is tapered externally to fit a tapered socket reamed in a boss in the roof of the respective pump casings; the spindle when driven home is locked in position with a transverse taper pin which passes diametrically through boss and spindle as shown. Each spindle extends into an individual socket in the crankcase rear sump floor.

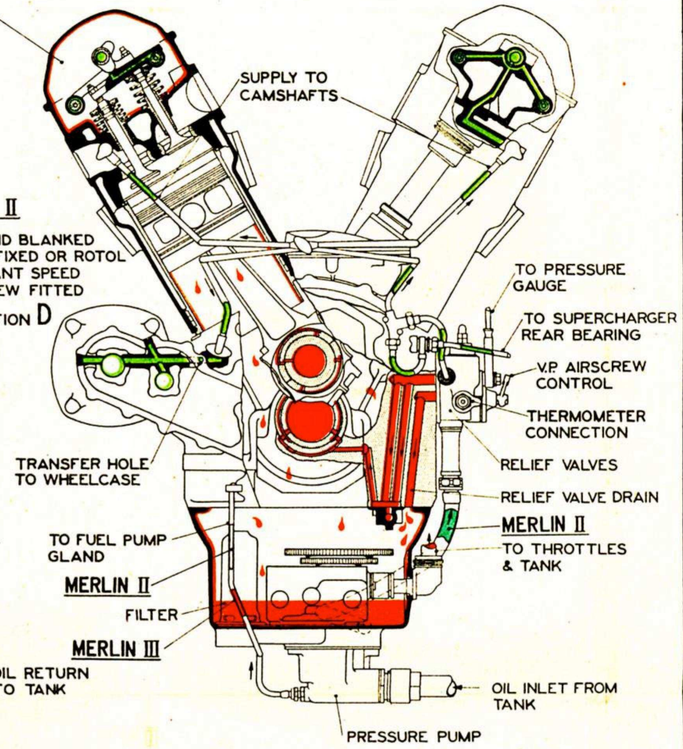
289. The composite pump casing, of cast aluminium alloy, is faced on its underside and each compartment is recessed to house, with fine radial and end clearances, its pair of pump gears. A shallow key recess is milled in the ceiling of each casing on the delivery side above the line where the gear teeth enter into mesh; this recess forms a by-pass for the oil which would otherwise get trapped between the teeth and set up severe fluid resistance to rotation. The casing is bossed and drilled vertically for the studs which hold it to the crankcase. The respective suction passages of each compartment are cored ducts which break into the jointing face of the casing and proceed into the casting to emerge opposite the demeshing line of the respective gears. The outlet passages combine at the top of the casting to form a single outlet which terminates in a faced aperture. A gland union is attached to this face and in it is inserted the short pipe connection through which

HIGH PRESSURE (MERLIN II)
MAIN PRESSURE
LOW PRESSURE
SCAVENGE & SPLASH

OIL DRAIN TO WHEELCASE
ATMOSPHERIC PIPE TO REAR BEARING
OIL JET
VENT TO ATMOSPHERE
TO BOOST CONTROL CHANGE-OVER VALVE
GREASER
TO THROTTLES & TANK
SCAVENGE PUMPS
PRESSURE PUMP
OIL INLET FROM TANK
MERLIN II
MERLIN III
CAMSHAFT OIL DRAINS THROUGH CYLINDER HOLDING BOLT TUBES TO CRANKCASE
CONNECTION D
TO V.P AIRSCREW
THIS END BLANKED WHEN FIXED OR ROTOL CONSTANT SPEED AIRSCREW FITTED
AUXILIARY OIL PIPE C TO CONNECTION E FOR LUBRICATION WHEN CONSTANT SPEED GOVERNOR IS NOT FITTED

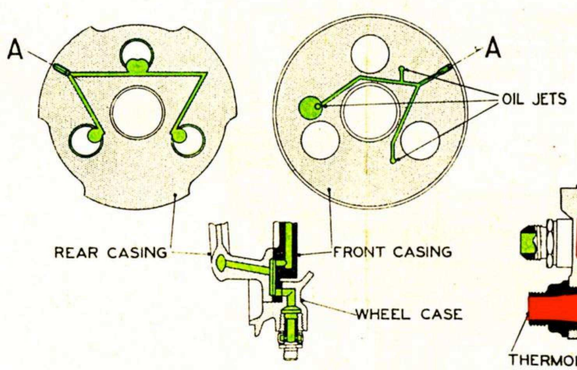


VACUUM PUMP & CONSTANT SPEED GOVERNOR DRIVE UNIT

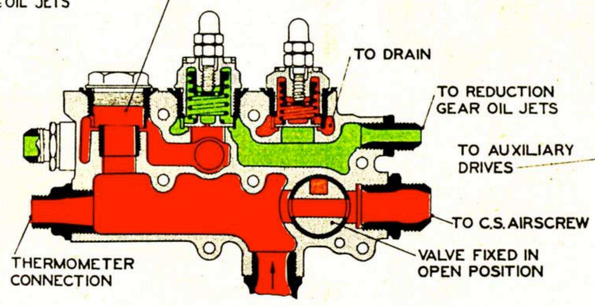




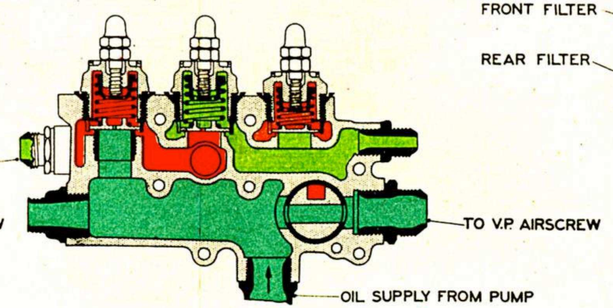

SECTION THROUGH THROTTLES



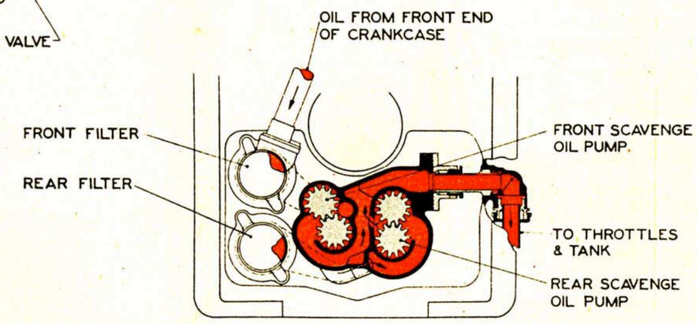
SECTION THROUGH SUPERCHARGER GEAR CASINGS AT A.A.A



RELIEF VALVES UNIT MERLIN III



RELIEF VALVES UNIT MERLIN II



SCAVENGE PUMPS & FILTERS

# FIG. 56, LUBRICATION DIAGRAM

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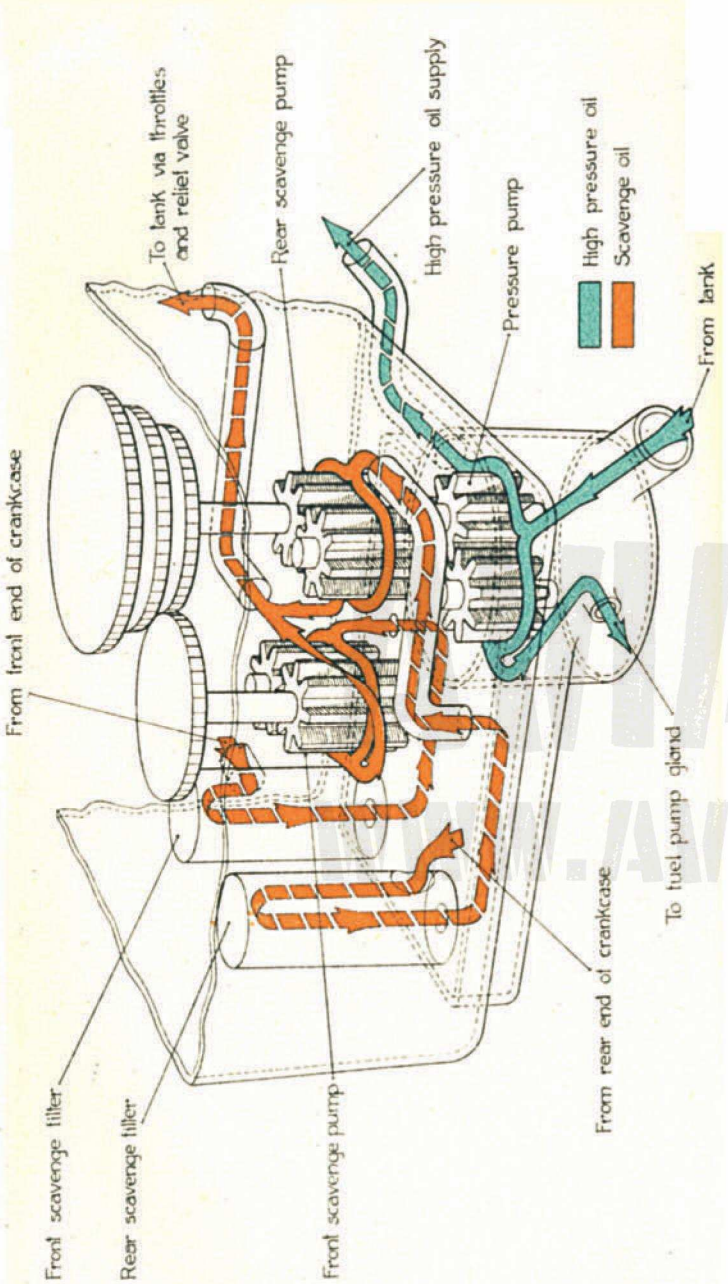



FIG. 57. OIL FLOW THROUGH PUMPS



all the scavenge oil is led to the elbow outlet union mounted on the starboard side of the crankcase sump. The pipe is thus able to float in the gland and so can allow for expansion.

290. The driving gear of the front scavenge pump is integral with its spindle, which is borne at its top and bottom ends in bushes pressed into the pump casing and the crankcase sump respectively. The gearwheel is splined to its top end and retained by a tab-washered locknut. The hub of this gear forms the bearing surface for the top bush, which is grooved for oil. The gearwheel meshes with and is driven by the lowest and smallest unit of the composite gear mounted as described on the main pump spindle.

*Pressure pump*

291. This pump is held up to the underside of the crankcase rear sump by studs. The driving gear of the pump is splined to the lower length of the hollow driving shaft. As already

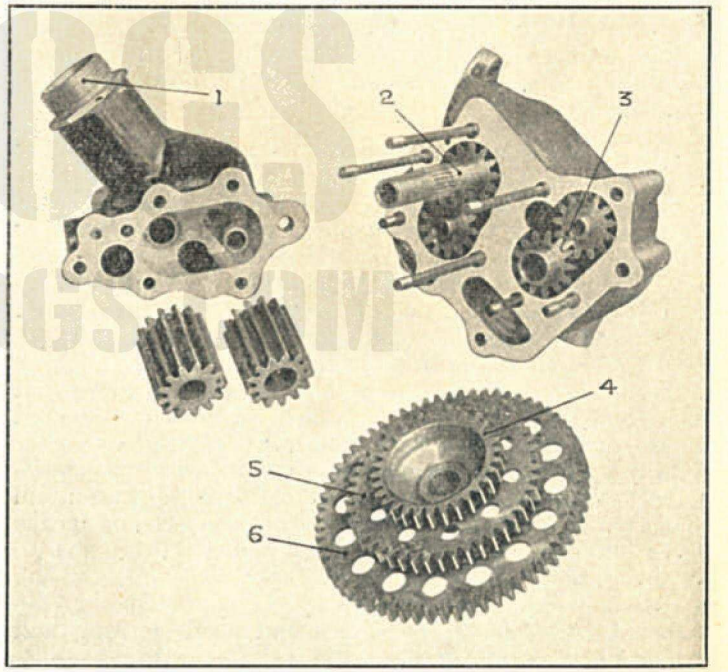



FIG. 58.—Oil pumps.

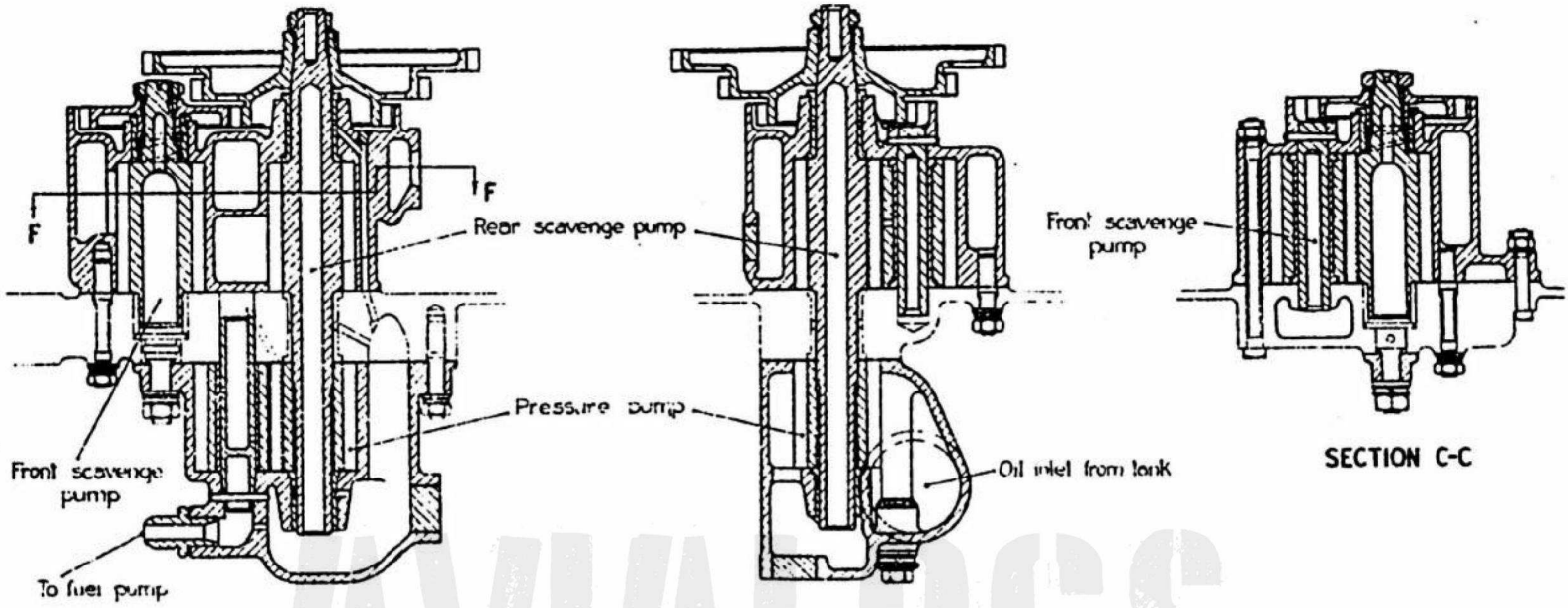
1. Oil inlet union to pressure pump.
2. Rear scavenge pump.
3. Front scavenge pump.
4. Front scavenge pump driving gear.
5. Lockheed pump driving gear.
6. Driven gear (meshes with idler gear).

described, this shaft runs in three sets of flanged bronze bushes, the central one of which is pressed into the underside of the crankcase floor, whilst the lower one is pressed into the pressure pump casing. The exterior of this lower bush has an annular groove on its outside which connects with its bore by a small radial hole ; oil from the delivery passage is led to this groove through a small hole in the casting and so provides for the lubrication of the bush.

292. The pump driving gear spindle is, as has been mentioned, integral with the rear scavenge driving spindle ; it is splined to carry the pressure pump driving gear.

293. The pressure pump driven gear has a plain bronze bush pressed into its bore. The gear rotates on a hollow nickel-steel spindle which is tapered at the lower end, driven into a taper socket in the pump casing, and locked thereto with a taper pin. The spindle at its upper end fits into the socket in the crankcase, which also houses the corresponding spindles of the scavenge pumps situated above. Pressure oil from a duct enters the open top end of the idler spindle and oil is directed to the bearing surfaces through two holes in the spindle.

294. The pressure pump casing is an aluminium alloy casting which is faced on the top side to bed up to the underside of the crankcase and recessed with limited radial and end clearances to take the pair of pump gears. A shallow key slot is milled on the floor of the recess in the direction of the meshing of the gears to allow oil trapped between the engaging teeth to escape. The floor of the recess is further bored and tapered to take the spindle for the idler gear, and also bored for the pressed-in brush which forms the lower bearing of the driving gear. The joint face is drilled through and counterbored for the studs by which the casing is secured to the crankcase. This joint face has a central part open to the delivery side of the pump which aligns with the passage in the base of the crankcase sump and supplies pressure oil to the outlet union on the sump which connects, by means of the external pipe, with the large vertical inlet union on the underside of the relief valves body. The inlet branch to the sump is a cored passage whose mouth faces to the starboard rear side of the engine and bends forward and upward to break into the floor and wall of the gear housing. It is bored and tapped at its outer end for the reception of a large union which is provided with a hexagonal collar near its centre and is threaded at its outer end for the reception of the union nut at the end of the oil pipe from the oil tank. A small boss on the rear of the casting holds a union which provides connection for the external pipe conveying oil to the




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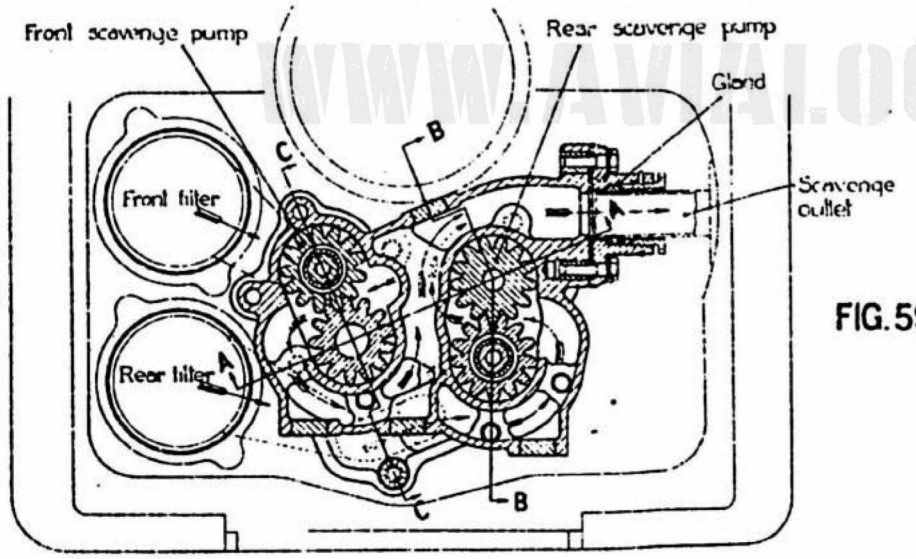



FIG.59. ARRANGEMENT OF OIL PUMPS

fuel pump (*see* para. 152); oil from the delivery passage of the pressure pump is led through a small hole in the casting to supply the inner side of this union.

### SCAVENGE PUMP FILTERS

295. The scavenge oil filters (*see* figs. 60 and 61) consist of bell-shaped cast aluminium alloy casings, which enshroud the filter gauzes as shown. The forward casing has its inlet port in a boss on the side which has two studs for attachment of the suction pipe; the rear casing has rectangular inlet ports cut through its wall near the base. Each casing has a spigot which fits a counterbored socket cut in the filter openings in the crankcase as shown. The casings are held in position by the cheesehead screws and also each by an axial stud by which the caps spigoted into the underside of the crankcase are held in place. These studs have squared collars where they fit into squared sockets at the apexes of the casings and are locked thereto with the nuts and washers shown. Each stud has a circular ring sprung into a groove to retain above it a sliding flanged collar and a helical spring which is lightly compressed against the underside of the stud collar at the top of the casing. The outer diameter of this ring is considerably smaller than that of the hole in its adjacent brass pressing and therefore does not obstruct the passage of the filter element. The lower end of the stud has a square neck to fit a square socket in the cap, and is threaded to suit the special mild steel nut which is closed at its outer end with a peened-in disc. This nut, with an intervening aluminium washer, secures the cap and its copper-asbestos packing washer upwards to the crankcase. The cap is of cast aluminium and has a spigoted flange to fit the crankcase, and diametrical ribs arranged crosswise, the edges of which spigot into the lower end cap of the filter frame. The edges of the ribs have semi-circular portions cut away to prevent the formation of oil pockets. A boss is tapped parallel and adjacent to the axis and this is fitted with a tap-bolt and lock plate which secure the nut holding the cap.

296. The filter element is built up between two three-step brass pressings, the top one differing from the bottom one by having an internal flange which fits against the underside of the collar mentioned above. To the inner steps of these pressings is riveted a brass cylinder whose walls are corrugated longitudinally and drilled with radial holes through the inner ridges of the corrugations. The second steps form spigots for copper gauze which is wrapped around, finished with a sweated lap joint, and finally soldered to the steps. The top outer step fits closely to the wall of the casing, whilst

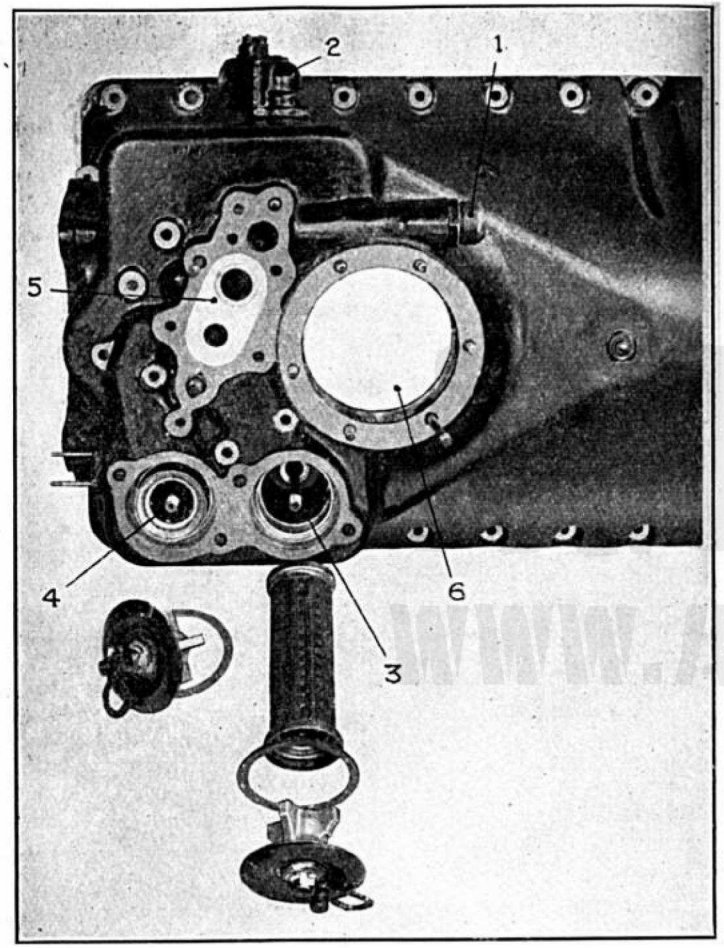



FIG. 60.—Oil filters.

1. Pressure oil outlet union.
2. Scavenge oil outlet union.
3. Front filter.
4. Rear filter.
5. Pressure pump mounting face.
6. Lockheed pump drive mounting.



the lower outer step which is larger, fits the counterbore at the lower end of the casing and over the spigot formed by the webs of the cap. When assembled in the casing the filter element is pressed upwards against the spring at the top of the casing and is thus steadied. The flow of the oil from the inlet ports is inwards through the gauze and corrugated cylinder, downwards, and out through the cored holes in the crankcase which lead to the separate scavenge pump inlet ports.

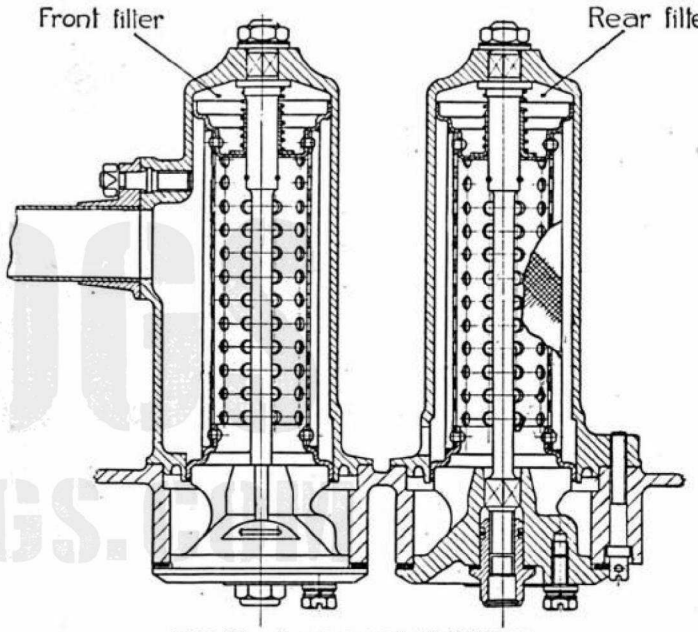



FIG. 61.—Arrangement of oil filters.

**RELIEF VALVES UNIT**

297. The unit housing the three relief valves (*see* figs. 62 and 63) is a single light alloy casting provided with internal passages and compartments and external unions and connecting ports for the segregation and operation of the four oil systems, i.e., high, main and low pressure feeds and scavenge, which pass through it. The unit has a broad machined face on its inner side by means of which it is mounted on the complementary face on the right-hand side of the crankcase by means of six studs and spring-washered nuts. This face is also used to connect various ports to corresponding ports in the crankcase face; the joint is made by means of a paper washer.

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298. The bottom rear portion of the body comprises the high pressure compartment into which oil passes at high pressure from the main oil pump on the rear underside of the crankcase sump, by means of an external pipe to a long union screwed into a boss on the underside of the body. At the rear end of this compartment is a second union for the reception of an oil thermometer. An opening in the front end of the compartment passes the high pressure oil directly to the two-position airscrew pitch control valve; when the valve is opened to obtain fine pitch position, the oil passes through the valve to a union screwed into the front end of the body which connects by means of an external pipe to the oil union on the top of the reduction gear case for two-position airscrew

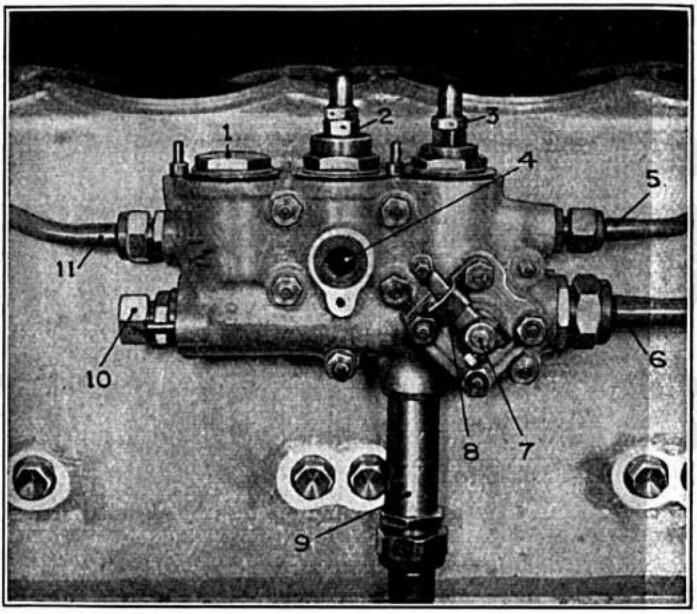
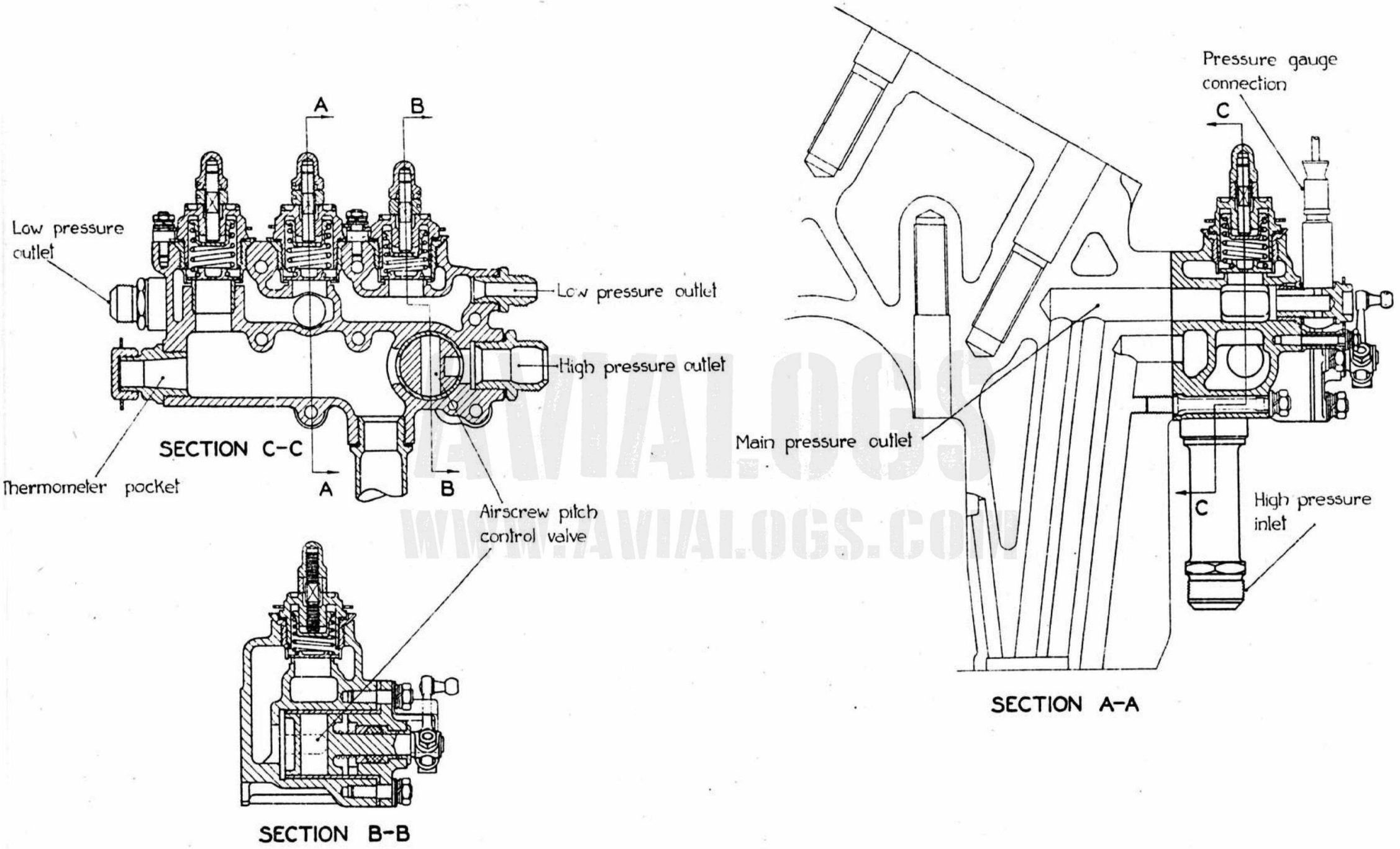



FIG. 62.—Oil relief valves unit (Merlin III and modified Merlin II engines).

1. High pressure valve (blanked off for Merlin III and modified Merlin II engines).
2. Main pressure valve.
3. Low pressure valve.
4. Pressure (main) gauge connection.
5. Low pressure pipe to reduction gears.
6. Oil supply pipe for airscrew control.
7. Two-position change-over valve. (Strapped in open position as shown when constant speed airscrew is used).
8. Strap (*see* 7).
9. Pressure oil inlet union.
10. Oil thermometer union.
11. Low pressure pipe to wheelcase and supercharger.




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FIG. 63. ARRANGEMENT OF OIL RELIEF VALVES UNIT (MERLIN II)

operation, or to the governor control unit mounted on the front of the reduction gear cover for constant speed airscrew operation. An outlet situated at the top rear end of the high pressure compartment conducts the high pressure oil to the rear or high pressure relief valve seating, which in this instance is a sleeve screwed into the light alloy body. After passing through this valve the oil enters, at a reduced pressure of 60 lb., a small compartment above the valve which accommodates the valve spring and retaining cap and which connects by means of a short internal passage with the inlet side of the middle or main pressure valve. A large port drilled through from the mounting face connects with this internal chamber and also aligns with a complementary port in the crankcase face; the port in the crankcase connects with two vertical passages drilled in the central crankcase webs where they meet the central inlet port of the main gallery (*see* para. 75). A union for the attachment of the oil gauge pipe is screwed into a boss on the outer side of the central relief valve body and connects with the main pressure internal compartment. Passing through this valve, which seats in this instance directly upon the light alloy of the body, the oil enters the compartment above this valve at a reduced pressure of 6 lb. per sq. in., and connects by means of a second short internal passage with the inlet side of the front or low pressure valve. This third valve lifts at pressures in excess of 6 lb. per sq. in., and excess oil passed by the valve to the compartment above it is returned to the crankcase through a short internal passage in the body which terminates in a port in the mounting face; this port aligns with a port in the crankcase into which it opens directly. A smaller union screwed into the front end of the body immediately above the larger high pressure union connects with the low pressure internal passage and delivers low pressure oil through an external pipe directly to the reduction gear oil jets incorporated in the right side of the gear casing. The low pressure passage is continued to the rear end of the body; a second small union situated immediately above the thermometer union provides attachment for an external pipe which conveys low pressure oil to the wheelcase and supercharger gears and the valve rocker operating mechanism.

299. The three relief valves are similar in design with the exception that the low pressure spring is of different strength to the main and high pressure springs which are of the same value.

300. Each valve is of the disc type and is forced down on to its seating by the valve spring anchored to it in a groove formed in the valve itself. The high and main pressure valves each have a small leak hole drilled in the centre to

ensure an auxiliary feed under conditions which cause the oil pressure to fall below the blow-off setting. The top end of the spring is imprisoned by a flanged thimble which slides upon a central projection formed inside the hexagon spring cap. Incorporated in the head of the cap is an adjusting screw, secured by two locknuts which after setting are secured by wired seals ; the lower end of the screw bears upon the thimble and so by screwing in the screw, the flange on the thimble compresses the spring and increases the resistance of the valve to lift from its seating. The spring cap screws into an adaptor having a projection on its inner end which acts as a guide for the disc valve; each cap is secured by means of a serrated lock plate which is itself anchored to a stud by means of a split-pinned nut. The adaptor screws into the body and seats by means of a bevelled lip on its upper end. A washer preserves an oil tight joint between the faces of the cap and adaptor.

301. The two-position airscrew operating control cock located in the front lower end of the body works in an open ended ported sleeve pressed into the casting and secured by an outer flange which abuts against the face on the body. The sleeve has two ports diametrically opposite to each other. The valve is of the barrel type with an integral spindle, to the extremity of which is clamped the actuating arm by means of which the valve is rotated through a total arc of 90° ; the outer end of the arm is formed with an eye for the attachment of the adjustable control rod. The spindle is borne in a double bushed hole in the centre of the valve cover which spigots into the valve sleeve and is retained by means of the same studs and spring-washered nuts as are used for the sleeve flange itself. Incorporated within the extended spigot of the cover is a bevelled packing gland which is pressed against the bevelled edge of the inner spindle bush by a similar bevelled washer which floats upon the spindle and is pressed against the gland by means of a spring imprisoned between it and the shoulder of the valve. The valve has one large port drilled straight through it and when it aligns with the two diametrically opposite ports in the sleeve, permits high pressure oil to pass to the airscrew actuating mechanism in the airscrew shaft. When this passage is rotated at right angles to the ports in the sleeve, the flow of high pressure oil is terminated and a longitudinal slot cut in the valve aligns with the outlet port in the sleeve and permits the oil in the airscrew shaft to return through the external pipe. The inner end of this slot connects with a continuation of the low pressure internal passage in the unit, and so finds its way into the crankcase through the return hole in the body and crankcase already mentioned. Oil leaking to the outer side of the valve



is intercepted by a small hole in the body which connects with a hole drilled in the casting which breaks through the front portion of the mounting face. This hole aligns with a corresponding hole in the crankcase and so provides a return for the leakage oil.

302. The foregoing description applies to Merlin II engines equipped for operation with a two-position variable pitch airscrew. In the case of engines equipped for operation with a constant speed airscrew, the high pressure relief valve is omitted and the valve aperture blanked off as shown in fig. 62. The oil from the pressure pump therefore enters the main oil pressure compartment unopposed and lifts the main pressure relief valve which is set to operate at 60 lb. per sq. in. The pressure in the high pressure compartment is therefore the same as in the main pressure compartment and, since the two-position change-over cock in the relief valves body is fixed permanently in the open position, by means of a steel strap (*see* fig. 62) when constant speed airscrews are used, oil at main pressure (i.e. 60 lb. per sq. in.) is delivered to the governor unit. The governor unit then varies the airscrew-operating oil pressure as delivered to the hollow airscrew shaft in accordance with working conditions.

## PRESSURE AND SCAVENGE FEED CIRCUITS

*High pressure*

303. This circuit is served directly by the pressure pump, which receives oil from a filter included in the pipeline between the aeroplane storage tank and the pump, being connected to the pump outlet union by an external pipe which conveys the total delivery volume of the pump to the high pressure compartment in the relief valves body. A small quantity of pressure oil is taken to the fuel pump for lubrication through the small union and pipe mentioned in para. 152. In Merlin II engines the delivery pressure of the pump is 150 lb. per sq. in. ; this pressure is only used for the operation of the two-position variable pitch airscrew. Engines equipped to use constant speed airscrews, use an average pressure of 60 lb. per sq. in. for this purpose (*see* para. 302). Delivery of this pressure to the inlet union on the reduction gear casing for the control of a two-position airscrew, such as is standard in Merlin II engines, is controlled by means of the cock incorporated with the relief valves body, while in Merlin III and modified Merlin II engines which are equipped to use constant speed airscrews, the control cock is kept permanently open by means of a steel strap (*see* fig. 62), and the supply pipe from it is taken to the governor control unit on the reduction gear cover, and then from this unit to the inlet union on the reduction gear casing

through a separate pipe(*see* figs. 54 and 56). The high pressure compartment in the relief valves body has a location for an oil thermometer.

*Main pressure*

304. This circuit is indirectly served by the pressure pump after its primary pressure has been reduced to 60 lb. per sq. in. This is accomplished, in the case of Merlin II engines equipped for two-position variable pitch airscrews, by means of the high pressure relief valve communicating with the high pressure compartment, working in conjunction with the main pressure relief valve in the relief valves body. In the case of Merlin III and modified Merlin II engines equipped for use with constant speed airscrews, the high pressure relief valve is omitted and the high and main pressure compartments are common and the main pressure is regulated solely by means of the main pressure relief valve. The main pressure oil is then delivered through a passage in the body *via* aligning holes in body and crankcase to the main bearings *via* the internal oil gallery attached to the port side of the crankcase and the individual ducts in crankcase webs and bearing caps. Oil from the journal bearings passes to the bore of each journal through three transfer holes in each journal, and thence to the crankpins through diagonal ducts drilled in certain crankwebs, that is, the two middle and the two end webs are not so drilled. Oil from each crankpin bore issued through four radial holes in the crankpin to lubricate the bearing surfaces of the big-end bearing surfaces.

*Low pressure*

305. This circuit is supplied with oil from the main pressure passage after it has passed through the central relief valve and has been reduced in pressure to 6 lb. per sq. in. by the front or low pressure relief valve. Two external pipes located on the front and rear ends of the relief valves body lead the oil to (*a*) the reduction gear oil jets and (*b*) the camshaft drives, the supercharger casing, the generator drive casing and the rear bearing bush of the supercharger spindle respectively.

*Front sump scavenge circuit*

306. This circuit is served by the port scavenge pump. Oil draining from the reduction gear, camshaft and rocker mechanism and crankshaft into the forward sump is led to the front filter by the pipe in the bottom of the crankcase. After passing through the filter element the oil flows into a duct cored in the bottom of the crankcase which leads to the suction side of the port pump. On emerging from this pump oil flows into the central passage in the scavenge pumps body



and so joins the common outlet passage which delivers the scavenge oil through the gland and outlet elbow on the crankcase sump and so back to the tank.

*Rear sump scavenge circuit*

307. This circuit is served by the starboard scavenge pump. Oil draining from the wheelcase and supercharger components, the crankshaft and the camshaft and rocker mechanism falls into the rear sump, and from there enters the slots in the bottom of the rear filter through whose element it passes before entering a passage cored in the bottom of the sump leading into the suction side of the starboard scavenge pump. The delivery outlet from this pump registers with the common outlet duct cored across the top of the pump casing, mentioned in the previous paragraph.

## LUBRICATION DETAILS

*Lubrication of the crankshaft, connecting rods and gudgeon pins*

308. Oil from the duct in each crankcase web flows through a passage (*see* fig. 56) drilled through the cap to the space between the cap and the bearing shell. Two transfer holes in the shell lead to distributing grooves formed in the working surface of each bearing shell except the rearmost one which is not grooved. Oil from the respective journal bearings passes to the bore of Nos. 2, 3, 5 and 6 crankshaft journals through three transfer holes. Each of these journals feeds the various crankpins through ducts in the intermediate crankwebs. Oil leaves each crankpin through a transfer hole, lubricates the inner surface of the bearing block attached to the forked connecting rod and, after passing through four transfer holes in the block, lubricates the big end of the plain connecting rod. The small ends of the rods and the gudgeon pins are lubricated by splash oil.

*Lubrication of the reduction gear unit*

309. Oil is supplied to the reduction gear through an external pipe. The pipe is taken from the low pressure side of the relief valves body to a union on the "A" side of the gear case rear portion. The union serves a horizontal duct through the joint faces of both portions of the casing and the duct supplies two jets which pass at right-angles through it in a horizontal plane level with the line of mesh of the gearwheels. This construction is shown in fig. 56. Both bearings of the driving pinion and the rear bearing of the airscrew shaft are lubricated by gear case splash oil. The airscrew thrust bearing housing components are lubricated by oil which collects in a trough above the housing and is drained into the housing through the large hole in its wall and radial grooves in the washer behind the roller bearing outer race and also

around the front portion of the thrust bearing outer race. The coupling gear teeth of the driving pinion are lubricated by oil collecting in a trough above the housing for the driving pinion front bearing. This oil is drained to the bore of the pinion through a duct in the reduction gear cover. A similar arrangement is used when the airscrew governor control unit is fitted, but in this case the oil is led first to the front ball bearing supporting the drive spindle and then, through a long central tube, to the bore of the driving pinion. Surplus oil is drained from the casing to the crankcase through two holes beneath the housing for the driving pinion rear bearing.

*Lubrication of the cylinders, camshaft and rocker mechanism, compressors and engine-speed indicator drives*

310. The cylinder barrels are lubricated by splash crankcase oil. The camshaft and rocker mechanism is lubricated by oil from the low pressure system which enters the cylinder block by a hollow tap-bolt screwed into the back of the block. It passes from here by a suitably drilled duct to a port in the seating for the rearmost camshaft bracket. Ducts in this bracket distribute the oil to the rear camshaft bearing and to the rear ends of the hollow rocker spindles. Oil delivered to the rear camshaft bearing lubricates that bearing and passes through a transfer hole to the bore of the camshaft. From the bore of the camshaft the oil passes to the remaining bearings through two transfer holes at each journal. The bushes of the gearwheels on the rear extremities of the rocker spindles, from which are driven the R.A.E. and B.T.H. compressors, are lubricated through radial holes in the spindles which permit oil from the spindle bores to reach the bearing surfaces.

311. Oil passes from the rocker spindles through a transfer hole opposite the mid-point of each of the rocker bushes. Oil thus supplied to the rocker bushes passes *via* grooves in the bushes and rings of transfer holes to a groove around the housing for each bush. From this groove the oil is conveyed by the duct in the rocker arm to a hole drilled in the working face of the pad in contact with the cam.

312. Oil escaping from the camshaft and rocker mechanism collects in troughs beneath the exhaust side cylinder block bridge pieces. It flows from there down to the crankcase through transfer holes in the bases of the sockets for the rubber sleeves at the lower end of the guard tubes. Oil also drains from the rear of each cylinder block to the housings for the upper camshaft driving spindles *via* one transfer hole at the back of each block. Some of this oil lubricates the bushes for the spindles through transfer holes drilled through the bush and its housing, whilst the rest of it passes into the wheelcase *via* the vertical transfer holes in the housing web,



down the bores of the drive shaft guard tubes and through the transfer holes in the housing for the lower camshaft drive spindle.

*Lubrication of the wheelcase assembly*

313. All components of the wheelcase, with the exception of the fuel and coolant pumps and the generator drive, are lubricated by splash oil from the crankcase and the camshaft rocker mechanism. The bearings for the upper and lower vertical drive shaft and the magneto drive shaft are open to the casing and are splash lubricated. The bush which supports the rear end of the outer shaft of the spring drive unit is lubricated by oil which finds its way into the front end of the outer shaft from the crankshaft rear journal *via* transfer holes and grooves in the spring drive inner shaft, and emerges from the shaft by two rows of transfer holes drilled near the centre and the rear end of the shaft. The components of the hand and electric turning gear are splash lubricated. The bearings supporting the upper ends of the lower camshaft driving spindles are lubricated by oil draining down the drive shaft guard tubes. The ball bearings at the lower ends of the spindles are splash lubricated. As previously stated, the upper bush of the rotor spindle of the coolant pump is lubricated by grease. The lower bush is coolant lubricated. The bush for the idler gear is lubricated by splash oil passing down the bore of its spindle and out through a row of transfer holes at the middle of the spindle.

314. The bush for the fuel pump driving pinion spindle is lubricated by oil from the high pressure system which enters the pump through the union screwed into the pump casing. This oil passes from the union to the bore of the bush and lubricates the various components of the fuel pump as described in paras. 152 and 153.

315. The generator drive components are lubricated by oil from the low pressure system which enters the generator drive casing through a banjo connection in the back of the casing. This oil passes consecutively through a hole in the casing and thence to a long duct drilled in the crankcase half of the generator drive extension casing which connects with the bushes supporting the idler and driving spindles. Cross ducts transfer the oil to the rear bushes in the wheelcase half of the drive extension casing. The bush supporting the rear end of the intermediate lay spindle is lubricated through the shaft itself from the same source.

*Lubrication of the supercharger assembly*

316. The three supercharger slipper clutch assemblies are each lubricated by a sprayer nozzle screwed into the front of the supercharger gear casing cover and connected, by

means of long ducts drilled in ribs cast with the cover and through aligning holes and mating faces of the supercharger gear casing and wheelcase flanges, to the low pressure supply union in the right-hand side of the wheelcase.

317. The double floating bush supporting the rear of the impellor spindle is supplied with low pressure oil through a separate pipe, while the ball bearing supporting the front end of the spindle is lubricated by oil spray thrown off by the three slipper clutch gears in the supercharger gear casing. Both bush and bearing have their inner sides connected to atmospheric pressure by means of an external pipe and a duct integral with the front wall of the supercharger induction casing respectively. This arrangement prevents the lubricant being sucked from the bearing surfaces of the two units by the depression existing at the intake side of the impellor, to which the inner sides of both bush and bearing would otherwise be exposed.



# CHAPTER 11

## HANDLING, STARTING AND RUNNING NOTES

### UNCRATING THE ENGINE

318. The engine will be received in a substantial wooden case, provided with four slinging eyes. The sling used for lifting should have four equal lengths of cables, each not less than about 3 ft. 6 in. long. Four large hexagon-headed setscrews will be found at the lower edges of the base, two on either side. When these are removed the case may be lifted off, leaving the engine bolted to a wooden cradle forming the bottom of the case. The removal of the case should be done carefully to avoid fouling the engine as the case is being removed.

319. Three points are arranged on the engine for attaching a sling, namely: a projection on each rear foot and an eye on the rear half reduction gear casing. A sling should be used as illustrated in fig. 64, having three cables each attached to a top ring, two of the slings having eyes for the rear connections and one a hook for the front eye. The lengths of the cables are shown in the illustration. Where the cables pass up against the cylinders, they should be sheathed with padded leather. The engine feet rest on four steel plates, the edges of

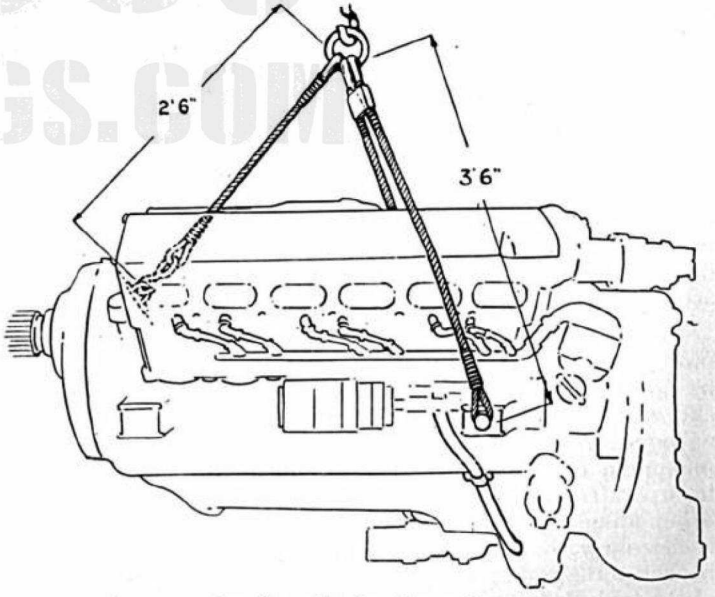



FIG. 64.—Slinging the engine.

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the two rear ones almost abutting against the coolant pipes from the pump to the cylinders. Care should be taken that the engine is not allowed to swing and foul these plates or damage may occur.

320. Inspect the engine carefully for damage in transit or uncrating, particularly the pipes and projecting parts, and confirm that parts to the appropriate checking list are present.

## ENGINE MOUNTING

321. The engine feet are flat and whatever type of bearer is used, the packings which are supplied with the engine must be inserted between the feet and the bearer, the Ferodo packings being used under the front feet, and the rubber packings both under and above the rear feet. The aluminium plates are for use on top of the rubber packings above the rear feet.

322. The engine feet and platforms must be cleaned before lowering the engine into position. The bolts through the front feet may be screwed up tightly, but a little judgment is necessary when screwing up the rear bolts, owing to the presence of the rubber packings. The bolts should be tightened until the rubber is compressed slightly. Expansion of the engine is thus permitted, suitable clearance holes being provided for the rear bolts.

## FUEL, OIL AND COOLING SYSTEMS

*Fuel system*

323. The carburettor float feed mechanism is adjusted to operate between pressures of 2 ft. and 8 ft. 6 in. head of fuel from either gravity or fuel pump feed. The dual fuel pump mounted on the left-hand side of the wheelcase ensures a positive supply. The tanks may thus be placed either above or below the pump, but when in the latter position the pump should have suitable priming means. As no filters are incorporated with the carburettors, one should be fitted in the pipe line between pump (or gravity feed) and tank at a point accessible for cleaning.

324. Connections for fitting $\frac{3}{4}$ in. bore flexible piping are provided on the pumps and carburettor and the system should be flow-tested to pass at least 20 per cent. + 10 gallons in excess of the maximum demand of the engine, i.e., 118 gallons an hour. As the capacity of each pump is greater than the maximum demand of the engine, a suitable relief valve is incorporated and a pressure gauge connection should be fitted. When an additional gravity tank is fitted, a non-return valve is necessary to prevent the possibility of the pump feeding back into the gravity tank when the cock is open. The venting of the tanks is important.



*Oil system*

325. Normally, the engine pressure pump draws oil from a tank through a separate filter which should be accessible for cleaning. After circulating through the engine it is returned by the two scavenge pumps through a cooler and thence back to the main tank.

326. Piping of $1\frac{1}{4}$ in. outside dia. is used for the main supply from the cooler and tank to pump, $\frac{3}{4}$ in. dia. for the scavenge return line, and $\frac{5}{8}$ in. dia. between the engine breather and oil tank. It is essential that the oil piping be free from both oil and air leaks and that suitable flexibility be arranged where necessary to prevent fracture from vibration or other causes. A thermometer connection is fitted on the triple relief valve on the engine and the main pressure gauge connection is also incorporated.

327. The oil cooler should be of such a capacity that an engine inlet temperature of 90° C. is not exceeded. Should a cock be fitted in the system, its operation should be so interconnected with either the fuel cocks or magneto switches that there is no possibility of running the engine with the oil supply shut off or restricted.

*Cooling system*

328. A centrifugal pump driven from the base of the wheelcase, delivers the coolant (ethylene glycol, Specification D.T.D. 344) from two outlets, one being connected to each cylinder block and thence to the heads from which it passes through two main outlet pipes which discharge into a header tank. The coolant then circulates to a radiator, is cooled and returned to a single inlet connection on the pump.

329. The coolant outlet connections on the engine are each for 2 in. outside dia. pipes and particular attention should be paid to joints to prevent failure under the combined influence of ethylene glycol and high temperatures. A thermometer connection should be arranged in the engine outlet line.

330. Four air release plugs are fitted in the engine main outlet pipes, two front and two rear, and a drain cock on the circulating pump base. The outlets from the engine are for 2 in. dia. pipes and can be arranged to deliver either forward or rearwards. The coolant capacity of the engine is $4\frac{1}{4}$ gallons.

Before the engine is started, it should be ascertained that the cooling system is correctly filled with the specified coolant and in accordance with the instructions contained in the relevant aeroplane Air Publication.

## ADJUSTMENTS

*Adjusting boost pressure (fixed datum type)*

331. Should the boost pressure setting need to be adjusted for any reason, the following procedure must be adopted. Remove the boost control aneroid cover after lifting off the clamping ring. Mark, with indelible pencil, a reference line on the aneroid body serrated locking ring and boost control casing (*see* fig. 45). Lift off the serrated locking ring. The aneroid unit can then be screwed up or down, a downward movement (clockwise) increasing and an upward movement (anti-clockwise) decreasing the maximum level flight boost pressure.

332. With the engine stationary, adjust the aneroid unit, up or down as necessary, remembering that a quarter of a turn alters the setting approximately half a pound per sq. in. Replace the locking ring cover and clamping ring, and secure by nuts and locking wire.

333. Run the engine up and observe the boost gauge reading; repeat the above adjustment if necessary until the specified boost (i.e. + 6¼ lb. per sq. in.) is obtained with the pilot's cockpit lever fully open and the throttle lever at the full throttle stop (*see* fig. 47). At this position the relay piston is approximately at the rear end of its stroke; this will be indicated when the relay piston lever linked to the engine control shaft points rearwards and is nearly horizontal. The closing movement of the pilot's throttle from this position first merely moves the relay piston through its stroke to its forward stop without altering the boost pressure, after which the carburettor throttle closes in conformity with the pilot's control.

334. Should complete removal of the aneroid unit from the casing be necessary the number of complete turns required to do this should be noted in order to enable the original setting to be restored on reassembly, and thus avoid unnecessary ground running of the engine. Before altering the setting, confirm that controls, relay piston and aneroid unit valve are all free.

*Boost gauge leakage*

334A. Any leak in the boost gauge case, such as may occur if the glass bezel becomes slack, will cause low boost pressure readings on the plus or minus side of zero, in spite of the fact that the gauge may indicate correctly when the engine is not running. It is imperative, therefore, that no actual adjustments be made to the boost pressure until the boost gauge itself has been checked and found to be correct.



*Resetting the variable datum cam*

335. To reset the variable datum cam after the boost pressure has been adjusted by the screw (21) in. fig. 46, the throttle operating lever should be set to the fully closed position. The length of the linkrod connecting the cam lever with the lever on the control shaft should then be adjusted so that the clearance between the face of the cam and the cam pad on the boost control unit is 0·087 in., as shown in fig. 46. Similarly, at full throttle or take-off position, the clearance between the lower end of the cam pad sleeve and the top of the casing should not be less than 0·03 in.

*Controls*

336. Normally, there are two engine controls for operation by the pilot, namely, the main throttle and a two-position mixture control. The action of the latter is explained in para. 226, *et seq.* Under exceptional conditions the third control, referred to in para. 261, which cuts out the boost control, may be used, but this control is usually sealed to obviate operation except in emergencies.

337. When the two-position variable-pitch airscrew is used, a fourth control, operating a barrel-type valve in the triple-oil-relief-valve unit, is used to direct the pressure oil to or from the airscrew piston. The valve is connected by a rod to a bracket on the rear of the engine, and from there to the pilot's operating lever. In the case of a constant speed airscrew, the two-position control in the cockpit is substituted for the governor cockpit control (*see* para. 360), and the two-position valve itself is locked in the open position.

338. The pilot's throttle quadrant must allow the full range of control determined by the control stops on the engine. One of these is for the slow-running position of the carburettor, and the other limits the opening movement of the manual control on the control shaft. This latter stop is adjusted to allow maximum boost of + 6¼ lb. per sq. in. (which is the maximum level flight, climbing, and take-off boost pressure) and is set with the relay piston approximately at the rear end of its stroke. Care must also be taken to ensure that the mixture-lever interconnecting device on the pilot's throttle control (*see* fig. 47) does not interfere with the application of weak mixture when the aeroplane is cruising at minimum speeds between 2,000 and 3,000 ft.

*Priming arrangement*

339. A hand-priming pump and piping system is fitted, a cock and filter being included. The pump should be capable of giving a good pressure, as the priming nozzles are small and consequently are easily choked by extraneous matter.

*Exhaust system*

340. The exhaust system will depend on the type of aeroplane and may comprise either separate stub pipes or special manifolds (*see* para. 46).

*Electric starting system*

341. The starter motor will require to be connected to a suitable 12-volt supply; the system incorporates switching mechanism, which is usually of the relay type.

*Oil priming the engine*

341A. The following procedure should be carefully observed immediately before starting a new or overhauled engine, or one that has been out of use for more than seven days.

(i) Unscrew the pressure gauge connection (*see* fig. 62) on the side of the relief valves body.

(ii) Couple a hand-pump (Stores Ref. 4C/384) to the union and pump in two gallons of warm (50° C. to 70° C.) engine oil (Specification D.T.D.109) while the crankshaft is turned slowly by the hand turning gear for at least three complete revolutions. If the high pressure relief valve (*see* para. 298) is fitted, the pressure to be overcome will be about twice that if this valve is omitted.

(iii) After priming, the pump connection must be removed and the pressure gauge connection replaced.

## STARTING, RUNNING, STOPPING AND MAINTENANCE

*Before starting*

342. When installing a new engine, first suitably remove from the combustion space any excess fluid which it may contain as received from stores; normally only 10 c.c. of corrosion inhibitor is sprayed into each combustion chamber before despatch. Inspect the engine suspension, and all pipes for leaks; clean the oil filters and use fresh oil when refilling. Verify that the airscrew fixing is correct and locked.

343. The hand-starter gear shaft which protrudes horizontally from the right-hand side of the wheelcase just beneath the magneto, is fitted with a freewheel device which only permits rotation in a clockwise direction.

343A. The following instructions concerning the starting of the engine should be observed unless precise experience is available to show that any particular engine requires different treatment.



*Starting*

344. The variable-pitch airscrew is generally left in the coarse setting after running, and should be kept so when the engine is about to be started up; this position ensures circulation of the operating oil. Turn on the fuel, oil and priming cocks, and with the ignition switches " off," the mixture lever at the automatic rich position and the throttles in the slow-running setting, turn the engine slowly by means of the starting handle whilst operating the hand-priming pump to inject three pumpfuls of fuel. Switch on the hand-starting and main magnetos, open the throttle slightly and operate briskly the starting magneto (or switch on the booster coil) whilst the engine is being turned. As soon as the engine starts, cease operating; switch off the starting magneto and turn off the priming cock. Should the engine fail to start, inject one further pumpful of fuel and repeat the above procedure.

345. When starting from cold it may be necessary to continue to prime if the engine fails to start without undue hesitation, but several attempts should be made before priming again. Should the engine fail to start after the injection of a total of four pumpfuls of fuel, not more than half a pumpful of fuel should be injected between each subsequent attempt to start. When starting a hot engine or under summer conditions, attempts should first be made to start without priming, but in the event of priming being found necessary, not more than half a stroke of the pump should be given between attempts to start.

346. In the event of overpriming or failure to start due to over-richness, the best method of clearing the engine is to give it a few backward turns by means of the airscrew (the switches being off) or, in cases where this is impracticable, to open the throttles to the full extent and give a few turns in the normal direction. In order to turn the airscrew backwards, it may be necessary first to disengage the starter dog by moving the airscrew in the normal direction. It is very important that the priming cock is never left open during standing periods when a gravity feed tank is employed. Cases have occurred of fuel leaking into the engine through the manifolds and valve ports, thereby necessitating complete change of engine oil and oil priming.

347. When starting with the electric turning mechanism, first make sure that the starting handle is disengaged and then follow the same procedure as regards priming, close the relay switch, switch on the ignition, open the throttle slightly and operate the starting magneto (or booster coil) until the engine fires. Cease operating and switch off the starting magneto

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immediately the engine fires. If the engine does not start within 10 seconds of closing the switch, a pause of 15 seconds should be made between subsequent attempts to start, otherwise the battery plates may be damaged or the starter brush gear overheated. Should the engine fail to start after eight successive attempts (*i.e.* each attempt consisting of ten seconds turning and 15 seconds waiting) a pause of not less than five minutes should be made in order to avoid overheating the electric starter motor.

*Running*

348. After starting, the oil pressure should build up to 60 to 70 lb. per sq. in. immediately. The normal oil pressure is 60 lb. per sq. in. and this pressure under normal flying conditions may vary between 60 and 75 lb. per sq. in. During slow running and at speeds below 1,000 r.p.m. the oil pressure may fall below the normal running figure with hot oil. The warming-up period can be reduced, particularly in cold weather, by pre-heating the oil; the engine must not be opened up with oil temperatures so low that the pressure then tends to fall.

349. Run the engine (mixture control at automatic rich position) at approximately 600 to 800 r.p.m. for about two minutes and then increase the r.p.m. to 1,000 to 1,200 until the oil inlet temperature is 15° C. and the outlet temperature of the coolant is not less than 60° C. The engine can then be opened up to + 6¼ lb. per sq. in. boost (with variable-pitch airscrew the control must be set to fine pitch before the engine is run up to the + 6¼ lb. per sq. in. boost position), but when checking ground r.p.m. and each ignition system, the engine should not be run at + 6¼ lb. per sq. in. boost longer than necessary. Check the working of each fuel system independently, and each magneto. Also check slow running by closing the throttle suddenly from approximately 1,200 r.p.m. to idling speed. Avoid also long periods of idling, but speed up the engine periodically to assist the functioning of the volute drain.

350. Check the variable-pitch airscrew operation by changing to coarse pitch at high speeds and to fine pitch at low speeds. Avoid high engine speeds or the use of the airscrew in coarse pitch for long periods on the ground and adhere strictly to the engine limitations given on the plate in the cockpit. The airscrew must not, at + 6¼ lb. per sq. in. boost, hold r.p.m. below 2,080 or detonation will occur.

350A. In the case of 35° (wide range) constant speed airscrews, when the airscrew governor control is set at or near the minimum r.p.m. position, the boost pressure must not exceed +1¼ lb. per sq. in. when using 87 octane fuel. If 100 octane fuel is used, reference should first be made to para. 358A (ii).



## IN FLIGHT

*Fixed pitch airscrew*

351. The performance ratings of the Merlin II and III engines given on pages 13 and 14 are based on the maximum limitations for climbing, level flight and take-off. With a variable pitch airscrew of either the two-position or constant speed type, the pitch can be adjusted to suit the maximum limitations for take-off and/or climbing and also for level flight. With fixed pitch airscrews however, the pitch is selected to suit the limitations for all-out level flight at the maximum power altitude; it will therefore not be possible to reach the limitations for take-off or climbing flight (at the maximum rate of climb). The r.p.m. at take-off of those engines fitted with fixed pitch airscrews, therefore, will be approximately 2,100 r.p.m., while the climbing r.p.m. at full throttle altitude will be of the order of 2,600. The period of running up on the ground at full throttle and maximum boost must be kept to a minimum. Detonation is likely to occur if the engine is permitted to run at speeds less than 2,080 r.p.m.

*Variable pitch (two-position) airscrew*

352. The variable pitch airscrew control must be in the coarse pitch position for all flight conditions other than for take-off and when gliding in to land with the engine throttled; in these cases, the control should be set to fine pitch in order to permit an emergency take-off if necessary. On no account should running up on the ground be done with the airscrew in the coarse pitch position.

353. *Take-off.*—The following points should be observed before taking off:—

(i) (*a*) The oil inlet temperature must not be less than 15° C.

(*b*) The coolant outlet temperature must not be less than 60° C.

(*c*) The engine oil pressure must not be less than 60 lb. per sq. in.

(ii) The mixture control must be in the automatic rich position.

(iii) The variable pitch airscrew control must be set at the fine setting before opening the throttle.

(iv) The throttle should be fully opened.

354. During the take-off with the airscrew in fine pitch, the engine speed will gradually increase, but must not exceed 2,850 r.p.m. (Merlin II) or 3,000 r.p.m. (Merlin III and V). The variable pitch airscrew control must not be maintained at the fine pitch setting after a height of 1,000 ft. has been reached, or in any case for more than three minutes after the take-off.

355. *Climbing.*—With the variable pitch airscrew control changed to the coarse pitch setting, the mixture control still in the automatic rich setting and the throttle fully opened to the automatic boost controlled pressure of + 6¼ lb. per sq. in., climbing can be continued to the desired altitude. The mixture control must not be changed to the automatic weak position at boost pressures above + 2¼ lb. per sq. in. The engine speed during the climb must not exceed 2,600 r.p.m. and the oil temperature should not normally exceed 90° C; temperatures in excess of 90° C. up to a peak temperature of 95° C. are permissible provided the duration does not exceed five minutes. The coolant outlet temperature must not exceed 120° C.

356. *All-out level flight.*—The variable pitch airscrew control must be at the coarse pitch setting. At full throttle in level flight (five minutes limitation) the engine speed must not exceed 3,000 r.p.m. nor must the boost pressure exceed + 6¼ lb. per sq. in. The mixture control should be in the automatic rich position and the temperatures of the coolant outlet and oil inlet must not exceed those specified above for the climbing conditions.

357. *Continuous cruising.*—For continuous cruising an engine speed of 2,600 r.p.m. and a boost pressure of + 4½ lb. per sq. in. must not be exceeded. The mixture control should be in the automatic rich position for all boost pressures in excess of + 2¼ lb. per sq. in., but if the control lever is inadvertently left in the weak position, the automatic control will readjust the mixture strength as explained in para. 230. With the automatic rich mixture setting, the consumption is approximately 25 per cent. greater than with the weak or automatic setting. The coolant temperature must not exceed 95° C. nor the oil inlet temperature 90° C. The oil pressure must not fall below 45 lb. per sq. in. and flying should only be continued at this pressure as an emergency condition for not longer than 5 minutes. It is possible with an engine that has been run for a considerable time and consequently has larger clearances than a new engine, that the oil pressure will be a pound or so below the figure of 60 lb. per sq. in. This is permissible for continuous operation, providing the pressure does not approach the emergency minimum of 45 lb. per sq. in.

358. *Economical cruising.*—Weak mixture may only be used when cruising at 2,600 r.p.m. or less and at + 2¼ lb. per sq. in. boost or below. The mixture is to be weakened by placing the mixture control lever in the automatic weak position. Any required opening of the throttle may be employed providing a boost pressure of + 2¼ lb. per sq. in.



and 2,600 r.p.m. are not exceeded. For operation at boost pressures in excess of + 2¼ lb. per sq. in., the mixture control lever must be in the automatic rich position.

*Cruising at maximum economy with constant-speed airscrew (Merlin III and V)*

358A. When a constant-speed airscrew is fitted and the power required for any desired cruising I.A.S. is obtainable without exceeding the maximum economical cruising limitations given above, maximum fuel economy at any given I.A.S. will be obtained by operating the airscrew governor control to reduce the engine speed and opening the throttle to increase the boost pressure and restore the power and I.A.S. This adjustment of engine control conditions must be restricted, however, to the following permissible boost pressures at various engine r.p.m. because of detonation or other detrimental characteristics which may lead to engine failure.

(i) (*a*) Fuel .. Specification D.T.D.230 (87 octane).

(*b*) Mixture control position .. Automatic weak.

(*c*) Engine speed.

| r.p.m. | Maximum permissible boost pressure, lb./sq. in. |
|---|---|
| 2,600 | +2¼ |
| 2,550 | +2 |
| 2,500 | +1¾ |
| 2,450 | +1½ |
| 2,400 | +1¼ |
| 2,350 | +1 |
| 2,300 | + ¾ |
| 2,250 | + ½ |
| 1,800 to 2,200 | + ¼ |

(ii) (*a*) Fuel .. Provisional Specification RDE/F/100 (100 octane).

(*b*) Mixture control position .. Automatic weak.

(*c*) When 100 octane fuel is used, the maximum economical cruising boost pressure of +2¼ lb./sq. in. may be used at any speed between 1,800 r.p.m. and 2,600 r.p.m.

359. *Diving.*—For diving operations the mixture control should be in the rich position and the variable pitch airscrew control in the coarse pitch setting as for level flight. The throttle position must be between one third and full open (or that which gives + 6¼ lb. per sq. in. boost) if speeds in excess of the maximum for level flight (3,000 r.p.m.) are likely to be exceeded (*see* A.M.O. A.57/1937). The momentary maximum r.p.m. permissible in terminal velocity dives must not exceed 3,600 r.p.m. and the total duration of speeds in excess of 3,000 r.p.m. must not be greater than twenty seconds.

*High boost for emergency*

359A. The emergency use of higher boost pressures up to +12 lb. per sq. in. is permitted for short periods by means of the modified boost control cut-out introduced by Mod. Merlin 154. The increased boost pressure may be obtained by operating the boost cut-out control in the cockpit; the increased boost pressure will be effective up to an altitude of 10,000 ft., after which the boost will fall to the pressure which is normal to the operational height of the aeroplane.

359B. It is emphasized that the high boost for emergency may only be employed with 100 octane fuel and when the modified boost control cut-out valve (Mod. Merlin 154) and the modified cylinder top joints (Mods. Merlin 64, 77 and 136) have been fitted. It should be noted that the fuel consumption will be increased by about 40 per cent. with a boost pressure of +12 lb. per sq. in. in operation. It is very desirable that type R.C.3. (Stores Ref. 37B/150) and type R.S.3. (Stores Ref. 37B/151) sparking plugs be used for the emergency high boost. If, however, these types are not available, type R.C.1. (Stores Ref. 37B/124) and type R.S.1. (Stores Ref. 37B/126) may be fitted.

359C. The use in an emergency of this high boost pressure is a definite overload condition on the engine. All occasions on which it is found essential to make use of the +12 lb. per sq. in. boost must, therefore, be reported and recorded in the engine log book in order that the reduction in life between overhauls and need for special inspections may be assessed.

*Constant speed airscrew*

360. When using an engine fitted with an airscrew of the constant speed type, the governor control and throttle can be set to maintain the maximum limitations for each condition of flight as detailed on pages 13 and 14. The various operations detailed in paras. 352 to 359 dealing with the operation of an engine fitted with a variable pitch (two-position) airscrew will apply with the exception that the two-position control will be replaced by a constant speed governor control. This governor control must be set to permit the r.p.m. for the various operating conditions as follows :—

| | |
|---|---|
| Take-off .. .. .. .. | 2,850 r.p.m. (Merlin II) or 3,000 r.p.m. (Merlin III and V) |
| Climbing .. .. .. .. | 2,600 ,, |
| All-out level flight .. .. .. | 3,000 ,, |
| Diving .. .. .. .. | 3,000 ,, |
| Landing (*i.e.* in readiness for take-off in case of emergency) .. .. | 2,850 ,, |



361. For continuous and economical cruising, the throttle and governor control may be set to give optimum cruising conditions within the respective permitted ranges. Under no circumstances should the control be set to give more than 2,600 r.p.m. for both cases.

*Flying in formation*

362. With the variable datum type of boost control unit there is no lost motion between cockpit throttle lever and butterfly valve, since the change of boost is progressive with the movement of the lever and the full travel of the cockpit lever is always available.

363. With the fixed datum type of automatic boost control there is a dead period of travel of the throttle lever (*see* para. 240), varying with the altitude, in which the boost control is limiting the output and the response of the engine irrespective of movements of the pilot's lever. It is essential therefore, in order to maintain "station" in formation flight, that the engine of the leading aeroplane should not be opened out to the position where the boost control takes charge, but should leave at least 1 lb. per sq. in. of boost still available for use by pilots of the aeroplanes following, before the automatic boost controls on their engines hinder immediate response to movements of their throttle levers. This means in effect that, on climbing, the boost pressure of the leader's engine should not exceed + 5¼ lb. per sq. in., but in cruising flight as the maximum permissible boost is only + 4½ lb. per sq. in. there is still a margin for momentary increases in output in order to maintain station without entering into the "dead" period of the throttle control.

*Stopping*

364. Before stopping the engine it is advisable, in the case of engines fitted with variable-pitch or constant speed airscrews, to open the throttle and change the airscrew setting to coarse-pitch for the reasons given respectively in paras. 352 and 360. It is essential to allow the engine to idle for a short period before switching off, otherwise it may continue to run under the influence of irregular and violent impulses which might throw excessive stresses on the engine and airframe. During this procedure the radiator shutters should be fully opened or the retractable radiator fully exposed. Turn off the fuel and switch off at the first signs of irregular firing. Do not attempt to stop the engine by opening the throttles at this stage, as the carburettor incorporates an accelerator pump which discharges into each choke on opening the throttle. In cases where the fuel and oil cocks are interconnected, throttle back to approximately 1,000 r.p.m.; allow the engine to idle for a short period to return the oil in the engine to the tank, and then switch off.

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364A. The final sentence in para. 364 refers to engines which are not fitted with a slow-running cut-off control as introduced by Mod. Merlin 97 (*see* para. 222A). Engines so equipped should be stopped in the following manner :—

(i) Allow the engine to cool down by permitting it to idle for about one minute in the slow-running position.

(ii) Pull out the cockpit control lever of the carburettor cut-out device and retain it in this position until the engine stops.

(iii) Switch off the ignition.

(iv) Allow the cut-off control to return to the normal position. The cut-off control should be released smartly to ensure its return to the open position. If this is done slowly, difficulty may be experienced in restarting the engine due to the failure of the cut-off to re-open fully.

(v) Turn off the fuel.

## RUNNING FAULTS

*Failure to start*

365. This may be due to :—

(i) Faulty sparking plugs, condensation or deposits of lead on points.

(ii) Priming fuel not reaching the inlet manifolds. Examine priming jets and atomizers, and clean if necessary.

(iii) Faulty hand-starting magneto or connections.

(iv) Faulty earthing switches or wiring.

(v) Overpriming.

(vi) Failure of electric starter circuits or current supply.

*Abnormal engine vibration*

366. This may be caused by :—

(i) Irregular firing due to faulty plugs, magnetos, slow running or fuel supply.

(ii) Detonation due to unsuitable fuel ; correct fuel (Specification D.T.D.230) must be used. Detonation may be caused by allowing the maximum boost pressure to be exceeded, or through incorrect mixture caused by choked jets. It is most important that detonation be avoided.

(iii) Airscrew flutter due to out-of-balance, loose or incorrectly adjusted variable-pitch mechanism.

(iv) Engine mounting with loose bolts or slack bracing wires.

(v) Coolant temperature being too low and thus affecting carburation.



*Overheating*

367. This may be caused by :—

(i) No coolant in header tank ; leaks in radiator.

(ii) Air lock in system.

(iii) Leaks or restrictions in system.

(iv) Breakdown of pump or leaky gland allowing admission of air into system.

(v) Radiator control incorrectly set.

(vi) Overweak mixture due to starving.

*Faulty compressions*

368. If a valve is observed to be blowing, the tappet clearance should be checked. Should this be found to be in order, a distorted valve or faulty seating may be suspected. Defective sparking plug washers or " gummed-up " piston rings may also be the cause of the trouble.

*Carburation*

369. " Popping " may be caused by any of the following faults, which should be corrected :—

(i) Air leaks in the induction system (low speeds mainly affected).

(ii) Partially choked main or slow-running jets or relevant passages.

(iii) Sticking of float-feed mechanism.

(iv) Broken valve springs or faulty valves or seats.

(v) Defective carburettor capsules.

370. Mixture strength may also be affected by either aneroid capsule being punctured, or its *internal* spring becoming weak. The capsule assembly must then be detached from the link at its upper end, withdrawn downwards with cover plate below, and replaced by a new one. Avoid pulling or distorting the metallic bellows, which should be treated as a sensitive instrument.

371. The four conditions which may obtain due to failure are as follows :—

(i) *Left-hand (altitude) capsule.* (*a*) *Puncture.*—This will cause strong mixture, increasing with altitude, throughout the working range, and can be checked when engine is not running by removing the cover and referring to the failed position shown in the left-hand scrap view in fig. 42.

(*b*) *Weak internal spring.*—This will also cause strong mixture, depending on the degree of spring weakness.

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(ii) *Right-hand (induction pressure controlled) capsule.*

(*a*) *Puncture.*—This will cause weak mixture when running at the take-off position, and can be checked by putting the mixture control into weak position when a change in running, namely, rough or " cutting-out " will occur. If with the cover removed, the main jet is definitely forced downwards into its full weak position, the aneroid has failed.

(*b*) *Weak internal spring.*—This causes strong mixture at the take-off position. It can also be checked by ground running at + 2 lb. per sq. in. boost and using economical cruising control. There should be a drop of 2½ per cent. in r.p.m. under normal conditions and this will be reduced or non-existent if the spring is weak.

*Oil pressure failure*

372. Assuming there is sufficient oil in the system, this may be due to :—

(i) A broken or leaking oil pipe. A small leak in a suction line will cause pressure to fail or become erratic.
(ii) Choked filter.
(iii) Dirt under a relief valve or damaged flat spring.
(iv) Faulty pressure gauge.
(v) Bearing failure (usually causing rise in temperature). Examine filters for metallic particles.

373. If the crankcase fills up with oil, or the exhaust is smoky, the engine filter joints between the covers and the crankcase should be inspected. If an air leak is causing the trouble an oil leak will appear at this point when the engine is not running. Examine the scavenge system.

*Defects in fuel system*

374. When the fuel pump supplies the carburettors direct, pressure failure may be due to :—

(i) Air leak in suction pipe.
(ii) Air lock in pipe system.
(iii) Dirt under relief valve or damaged flat spring.
(iv) Defective pump. See that both sections of the pump are functioning.
(v) Faulty pressure gauge.

*Flooding of carburettor*

375. This may be due to :—

(i) Pressure too high (4 lb. per sq. in. is the maximum pressure).
(ii) Float needle sticking.
(iii) Dirt under float needle.
(iv) Faulty float needle or seating.



## FUEL LEVEL TEST

376. With the accelerator pump and cover removed from the carburettor and a suitable gravity tank connected, check that the following fuel levels are maintained for at least three minutes, and that " creeping " is not taking place :—

(i) With an 8 ft. 6 in. head of fuel, 0·460 in. below joint face.
(ii) With a 2 ft. head of fuel, 0·900 in. below joint face.

377. The valve seating is locked by an aluminium tab-washer obtainable in four thicknesses for selection to give the correct fuel level (*see* para. 237).

## TIMING

*Valve timing*

378. The timing disc (*see* fig. 15) and pointer are arranged at the forward end of the crankshaft and No. 1 bearing cap respectively, and can be seen after removing a screwed plug in the crankcase lower half. Remove the camshaft covers, the thrust plates at the upper ends of the camshaft drive shafts, undo the upper gland nuts of the camshaft drive casings and telescope the casings downwards to obtain access to the serrated drive shafts. By lifting these serrated shafts about half an inch the camshafts can be rotated independently of the crankshaft.

379. Valve timing is usually set with reference to the inlet valve closing position although the opening position is also marked on the timing ring (*see* para. 65) ; the procedure is as follows :—

(i) Lift the serrated drive shafts out of engagement.
(ii) Set the tappets of A.6 and B.1 inlet valves to 0·025 in. clearance.
(iii) Unscrew the plug at front end of the crankcase to inspect the timing ring and pointer. Turn the crankshaft to bring mark " A.6.I.C." opposite the pointer. This sets the crankshaft at its relative position corresponding to the closing of A.6 inlet valves.
(iv) Insert a 0·005 in. feeler in A.6 inlet valve tappet clearance, and rotate the " A " side camshaft anti-clockwise as viewed from the rear end until the 0·005 in. feeler is just tight.
(v) Engage the drive shaft to its nearest setting.
(vi) Replace the thrust cover and camshaft drive casing.

(vii) Set " A " side tappets to 0·020 in. (cold).

(viii) Proceed with " B " side in the same way, working on B.1 inlet tappets and setting the timing pointer to B.1.I.C. by turning the engine through 60° in the normal direction of rotation from A.6.I.C.

(ix) Set " B " side tappets finally to 0·020 in. (cold.)

380. If the engine is timed to the inlet opening marks the camshaft will have to be turned in its normal direction of rotation to nip the feeler.

*Magneto timing*

381. This is effected by means of the two splined drive couplings, each of which drives a magneto, and the timing ring (*see* fig. 15) and pointer fitted to the crankshaft and bearing cap respectively. Both magnetos must be timed to fire at 45° before T.D.C. when fully advanced. Proceed as follows :—

(i) Turn the engine until the A.6 piston is rising on its compression stroke (i.e. with inlet and exhaust valves closed) and set the crankshaft at the point where the A.6.M.A. mark is registered on the timing ring and pointer. (The B.1.M.A. mark can be used if the B.1 piston is put on its compression stroke.)

(ii) Check that magneto contact breaker gaps are 0·012 in. with control levers in *fully advanced* position.

(iii) Fully advance magneto control levers.

(iv) Each magneto has two H.T. distributor points ; a third and smaller one is for the hand-starting magneto and should be ignored for the present operation. Set the large distributor point of the right-hand or " A " side magneto opposite the corresponding A.6 inlet cable socket. (The loose plate is marked accordingly ; care should be taken to set this correctly, otherwise the connections will be made incorrectly) (*see* A.P. 1374, Vol. I, Sect. H, Chap. 1, para. 19). Make certain that the correct side point is registering, as there are two rows of six leads to operate with the two main distributor points already mentioned.

(v) Move the armature slightly (if necessary) until the contact points are just breaking. A magneto synchronizer (*see* A.P. 1095, Sec. VI, Chap. 4) in circuit with the contacts will assist this procedure.

(vi) Offer up the magneto without disturbing the setting, varying the serrated coupling as may be necessary until an accurate engagement is found.



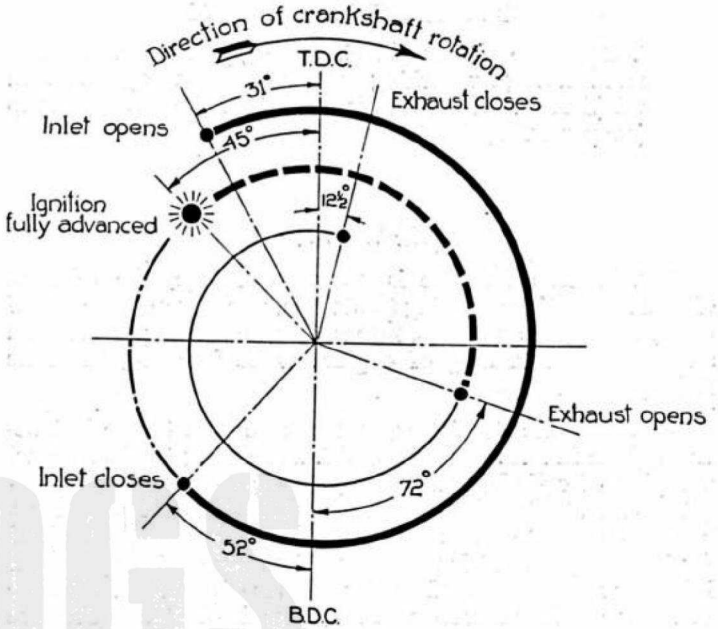



FIG. 65.—Valve and ignition timing diagram.

(vii) Repeat operations for the " B " side magneto and finally secure the cables of both distributors.

(viii) When replacing the distributor cover, turn the engine until the distributor points, furthest from the operator, are vertically upwards. Place the cover on its horizontal face and push it into position endwise. If replaced in any other manner, the felt joint washer is liable to be pushed into the distributor gear teeth, with the possibility of serious results.

**LUBRICATION OF BOOST CONTROL**

382. Use oil to Specification D.T.D. 44B. The control shaft can be oiled through the axial holes at either end. The boost control piston should not be lubricated by removing the stop plug at the forward end of the cylinder. Oil to lubricate this member and its trunk rod should be introduced directly on to the latter member by removing the triangular cover and pouring about one teaspoonful of oil thereon. Lubrication of the change-over cock and piston valve can be effected by removing the pipe to the change-over cock and squirting about one teaspoonful of oil up the connection, first closing the throttle to ensure that the ports in the cock will be open.

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### GREASE FOR COOLANT PUMP GLAND

383. Owing to the use of ethylene glycol in the cooling system and the higher working temperatures employed, special lubricant (Stores Ref. 34A/73) is needed for the coolant pump gland (*see* para. 146).

## STORING THE ENGINE

384. When an engine is put into storage, the relevant official instructions relating to storage, packing and the use of cases, closing of apertures, internal and external preservation and periodical turning of engines while in store, must be strictly observed.

385. Special attention should also be paid to the instructions given in A.P.1464, C.32, Vol. II relating to the internal spraying of cylinders with the approved corrosion inhibitor (Stores Ref. 33C/563) to counteract the effects of leaded fuels. The spraying apparatus (Stores Ref. 4A/1261) should be used for this purpose. It is normally not necessary to remove the inhibitor from the cylinders since this is dispelled in the form of black smoke as soon as the engine is started. (*See* also para. 342).

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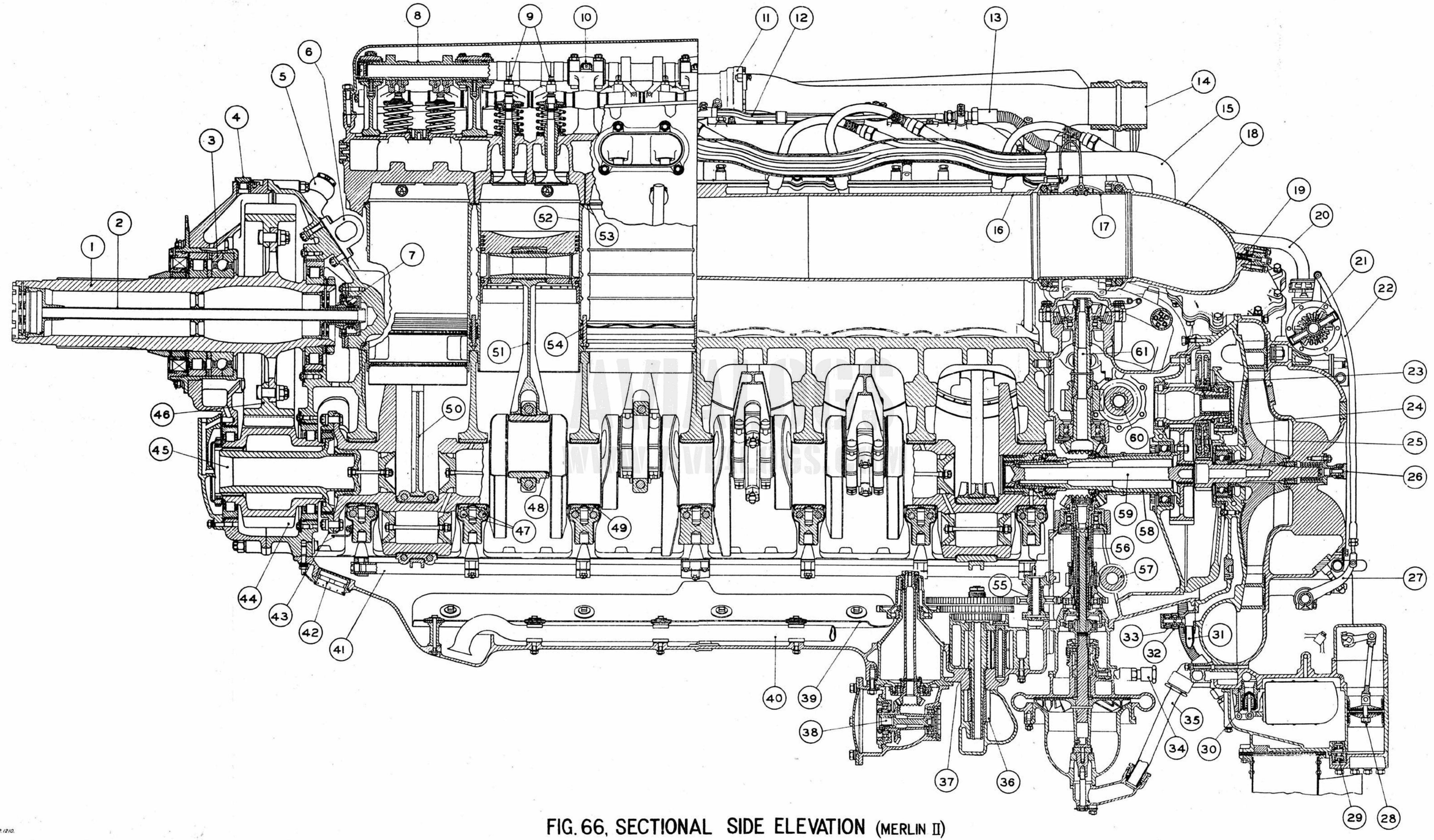



FIG. 66, SECTIONAL SIDE ELEVATION (MERLIN II)

LIST OF PARTS ENUMERATED IN FIG. 66

1. Airscrew shaft.
2. Oil pipe for airscrew pitch operation.
3. Airscrew shaft thrust race.
4. Hole for reduction gear lifting eye.
5. High pressure oil inlet for airscrew operation.
6. Engine front lifting eye.
7. Spherical oil gland for rear end of 2.
8. Camshaft.
9. Valve rocker adjustment screws.
10. Camshaft bearing bracket.
11. " A " side coolant outlet manifold.
12. " A " side priming and slow-running suction pipes.
13. Slow-running suction pipe to carburettor drain venturi.
14. " A " side coolant outlet.
15. Screened ignition harness for inlet sparking plugs.
16. Central induction trunk.
17. Induction trunk short connection.
18. Induction elbow.
19. Induction elbow primer inlet.
20. " A " side coolant inlet pipe to carburettor jacket.
21. Control shaft differential gear.
22. Throttle operating rod.
23. Supercharger lay spindle and clutch driving shaft.
24. Impellor.
25. Impellor spindle and pinion.
26. Oil feed union to impellor spindle rear bearing.
27. Throttle lever.
28. Accelerator pump.
29. Accelerator pump non-return valve.
30. Carburettor float and fuel inlet valve mechanism.
31. Atmospheric balance vent pipe.
32. To impellor spindle rear bearing.
33. To boost control change-over valve.
34. Coolant pump spindle lubricator.
35. Coolant outlet from carburettor jackets.
36. Pressure oil pump.
37. Rear scavenge pump.
38. Lockheed pump drive.
39. Crankcase sump baffle plate.
40. Oil feed pipe to front scavenge pump.
41. Main pressure oil gallery for main and big-end bearings.
42. Timing disc inspection plug.
43. Timing disc and pointer.
44. Reduction gear driving pinion.
45. Reduction gear coupling shaft.
46. Reduction gear driven gear.
47. Crankcase transverse bolts.
48. Big-end bearing.
49. Main journal bearing.
50. Plain connecting rod.
51. Forked connecting rod.
52. Cylinder liner.
53. Cylinder liner upper joint.
54. Cylinder liner joint gland.
55. Idler gear.
56. Lower vertical drive shaft.
57. Fuel pump cross drive shaft.
58. Spring drive unit.
59. Spring drive inner torsion shaft.
60. Magneto cross drive shaft.
61. Upper vertical drive shaft.

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## LIST OF PARTS ENUMERATED IN FIG. 67

1. B.T.H. compressor driving gear.
2. " A " side camshaft driven bevel gear.
3. Gun turret generator pump driving gear.
4. " A " side coolant outlet manifold.
5. " A " side induction manifold.
6. Central induction trunk.
7. Ignition harness for inlet sparking plugs.
8. " B " side coolant outlet manifold.
9. " B " side induction manifold.
10. Spare auxiliary driving gear.
11. " B " side camshaft driven bevel gear.
12. R.A.E. compressor driving gear.
13. " B " side ignition harness for exhaust sparking plugs.
14. Electrical generator flexible driving shaft.
15. Crankcase transverse bolts.
16. Fuel pumps unit.
17. Coolant inlet pipe to " B " side cylinder block.
18. Air intake.
19. Coolant pump inlet.
20. Coolant return inlet from carburettor jackets.
21. Lockheed pump drive.
22. Coolant inlet pipe to " A " side cylinder block.
23. Scavenge outlet union from crankcase.
24. Inlet to scavenge relief valve.
25. Scavenge relief outlet to tank.
26. Hand turning gear.
27. Wheelcase relief valve.
28. " A " side ignition harness for exhaust sparking plugs.
29. Plain connecting rod.
30. Forked connecting rod.
31. Main pressure oil gallery for main and big-end bearings.
32. Front scavenge filter and feed pipe.
33. Lockheed pump spindle.
34. Oil pumps spindle.

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