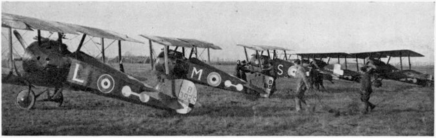


Not a railway advertisement, but Sopwith Camels lined up on an aerodrome in France. With the 300 h.p. Bentley rotary engine, the Camel was one of the best single-seater fighting machines in France in 1918.

THOSE REMARKABLE ROTARIES

The Ingenious Gnome, Le Rhone, and Monosoupape Engines of Long Ago

By

W. BODDY

THE modern aero-engine is a remarkably fine example of a very specialised branch of engineering, but for ingeniousness the old rotary-units stand absolutely alone. If any excuse is needed for recalling a type of engine that has been dead for more than a decade I would remind the reader that in the days when flying was still something of an adventure, when aeroplanes were composed largely of wood and canvas held together by hordes and hordes of bracing wires, and when "aerodrome" more often than not signified a field quite barren save for a Bessoneau hangar on a cinder island beneath a solitary wind-sock, the "rotary" held undisputed sway in many types of aircraft, and that during the war most of the famous fighting machines depended upon this class of engine.

To anyone with an engineering turn of mind the old rotary-units make an extremely interesting study. That the type failed to survive the passage of time can be attributed to inherent disadvantages rather than to crude design of the better examples. For example, a rotary engine must be air-cooled, and power-loss due to the resistance of the moving cylinders to the air stream was found to represent fully 10 per cent. of the maximum output. Any attempt at stream lining would, of course, have an adverse effect on cooling. Again, the leading surfaces of the cylinders tended to become much cooler than did the trailing sides, with the result that bad distortion of the barrels was by no means uncommon. And, of course, carburation and lubrication were fraught with difficulties.

Nevertheless in 1913, when vertical and vee-engines were often unduly heavy, and sadly lacking in smoothness, the rotary-type achieved a very considerable degree of popularity. It was definitely smooth running, it was light and compact, and it kept very cool.

Probably the most famous and respected example of this type of power unit was the Gnome, designed by the Frenchman, M. Laurent Seguin. In its very early form the engine was a five-cylinder with a bore of 3.94 inches. Later the famous 7 cylinder, 50 h.p., model was introduced, and this was followed by the 60 and 80 h.p. 7 cylinder; 100 h.p. 9 cylinder, and 100, 120, and 160 h.p. 14 cylinder types. There was also a 200-h.p. model with 18 cylinders. These engines were highly ingenious in design and very beautifully constructed. In 1913 the 50-h.p. type was priced at £520 and the 200-h.p. model was listed at £1,760.

The crank shaft of a Gnome engine consisted of a two-piece nickel-chrome shaft anchored to the aeroplane fuselage by plates. In the case of the 7-cylinder engines there were seven H section nickel-chrome steel connecting rods, one of these being a master rod to which the remaining rods were attached by means of pins passing into bronze bushed big ends. The master rod was actually longer than the other rods, resulting in a variation in the position, velocity and acceleration of the six subsidiary pistons, without any noticeable effect on the smooth running qualities.

The pistons were of cast iron, of very thick section. Each carried two rings, the upper of which consisted of a thin "L" section bronze ring, backed by a cast iron padding-ring to ensure gas tightness.

It was usual to provide a ring-gap of at least 1 mm.

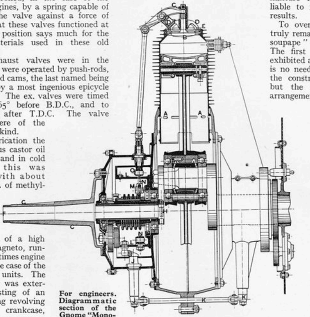
The cylinders were of nickel chrome steel machined out of solid ingots, the cooling fins being left on in the process of machining. The finished thickness of the working barrels was only $1\frac{1}{2}$ mm.; i.e., less than $\frac{1}{16}$ inch.

The carburation layout was really rather wonderful. The carburetter itself was of the floatless type, the petrol supply being regulated by a hand control in the pilot's cockpit. Mixture was drawn up the hollow crank shaft (which, of course, was stationary) into the crank case, from whence it was admitted to the combustion spaces via inlet valves *situated in the piston crowns!* These inlet valves were of automatic type, controlled, in the case of the 50 h.p. engines, by a spring capable of shutting the valve against a force of 4 lbs. That these valves functioned at all in this position says much for the sound materials used in these old engines.

The exhaust valves were in the heads, and were operated by push-rods, rockers, and cams, the last named being operated by a most ingenious epicycle gear train. The ex. valves were timed to open 65° before B.D.C., and to close 13° after T.D.C. The valve springs were of the laminated kind.

For lubrication the now famous castor oil was used, and in cold weather this was diluted with about 8 per cent. of methylated spirit to increase fluidity.

Ignition was by means of a high tension magneto, running at $1\frac{3}{4}$ times engine speed in the case of the 7-cylinder units. The distributor was external, consisting of an ebonite ring revolving with the crankcase, and having seven contact studs. Each stud was connected to a plug by a brass wire. The firing order was 1, 3, 5, 7, 2, 4, 6, for the 7-cylinder engines, working impulses occurring at equal intervals of $102\frac{6}{7}$° of cylinder rotation.



For engineers. Diagrammatic section of the Gnome "Mono-soupape" rotary engine.

The engine revolved on ball bearings, and very little trouble was experienced with these despite the heavy loading. Incidentally, to ensure smooth running conditions it was necessary to see that all the cylinders weighed within half an ounce of each other.

When properly assembled and carefully used a Gnome engine was supposed to function for 16 hours at full load without requiring attention. The correct running speed ranged from 600—1,100 r.p.m. In the case of the popular 80 h.p., 120 h.p. and 160 h.p. models the weight per effective b.h.p. was 2.9 lbs., 2.7 lbs., and 2.7 lbs., respectively. Tests made in 1910, by R. A. Brewer, on a 7-cylinder 50-h.p. model, showed a petrol consumption of 0.63 lb. per b.h.p.-hour, and an oil consumption of nearly $1\frac{1}{2}$ gallons per hour. Heavy oil consumption was one of the biggest drawbacks of these engines, the exhaust valve stems and rocker gear, etc., being lubricated as a matter of course by oil which had passed the piston rings. No aluminium was to be found in a Gnome engine.

Excellent though the Gnome engines proved to be in practice, they had one serious drawback. The inlet valves in the piston crowns were apt to break and when this occurred the whole charge of mixture in the crankcase was liable to ignite, with disastrous results.

To overcome this danger the truly remarkable Gnome "Monosoupape" design was evolved. The first of these engines was exhibited at Paris in 1913. There is no need here to go fully into the construction of the engine, but the very ingenious valve arrangement is certainly worthy of mention. In the cylinder heads was a single push-rod actuated poppet-valve. On the exhaust stroke the burnt gas left the cylinder via this valve, but on the suction stroke the valve remained open for about $\frac{1}{3}$ of the stroke, allowing pure air to enter. During the last part of the suction stroke ports in the base of the cylinder-barrel were uncovered, allowing mixture now compressed in the crankcase to enter, and mix with, the air in the cylinder. It must be explained that air entered the crank case via a hollow passage in the nose of the crankcase, and in doing so encountered a petrol supply tube. The supply tube was fed with petrol in proportion to the engine speed by means of a small force-pump. The resultant mixture was so rich as to be non-explosive, so that there was no risk of it being fired by the residual exhaust when the inlet gas-ports were uncovered by the pistons.

The speed of a "Monosoupape" was regulated by varying the extent and duration of exhaust-valve opening, by means of a system of linkage operated by the pilot. This method at first gave rise to bad burning of the valves, so that subsequently they were made very massive.

In the early engines the pistons were of pressed steel, but later a change was made to the cast-iron type.

(*Continued on page* 54)

THOSE REMARKABLE ROTARIES

(*Continued from page 27*)

It is interesting to note that the use of a single valve gave the "Monosoupapes" a very characteristic note, and, of course, no silencers could be fitted. These engines would run down to as low a speed as 200 r.p.m. In 1914 they were made in two sizes, a 7-cylinder 90 h.p., and a 9-cylinder 100 h.p. Both these engines ran at 1,200 r.p.m. and the 100-h.p. model was priced at about £880.

The Le Rhone engines were of more normal design. They had two valves per cylinder, operated by push rods, and the carburetter was in the crankcase, mixture being fed to the cylinders via a series of radiating pipes. These engines were constructed almost solely of steel, and it is interesting to note that the cylinders consisted of thin cast-iron liners shrunk into steel barrels. Le Rhone engines were made in 7, 9, 14 and 18 cylinder types, of 50, 80, 120 and 160 h.p. respectively. In addition there was an 11-cylinder engine of 100 h.p.

Quite apart from these well known makes one can recall other pre-war radial engines; the American Gyro which had inlet valves in the pistons in its early forms; the D'Henain, which had cast iron cylinders and crankcase in one piece (!); the Burlot design in which the crankshaft rotated twice as fast as the cylinders; the Day, Lamplough and Laviator two-stroke rotary engines, etc., etc.

Present-day engineers may laugh at these early designs, but I defy any of them to lay out a working plan for such an engine without a vast amount of trouble! Gentlemen, M. Laurent Seguin!