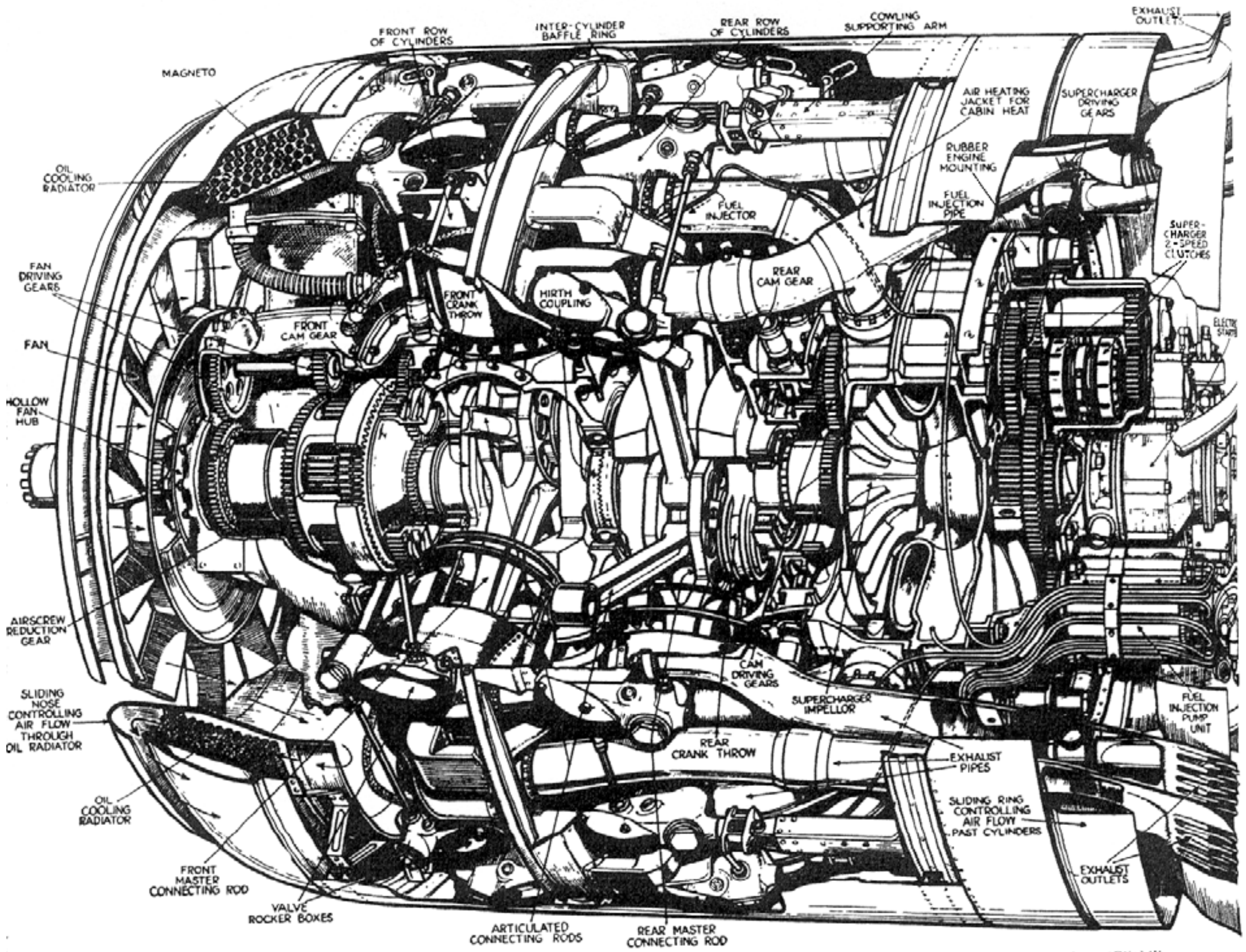


Fig. 1 *Illustrations courtesy "Flight"*

FIG.1. Cut-away drawing of the BMW-801A 14-cylinder radial engine which represents greatest advance in the aircooled field. A power-driven fan together with extensive baffling provides adequate cooling with unusually close fitting cowling. Note the oil radiator in the nose of the cowling and the reverse flow of air through it.

Design Details of The BMW-801A Engine

By MYLES V. CAVE, *"Aviation's" British Correspondent*

First-hand study by an AVIATION correspondent shows Germans have built a very fine powerplant with many interesting features, especially in cooling systems.

THE BMW801A FOURTEEN cylinder twin row radial engine powering the Dornier Do217 series – and a modification of which powers the Focke_Wulf 190 fighter – represents the farthest production advance of German design in the aircooled field. An 18-cylinder model – 802 – developing some 2,000 hp., reported coming into production, is the only Nazi engine to better it.

In layout, conception and compactness the 801 represents a big advance in German design; it is a complete power unit housed in exceptionally close-fitting cowling. Conforming to modern Luftwaffe practice, it is a direct fuel injection engine.

The 14 cylinders are arranged in staggered positions in a triple split cast steel crankcase with the bottom cylinder of the front row and top cylinder of the rear row being vertical. Characteristic of construction throughout the engine, no expense appears to have been spared to give the most rigid case possible. The whole case is machined all over and, for wartime construction, is very finely finished.

The crankshaft is machined from two steel forgings, coupled in the center by a serrated Hirth joint, the halves of which are threaded coarse and fine in each half of the shaft. To lock the shaft up a solid steel bush, internally splined for the assembly tool, is screwed into the threads bringing the serrations on the coupling into close engagement. The outer circumference of the Hirth coupling acts a s the journal for a center bearing for the crankshaft. The bearing itself is a heavy-duty single row ball bearing type, while both front and rear crankshaft bearings are of the roller type.

The crankshaft has four heavy webs with counterweight integral, the webs being drilled and lead filled for balancing.

Master connecting rods are located in the low port cylinder in both front and rear rows. Connecting rod bearings are steel, lead-bronze lined.

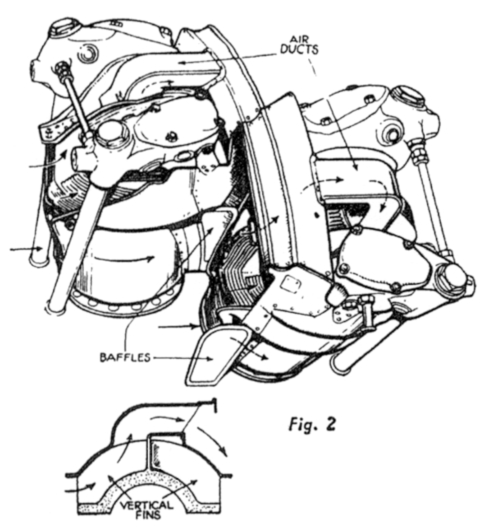
The steel cylinder barrels are closely finned, and at the base of each there is a thick flange drilled circumferentially for the retaining studs fixed in the crankcase. Cylinder heads are of aluminum alloy and appear to be screwed and shrunk to the steel cylinder. Each head has two large diameter valves – one inlet and one exhaust, the latter having a hollow stem and is sodium cooled.

Valves are operated by push-rods from circular cam rings located at the front and rear of the engine, each series of cams operating the valves on front and rear rows of cylinders. Valve rockers run on needle bearings and are completely enclosed and pressure lubricated closely following current American practice.

A simple epicyclic gear train for driving the front valve train cam ring is carried on the front end of the crankshaft in front of which is a steel drum containing the epicyclic star gearing for the propeller reduction gear.

At the front end of the drum is cut a large diameter spur gear driving a shaft which drives a geared sleeve on the crankshaft center line. This sleeve is flanged forward of the gear teeth and bolted to a corresponding flange on the rear of the cooling flan thus forming a drive for th fan.

From the fan drive gears is taken the drove for the Twin Bosch type Z.M.14 magnetos. Both magnetos



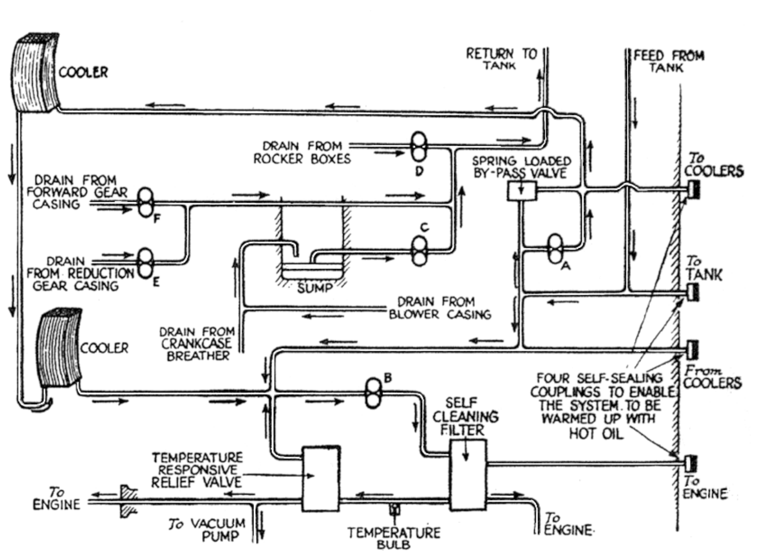


FIG.2. Detail illustrating part of the baffling and air ducts employed to direct cooling air to both front and rear cylinders of the BMW-801A.

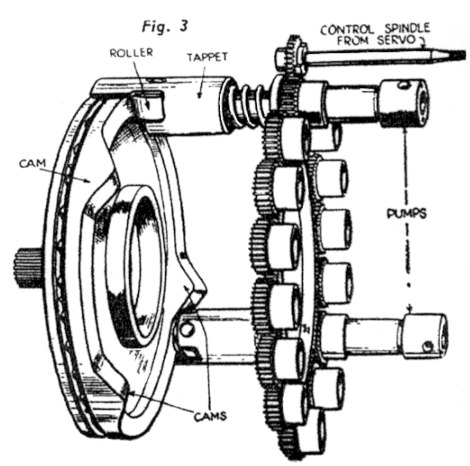


FIG.3. Section showing concentric arrangement of fuel injection pump plungers around the circumferential gear ring which forms the master control for all pumping elements

are vertical mounted on the aluminum alloy front casing.

Unusual Cooling Fan Used

The cooling fan is mounted directly behind the screwed and splined propeller shaft. Slightly to the rear of the fan and located circumferentially in the forward part of the cowling is the special oil cooler through which cooling air is forced between the cooling gills until it exits thru a controllable peripheral slot near the cowling nose.

Between cylinders there is an annular ring forming a center tracing for the cowl and also acting as a collector ring for cooling air for the rear cylinder leads. Air form the front fan is forced into the ring from which it passes through "scoop-ducts" which are riveted to the ring and which guide the air direct to the cylinder head fins. Front and rear cylinders have these "sc oop-ducts."

Around the cylinder barrels and sides of the cylinder heads are elaborately shaped one-piece cooling baffles, the throats of which lead into the center annular collector ring. At the front of teach of these skirt baffles are riveted small fin-shaped deflector baffles for directing the flow air to the rear of the engine.

The aluminum alloy supercharger delivery casing is bolted at the rear of the crankcase,in turn having a heavily ribbed magnesium alloy intake case bolted to it. Bolts fixing the two casings together pass through into the crankcase and secure the whole assembly

The supercharger has a two-speed gear train – the drive to both gear rations being made through a main drive gear with a hydraulic-operated clutch mechanism. The supercharger impeller is a little more than 13 in. diameter and has 24 blades. It is machined fro an aluminum forging. Alternate blades have a curl-over center portion to direct the air to the blade tips form the center intake. The rear half of the super charger casing is a good example of fine German magnesium casting technique. This cover carries flanged bosses for the generator, vacuum pump, gasoline delivery pump and the elaborate 14-cylinder injection pump.

The Gasoline Injection System

This injection pump is interesting in that it is the first multi-plunger high pressure pump built for production in radial form. The pump is made by Friedrick Deckel and, typical of that firm's products, is real precision engineering.

The 14 radially disposed plungers are moved back and forth by a cam ring with three cams driven from the supercharger drive at 1/6 engine speed. Each plunger is moved by a spring loaded roller cam follower which is in constant running contact with the base of the cam ring.

Each pump plunger-sleeve carries a gear ring at its lower end and in slots in this gear – with its flat-sided wings – slides the plunger. Rotation of the gear rotates the plunger altering the cut-off angle of the quantity control which is helically cut into the head of the plunger. The whole set-up is similar in design to the familiar Bosch diesel pump.

The quantity control mechanism for the 14 plungers is ingenious. As stated, each plunger sleeve has a gear at the inner end; this gear and other plunger gears are inter-meshed by a circular gear ring which rotates each plunger. Control to the pilot is made by a short shaft geared at one end and meshing with the top plunger sleeve bear.

Gasoline is fed to the injection pump plungers through a circumferential core in the pump casting from the supply pump located close-by on the rear supercharger case. Provision is made for any air accumulation in the liquid to be diverted trough a series of cored passages to an air collector located in the injection pump body within the circumference of the ring of plungers.

Plunger design closely follows standard diesel practice. Each plunger head is helically cut and grooved to provide a suitable angle face to the intake and cutoff ports in the sleeve to allow of varying throttle condition. Every pumping element is provided with a sliding-type non-return valve on the deliver side. This is in no way similar to the famous Bosch-Atlas valve but no doubt fulfills the same purpose as far as is necessary on a lower pressure injection system.

The injector which is located between the valves in the cylinder head is of interesting design. In contrast to Mercedes-Benz design, the injector orifice is of the open type and the head of the needle closely resembles the Bosch pintle type injector. Diameter of the pintle injector needle is .050 in.

Directly inside the injector body at the injection end the needle diameter is increased and a three-start sharp-cut thread is used both as a fuel passage and also to impart a swirling action to the gasoline when entering the cylinder. The remainder of the injector design follows standard practice. A small circular filter is incorporated within the body of the screw-in gasoline inlet plug located at the top of the injector.

Lubrication System

The lubrication system in the BMW motor is interesting in view of its complexity and thoroughness. No fewer than six pumps are used – two pressure and four scavenger pumps.

Reference to the accompanying diagram showing this lubricating system lay-out readily shows the oil flow.

The pump *A* in the drawing delivers at 175 lb. psi, and a special check valve is provided between the outlet and the inlet side of the pump to prevent excessive build-up in the aircooling system. The pump *B* delivers through a rotating vane type filter driven by gearing from the pump. Pumps *A* and *B* are coupled on the delivery side and the common outlet is fitted with an automatic pressure control valve which maintains a constant oil delivery when hot at a little in excess of 100 psi. This valve also serves to provide excessive oil pressure when the motor is cold.

There is a lead-off through a pressure-reducing valve to the valve gearing which is lubricated at much lower pressure. The valve gear is scavenged by the pump *B*.

Drainage and scavenging from the whole of the front of the engine including the fan drive gear, propeller reduction gear and front cam epicyclic gearing are scavenged by the two pumps *E* and *F*. Drainage from the lower half center crankcase and the accessory drives located on the rear supercharger casing are all drained and scavenged through pump *C*.

Very thorough arrangements have been made for de-icing and heating, all of which are taken from the exhaust system. in the Dornier 217E the effectiveness of this heating setup is shown by a plate on the instrument panel giving the pilot instructions as to what to do when the cabin and other parts get too hot. Air is led across the finned exhaust pipes to such places as the wing leading edges,the front bomb compartment and the cabin. A special multi-drilled tube runs round the transparent cockpit cover through which hot air is distributed over the wind shield.

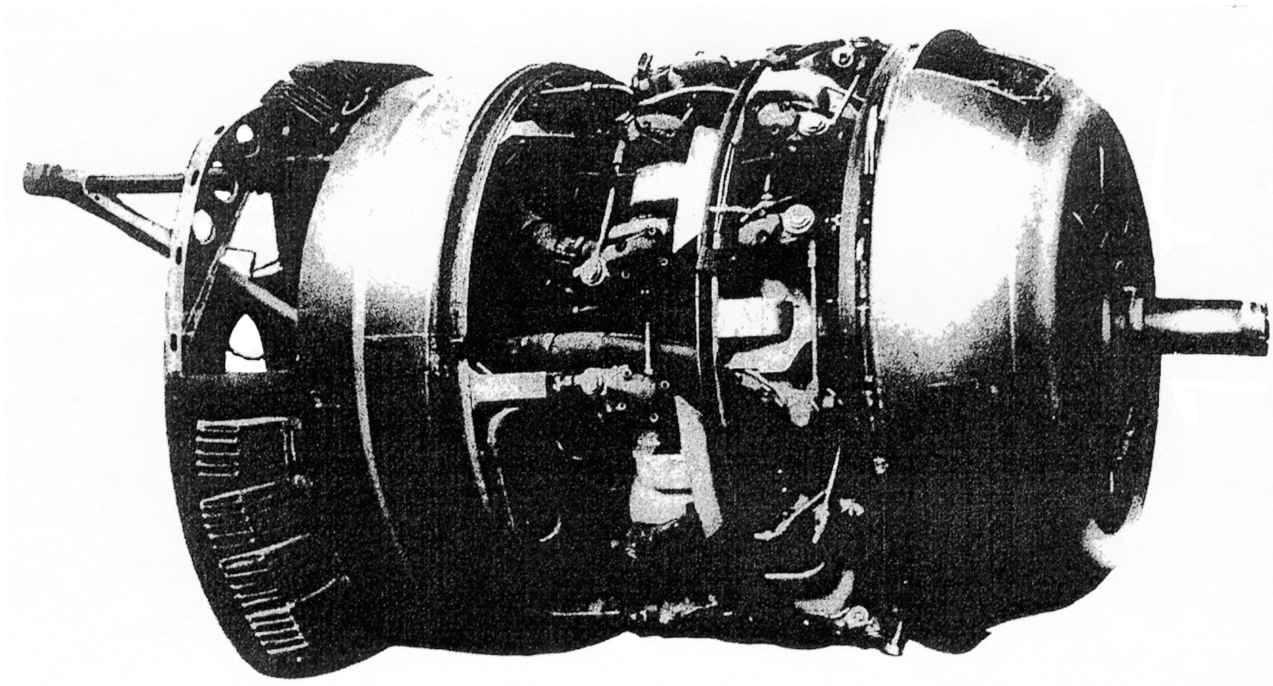
Specifications are as follows:

International power rating – 1,460 bhp. @ 2,400 rpm. @ 16,250 ft. @ 3.6 psi manifold pressure.
Maximum cruising power (continuous) – 1,280 bhp. @ 2,300 rpm. @ 18,500 ft. @ 2.2 psi manifold pressure.
Maximum power (emergency) – 1.585 bhp. @ 2,550 rpm. @ 15,750 ft. @ 4.5 psi manifold pressure.
Normal cruise (economy) – 1,150 bhp. @ 2,100 rpm. @ 19,500 ft. @ psi. manifold pressure.
Maximum power for takeoff for 3 min. -- 1,580 bhp. @ 2,700 rpm. @ 4.7 psi. manifold pressure.

Bore – 6.15 in.
Stroke -- 6.15 in.
Volume – 2,520 cu. in.
Overall diameter of engine – 50 in.
Overall diameter of cowling – 52 in.
Length – 58 in.
Propeller reduction gear – 0.54 crankshaft speed.
Supercharger twin speed.
low ratio – 5.07 x crankshaft speed.
high ratio – 7.46 x crankshaft speed.
Forward cooling fan – 1.72 x crankshaft speed.
Three blade constant speed propeller – 13 ft. diameter.
Spinner diameter – 19-1/2 in.

The BMW-801A, as installed in the Dornier 217E, is a complete and compact power unit — its 1,460 bhp. at 2,400 rpm. at 16,250 ft. making it the highest powered German aircooled motor yet put in large-scale production. The 802 — said to develop some 2,000 hp. — has only recently been reported to be coming off assembly lines in sizable quantities. But, while the 801 is a compact unit, it is far from a maintenance man's dream, for accessibility has been sacrificed to a large degree. Apparently the German designers have, instead, figured on speed of replacing the entire engine, for removal of the five engine mount bolts serves to disconnect the whole powerplant except for fuel lines and engine recording instruments.

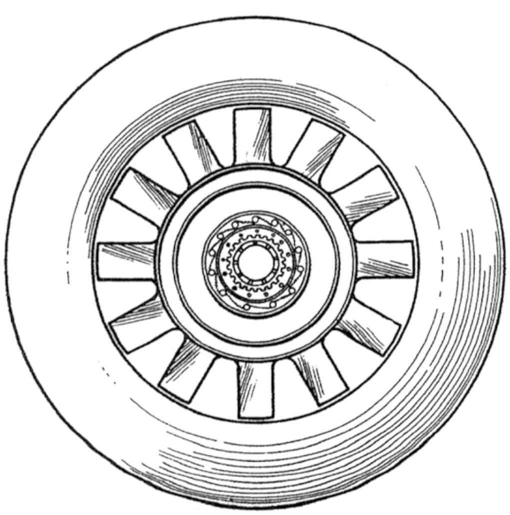
Illustrations courtesy "Flight"

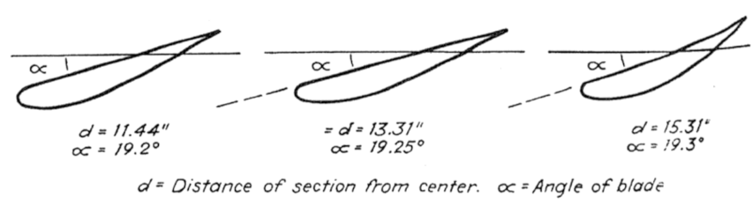


Design Details of the BMW-801A Engine

Second part of a first-hand study by an "Aviation" correspondent, showing additional construction features of a leading German aircooled powerplant

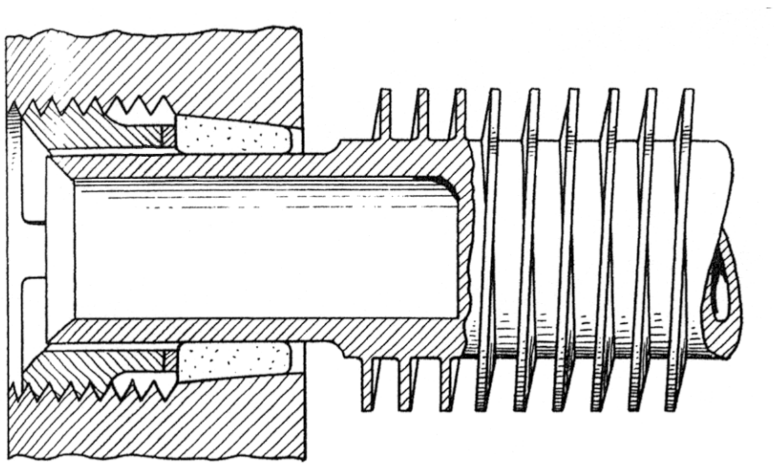
By MYLES V. CAVE, *"Aviation's" British Correspondent*



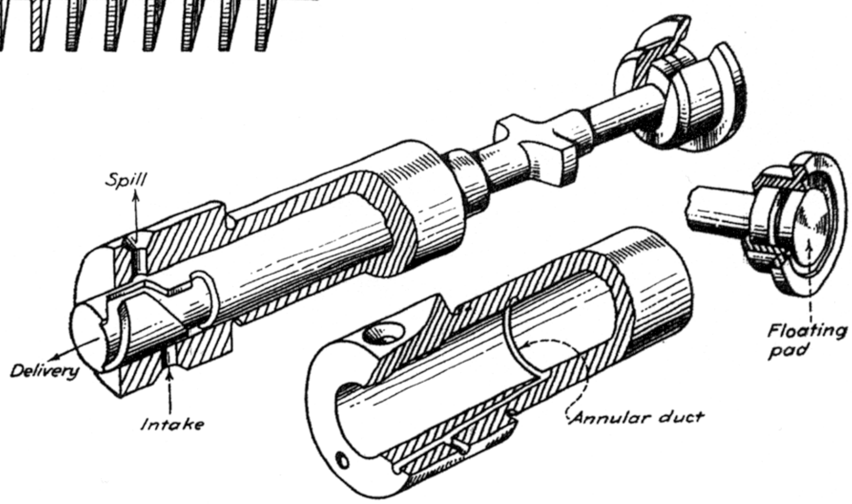


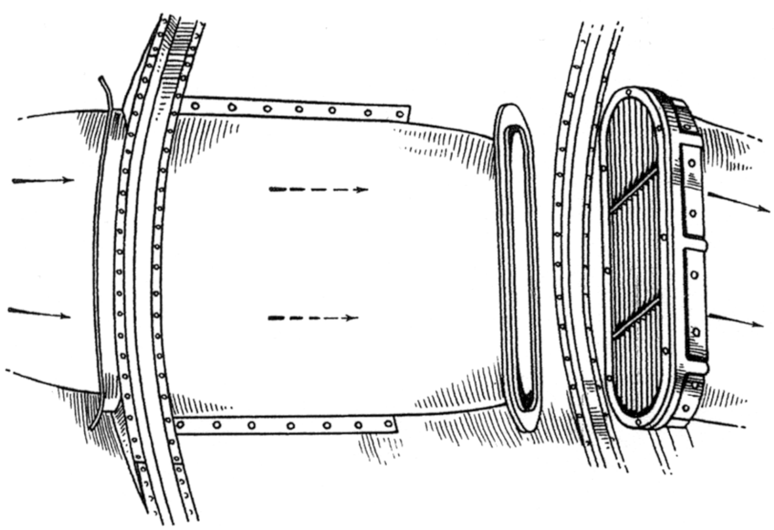
The extremely close-fitting cowling and the fact that supercharger intakes are located withing the cowling have necessitated installation of a cooling fan turning at 1.72 x crankshaft speed located just behind the 13-ft. three-bladed propeller which turns at 0.54 x crankshaft speed. From the fan drive gears is taken the drive for the twin-Bosch ZM 14 magnetos, both of which are mounted vertically on the aluminum alloy front case.

Oil radiator tubes are sealed by the simple process shown here. The threaded end-fitting screws down onto a taper sleeve to make a leakproof joint by pinching the tube.

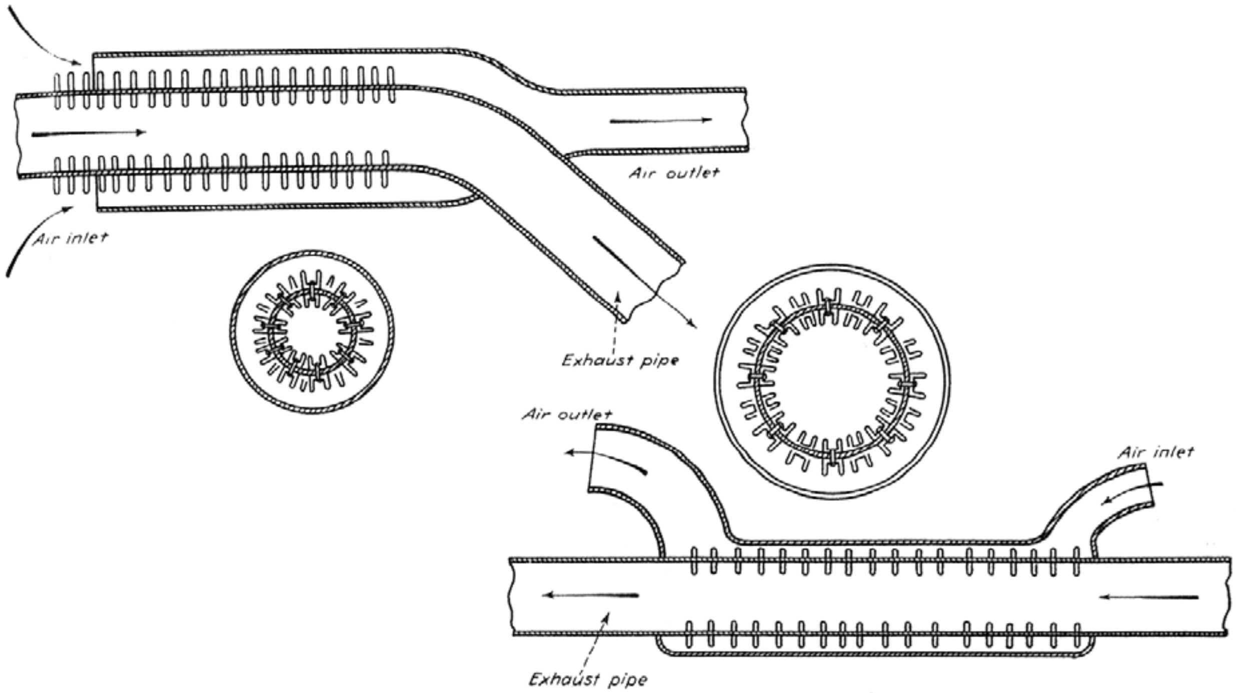


The fuel injection pump for the BMW-801 is the first multiplunger high pressure pump built for production in radial form and, in many respects, the injection system is similar in design to the familiar Bosch Diesel pump. Each plunger head is helically cut and grooved to provide a suitable angle face to the intake and cutoff ports in the sleeve to allow for varying throttle conditions.



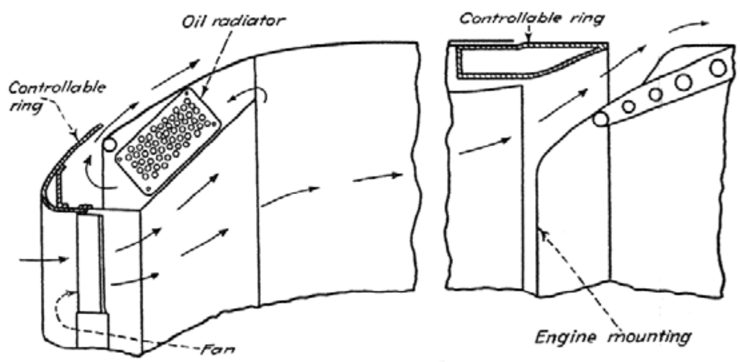


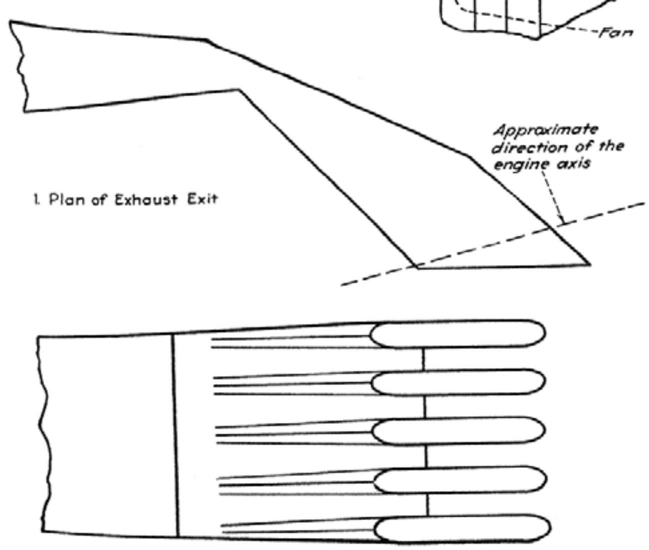
This detail sketch shows one of the supercharger air intakes, set within the cowling. In the photograph opposite the right hand intake can be seen directly behind the mid-lower cylinder and just in front of the rear portion of the cowling. A similar intake is set in a corresponding position on the opposite side. The supercharger operates at 5.05 x crankshaft speed in low gear and 7.46 x crankshaft speed in high gear.



Both wing de-icing and cabin heating are taken care of through utilization of exhaust heat by a system found on American aircraft at least 15 years ago. At top is shown the arrangement for taking heat off for de-icing of wings and bombardier's compartments; Above is the exhaust jacket for heating the main cabin of the DO-217E. (Also see AVIATION, November 1942, page 228.)

The engine cowling has two pilot-controlled rings for cooling adjustments, one located in the nose and one behind the rear cylinders. The oil radiator is located just behind the nose ring, the cooling air being forced in by the fan and its flow reversed to go through the radiator and out around the cowling. In the Focke-Wulf 190 fighter plane installation, the rear controllable ring is eliminated.





2. Elevation of Exhaust Exit

Exhaust flame damping is accomplished with what appear to be exceptionally short stacks which, as may be seen in the photo on page 256, are grouped at the top of the engine and below the middle on each side. In reality, however, the exhaust pipes have considerable length, since they are inside the cowling well back of the engine the only exposed part being the flame damping exits.

Editor’s Note:

This article originally appeared in the November and December, 1942, (Volume 41, Numbers 11 and 12) issues of *Aviation* magazine, published by McGraw- Hill Publishing Company of New York, NY, USA

It was reconstructed from microfilm by J.L. McClellan. The microfilm was taken from a tightly bound volume, so that there is some distortion of the images, especially near the binding. It has not been practical to remove or compensate for all the distortions, so none of the illustrations in this reconstruction should be considered reliable sources as to fine details of shape, proportion or spatial relationship. The distortions are, in general, small, and should not detract from a general appreciation of arrangement and relationship. Mr. McClellan has attempted to represent the original layout of the article, but there are some exceptions. Limitations in the compositing tools cause a difference in the text flow relative to the illustrations, compared to the original, so that some changes have been made, to compensate partially for that effect, and the tabular data have been removed from the flow of text and brought together on a single page after the text, partly to make them more accessible, and partly to sidestep problems with page layout.