

Sept. 26, 1939.

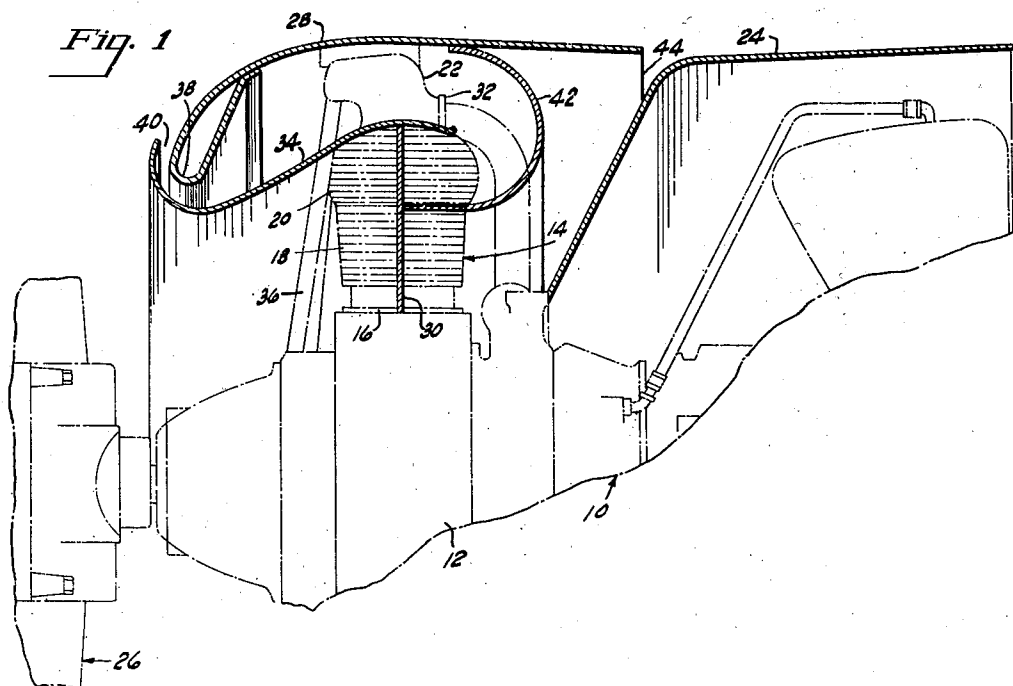
D. S. HERSEY

2,174,418

ENGINE COOLING MEANS

Filed March 26, 1937

2 Sheets-Sheet 1



INVENTOR.
Donald S. Hersey
BY *Harris G. Luther*
ATTORNEY

UNITED STATES PATENT OFFICE

2,174,418

ENGINE COOLING MEANS

Donald S. Hersey, West Hartford, Conn., assignor
to United Aircraft Corporation, East Hartford,
Conn., a corporation of Delaware

Application March 26, 1937, Serial No. 133,167

10 Claims. (Cl. 123—171)

This invention relates to improvements in air distributing means for the cooling system of air-cooled engines and has for an object the application of the available amount of cooling air to the heat radiating surfaces of the engine in a manner to produce the most efficient cooling of the engine with the amount of cooling air available.

A further object resides in the provision of an air distributing means of the character specified arranged to proportion the flow of engine cooling air in accordance with the cooling requirements of different portions of the engine cylinders.

A still further object resides in the provision of an air distributing means of the character specified arranged to proportion the cooling effect of the cooling air on different portions of the cylinder cooling surfaces by providing a pre-selected ratio of air pressure differentials across the different portions of the cylinder cooling surfaces.

An additional object resides in the provision of an air distributing means of the character specified which is effective to divide the stream of engine cooling air and apply substantially independent streams of cooling air to different parts of the engine cylinders.

Other objects and advantages will be more particularly pointed out hereinafter or will become apparent as the description proceeds.

In the accompanying drawings in which like reference numerals are used to designate similar parts throughout, there is illustrated a suitable mechanical embodiment of what is now considered to be the preferred form of the idea of the invention and two somewhat modified forms thereof. The drawings, however, are for the purpose of illustration only and are not to be considered as limiting the invention, the scope of which is to be measured entirely by the scope of the appended claims.

In the drawings,

Fig. 1 is a partly schematic side elevational view of an air-cooled engine showing an air distributing device constructed according to what is now considered to be the preferred form of the idea of the invention applied thereto, the air distributing device being shown in section to better illustrate the construction thereof.

Fig. 2 is a view similar to Fig. 1 showing a somewhat modified form of air distributing device constructed according to the idea of the invention and

Fig. 3 is a view similar to Fig. 1 showing a

still further modified form of the idea of the invention.

Referring to the drawings in detail, the numeral 10 generally indicates an air-cooled engine such as a radial internal combustion engine ordinarily employed for the propulsion of aircraft, although it is to be understood that the improved air distributing means may be applied to other forms of air-cooled engines without in any way departing from the scope of the invention.

The engine illustrated comprises a crankcase portion 12 upon which are mounted a plurality of radially disposed cylinders generally indicated at 14, each cylinder comprising a base portion 16, a barrel portion 18, a head portion 20 and suitable valve rocker arm boxes 22 mounted upon the outer surface of the cylinder head adjacent to the valve ports. The barrel, head and port portions of these cylinders are provided with suitable heat exchanging fins in a manner well known to the art.

The engine is mounted at one end of an engine supporting structure, and, in the ordinary case, is partly received within a wrapper cowl 24 on the front end of the fuselage of the airplane or engine supporting nacelle. The engine drives an aeronautical propeller generally indicated at 26 and is enclosed in an annular, drag reducing cowl generally indicated at 28 having an air inlet opening in the end adjacent the propeller and an air outlet opening at the end adjacent to the end of the fuselage or nacelle. With this arrangement air is induced by the action of the propeller and the forward motion of the aircraft upon which the engine is mounted to flow into the cowl through the air entrance opening, past the engine, and out of the cowl through the air outlet openings.

While a tractor form of engine mounting has been shown in all of the three modifications illustrated for the reason that this is the form almost universally employed in modern aircraft, it is to be understood that the invention could be applied to a pusher type engine without excessive modification of the structure and without departing from the scope of the invention.

The engine is provided with a system of pressure baffles as indicated at 30 for constraining the cooling air flowing through the cowl and past the engine to flow in direct contact with the cooling fins on the engine cylinders and to provide a pressure drop across the engine cylinders from a high pressure space within the cowl in front of the cylinders to a low pressure space within the cowl at the rear of the cylinders. For a more detailed

description of a suitable baffle arrangement, reference may be had to Patent No. 2,031,541, issued February 18, 1936, to A. L. MacClain for Engine cooling system and to application Ser. No. 65,336 filed by E. H. Granville February 24, 1936 for Baffles.

With a streamlined enclosing cowl 28 and a set of pressure baffles 30 of the character specified, the cooling air is caused to flow past the engine cylinders in direct contact with the cylinder cooling fins, and cool the cylinders in proportion to the velocity imposed upon the cooling air by the pressure differential between the air space ahead of the cylinders and the air space at the rear of the cylinders.

It is a well-known fact that in operation, certain portions of the engine cylinders reach excessively high temperatures, the hottest spot of the cylinder usually being the portion of the head immediately adjoining the exhaust port 32. The base portion 16 remains relatively cool, the barrel portion 18 generally attains to an intermediate temperature, the major portion of the head reaches a relatively high but usually safe temperature while the portion of the head surrounding and immediately adjacent to the exhaust port may easily reach dangerously high temperatures. The rocker boxes remain comparatively cool, most of the heat which they acquire being transferred to them from the cylinder head to which they are generally integrally attached.

It is among the objects of the present invention to maintain all portions of all the engine cylinders at safe operating temperatures by distributing the cooling air in substantially separate air streams to the various portions of the cylinders, and to attain the proper cooling of the various portions of the cylinders by providing for a preselected ratio of the air pressure differentials past the various portions of the cylinders.

In the form of the invention illustrated in Fig. 1, the above objects are attained by providing a plurality of passages for the cooling air so arranged that the various passages have different airflow characteristics. In this form of the invention, the interior of the cowl 28 is divided into two separate annular portions by an annular partition member or guide member 34.

By use of the device of the invention, the hot-spots which normally exist with present cooling systems, and the overcooled portions of the cylinders, such as the cylinder bases, may be eliminated during operation.

As is particularly illustrated in Fig. 1, the annular partition member 34 is so dimensioned and positioned that its rearward end surrounds the outer portions of the cylinder heads at the circle including the line of jointure between the cylinder heads and the valve rocker arm boxes. The guide member is suitably apertured to receive the lower portions of the rocker arm boxes and to permit the pushrod casings 36 to extend there-through. At its forward end, the annular guide member 34 overlaps the forward portion of the cowl surrounding the air inlet aperture and extends somewhat beyond the cowl and diametrically beyond the aperture to provide an annular air passage between the guide member and the adjacent surface of the cowl bead 38, and terminates in an annular air outlet slot 40 positioned around the shoulder of the cowl. The air outlet slot 40 is located in the region of low air pressure and high air velocity which exists over the cowl shoulder when the cowl is subjected to a relative wind so that air, leaving the cowl through the

slot 40, is subjected to an inductive action by the air stream flowing past the cowl.

A second guide member 40 of substantially semi-toroidal shape is disposed immediately at the rear of the engine cylinders and extends from the baffles 30 at approximately the circle including the lines of jointure between the cylinder heads and the cylinder barrels to the interior surface of the cowl and is effective to provide, in combination with the guide member 34, a low pressure chamber for the reception of cooling air flowing past the cylinder heads through the outer portions of the baffles 30.

All of the engine cooling air enters the engine space through the circular front end of the annular partition member 34 and passes through the engine past the engine cylinders and the baffles 30. After the air stream has passed the baffles 30, it is divided into two streams. The inner stream flows past the inner portion of the guide member 42 and exists through the air outlet opening or gill opening 44. The other air stream is deflected by the guide member 42 and reverses its flow to flow past the rocker boxes 22 and through the space between the annular partition member and the cowl 28 to the outlet opening 40. As the outlet opening 40 is located in a region of external air pressure, much lower than the air pressure over the outlet opening 44, a greater pressure differential will be imposed on the stream of air flowing past the cylinder heads than on the air stream flowing past the cylinder barrels. This follows from the fact that, while the air for both air streams enters the cowl through the same front opening, the air stream cooling the cylinder heads vents into a region of lower pressure than does the air stream cooling the cylinder barrels and the baffles in combination with the cooling fins serve as a restriction preventing the equalization of air pressures along or between the two air streams. The high pressure drop in the air stream flowing past the cylinder heads will cause the air to flow along the head fins at high velocity, thus providing a greater cooling effect on the heads than on the barrels where the pressure drop is less and the air moves slower.

The openings 40 and 44 are preferably so dimensioned that the flow of air through the two openings is proportioned in accordance with the cooling requirements of the cylinder heads and the cylinder barrels so that an adequate amount of cooling air is supplied to all parts of the cylinders.

While, by the arrangement illustrated and described above, an increased amount of cooling air is directed at an increased velocity past those portions of the engine cylinders which normally operate at the highest temperature, the invention also contemplates reducing the flow of air past the portions of the cylinders that are normally relatively cool and are generally overcooled when existing forms of engine cooling devices are used.

In the form of the invention illustrated in Fig. 2, the cowl, generally indicated at 46, is formed with a double thickness comprising an outer member 48 and an inner portion 50 separated by a space sufficient to include the upper portion of the valve rocker arm boxes 22. At its rear end, this cowl is desirably provided with a set of adjustable flaps 52 for controlling the total amount of engine cooling air flowing through the cowl. For a more detailed description of a suitable flap arrangement, reference may be had to application Ser. No. 705,094 of R. B. Beisel and

A. L. MacClain filed January 3, 1934, for Air regulating means, or to Patent No. 2,049,751 issued August 4, 1936 to J. M. Shoemaker for Engine cooling means.

In this modified form of the arrangement, a plurality of annular guide members, as indicated at 54 and 56, are disposed concentric with the engine 10 and extend from the baffles 30 to locations adjacent to the forward end of the engine supporting body 24. By this arrangement, a plurality of air outlet openings, as indicated at 58, 60 and 62 are provided between the baffles 30 and the gill opening 64, each of the openings 58, 60 and 62 being connected with a separate respective air passage past the different portions of the engine cylinders. In this form of the invention, the opening 58 terminates the passage between the inner surface of the cowl and the annular guide member 54 through which passage cooling air flows to cool the valve ports including the exhaust ports 32, the opening 60 terminates the passage between the annular guide member 54 and the annular guide member 56 through which cooling air flows to cool the cylinder head 20, and the opening 62 terminates the passage between the inner annular guide member 56 and the crankcase 12 of the engine through which cooling air flows to cool the cylinder barrels 18 and bases 16.

While two guide members 54 and 56 have been illustrated providing three separate air passages for the flow of cooling air past the cooling surfaces of the cylinders, it is to be understood that any suitable number of guide members may be used as may be necessary to attain desired operating temperatures in the different portions of the engine cylinders.

The flow of air past the various portions of the engine cylinders is controlled by the effective areas of the air outlet openings 58, 60 and 62, which are more or less restricted to provide throttling effects on the respective air passages to thereby impose the correct pressure heads on air flowing through the passages past the respective portions of the cylinders. In a normal installation, the opening 62 would be the most restricted for the reason that the barrel portions of the cylinders have a relatively low cooling requirement. The opening 58 would be the next most restricted for the reason that, while the portions of the heads to be cooled by the air flowing out through this opening is the hottest since it includes the valve ports 32, the portions of the cylinders cooled by this air is relatively small. The opening 60 would be the widest since the head portions of the cylinders, namely the cylinder heads, which are cooled by the air flowing out of this opening, require the greatest amount of cooling air.

After the air has passed through the openings 58, 60 and 62, it is gathered in the space between the forward portion of the engine supporting body or the wrapper cowl and the adjacent interior surface of the cowl 46 at the rear of the guide members 54 and 56 and is vented through the adjustable gill opening 64.

By means of the arrangement illustrated in Fig. 2, the cooling air is divided into separate streams for the different parts of the engine cylinders and the pressure drop of the separate air streams across the respective parts of the baffled engine cylinders is controlled by the throttling action of the air outlet openings, thus providing desired degrees of cooling for the various parts of the engine cylinders, and the resulting

temperature of the engine can be controlled by adjustment of the cowl flap 52.

In the form of the invention illustrated in Fig. 3, a cowl 66 is provided similar to the cowl 28 in Fig. 1. Preferably, a set of cowl flaps 52 are secured to the rear end of the cowl to control the air vent or gill opening 66.

Within the open front end of the cowl, there is provided a rotatable fan or blower, generally indicated at 70, which may be mounted upon and drivingly secured to the propeller 26 by suitable means, such as the cup-shaped member 72 rigidly secured to the fan at its flared rear end and attached to the propeller at its closed front end by means of extensions upon the ends of the propeller hub clamp bolts 74.

The fan 70 comprises a plurality of concentric annular members of different diameters, as indicated at 76, 78 and 80 and a plurality of radially disposed vanes, as indicated at 82, secured between the annular members in radially spaced relation with respect to each other.

Each of the annular members 76, 78 and 80 is of a substantially fustro-conical shape and, when in operative position, flares outwardly from the front end to the rear end thereof. The flared end 84 of the cup-shaped member 72 constitutes the innermost one of the series of annular members and, at the same time, constitutes the hub of the rotatable fan or blower.

With the construction illustrated in Fig. 3 and described above, it will be observed that the fan comprises a plurality of concentric annular air passages, each sloping rearwardly and outwardly from the front opening of the cowl to the space within the interior of the cowl at the front of the engine. This construction will provide a fan operative to move the cooling air through the cowl opening and into the cowl by the effect of centrifugal action of the fan upon the air. If desired, the vanes 82 may also be given a certain amount of angularity in a circumferential direction in order to add an axial force to the centrifugal action of the fan.

From an inspection of Fig. 3, it will be noted that each of the air passages, as indicated at 86, 88 and 90, terminates at the inner side of the fan at the entrances to respective air passages 92, 94 and 96 constituted by the annular guide members 98, 100 and 102 and leading past the valve ports, heads, and barrels of the cylinders, respectively. By properly proportioning the relative sizes of the passages 86, 88 and 90, desired cooling effects may be applied to the various portions of the engine since the velocity of the air leaving the various parts of the fan will be proportional to the vane tip speed of the various fan portions. In the construction illustrated, the passage 90, which cools the barrel portions of the cylinders, is proportionately large as it is located nearest to the hub of the fan and is, therefore, in the portion of the blower where the vane tip speed is relatively slow. The passage 88 is made relatively large for the reason that the air passing through this passage is used to cool the heads of the cylinders and a relatively large amount of cooling air is required and the passage is so located that the vane tip speeds are relatively high. The passage 86 is made relatively small for the reason that the valve port area of the heads, cooled by the air passing through this passage, is relatively small and, while the temperature tends to run high, the total amount of heat removed is not excessive because of the relatively small area from which

it is removed. Also this passage is located in the outer portion of the fan, where the vane tip speed is highest. The baffle members 30, in this case, are extended all the way from the crankcase to the inner surface of the cowl and are arranged to restrict the flow of cooling air past the engine to substantially the spaces between the engine cooling fins, and the annular guide members 98, 100 and 102 extend from a location adjacent to the inner side of the fan 70 to the baffles 30.

From the above description, it will be observed that there has been provided a power actuated cooling device, which is effective to distribute the cooling air along the cylinders 14 in such a manner that all portions of the cylinders will be cooled to a desired temperature during operation of the engines. While the fan, as explained above, is effective to maintain the desired temperature limits throughout the various portions of the cylinders, the temperature of the engine as a whole can be controlled for various conditions of flight by adjustment of the cowl trailing edge flaps 52 which control the total amount of cooling air flowing through the engine.

From the above description, it will be observed that there has been provided means for distributing the engine cooling air flowing past an air-cooled internal combustion engine in such a manner that all portions of the engine cylinders will be maintained at desired operating temperatures and thus overcooling of certain portions of the cylinders and hotspots on other portions of the cylinders will be effectively avoided with highly beneficial results in the operation of the engine.

While there has been illustrated and described a suitable, mechanical embodiment of what is now considered to be the preferred form of the idea of the invention and two somewhat modified forms thereof, it is to be understood that the invention is not limited to the constructional forms, so illustrated and described, but that such changes in the size, shape and arrangement of parts may be resorted to as come within the scope of the subjoined claims.

Having now described the invention so that others skilled in the art may clearly understand the same, what it is desired to secure by Letters Patent is as follows:

What is claimed is:

1. In combination with a radial air-cooled internal combustion engine having a plurality of radially disposed cylinders each comprising a barrel portion and a head portion provided with cooling surfaces, and means providing a flow of cooling air past said cylinders, means comprising a plurality of concentric annular guide members providing separate air passages to the head portions and barrel portions of all of said cylinders, like portions of said cylinders being included in a single passage, said guide members being arranged to provide, for said passages, air-outlet openings of different degrees of restriction to impose on the air flowing through said passages differential pressure heads proportional to the cooling requirements of the head portions and the barrel portions of said cylinders.

2. In combination with an air-cooled radial internal combustion engine having a plurality of radially disposed cylinders each comprising a head portion and a barrel portion of different cooling requirements provided with cooling surfaces, means associated with said engine to restrict the flow of cooling air past said cylinders and provide a relatively sharp pressure drop in said flow as it flows past the cylinders, means

comprising a plurality of concentric annular guide members providing a plurality of substantially separate airflow passages connected with the barrel portions and the head portions of said cylinders like portions of all of said cylinders being included in the same passage, for proportioning the pressure drop in the cooling air streams flowing past the respective portions of said cylinders in direct proportion to the cooling requirements of the respective cylinder portions.

3. In combination with an air-cooled radial internal combustion engine having a plurality of radially disposed cylinders provided with cooling surfaces, baffles between said cylinders to restrict the flow of cooling air to said cooling surfaces and impose a pressure drop on the air flowing past said cylinders, and means providing a flow of cooling air past said cooling surfaces, means comprising a plurality of concentric annular guide members associated with said baffles to provide substantially independent air passages connected with respective portions of all of said cylinders, said guide members being arranged to provide in said air passages air pressure drops across said cylinders proportional to the cooling requirements of said respective portions of said cylinders.

4. In combination with a radial air-cooled internal combustion engine having a plurality of radially disposed cylinders provided with cooling surfaces, a power-driven blower for forcing cooling air past said cylinders, said blower having annular zones of different airflow capacity proportional to the cooling requirements of the respective portions of the engine cylinders opposite said zones, to provide the respective portions of said cylinder cooling surfaces with a flow of cooling air in direct proportion to the cooling requirements thereof.

5. In combination with an air-cooled radial internal combustion engine having a plurality of radially disposed cylinders provided with cooling surfaces and means providing a flow of cooling air past said cylinders, means comprising a plurality of concentric annular guide members providing air passages of different airflow capacity connected with respective portions of all of such cylinders having cooling requirements proportional to the airflow capacity of said air passages to distribute the flow of cooling air past said cylinders in direct proportion to the cooling requirements of the respective portions of the cylinder cooling surfaces, and means for controlling the total amount of air flowing through said engine to vary the resultant cylinder temperature maintained by said airflow distributing means.

6. In combination with a radial air-cooled engine having a group of radially disposed cylinders provided with cooling surfaces, means providing a flow of cooling air past said cylinder group, means comprising a plurality of annular concentric guide members providing separate air passages past different portions of said group one passage including like portions of all of said cylinders, and means creating air pressure heads of different magnitudes across the cylinder portions in said separate air passages, the pressure heads in said air passages being proportional to the cooling requirements of the respective cylinder portions.

7. In combination with an air-cooled radial internal combustion engine having a plurality of radially disposed cylinders each comprising a head portion and a barrel portion of different cooling

5 requirements provided with cooling surfaces and
a streamlined cowl enclosing said engine, means
associated with said engine and said cowl to re-
strict the flow of cooling air past said cylinders,
and means comprising a plurality of annular
10 guide members providing a plurality of substan-
tially separate airflow passages connected with
the barrel portions and the head portions of said
plurality of cylinders and opening to the exterior
of said cowl at spaced locations there along for
proportioning the pressure drop in the cooling air
stream flowing past the respective portions of
said cylinders in direct proportion to the cooling
requirements of the respective cylinder portions.

15 8. The arrangement as set forth in claim 7
in which at least one of said cooling air passages
opens to the exterior of said cowl adjacent to the
front end thereof.

20 9. Cooling means for an air-cooled engine hav-
ing a group of cylinders each comprising a barrel
portion and a head portion provided with heat
radiating surfaces comprising, means for direct-
ing a flow of cooling air past said cylinders, means
providing an air chamber at each side of said
25 cylinder group, pressure baffles between said cyl-
inders creating an air pressure difference between
said chambers and cooperating with said heat
radiating surfaces to divide said airflow into sub-

stantially separate air streams, means separating
the air streams into separate groups of air streams
and directing one of said groups of air streams
over the barrel portions of said cylinders and
another of said groups of air streams over the
5 head portions of said cylinders, and means modi-
fying said pressure difference to provide different
rates of airflow in said separate groups of air
streams in proportion to the cooling requirements
of the barrel portions and the head portions of
10 said cylinders.

10. In combination with an air-cooled engine
having a group of cylinders provided with cooling
surfaces, means providing a flow of cooling air
past said cylinder group, means cooperating with
said cooling surfaces to divide the stream of cool-
15 ing air into separate air streams, means compris-
ing a plurality of guide members dividing said
separate air streams into separate groups of air
passages, like portions of said cylinders being
included in the same group of air passages, and
20 means creating air pressure heads of different
magnitudes across the cylinder portions in said
separate groups of air passages, the pressure
heads in said passages being proportional to the
25 cooling requirements of the respective cylinder
portions.

DONALD S. HERSEY.