July 16, 1957 F. A. E. PORSCHE ET AL 2,799,262

AIR-COOLED INTERNAL-COMBUSTION ENGINES

Filed Jan. 26, 1955

FIG. 1

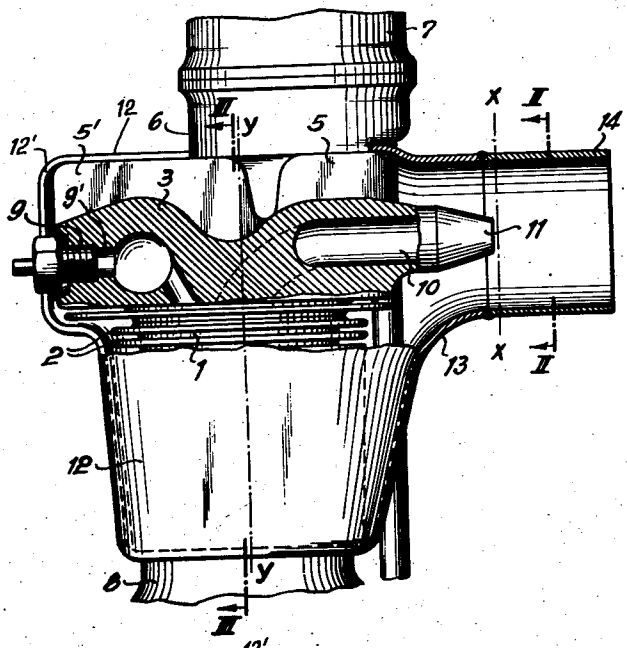
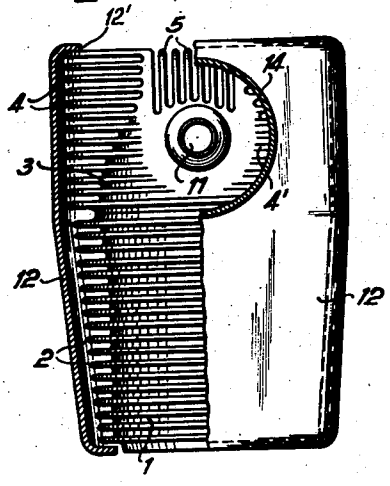


FIG. 2



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2,799,262

AIR-COOLED INTERNAL-COMBUSTION ENGINES

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Application January 26, 1955, Serial No. 484,092

Claims priority, application Germany February 27, 1954

5 Claims. (Cl. 123—41.64)

This invention relates to improvements in air-cooled internal-combustion engines, in which the air for cooling the engine is impelled thereover by the ejector effect of the exhaust gases discharged from the engine through an ejector nozzle.

The primary object of the invention is to provide an air-cooled engine construction adapted to avoid the losses in effectiveness incurred in cooling systems of this kind previously used.

A further object of the invention is to provide an air-cooled internal-combustion engine construction, in which effective and efficient use is made of the exhaust gases for cooling the engine.

In accordance with the invention, the foregoing objects are achieved by providing an engine construction in which the cross-sectional area available for the flow of cooling air through the ejector tube surrounding the ejector nozzle is substantially the same as the free flow area made available for the passage of air around the cylinder and cylinder head of the engine. The cylinder or cylinders of the engine are, at least in part, surrounded by a casing or jacket for directing the cooling air over the cylinder or cylinders, and the arrangement of this jacket with respect to the cylinder or cylinders is correlated with the ejector which makes use of the exhaust gases flowing from the engine. By effecting this correlation and arrangement of the areas in this manner, a distinctly increased efficiency of the ejector is attained.

Tests have shown that with higher air velocities at the intake end of the mixing tube of the ejector, losses in cooling effectiveness arise due to the greater frictional resistance of the air on the walls of the engine and to the sudden reversals of the air stream on the cooling ribs of the cylinder and cylinder head so that a greater part of the subatmospheric pressure created by the waste gases in the ejector is not available for drawing cooling air to cool the internal-combustion engine.

We have discovered that the most advantageous cooling action is attained when the cross-sectional area provided for the flow of cooling air in the mixing tube of the ejector, less the cross-sectional area of the discharge end of the ejector nozzle, is 0.8 to 1.1 times the cross-sectional area of the cooling air stream between the air-guiding casing and the cylinder and cylinder head.

The essential features of the invention are described more in detail hereinafter in connection with the accompanying drawings which show, by way of example, one form of or embodiment of the invention applied to a one-cylinder air-cooled diesel internal-combustion engine.

In the drawings:

Fig. 1 is a side view of an internal combustion engine partly in longitudinal section through the center, with parts broken away; and

Fig. 2 is a view, in which the right-hand side is a section taken along the line II—II of Fig. 1, and in which the left-hand side is a section through the casing taken on the line III—III of Fig. 1.

As shown in the drawings, the improved internal-combustion engine comprises a cylinder 1 formed with horizontal cooling ribs 2, a cylinder head 3 formed with horizontal cooling ribs 4 and 4' and vertical cooling ribs 5 and 5'. The cooling ribs 5 and 5' on top of the cylinder head extend in the same direction from front to rear. A cup or sleeve 6 is mounted on the cylinder head 3 and carries a cap or hood 7, in which the control or actuating mechanisms for the engine are mounted, such as the means for actuating engine valves. A crankcase 8 is connected to the lower face of the cylinder 1. An injection nozzle 9 is disposed on the cylinder head 3 and extends toward the front of the engine. The injection nozzle 9 is connected into an injection conduit 9' in the cylinder head. The nozzle 9 may be replaced by a spark plug. An exhaust gas conduit 10 is provided in the cylinder head opposite the injector nozzle 9. Outside of the cylinder head 3, the conduit 10 merges into or terminates in an exhaust gas nozzle 11 having a tapered exterior surface.

Cooling air is guided over the cylinder 1 and cylinder head 3 by means of a surrounding sheet metal jacket or casing comprising cowls or casing sections 12, which on the injector side of the engine are spaced apart sufficiently to provide a free wide gap through which air can flow into the space between the edges of the casing sections 12 directly onto the cylinder and cylinder head of the engine. Fig. 1 shows the edge 12' of the casing section on the far side of the cylinder and cylinder head, which borders one side of the gap. The overlap of the casing on the sides of the gap at the front of the engine is indicated by the edge 12' in Fig. 2.

On the exhaust side of the cylinder head 1, the air guiding casing sections 12 merge into each other to form a funnel-like conduit 13 around the exhaust nozzle 11, to which a cylindrical mixing pipe 14 is connected by a welded joint, as shown. It is to be understood, of course, that the mixing pipe 14 may have a cross-section other than circular. In the construction as shown, the exhaust gas nozzle 11 extends through the funnel-shaped part 13 of the casing into the mixing pipe 14.

During the operation of the engine, the exhaust gases flow directly through the exhaust gas conduit 10 of the cylinder head, through the nozzle 11 and into the mixing tube 14. Due to the ejector or suction effect of the exhaust gases flowing from the nozzle 11, air is drawn by suction, by the operation of the internal-combustion engine, through the gap between the air-guiding cowls 12 on the injector side of the cylinder and cylinder head and up into the mixing pipe 14, where it is admixed with the exhaust waste gases discharged through the nozzle 11. In this operation the cooling air entering through the gap on the injector side of the engine flows substantially without change in direction of flow into the funnel-shaped conduit section 13.

In order to make the most effective use of the suction effect of the waste exhaust gases of the engine in accordance with the invention, the internal cross-sectional area of the mixing pipe 14, at the position of the plane X—X in Fig. 1, within the range of the exhaust gas nozzle 11, less the cross-sectional area (external), of the tip of the exhaust gas nozzle 11, for the flow of the cooling air, is substantially the same as the free area provided or remaining at the position of the plane Y—Y in Fig. 1, for the flow of air around the cylinder and cylinder head inside the air-guiding casing sections 12. This latter area for the passage of cooling air is measured at the position of a vertical section passing through the axis of the cylinder 1, that is, at the plane Y—Y, which extends transversely to the direction of the flow of air over the cylinder and cylinder head from the gap or opening in the casing toward the ejector. At this position the casing sections 12 are arranged closest to the cylinder and cylinder head and determine the minimum

flow area for the air stream flowing over the cylinder and cylinder head.

Due to the uniform velocity of the air flow over the cylinder and cylinder head within the casing and through the mixing tube 14 around the tip of the nozzle 11, the losses in efficiency are held at such a low value that substantially the full ejector action of the waste gases is made available for cooling the internal-combustion engine. The construction of the casing sections, including the funnel-shaped section 13, and of the ejector, including the mixing pipe 14, and their arrangement in the manner described so as to correlate and substantially equalize the flow areas referred to, provides an arrangement in which the ejector action of the exhaust gases is most effectively utilized for cooling the engine.

It is to be understood that the invention is not limited to any particular kind of air-cooled internal-combustion engine and that the mixing pipe and correlated elements provided in accordance with the present invention may be used in connection with diesel or Otto-cycle engines, whether or not they have one cylinder or a plurality of cylinders.

This application includes subject matter disclosed in the applicants' copending application Serial. No. 483,336, filed January 21, 1955.

We claim:

1. An air-cooled internal combustion engine including a cylinder having a cylinder head provided with a jacket for guiding cooling air thereover and with an exhaust gas ejector for impelling the cooling air over the cylinder, the jacket being open on the side of the cylinder and its cylinder head opposite that of the ejector permitting unrestricted access of cooling air directly to the cylinder and cylinder head, an exhaust gas conduit in the cylinder head, the exhaust gas ejector including a single exhaust gas ejector nozzle forming a direct, substantially straight line continuation of said exhaust gas conduit and an air flow pipe connected into said jacket and surrounding the discharge end of said ejector nozzle, said ejector nozzle being spaced substantially centrally with respect to the air flow pipe and extending from the cylinder head on the side directly opposite that of the open side of the jacket in a direction directly away from the cylinder head so as to eject air through said air flow pipe and to draw the cooling air through the opening in the jacket and over the cylinder and cylinder head without appreciable change in the direction of flow, characterized in that the cross-sectional area available for the flow of air in the air flow pipe around the discharge end portion of the ejector nozzle is substantially the same as the free flow area available for the flow of cooling air around the cylinder and cylinder head inside the jacket.

2. An air-cooled internal combustion engine as claimed in claim 1, in which the cross-sectional area of the air flow pipe at the position of the tip of the exhaust gas nozzle, less the cross-sectional area of the tip of the exhaust gas nozzle is from 0.8 to 1.1 times the cross-sectional area available for the flow of cooling air around the cylinder and cylinder head inside the jacket.

3. An air-cooled internal combustion engine as claimed in claim 1, in which the flow area available for the flow of cooling air around the cylinder and cylinder head comprises the flow area measured on a vertical section through the axis of the cylinder transversely to the direction of flow of the cooling air from the opening in the jacket to the exhaust gas ejector.

4. An air-cooled internal combustion engine including at least one cylinder having a cylinder head, a casing of sheet material for guiding cooling air over the cylinder and cylinder head having spaced edges on one side of the cylinder and cylinder head defining an opening permitting access of cooling air directly to the cylinder and cylinder head, an exhaust gas ejector comprising a single ejector nozzle located on the side of the cylinder and cylinder head opposite said opening, and means interconnected with said casing forming an annular air-flow passageway surrounding the discharge end of said nozzle, said nozzle projecting from the side of the cylinder head substantially centrally into said air-flow passageway and arranged to deliver exhaust gases from the cylinder head in a direction away from the cylinder head to eject air through said annular air-flow passageway and to draw cooling air through said opening in the casing and over the cylinder and cylinder head without appreciable change in its direction of flow, characterized in that the cross-sectional area of the air-flow passageway around the ejector nozzle at its discharge end is approximately the same as the free flow area available for the flow of cooling air around the cylinder and cylinder head inside the casing, whereby the full ejector action of the exhaust gases issuing from the cylinder through the ejector nozzle is made available for cooling the cylinder and cylinder head of the engine.

5. An air-cooled internal combustion engine including at least one cylinder having a cylinder head, a casing of sheet material for guiding cooling air over the cylinder and cylinder head having spaced edges on one side of the cylinder and cylinder head defining an opening permitting access of cooling air directly to the cylinder and cylinder head, an exhaust gas ejector located on the side of the cylinder and cylinder head opposite said opening, comprising means connected with said casing forming a passageway for mixing air with exhaust gases extending in a direction away from the cylinder head of the engine, said cylinder head being provided with an exhaust gas conduit leading directly to the side of the cylinder head toward said passageway, and a single exhaust gas ejector nozzle integral with the cylinder head of the engine extending axially into said passageway in spaced relation to the wall thereof and constituting a substantially straight line continuation of said exhaust gas conduit, characterized in that the cross-sectional area of the passageway around the ejector nozzle at its discharge end is approximately the same as the free flow area available for the flow of cooling air around the cylinder head inside the casing, whereby the full ejector action of the exhaust gases issuing from the cylinder through the ejector nozzle is made available for cooling the cylinder and cylinder head of the engine.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,799,262 July 16, 1957

Ferdinand A. E. Porsche et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 33, after "exhaust" insert -- gas --; column 4, line 12, for "interconnected" read -- connected --; line 51, after "cylinder" insert -- and cylinder --.

Signed and sealed this 19th day of November 1957.

(SEAL)
Attest:
KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents