

[54] ROTARY COMBUSTION AIR COOLING ARRANGEMENT

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[52] U.S. Cl. .... 123/8.01, 418/101

[51] Int. Cl. .... F02b 55/12

[58] Field of Search. .... 418/101; 123/8.01

[56] References Cited

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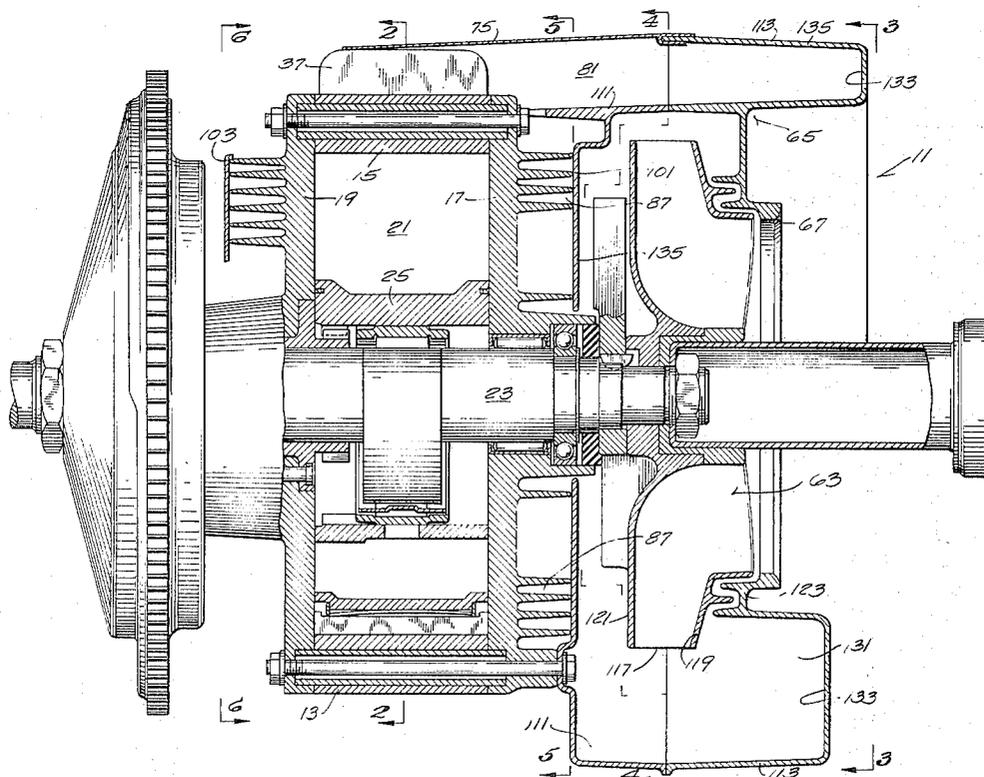
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Primary Examiner—Clarence R. Gordon  
Attorney, Agent, or Firm—Michael, Best & Friedrich

[57] ABSTRACT

Disclosed herein is a rotary combustion engine comprising a plurality of cooling fins extending radially outwardly from a hollow housing in generally parallel relation to a rotor shaft rotatably journaled by end walls interconnected with the hollow housing, a fan driven by the rotor shaft, a shroud enclosing the fan and including an air inlet and an air outlet, wall means including a first portion engaging the radially outer ends of the cooling fins to provide a first plurality of cooling passages extending axially of the housing, and a second portion extending from the first portion and cooperating with the shroud to define a conduit extending from the shroud outlet to the first plurality of cooling passages, a second plurality of cooling passages extending arcuately along the outer surface of one of the end walls, a third plurality of cooling passages extending arcuately along the outer surface of the other of the end walls, and duct means independently communicating each of said second and third pluralities of cooling passages with said shroud outlet independently of each other and of the conduit.

15 Claims, 9 Drawing Figures



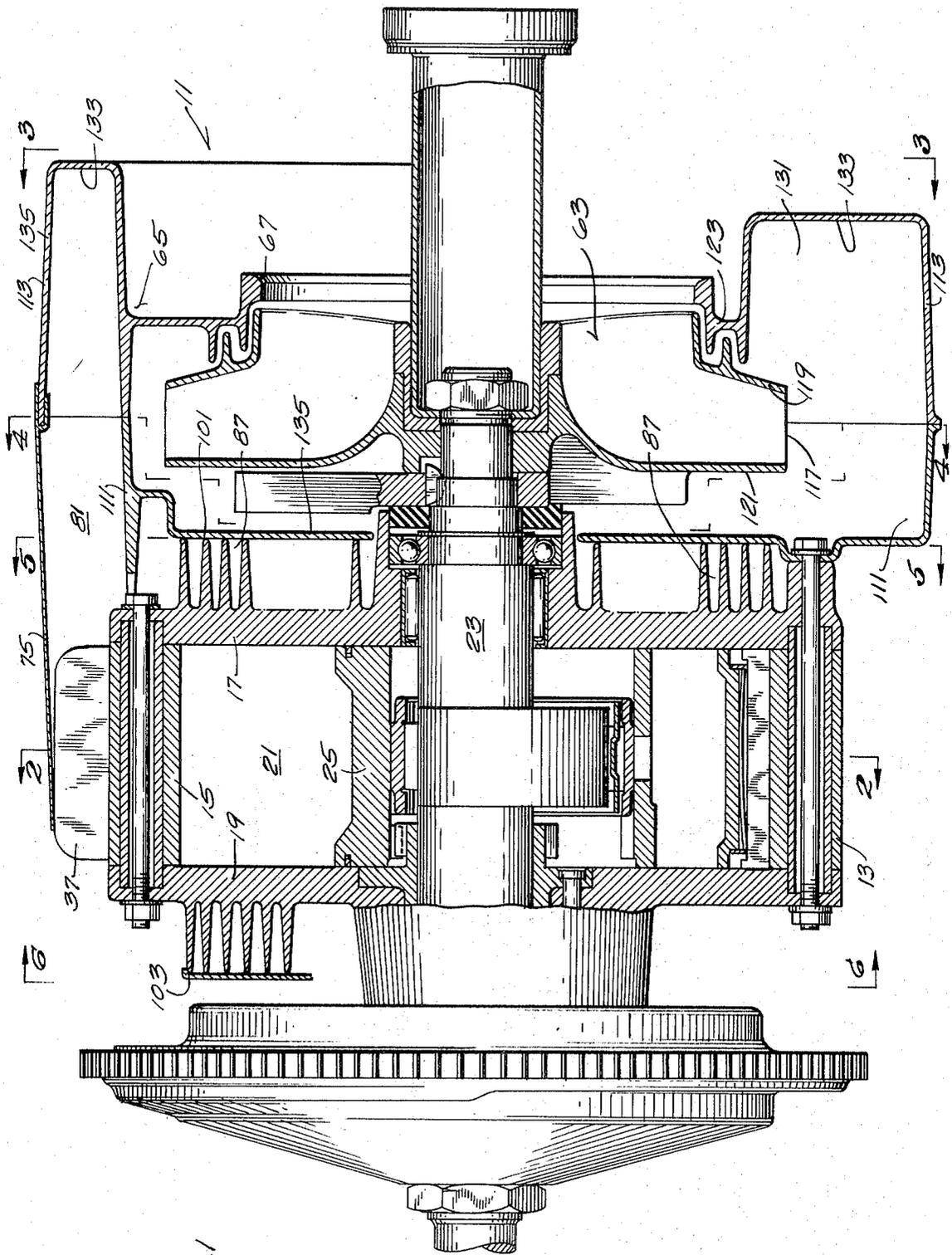


Fig-1

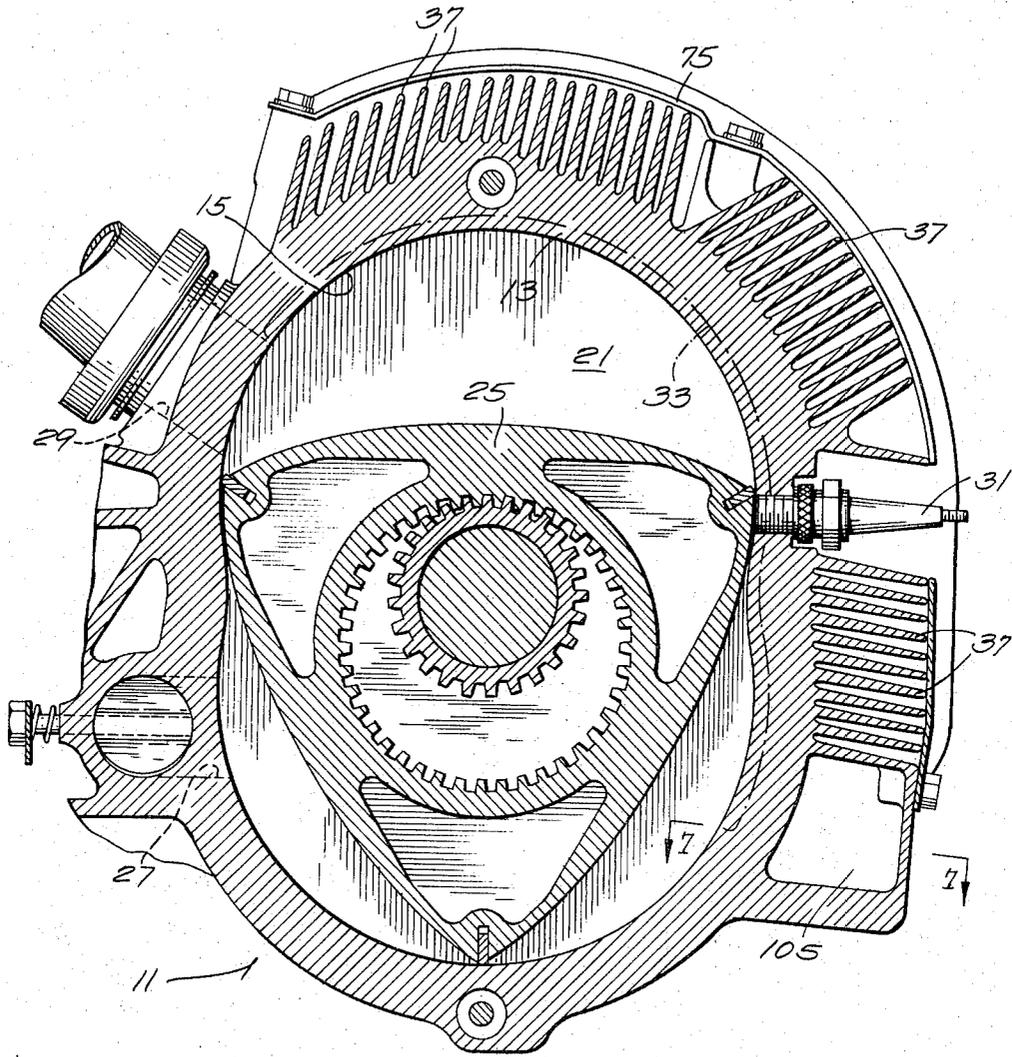
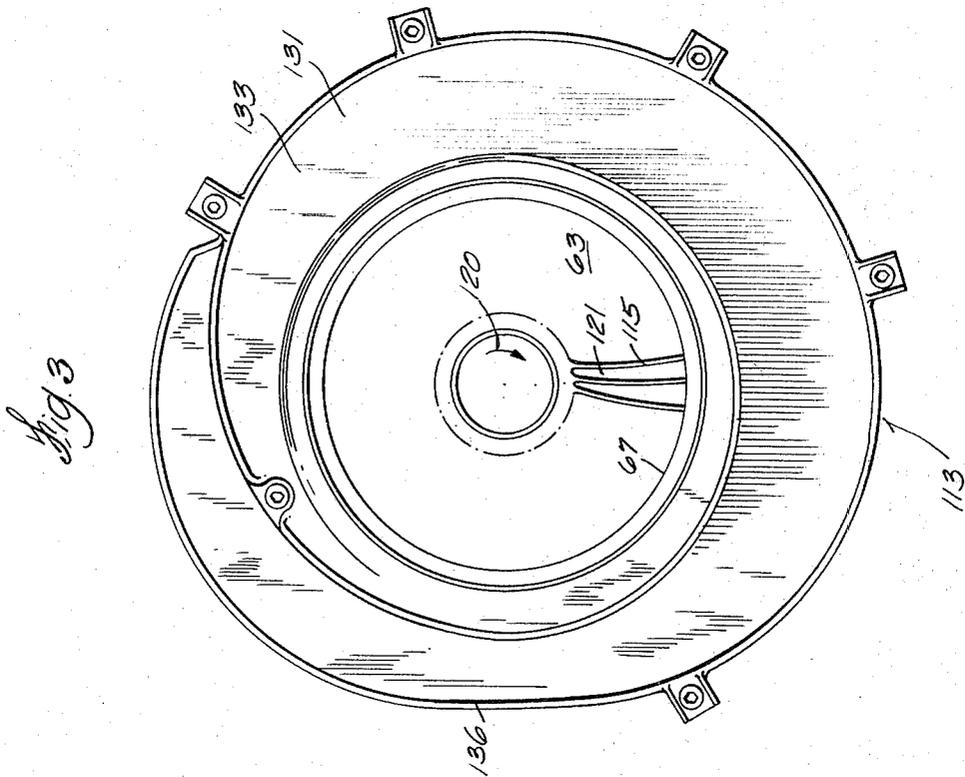
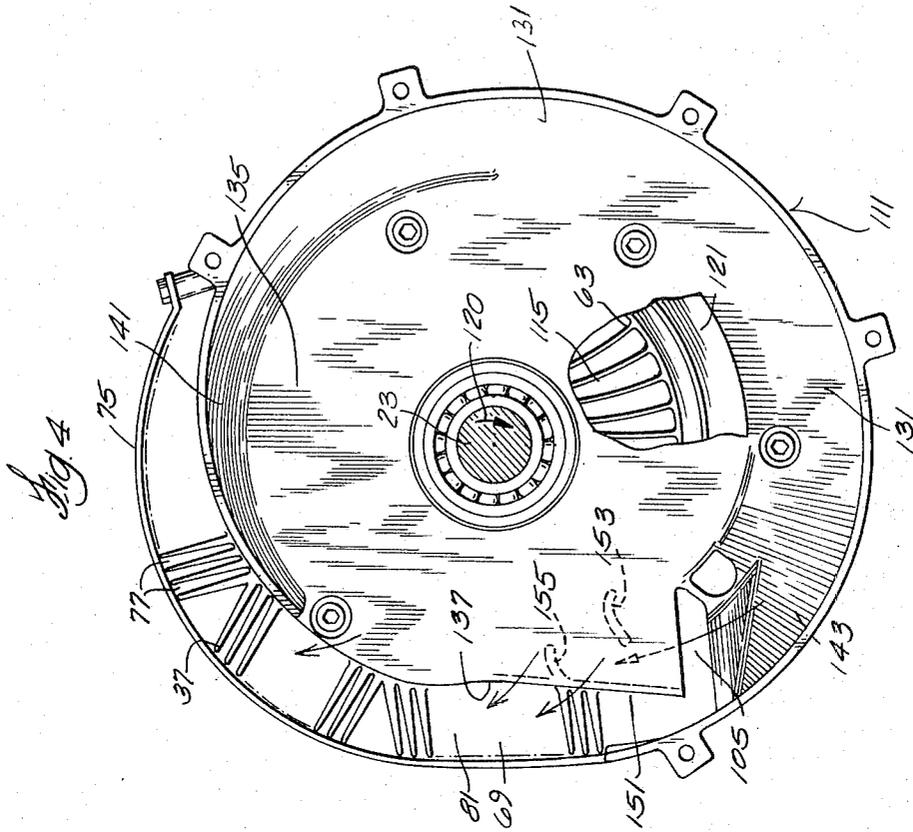
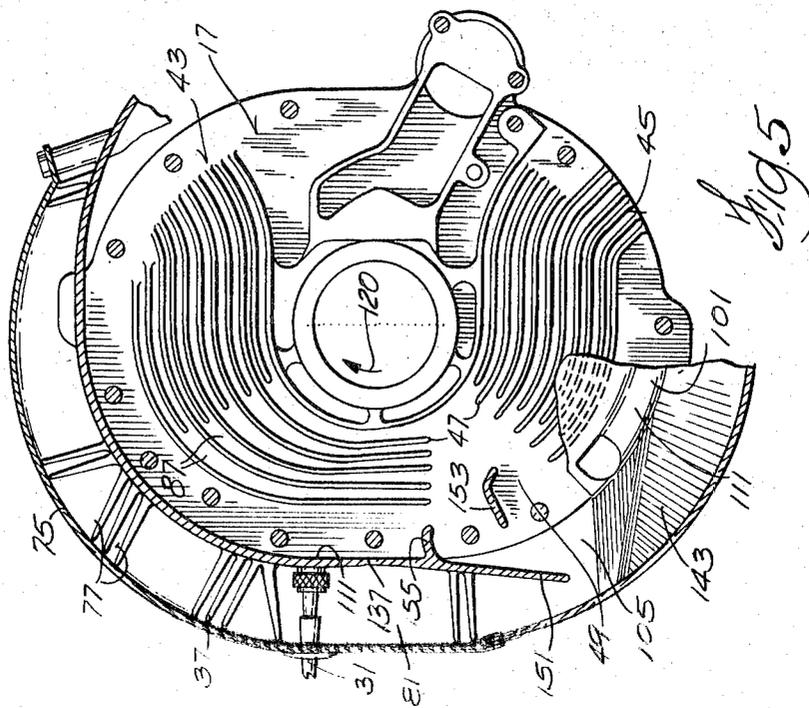
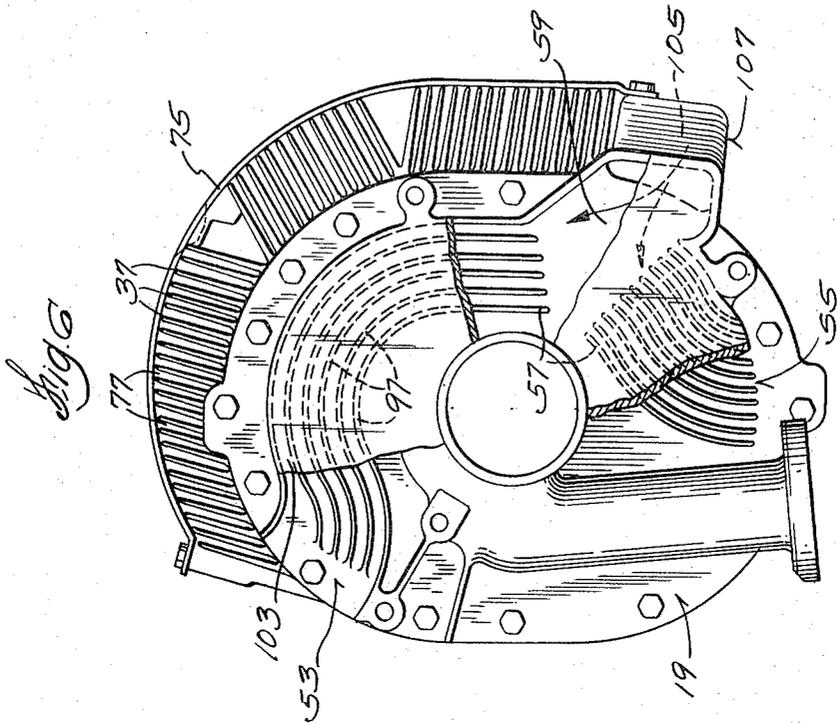
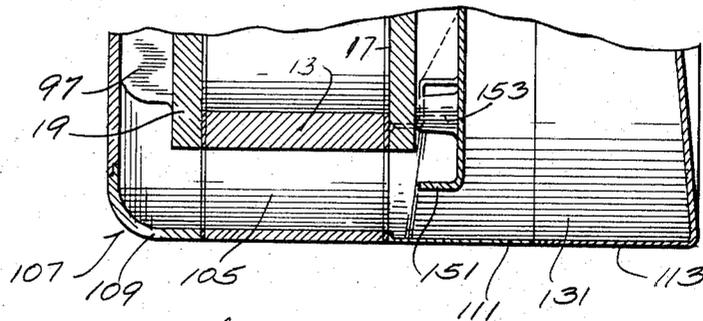
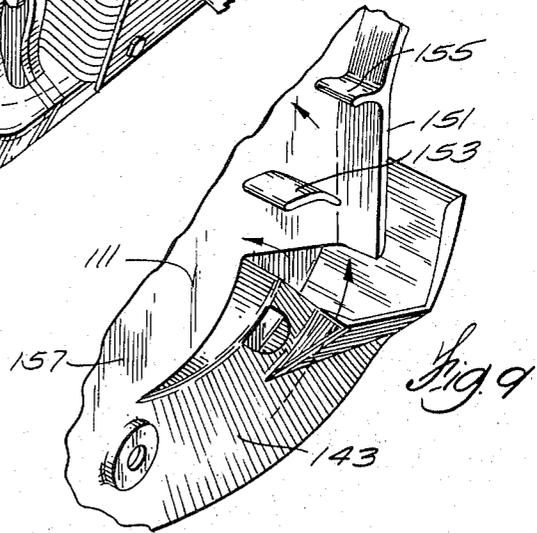
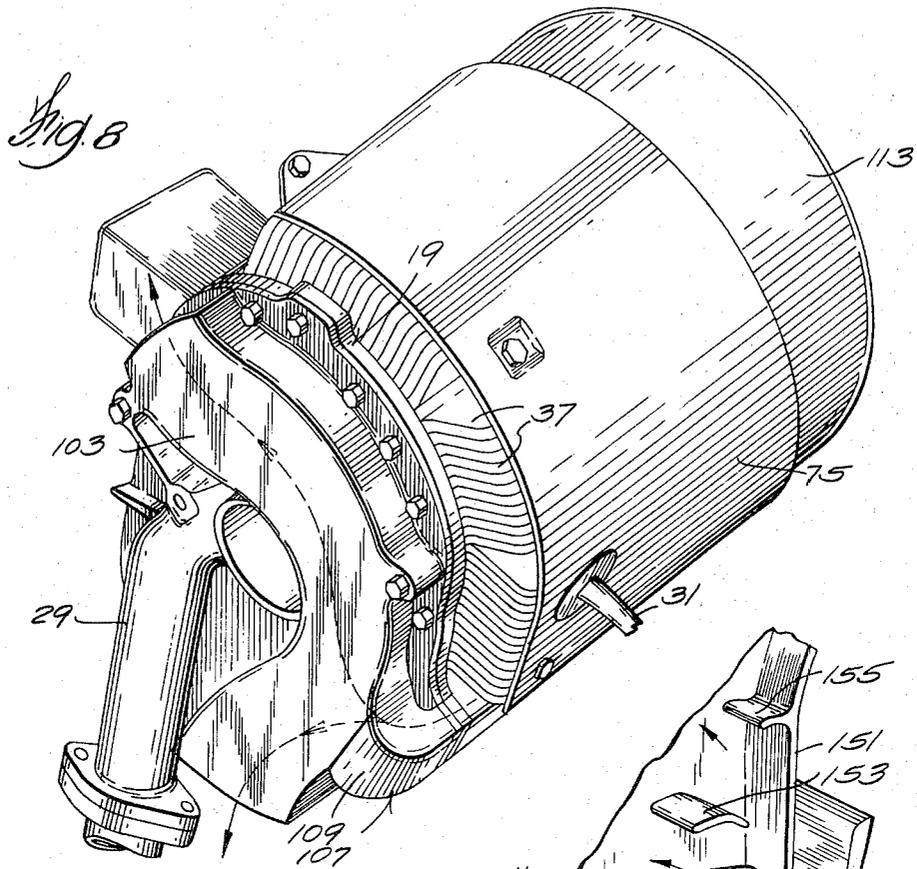


Fig. 2







*Fig. 7*

## ROTARY COMBUSTION AIR COOLING ARRANGEMENT

### BACKGROUND OF THE INVENTION

The invention relates generally to rotary type internal combustion engines such as disclosed in the Jones U.S. Pat. No. 3,196,850, issued July 27, 1965. More particularly, the invention relates to arrangements for air cooling such engines. One example of a prior arrangement for air cooling a rotary internal combustion engine is disclosed in said Jones U.S. Pat. No. 3,196,850.

In the Jones U.S. Pat. No. 3,196,850, the engine includes an air duct or plenum which extends from a fan axially of the engine and which communicates successively, one after the other, with cooling passages along the end wall adjacent to the fan, with circumferentially extending air passages around the hollow housing and with air cooling passages along the end wall remote from the fan. As a consequence, there is a decreasing pressure gradient extending axially along the duct, which decreasing pressure gradient progressively adversely affects cooling air flow through the cooling passages in the direction from adjacent to the fan to the end of the engine remote from the fan.

### SUMMARY OF THE INVENTION

The invention provides an air cooling arrangement for a rotary internal combustion engine wherein the fan communicates separately or directly with end wall cooling passages and with cooling passages along the hollow housing, as compared to arrangements including sequential or successive communication as, for instance, in the Jones U.S. Pat. No. 3,196,850.

The invention also provides an air cooling arrangement for a rotary internal combustion engine in which the hollow housing is provided with cooling fins or passages which extend axially of the engine and in which all of the cooling passages have substantially equal access to the air delivered by the fan and are subject to substantially the same pressure head.

The invention also provides an air cooling arrangement for a rotary internal combustion engine wherein the end wall remote from the fan is provided with cooling passages which communicate directly with the fan (separately from the supply of cooling air to the hollow housing passages) through a duct in the hollow housing and so as thereby to have available substantially full fan pressure for pumping air through the remote end wall cooling air passages. More specifically, in the disclosed construction, the only loss of head as between the cooling passages along the adjacent end wall and the cooling passages along the remote end wall involves pressure losses due to flow through the duct in the hollow housing.

One of the principal objects of the invention is the provision of an air cooling arrangement for a rotary internal combustion engine in which the hollow housing is cooled by axial flow cooling passages.

Another of the principal objects of the invention is the provision of a rotary internal combustion engine in which cooling passages associated with the adjacent and remote end walls, as well as cooling passages extending along the hollow housing, communicate in parallel relation with the fan as compared with communication in series with the fan, i.e., as compared to successive communication with a single outlet duct leading from the fan.

Another principal object of the invention is the provision of a cooling arrangement for rotary internal combustion engines in which passageways or ducts leading to the end wall passages and to the axial cooling passages along the hollow housing communicate with a common outlet from a fan shroud so as to substantially reduce variation in the pressure head available to the cooling passages extending along the hollow housing and along the adjacent and remote end walls.

Other objects and advantages of the invention will become known by reference to the following description, claims, and accompanying drawings.

### THE DRAWINGS

FIG. 1 is a side elevational view, partially broken away and in section, of a rotary internal combustion engine embodying various of the features of the invention.

FIG. 2 is a sectional view taken generally along the line 2—2 of FIG. 1.

FIG. 3 is a somewhat reduced sectional view taken generally along line 3—3 of FIG. 1.

FIG. 4 is a somewhat reduced sectional view, with portions broken away, taken generally along line 4—4 of FIG. 1.

FIG. 5 is a somewhat reduced sectional view, with parts broken away, taken generally along line 5—5 of FIG. 1.

FIG. 6 is a somewhat reduced sectional view, with parts broken away, taken generally along line 6—6 of FIG. 1.

FIG. 7 is a fragmentary sectional view taken generally along line 7—7 of FIG. 2.

FIG. 8 is a perspective view of one end of the rotary internal combustion engine shown in FIG. 1.

FIG. 9 is an enlarged perspective view of the undersurface of a portion of the inner shroud member incorporated in the rotary internal combustion engine shown in FIG. 1.

Before explaining the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts set forth in the following general description or illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

### General Description

Illustrated in FIG. 1 is a rotary internal combustion engine 11 which includes a hollow housing or member 13 formed with peripheral inner wall 15 having an interior surface in the form of a trochoid. Connected to the ends of the hollow housing 13 are a pair of spaced end walls 17 and 19 which, together with the hollow housing 13, define a cavity including a rotary, variable volume combustion zone defined by the housing 13 and the rotating rotor 25. Carried in the cavity 21 on a rotor shaft 23 journaled in the end walls 17 and 19 is a three-sided rotor 25. Extending through the hollow housing 13 are intake means 27 for admitting into the chamber or cavity 21 an air-fuel mixture in response to rotor rotation and an exhaust discharge means or outlet 29 affording outflow of the products of combustion from the chamber or cavity 21 in response to rotor rotation. Lo-

cated between the intake means 27 and the exhaust discharge means 29 is a spark plug 31 which is periodically fired to explode the air-fuel mixture. As a consequence of the foregoing construction, the hollow housing 13 includes a sector 33 which extends from both sides of the spark plug 31 and which, during operation, is relatively hot as compared to the remainder of the hollow housing 13.

In order to cool the sector 33 of the hollow housing 13, the hollow housing 13 is provided throughout the sector and in accordance with the invention, with a plurality of closely spaced, axially extending cooling fins 37 extending radially outwardly and in generally parallel relation to the rotor axis.

In order to cool the end walls, the end wall 17 is provided (See especially FIG. 5) with two arcuately spaced series 43 and 45 of closely spaced cooling fins 47 extending axially and partially circumferentially around the rotor axis and from an intermediate area or plenum space 49 into which cooling air is delivered for further travel in opposite directions between the cooling fins 47. In addition, the end wall 19 is provided (See especially FIG. 6) with two arcuately spaced series 53 and 55 of closely spaced cooling fins 57 extending axially and partially circumferentially from an intermediate area of plenum space 59 into which cooling air is delivered for further travel in opposite directions between the cooling fins 57.

In order to supply air for travel over the cooling fins 37, 47 and 57, an air delivery system is provided. In accordance with the invention, the air delivery system includes (See FIG. 1) a fan 63 mounted on and driven by a portion of the rotor shaft 23 extending exteriorly of the end wall 17, together with a shroud 65 which encloses the fan 63 and includes an inlet 67 co-axial with the fan 63 and (See FIG. 4) an arcuately extending discharge outlet 69 aligned axially with the area occupied by the hollow housing cooling fins 37. The air delivery system further includes wall means in the form of an arcuate plate 75 (See FIGS. 1, 4, 5, 6, and 8) including a first portion for shrouding or covering the radially outer ends of the hollow housing cooling fins 37 so as to form between the fins 37 a plurality of cooling passages 77 which are open at each end adjacent to the end walls 17 and 19. Still further, the air delivery system includes a duct or conduit 81 which (See FIGS. 1, 4 and 5) is formed, in part by another portion of the plate 75 and which extends between the shroud discharge outlet 69 and the adjacent ends of the hollow housing cooling air passages 77.

Respective cooling air passages 87 and 97 are also formed (See FIGS. 5 and 6) along each of the end walls 17 and 19 by attachment thereto of covers 101 and 103 which engage the axially outer edges of the cooling fins 47 and 57.

Air is supplied to the cooling passages 97 associated with the end wall 19 remote from the fan 63 by including in the hollow housing 13 (See FIGS. 2 and 7) an axially extending conduit, passage, or duct 105 located in adjacent relation to the cooling fins 37. Further, in this regard, the remote end wall 19 includes (See FIGS. 2 and 7) a three-sided portion 107 which meets with the adjacent end of the duct 105 in the hollow housing 13 and includes a curved wall 109 which deflects the incoming air toward the plenum space 59 (See FIG. 6) between the arcuately spaced series 53 and 55 of cooling fins 57 or passages 97.

More specifically, the shroud 65 is formed (See FIGS. 1, 3 and 4) at one end of the engine 11 from inner and outer members 111 and 113 respectively, with the inner shroud member 111 being suitably fixed to the adjacent end wall 17 in engagement with the arcuately spaced series 43 and 45 of cooling fins 47, thereby providing the before-mentioned cover 101. As already indicated, such engagement of the inner shroud member 111 with the ends of the cooling fins 47 defines (See FIG. 5) the cooling passages 87 which extend in opposite directions from the supply plenum 49 which communicates with the shroud outlet 69.

The outer shroud member 113 (See FIGS. 1 and 3) is suitably fixed to the inner member 111 so as to include therein the fan 63 which is preferably of the centrifugal or radial type and which includes a series of radially extending forwardly curved vanes 115 and a circumferentially extending radial discharge area or opening 117 (See FIG. 1) located between upper and lower flanges 119 and 121. The outer shroud member 113 is formed with the air inlet 67 which affords axially inward air flow into the fan 63. The periphery of the outer shroud member 113 around the air inlet 67 forms (See FIG. 1) a labyrinthine seal 123 with a portion of the fan 63 and is connected to walls forming a spiralling, doughnut-like shroud portion 131 which extends radially outwardly from the fan 63.

As shown best in FIGS. 3 and 4, the spiralling portion 131 of the shroud 65 extends in the clockwise direction, i.e., the direction of intended rotor rotation as indicated by the arrow 120 in FIG. 3, from about 10:00 o'clock to about 1:00 o'clock (12:00 o'clock being at the top of the view) for a total arcuate distance of about 450°. The shroud 65 is formed so as to deliver air to the outlet 69 to maintain an approximation of uniform pressure at the outlet 69. In this regard, the radial dimension of the spiralling shroud portion 131 gradually increases from 10:00 until about 6:00 o'clock, thereafter decreases until about 9:00 o'clock, thereafter increases to about 10:00 o'clock, and thereafter decreases to about 1:00 o'clock.

In addition, the outer shroud member provides a transversely extending ceiling or upper wall 133 along the length completely around the spiralling shroud portion 131, and the inner shroud member 111 provides a transversely extending floor 135 along the bottom of the spiralling shroud portion 131 between about 10:00 o'clock and about 7:00 o'clock, thereby permitting at least a part of the air which flows radially and arcuately outwardly from the fan 63 into the shroud 65 to rotate in a clockwise direction, as seen in FIGS. 3, 4 and 5, to the area between about 7:00 o'clock and 1:00 o'clock. The height of the ceiling 133 above the floor 135 gradually increases from about 10:00 o'clock to about 8:00 o'clock and thereafter remains substantially constant. The floor 135 is generally planar, except (See FIG. 4) for an inclined ramp 141 which extends from an elevated position at about 10:00 o'clock to about 3:00 o'clock where the ramp 141 merges into the floor 135. In addition, an inclined ramp 143 (See FIGS. 4, 5 and 6) extends downwardly below the floor 135 from about 6:00 o'clock to about 7:00 o'clock and to a position of engagement with the hollow housing 13 adjacent to the end of the duct 105. In the area between about 7:00 o'clock and 1:00 o'clock, the inner shroud member 111 terminates (See FIGS. 4 and 5) along an edge 137 in inwardly spaced relation from the plate 75 which ex-

tends from the outer wall 136 (See FIG. 3) of the outer shroud member 113 to thereby define the shroud outlet 69 which extends between about 7:00 o'clock to about 1:00 o'clock.

The shroud outlet 69 communicates separately with the cooling air passages 97 in the remote end wall 19 through the duct 105 in the hollow housing 13, separately with the plenum 49 space between the arcuately spaced air passages 87 along the adjacent end wall 17, and separately with the axially extending air passages 77 along the hollow housing 13. In this regard, the communication between the shroud outlet 69 and the end wall passages 87 and 97 occurs approximately between 7:00 and 8:00 o'clock, and the communication between the shroud outlet 69 and the axial passages 77 along the hollow housing 13 extends from approximately 8:00 to about 1:00 o'clock.

Further in regard to communication between the end wall passages 87 and 97 and the spiralling shroud portion 131, the inclined ramp 143 extending from in the area of about 6:00 o'clock to about 7:00 o'clock and from the floor 135 provided by the inner shroud member 113 leads the arcuately flowing air axially inwardly to the axial duct 105 in the hollow housing 13 leading to the air passages 97 in the remote end wall 19 and to the plenum space 49 at the adjacent end wall 17.

A further portion of the inner shroud member 111 in the form of an axially inwardly extending flange 151, shown best in FIGS. 5 and 9, is also employed to separate air flowing to the remote end wall cooling passages 97 from the air flowing to the adjacent end wall cooling passages 87 and to deflect air toward the plenum space 49. Still further in addition, a pair of curved deflectors 153 and 155 (See FIGS. 4, 5 and 9) extend from the inner shroud member surface 157 (See FIG. 9) adjacent to the end wall 17 so as to deflect air incoming from the shroud outlet 69 for travel into the plenum space 49 and through the end wall cooling passages 87.

In operation, rotation of the rotor 25 causes common rotation of the fan 63 which inhales cooling air through the shroud inlet 67 and which discharges cooling air radially outwardly into part of the spiralling shroud portion 131 between about 1:00 o'clock and 7:00 o'clock for movement arcuately toward the end of the shroud outlet 69 at about 7:00 o'clock, and for travel to the end wall cooling passages 87 and 97 and for travel through the duct 81 to the axially extending passages 77 along the hollow housing. In addition, the fan 63 also discharges cooling air radially outwardly and in the clockwise direction, as seen in FIG. 4, over the edge 137 into the shroud outlet 69 between about 7:30 and about 10:00 o'clock for travel through the duct 81 into the axial cooling passages 77 extending along the hollow housing 13.

The form of the shroud 65 in the area of the shroud outlet 69, i.e., from about 7:00 o'clock to about 1:00 o'clock, serves to create an area of substantially uniform pressure so as to afford substantially equal cooling air flow through all of the axially extending passages 77. At the ends of the hollow housing 13 from the fan, the cooling air exits directly from the passages 77 into the environment.

In addition, cooling air is also supplied through the outlet 69 from the shroud 65 to both of the end wall passages 87 and 97 for flow around the axis of the rotor 25 and radially outwardly directly into the environ-

ment. The head developed by the fan 63 is available to the end wall cooling passages 97 independently of air supply to the axial passages 77 and the end wall passages 87. In addition, air is supplied to the end wall cooling passages 87 independently of the end wall cooling passages 97 and the axial cooling passages 77, and air is supplied to the axial cooling passages 77 independently of the end wall cooling passages 87 and 97. Furthermore, the axial passages 77 extending along the hollow housing 13 are subject to substantial uniform pressure head, and the same pressure head is generally available in the plenum spaces 49 and 59 at the adjacent and remote end walls 17 and 19, except only for flow losses occurring in the axially extending housing duct 105 during travel to the remote plenum space 59. As a result of the foregoing construction, variation in pressure head available at the entrance to all of the various cooling passages 77, 87 and 97 is substantially minimized.

In addition, the arrangement for separately supplying cooling air to each of the end wall passages and to the axially extending housing passages is also applicable to housing passages which, while also extending axially, also extend, at least in part, at an angle to the housing axis. Such an arrangement would permit flow from the shroud to the housing passages in a manner avoiding a relatively sharp 90° change in direction.

Various of the features of the invention are set forth in the following claims.

We claim:

1. A rotary combustion engine comprising a hollow housing, a pair of spaced end walls interconnected with said hollow housing to form a cavity, a rotor shaft extending in said cavity and rotatably journaled by said end walls, fuel intake means communicating with said cavity, exhaust discharge means communicating with said cavity, a combustion zone in said cavity between said intake means and said exhaust discharge means, whereby said housing includes a sector which extends between said intake means and said exhaust discharge means and which is relatively hotter than the remaining portions of said housing, a plurality of cooling fins extending radially outwardly from said housing sector in generally parallel relation to said rotor shaft, a centrifugal fan driven by said rotor shaft and having a circumferentially extending radially open outlet, a shroud defined by first wall means enclosing said fan and extending radially outwardly from said fan outlet, said shroud communicating with said radially open circumferentially extending fan outlet and including a shroud discharge outlet, and second wall means including a first portion engaging the radially outer ends of said cooling fins to provide a plurality of cooling passages extending axially of said housing, and a second portion extending from said first portion and cooperating with said shroud to define a duct extending from said shroud discharge outlet to said plurality of cooling passages.

2. A rotary combustion engine in accordance with claim 1 wherein said shroud further includes an axially inner member mounted on one of said end walls and an axially outer member mounted on said inner member and having therein an air inlet for said fan.

3. A rotary combustion engine in accordance with claim 2 wherein said air inlet is concentric with said rotor shaft.

4. A rotary combustion engine in accordance with claim 1 therein said shroud discharge outlet has a lim-

ited arcuate extent and is aligned arcuately with said cooling passages.

5. A rotary combustion engine in accordance with claim 1 wherein said shroud includes means for maintaining substantially uniform air pressure at said shroud discharge outlet.

6. A rotary combustion engine comprising a hollow housing, a pair having spaced end walls interconnected with said housing to form a cavity, a rotor shaft extending in said cavity and rotatably journaled by said end walls, intake means communicating with said cavity, exhaust discharge means communicating with said cavity, a combustion zone in said cavity between said intake means and said exhaust discharge means whereby said housing includes a sector which extends between said intake means and said exhaust discharge means and which is relatively hotter than the remaining portions of said housing, a first plurality of cooling passages extending axially along the outer surface of said housing sector, a second plurality of cooling passages extending arcuately along the outer surface of one of said end walls, a centrifugal fan driven by said rotor shaft and hving a circumferentially extending radially open outlet, a shroud defined by walls means enclosing said fan and extending radially outwardly from said fan outlet, said shroud communicating with said radially open circumferentially extending fan outlet and including a shroud discharge outlet, and duct means independently communicating each of said first and second pluralities of cooling passages with said shroud discharge outlet.

7. A rotary combustion engine comprising a hollow housing, a pair of spaced end walls interconnected with said housing to form a cavity, a rotor shaft extending in said cavity and rotatably journaled by said end walls, intake means communicating with said cavity, exhaust discharge means communicating with said cavity, a combustion zone in said cavity between said intake means and said exhaust discharge means whereby said housing includes a sector which extends between said intake means and said exhaust discharge means and which is relatively hotter than the remaining portions of said housing, a first plurality of cooling passages extending axially along the outer surface of said housing, a second plurality of cooling passages extending arcuately along the outer surface of one of said end walls, a third plurality of cooling passages extending arcuately along the outer surface of the other of said end walls, a fan driven by said rotor shaft, a shroud enclosing said fan and including an air discharge outlet, and duct means independently communicating each of said first and second and third pluralities of cooling passages with said shroud discharge outlet.

8. A rotary combustion engine in accordance with claim 6 wherein said fan is located adjacent to the other of said end walls, and wherein said duct means includes a duct extending in said housing adjacent to said first plurality of cooling passages and communicating between said shroud discharge outlet and said second plurality of cooling passages.

9. A rotary combustion engine in accordance with claim 6 wherein said shroud includes an axially inner

member mounted on one of said end walls and an axially outer member mounted on said inner member and having therein an air inlet for said fan.

10. A rotary combustion engine in accordance with claim 9 wherein said air inlet is concentric with said rotor shaft.

11. A rotary combustion engine in accordance with claim 6 wherein said shroud discharge outlet has a limited arcuate extent and is aligned arcuately with said first plurality of cooling passages.

12. A rotary combustion engine in accordance with claim 6 wherein said shroud includes means for maintaining substantially uniform air pressure at said shroud discharge outlet.

13. A rotary combustion engine comprising a hollow housing, a pair of spaced end walls interconnected with said hollow housing to form a cavity, a rotor shaft extending in said cavity and rotatably journaled by said end walls, fuel intake means communicating with said cavity, exhaust discharge means communicating with said cavity, a combustion zone in said cavity between said intake means and said exhaust discharge means, whereby said housing includes a sector which extends between said intake means and said exhaust discharge means and which is relatively hotter than the remaining portions of said housing, a centrifugal fan driven by said rotor shaft and having a circumferentially extending radially open outlet, a shroud defined by first wall means enclosing said fan and extending radially outwardly from said fan outlet, said shroud communicating with said radially open circumferentially extending fan outlet and including a shroud discharge outlet, a plurality of cooling fins extending radially outwardly from said housing sector in generally parallel relation to said rotor shaft, second wall means including a first portion engaging the radially outer ends of said cooling fins to provide a first plurality of cooling passages extending axially of said housing, and a second portion extending from said first portion and cooperating with said shroud to define a conduit extending from said shroud discharge outlet to said first plurality of cooling passages, a second plurality of cooling passages extending arcuately along the outer surface of one of said end walls, a third plurality of cooling passages extending arcuately along the outer surface of the other of said end walls, and duct means independently communicating each of said second and third pluralities of cooling passages with said shroud discharge outlet independently of each other and independently of said conduit.

14. A rotary combustion engine in accordance with claim 13 wherein said fan is located adjacent to one of said end walls, and wherein said duct means includes a duct extending in said housing adjacent to said first plurality of cooling passages, and communicating between said third plurality of cooling passages and said shroud discharge outlet.

15. A rotary combustion engine in accordance with claim 13 wherein said shroud includes means for maintaining substantially uniform air pressure at said shroud discharge outlet.

\* \* \* \* \*

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,845,747 Dated November 5, 1974

Inventor(s) James A. Donohue, John H. Winston, and Harry M. Ward, III

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 4, line 67,

"therein" should be  
---wherein---

Claim 6, line 8,

"having" should be  
---of---

Claim 6, line 24,

"walls means" should be  
---wall means---

Signed and sealed this 1st day of July 1975.

(SEAL)

Attest:

RUTH C. MASON  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents  
and Trademarks