

Filed Aug. 29, 1962

INTERNAL COMBUSTION ENGINE

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FIG. 1 is a cross-sectional view of a mechanical assembly, likely a pump or valve, showing a central rotating component (14) with a central shaft (141) and a central opening (142). The assembly is housed within a complex, multi-chambered structure (10) with various internal components and seals. The diagram is labeled with numerous reference numerals (1-27) and includes a vertical section line II-II at the top and bottom.

Michael J. Striker
ATTORNEY

Aug. 17, 1965

H. DILLENBERG

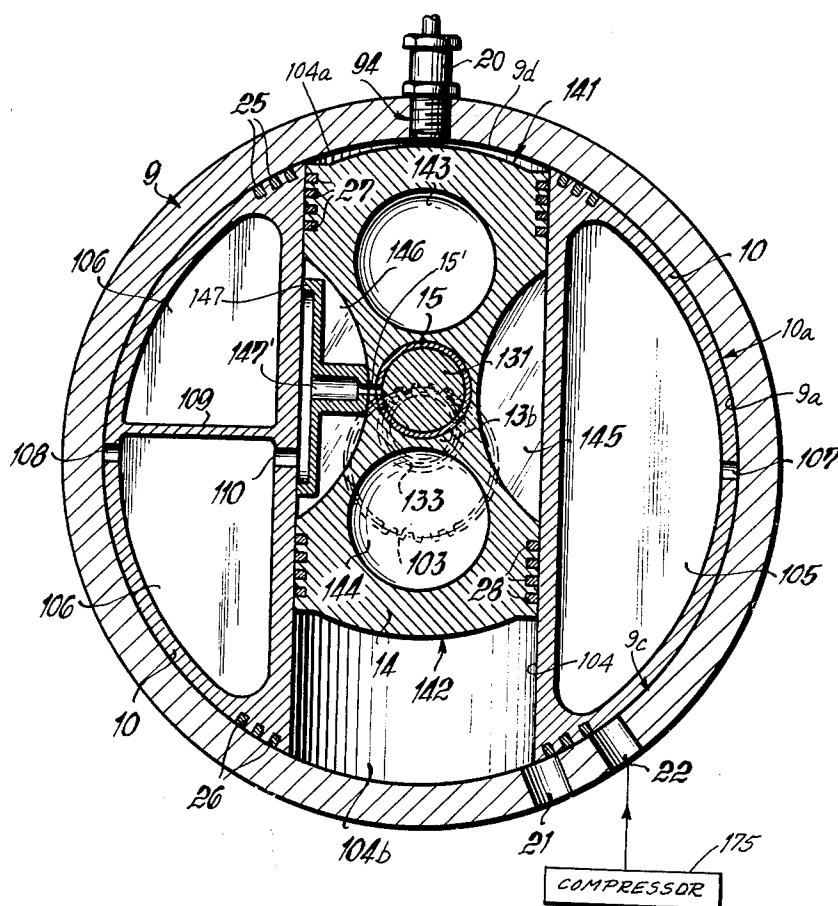
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FIG. 2



INVENTOR:
HORST DILLENBERG

BY

Michael S. Striker
ATTORNEY

Aug. 17, 1965

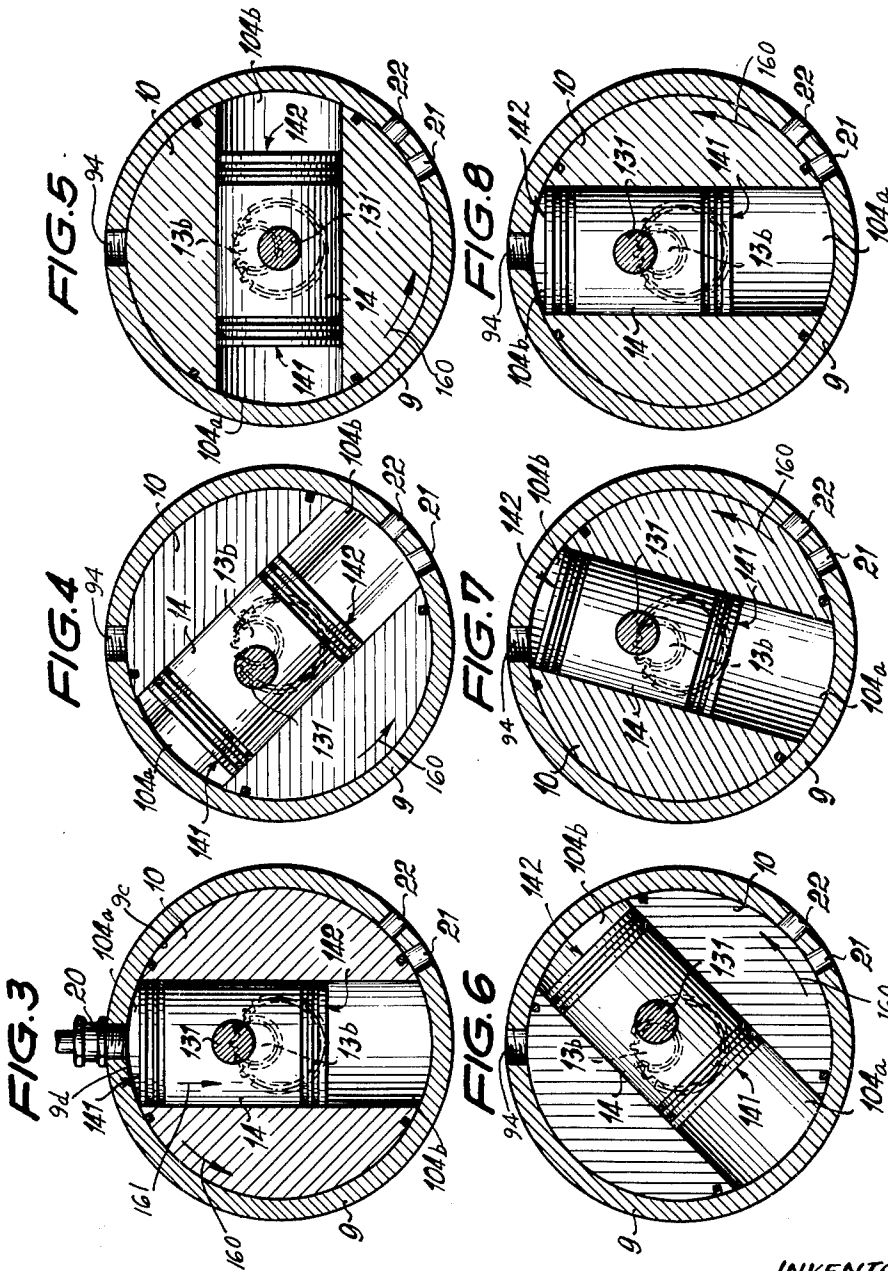
H. DILLENBERG

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INVENTOR:
HORST DILLENBERG

BY

Michael S. Striker
ATTORNEY

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INTERNAL COMBUSTION ENGINE

Horst Dillenber, Koeniggratzer Strasse 25,

Haan, Rhineland, Germany

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The present invention relates to internal combustion engines in general, and more particularly to internal combustion engines of the rotary cylinder type.

In many internal combustion engines which are used in automotive vehicles and for similar purposes, the wheels are driven by a crank shaft whose crank pins receive motion from connecting rods. The connecting rods are coupled to pistons which are reciprocable in the cylinder block in response to expansion of combustion products. Such engines are subdivided into two main groups including diesel engines and Otto engines, depending on whether combustion of the fuel-air mixture is spontaneous or must be initiated by an ignition system.

As regards their mode of operation, the engines are grouped into two-stroke-cycle and four-stroke-cycle engines. In a four-stroke-cycle engine, transmission of torque from the piston to the crank shaft occurs during the third (power) stroke. It requires no explanation that the connecting rods and their bearings add to the weight, dimensions and cost of an internal combustion engine and that they generate at least some friction with attendant losses in output energy of the engine.

Accordingly, it is an important object of my invention to provide an exceptionally simple, rugged and inexpensive internal combustion engine with a small number of component parts, wherein frictional losses are reduced to a minimum with attendant improvement in the efficiency of the engine, which is capable of transmitting rotary motion from the piston directly to the output shaft, which operates without connecting rods, and which is equally useful for operation on the diesel principle or as an Otto engine.

Another object of my invention is to provide an internal combustion engine of the just outlined characteristics which takes greater advantage of the strokes of its piston or pistons to increase the output torque, which is constructed in such a way that each displacement of each piston produces a compression stroke, which weighs less than any equivalent conventional engine, and which contributes to a substantial reduction in the size and weight of an automotive vehicle or another machine wherein my invention is put to use.

With the above objects in view, the invention resides in the provision of an internal combustion engine which is especially suited for use as a diesel engine and which comprises a housing having an internal cylindrical space, a cylinder rotatably received in the internal space and having a cylindrical through bore defining a cylinder chamber whose axis is perpendicular to the axis of the internal space, a piston reciprocably received in the cylinder chamber, and motion transmitting means for rotating the cylinder in response to reciprocation of the piston.

In accordance with a feature of my invention, the motion transmitting means comprises a single-throw crank shaft whose coaxial journals are parallel to the axis of but are eccentric with respect to the cylinder and whose crank pin is rotatably mounted in the piston so that the piston may transmit rotation to the crank shaft and that the latter may transmit rotation to the cylinder, preferably through a step-down transmission which causes the cylinder to complete one-half of a full revolution

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when the crank pin completes a full revolution about the common axis of the journals.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of a specific embodiment with reference to the accompanying drawings, in which:

FIG. 1 is an axial section through an internal combustion engine which embodies my invention;

FIG. 2 is a transverse section as seen in the direction of arrows from the line II—II of FIG. 1;

FIG. 3 is a smaller scale axial section through the housing and through the cylinder of the engine in a position corresponding to that of FIG. 1 or 2;

FIG. 4 illustrates the engine in section and in a position its parts assume when the cylinder has been rotated through 45 degrees in an anticlockwise direction, as viewed in FIG. 3;

FIG. 5 illustrates the engine in a position its parts assume when the cylinder has been rotated through 90 degrees;

FIG. 6 is a similar section through the engine showing the parts in a position they assume after the cylinder has been rotated through about 135 degrees;

FIG. 7 shows the moving parts of the engine in a position they assume after the cylinder has been rotated through little less than one-half of a full revolution; and

FIG. 8 is an axial section through the engine in a position its parts assume when the cylinder has completed one-half of a full revolution.

Referring now in greater detail to the drawings, and first to FIGS. 1 and 2, there is shown an internal combustion engine which comprises a housing 9 defining an internal cylindrical space 9a and having its axial ends connected to covers or caps 91, 92 by bolts 9b. The space 9a accommodates a cylinder 10 whose peripheral surface 10a is in sealing engagement with the internal surface 9c of the housing which surrounds the space 9a. The cylinder 10 is rotatable in the housing 9 and is formed with a diametral through bore 104 whose axis is perpendicular to the axis of the cylindrical space 9a and whose open axial ends terminate at the internal surface 9c of the housing 9. The axial ends of the cylinder 10 are mounted in coaxial antifriction bearings 11, 12 respectively provided in the caps 91, 92.

The bore 104 constitutes the cylinder chamber of the engine and accommodates a reciprocable piston 14 whose identically configured end faces are respectively identified by reference numerals 141, 142. The operative connection between the piston 14 and the cylinder 10 comprises a single-throw crank shaft 13 whose crank pin 131 is perpendicular to the axis of the chamber 104 and which is rotatable in a sleeve bearing 15 provided in a diametral aperture of the piston 14. The axis of the pin 131 intersects the axis of the piston 14 and its ends are rigid with the lever arms 131a, 131b which are respectively received in cutouts 101a, 101b provided in the cylinder 10 at diametrically opposite sides of the axis of the piston 14 and communicating with the chamber 104. The radius of each of these cutouts exceeds the throw of the crank pin 131. The coaxial journals 13a, 13b of the crank shaft 13 are rotatable in pairwise arranged antifriction bearings 16, 17 and 18, 19 respectively provided in covers 91, 92, and it will be noted that these journals are parallel with the axis of the internal space 9a but are eccentric with respect to the cylinder 10 by a distance equal to the throw of the crank pin 131, i.e., the eccentricity of the crank pin 131 with respect to the journals 13a, 13b is the same

as the eccentricity of these journals with respect to the cylinder 10.

The motion transmitting means between the piston 14 and the cylinder 10 further comprises a step-down transmission including a pair of pinions 132, 133 which are respectively secured to and are coaxial with the journals 13a, 13b, and internal gears 102, 103 provided in the cylinder 10 and mating with the pinions 132, 133 so that the transmission drivingly couples the crank shaft to the cylinder.

I prefer to assemble the crank shaft 13 of two components including a left-hand component and a right-hand component, as viewed in FIG. 1. These components are coupled to each other at 131c, i.e., substantially midway between the journals 13a, 13b. The common axis of the gears 102, 103 coincides with the axis of the cylinder 10.

Owing to the fact that the throw of the crank pin 131 equals the eccentricity of the journals 13a, 13b with respect to the cylinder 10, the cylinder completes a full revolution in response to two revolutions of the crank shaft 13. In other words, when the piston 14 reciprocates and when the crank pin 131 completes a full revolution, the cylinder 10 is rotated through 180 degrees and the piston completes two full compression and expansion strokes.

Furthermore, such eccentric mounting of the crank pin 131 and of the journals 13a, 13b causes the end faces 141, 142 of the piston 14 to move closer to a certain section 9d of the internal surface 9c. Thus, when the piston has completed a compression stroke and assumes the position of FIG. 1, 2, or 3, its end face 141 is very close to the surface section 9d whereas, when the piston thereupon completes an expansion stroke in the opposite direction (FIG. 5), its other end face 142 is more distant from the surface 9c than the minimal distance between the end face 141 and the surface section 9d in FIGS. 1, 2 and 3. When the piston thereupon completes a next compression stroke (FIG. 8), its other end face 142 moves into close proximity of the surface section 9d. This surface section 9d is traversed by an aperture 94 for a fuel-injecting nozzle 20 which admits atomized fuel to the chamber portion 104a at the time the piston 14 has completed its stroke in upward direction, as viewed in FIGS. 1, 2 and 3. The housing 9 is formed with two ports 21, 22 which are angularly spaced from the aperture 94 through 230-250 degrees, as viewed in the direction in which the cylinder 10 rotates. The port 21 permits escape of combustion products and the port 22 is connected to a compressor 175 to admit compressed air into the chamber 104. It will be noted that each of the chamber portions 104a, 104b first communicates with the port 21 to permit escape of the products of combustion and thereupon with both ports so that compressed air may expel the remaining combustion products.

The manner in which the chamber 104 is sealed is shown in FIGS. 1 and 2. The peripheral surface of the cylinder 10 is formed with recesses for annular sealing members 25, and 26 which are disposed at diametrically opposite sides of the chamber 104 and which engage the internal surface 9c. The piston 14 is provided with two groups of piston rings 27, 28 which are accommodated in peripheral recesses respectively located in the proximity of the end faces 141, 142.

As shown in FIGS. 1 and 2, the piston 14 and the cylinder 10 are formed with cavities which reduce the weight of the engine and which also facilitate cooling and lubrication of moving parts. The piston 14 is formed with cavities 143, 144, 145, 146, and the cylinder 10 is formed with cavities 105, 106. The cavities 105, 106 are filled with a coolant, e.g., oil, which may simultaneously serve as a lubricant. These cavities communicate with openings 107, 108 which convey lubricant to the internal surface 9c of the housing 9. The cavity 106 is subdivided into two equal halves by an internal partition

109 of the cylinder 10, and this partition serves as a deflecting baffle for lubricant flowing from the chamber 106, through an opening 110 in the cylinder and into the cavity 146 of the piston 14. The cavity 146 accommodates a nipple 147 whose channel 147' leads to registering passages or channels 15' extending through the piston 14 and through the bearing sleeve 15 so that lubricant may reach the crank pin 131. The cutouts 101a, 101b and the antifriction bearings 11, 12, 16-19 receive lubricant through channels 151, 152 provided in the cylinder 10 and alignable with channels 153, 154 respectively provided in the covers 91, 92. The channels 153, 154 are sealable by screws 155, 156.

The operation of my engine will now be described with reference to FIGS. 3 through 8. It is assumed that the engine of my invention is a diesel engine. In FIG. 3, the piston 14 and the cylinder 10 assume positions corresponding to those of FIG. 1 or 2, i.e., the end face 141 of the piston is close to the surface section 9d so that the volume of the upper chamber portion 104a is reduced to a minimum. This chamber portion 104a accommodates a supply of compressed air which forms a combustible mixture with atomized fuel injected by the nozzle 20 at the time the piston assumes the position of FIG. 3. The direction in which the cylinder 10 rotates is indicated by an arrow 160.

The fuel-air mixture is ignited automatically and the expanding combustion products cause the piston 14 to move in a direction indicated by arrow 161 so that the volume of the chamber portion 104a increases simultaneously with rotation of the cylinder in an anticlockwise direction and into the position which is shown in FIG. 4. When the cylinder assumes such position in response to rotary torque transmitted to it by the step-down transmission 102, 103, 132, 133, the cylinder has rotated through 45 degrees whereas the crank pin 131 has rotated through 90 degrees about the common axis of the journals 13a, 13b.

While the piston moves its end face 141 away from the internal surface 9c, the opposite end face 142 expels combustion products from the chamber portion 104b and through the port 21 at the time the cylinder 10 assumes a position somewhere between the positions of FIGS. 3 and 4, and the chamber portion 104b is filled with air when it is permitted to communicate with the port 22, i.e., when the cylinder 10 rotates toward the position of FIG. 4.

The volume of the chamber portion 104a continues to increase while the cylinder 10 rotates through the positions of FIGS. 5, 6, 7 and finally assumes the position of FIG. 8 in which the end face 142 is nearest to the surface section 9d. In the position of FIG. 5, the cylinder 10 has been rotated through 90 degrees whereas the crank pin 131 has rotated through one-half of a complete revolution. The volume of the chamber portion 104a continues to increase as the piston 14 now starts a compression stroke in that its end face 142 begins to move toward the internal surface 9c and reduces the volume of the chamber portion 104b (FIGS. 6 and 7) so that air admitted through the port 22 is further compressed and forms a mixture with fuel admitted through the nozzle 20 at the time the cylinder 10 reaches the position of FIG. 8, i.e., when the cylinder has completed one-half of a full revolution and when the crank pin 131 has completed a full revolution. The cycle is then repeated in that the expanding combustion products compel the end face 142 to move away from the surface section 9d and the end face 141 expels combustion products from the chamber portion 104a as soon as the latter begins to communicate with the port 21.

An important advantage of the feature that the angular distance between the nozzle 20 and the ports 21, 22 is about 230-250 degrees is that such construction improves the efficiency of the engine because torque transmitted by expanding combustion products to the crank

pin 131 is of longer duration than in conventional interval combustion engines of which I am aware at this time. Thus, the length of expansion strokes exceeds the length of compression strokes. In fact, such construction enables the engine to discharge combustion products at atmospheric pressure.

When the cylinder 10 completes a full revolution, the crank pin 131 has completed two full revolutions and the piston 14 has performed two expansion and two compression strokes. It will be seen that an expansion stroke always occurs simultaneously with a compression stroke and that each such stroke takes place while the cylinder completes one-half of a full revolution.

As stated above, the engine of my invention was shown in a form which is especially advantageous if the engine operates on the diesel principle because it can be operated at high compression and because the moving parts may be sealed in an extremely simple way. Of course, the engine is equally useful for operation at lower pressures as an Otto engine. All that is necessary is to replace the nozzle 20 by suitable igniter means to alternately ignite the fuel-air mixture in the chamber portions 104a, 104b. The fuel-air mixture is then admitted through the port 22.

Losses due to friction are minimal in an engine of the above outlined characteristics because the engine operates without connecting rods since the piston is coupled directly to the crank shaft. The crank shaft transmits rotary motion to one or more driven parts, depending on the intended use of my engine.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A diesel engine, comprising a housing having an internal cylindrical space and an internal cylindrical surface surrounding said space; a cylinder rotatably received in said space and having a diametral through bore defining a cylinder chamber whose axis is perpendicular to the axis of said space; a piston reciprocally received in said chamber and having two end faces; motion transmitting means operatively connected with said cylinder and with said piston for rotating the cylinder in said space in response to reciprocation of said piston in said chamber, said cylindrical surface having a section which is nearest to the one and thereupon to the other end face of said piston during each revolution of said cylinder and said housing having a pair of ports communicating with said space, each of said ports communicating with the one and thereupon with the other axial end of said chamber during each revolution of said cylinder; and fuel-injecting nozzle means provided in said surface section for injecting fuel into said chamber, the angular distance between said nozzle means and said ports as seen in the direction of rotation of said cylinder exceeding 180°.

2. An internal combustion engine, comprising a housing having an internal cylindrical space; a cylinder rotatably received in said space and having a diametral through bore defining a cylinder chamber whose axis is perpendicular to the axis of said space, said cylinder

further having at least one lubricant-containing internal cavity and opening means providing a communicating passage between said cavity and said chamber; a piston reciprocally received in said chamber and having a diametral aperture and channel means communicatively connecting said opening means with said aperture; and motion transmitting means operatively connected with said cylinder and with said piston for rotating said cylinder and with said piston for rotating said cylinder in response to reciprocation of said piston, said motion transmitting means comprising a crank shaft having journals eccentric with respect to and parallel with the axis of said cylinder and a crank pin rotatably received in said diametral aperture whereby said crank pin is automatically lubricated by lubricant contained in said cavity.

3. An internal combustion engine, comprising a housing having an internal cylindrical space; a cylinder rotatably received in said space and having a diametral through bore defining a cylinder chamber whose axis is perpendicular to the axis of said space, said cylinder further having at least one lubricant-containing internal cavity and opening means providing a communicating passage between said cavity and said chamber; a piston reciprocally received in said chamber and having a diametral aperture and channel means communicatively connecting said opening means with said aperture; a bearing sleeve received in said aperture and having channel means in registry with said first mentioned channel means; and motion transmitting means operatively connected with said cylinder and with said piston for rotating said cylinder in response to reciprocation of said piston, said motion transmitting means comprising a crank shaft having journals eccentric with respect to and parallel with the axis of said cylinder and a crank pin rotatably received in said bearing sleeve whereby said crank pin is automatically lubricated by lubricant contained in said cavity.

4. An engine as set forth in claim 3, wherein said cylinder comprises baffle means provided in said cavity thereof for deflecting lubricant into said opening means.

5. An engine as set forth in claim 3, wherein said cylinder has additional opening means permitting flow of lubricant from said cavity against that surface of said housing which surrounds said internal space.

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RICHARD B. WILKINSON, *Primary Examiner*.
KARL J. ALBRECHT, *Examiner*.