SEPARATOR ARRANGEMENT FOR INTERNAL COMBUSTION ENGINE

Filed Sept. 11, 1959
The present invention relates to separator arrangements for internal combustion engines, and more particularly to an arrangement for separating particles of a liquid lubricant from a gaseous component of the fuel mixture, the combustion of which provides the energy of the engine.

In two-stroke cycle gasoline engines it is common to provide the cylinder with a transfer port which connects the crankcase of the engine with the combustion space in the cylinder. Air of combustion is drawn into the crankcase and is compressed during the downward stroke of the piston. The precompressed air is then admitted to the cylinder through the transfer port. While passing through the crankcase, the air entrains droplets of liquid lubricant which cause smoking of the engine. When they reach the combustion chamber and are admixed to the fuel.

It is the object of the invention to provide a centrifugal separator of the air into the air, and to return the separated lubricant to the crankcase.

Another object of the invention is to provide a centrifugal separator by the engine itself, but to permit operation of the centrifugal separator at a rotary speed greater than the engine speed.

With these and other objects in view, the invention provides for an internal combustion engine a centrifugal separator having a rotor, an intake duct communicating with the crankcase of the engine, and a discharge duct communicating with a port in the engine cylinder. The centrifugal separator is actuated by motion transmitted by means connected to the rotor of the separator and to the crankshaft of the engine for rotating the rotor at a speed different from, and preferably greater than, the rotary speed of the crankshaft.

In its more specific aspects, the invention provides for a housing, a centrifugal basket rotatably mounted in the housing in such a manner as to separate the space in the housing into two portions. The basket communicates with both portions so that fluid may flow from one portion to the other through the basket only. These elements form a centrifugal separator the two space portions of which communicate with the crankcase of the engine and with a port of the cylinder by means of an intake duct and a discharge duct respectively. The basket is rotated at a speed different from that of the engine crankshaft.

The air of combustion entering the separator housing is preferably passed through the centrifugal basket in a radially inward direction. The lubricant particles entrained by the stream of air are thereby caused to impinge first on portions of the basket or rotor which are relatively remote from the axis of rotation. Being somewhat thicker and more viscous, they adhere to the rotor and are rapidly accelerated in a tangential direction by the movement of the rotor until their speed is sufficiently high to cause them to be thrown outwardly away from the rotor by centrifugal force.

The lubricant particles are therefore collected on the walls of the housing portion communicating with the intake duct of the separator and may be returned thereto from the crankcase by gravity.

Since the centrifugal force increases with the square of the rotary speed, the efficiency of the centrifugal separator is greatly enhanced by a high rotary speed of the basket or rotor. Means are provided for this reason to drive the basket or rotor at a speed which is higher than the speed of the engine, that is, the speed of the crankshaft. The lubricant particles are entrained by the stream of air through which they must pass before abutting against the separator housing.

According to an additional feature of the invention, the basket of the separator is provided with a filter element interposed in the path of the air between that portion of the housing space which communicates with the crankcase by means of the intake duct, and the interior space of the basket. The filter element forms a portion of the basket wall, and preferably a peripheral portion, and permits the passage of air into the basket of the separator, but interferes with the passage of oil particles into the basket. The filter element may consist of a woven wire screen or of a perforated metal sheet of substantially cylindrical shape forming the axially extending wall of the separator rotor.

It has been found that the effectiveness of the separator arrangement of the invention does not increase indefinitely with increasing speed of the rotor. While the rotor speed should be higher than the engine crankshaft speed under almost all conditions, the technical and economic effectiveness of the device may actually be decreased by too high a rotary speed of the separator. The centrifugal effect increases with speed as described above. The filtering effect, however, has to be taken into consideration well when the rotary speed of the basket is selected. Very high basket speed furthermore may require appreciable energy to be diverted from the engine output for driving the basket. The structural strength of the rotor must be increased for high speed operation. It will thus be understood that the best operating speed of the centrifugal separator must be determined for each individual case. The optimum speed is also influenced by the nature of the lubricant which is to be separated from the air of combustion, and by variable factors of engine operation such as the temperature prevailing in the crankcase.

It is, therefore, preferred to provide the rotor of the centrifugal separator with a variable speed transmission connected to the crankshaft of the engine so that the rotor can be driven at a speed which is adjustable when changes in operating conditions require. The transmission may be a belt transmission each pulley of which has two conical faces the distance of which is adjustable so that a V-belt will travel over the pulleys at an effective radius which can be increased by moving the pulley faces towards each other, and vice versa. Such a pulley arrangement provides a well-known steeply variable speed transmission.

The transmission drives a shaft on which the separator is mounted. It is also contemplated to mount the rotors of a plurality of separators on a common shaft. The rotors are each interposed in the path of an air stream flowing from the crankcase to one of a plurality of ports on the same cylinder, or to the ports of a plurality of cylinders.

The rotor shaft may also carry means for driving other devices associated with the engine. In the case of a motor cycle engine, a pulley arranged on the separator shaft may serve as a source of power for driving a dynamo, a blower for cooling air, a rotary control valve, or other auxiliary equipment.

The basket and cooperating portions of the housing should preferably be equipped with a seal which ensures substantially perfect separation of the two portions of the
space in the separator housing by the basket so that air can pass from one space portion to the other through the basket itself only. Since the seal must permit free rotation of the basket, it is preferably of the mechanical type such as a labyrinth packing. If the cylinder cooperating with a single separator has two transfer ports, the basket is arranged in the housing in such a manner as to prevent the space therein from three portions of which communicates with the intake duct whereas the other two respectively communicate with the cylinder ports.

Other features and many of the attendant advantages of this invention will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof, and wherein:

FIG. 1 shows a fragmentary front view of an internal combustion engine equipped with a preferred embodiment of the centrifugal separator of the invention;

FIG. 2 shows the device of FIG. 1 in radial section on the line II—II; and

FIG. 3 schematically illustrates the arrangement of two centrifugal separators of the invention on a common shaft, the separators being shown in axial section.

Referring now to the drawing and first to FIG. 1, there is shown the crankcase 1 of a single-cylinder two-stroke cycle gasoline engine on which the cylinder 31 is mounted. The cylinder is of the kind usual in this type of engine and has three kinds of ports, an intake port 33, an exhaust port 34, and two transfer ports 35 (only one of which is visible in the drawing) for receiving air of combustion from the crankcase 1 from which it is drawn through a port 36. A piston 37 is reciprocally mounted in the cylinder and actuates rotation of a crankshaft 21 mounted in the crankcase 1 and having a portion projecting from the crankcase as will become apparent as the description proceeds.

The substantially cylindrical housing 2 of a centrifugal separator is mounted on the crankcase 1 by means of a flanged connection 3. The intake duct connecting the housing 2 and the crankcase 1 has a cross section as great as that of the housing itself and is downwardly inclined towards the crankcase 1. The rotor shaft 4 of the centrifugal separator projects through the housing wall and passes also through a discharge duct 11 which communicates with the interior of the housing 2 at one end whereas the other end is connected to a transfer port 35 of the cylinder 31.

As best seen from FIG. 2, which shows the separator assembly of FIG. 1 in axial and radial section along line II—II, the rotor shaft 4 is journaled in bearings 5 and 6 and both ends thereof project from the housing 2. One end of the shaft carries a driven pulley 6. The basket-shaped separator rotor 7 is fixedly mounted on the shaft 4. It consists essentially of two annular end plates 8 axially spaced from each other and connected by a plurality of axially extending ribs 10 which support a cylindrical filter element 11. The annular end plates 9 are connected to the shaft by radial ribs between which axial openings 13 permit flow of fluid between the interior of the rotor 7 and a space in the housing 2 which communicates with two discharge ducts 11 provided with flange connections 12 for attachment to the transfer ports 35 of the cylinder 31.

The space in the housing 2 communicating with the discharge ducts 11 is separated from the remainder of the housing space by mechanical seals having cooperating annular elements 14a and 14b arranged on the outer surfaces of the end plates 9 and the inner circular surfaces of the housing 2 respectively. The sealing elements form a labyrinth packing which offers very high resistance to the passage of fluid but permits the rotor to rotate freely about the axis of the shaft 4. Fluid may thus flow from the crankcase 1 to the transfer ports of the cylinder 31 only through the filter element 8, the interior of the basket 7 and the openings 13.

The free end of the shaft 4 carries a V-belt pulley 15 which provides a convenient power take-off for auxiliary devices associated with or integrally connected with the engine.

The driven pulley 6 consists of a fixed pulley disc 17 which has a conical face arranged opposite an axially movable pulley disc 18 of substantially the same configuration. The movable disc 18 is urged toward the fixed disc 17 by one end of a strong compression spring 19 to the other end of which is attached to a collar on the shaft 4. A V-belt 20 is trained around the pulley 6. The effective diameter of the pulley 6 depends on the spacing of the discs 17 and 18.

The belt 20 is also trained around a second pulley constituted by a fixed pulley disc 21 and a movable pulley disc 22 substantially identical with the pulley discs 17 and 18 and mounted on a portion of the crankshaft 21 which projects from the crankcase 1. While the disc 23 is fixedly secured to the crankshaft, the disc 22 is axially slidable thereon, but secured against rotation by a key arrangement (not shown). The axial position of the disc 22 is adjusted by a forked control member 24 in which a portion of the disc is journaled. The control member 24 threadedly engages a threaded control spindle 25 which is rotatably mounted in the crankcase but the axial position of which is fixed. The spindle 25 is equipped with a crank by means of which the relative distance of the discs 22 and 23 can be adjusted. Movement of the discs 22 and 23 toward and away from each other results in an increase and decrease respectively of the effective diameter of the driving pulley jointly formed by them and thus varies the tension of the belt 20 which causes the pulley discs 17 and 18 to move relatively to each other. The entire pulley arrangement described constitutes a well-known stepless variable-speed transmission which permits the separator rotor to be operated at a speed different from, and preferably greater than the speed of the crankshaft 21.

It is apparent that the variable belt transmission illustrated in FIG. 2 may be replaced by any other variable speed transmission of known design, such as a gear or friction drive, without departing from the spirit of the invention.

As shown in FIG. 3, the single rotor of FIG. 2 communicating with two discharge ducts may be replaced by two rotor arrangements 16 mounted on a common shaft 32 and cooperating each with a single intake duct 33. The arrangement otherwise is the same as shown in FIGS. 1 and 2.

When operating the device of the invention of FIGS. 1 and 2 for the first time with an untried combination of lubricant and operating conditions, the crank of the control spindle 25 is turned forth and back until the most favorable rotor speed is experimentally determined. The variable speed transmission is selected in such a manner that the speed of the rotor even at the highest engine speed and the highest transmission ratio will not exceed the safe structural limits of the basket and of the filter material which is also subjected to appreciable centrifugal force.

Air drawn from the crankcase 1 passes into the cylindrical tubular space between the basket 7 and the cylindrical wall portion of the housing 2. It is then forced through the filter element 8 by the suction of the engine and the pressure created in the crankcase. Lubricant particles impinging on the filter element 8 and on other parts of the basket 7 adhere. A plurality of droplets coalesce to form larger drops which are no longer held to the basket by adhesion but which are thrown off centrifugally against the housing 2 on which they flow downward under the influence of gravity, and find their way back into the crankcase 1.
The air freely passes through the filter element 8 in a radially inward direction, and leaves the basket 7 in an annular path through the discharge ducts 11 and the transfer ports 35 of the cylinder.

Because of the high rotary speed of the basket, the filter element is practically self cleaning and requires but a minimum of maintenance. The kinetic energy of the lubricant particles thrown off from the basket at a high speed toward the housing 2 is too high to permit them to be again entrained by the stream of air moving radially inward toward and through the filter element.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that it is intended to cover all changes and modifications of the example of the invention herein chosen for the purpose of the disclosure which do not constitute departures from the spirit and scope of the invention set forth in the appended claims.

We claim:

1. In an internal combustion engine, in combination, a cylinder formed with a port for admitting fluid to said cylinder; a crankcase; a crankshaft rotatably mounted in said crankcase; a piston reciprocable in said cylinder for rotating said crankshaft; a centrifugal separator having a rotor, an intake duct communicating with said crankcase, and a discharge duct communicating with said port; and means for rotating said rotor at a speed different from the speed of said crankshaft.

2. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a space therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means mounted on said rotor shaft in said housing space so as to separate two portions thereof, said basket means communicating with said port; an intake conduit communicating with said crankcase and one of said portions; a discharge conduit communicating with the other one of said portions and with said port; and motion transmitting means connected to said rotor shaft and to said crankshaft for rotating said rotor at a speed different from the speed of said crankshaft.

3. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a space therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means mounted on said rotor shaft in said housing space so as to separate two portions thereof, said basket means communicating with said port; an intake conduit communicating with said crankcase and one of said portions; a discharge conduit communicating with the other one of said portions and with said port; and motion transmitting means connected to said rotor shaft and to said crankshaft for rotating said rotor at a speed different from the speed of said crankshaft.

4. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a space therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means mounted on said rotor shaft in said housing space so as to separate two portions thereof, said basket means being secured to said rotor shaft; an intake duct communicating with said crankcase and a discharge duct communicating with said port; and means for rotating said rotor at a speed different from the speed of said crankshaft.

5. In an internal combustion engine, in combination, a cylinder formed with a port for admitting fluid to said cylinder; a crankcase; a crankshaft rotatably mounted in said crankcase; a piston reciprocable in said cylinder for rotating said crankshaft; a centrifugal separator having a rotor, an intake duct communicating with said crankcase, and a discharge duct communicating with said port; and variable-speed transmission means connected to said rotor and to said crankshaft for rotating said rotor at a plurality of selected speeds, at least one of said speeds being different from the speed of said crankshaft.

6. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a space therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means mounted on said rotor shaft in said housing space so as to separate two portions thereof; a filter element on said basket means, said filter element forming a wall of said basket means and being located in one of said portions for permitting passage of a gaseous fluid from said one portion into said basket means, said basket means being formed with an opening communicating with the other one of said portion; an intake conduit communicating with said crankcase and said one portion; a discharge conduit communicating with the other one of said portions and with said port; and motion transmitting means connected to said rotor shaft and to said crankshaft for rotating said basket means at a speed different from the speed of said crankshaft.

7. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a space therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means rotatably mounted on said rotor shaft in said housing space so as to separate two portions thereof; a filter element on said basket means, said filter element forming a peripheral wall of said basket means and being located in one of said portions for permitting passage of a gaseous fluid from said one portion into said basket means, said basket means being formed with an opening communicating with the other one of said portions; an intake conduit communicating with said crankcase and said one portion; a discharge conduit communicating with the other one of said portions and with said port; and motion transmitting means connected to said basket means and to said crankshaft for rotating said basket means at a speed different from the speed of said crankshaft.

8. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a space therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means rotatably mounted on said rotor shaft in said housing space so as to separate two portions thereof; a screen element on said basket means, said screen element forming a wall of said basket means and being located in one of said portions for permitting passage of a gaseous fluid from said one portion into said basket means, said basket means being formed with an opening communicating with the other one of said portions; an intake conduit communicating with said crankcase and said one portion; a discharge conduit communicating with the other one of said portions and with said port; and motion transmitting means connected to said basket means and to said crankshaft for rotating said basket means at a speed different from the speed of said crankshaft.

9. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a space therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means rotatably mounted on said rotor shaft in said housing space so as to separate two portions thereof; a screen element on said basket means, said screen element forming a wall of said basket means and being located in one of said portions for permitting passage of a gaseous fluid from said one portion into said basket means, said basket means being formed with an opening communicating with the other one of said portions; an intake conduit communicating with said crankcase and said one portion; a discharge conduit communicating with the other one of said portions and with said port; and motion transmitting means connected to said basket means and to said crankshaft for rotating said basket means at a speed different from the speed of said crankshaft.
arate two portions thereof, said basket means communicating with said portions; a plurality of intake conduits respectively communicating with said crankcase and one of said portions of each one of said plurality of housing spaces; a plurality of discharge conduits respectively communicating with the other one of said portions of each one of said plurality of housing spaces and with said port; and motion transmitting means connected to said plurality of basket means and to said crankshaft for rotating said basket means at a speed different from the speed of said crankshaft.

10. In an internal combustion engine, in combination, a cylinder formed with a port; a crankcase; a crankshaft rotatably mounted in said crankcase; a housing enclosing a plurality of spaces therein; a rotor shaft spaced from said crankshaft and mounted in said housing; centrifugal basket means mounted on said rotor shaft in each of said housing spaces so as to separate two portions thereof, said basket means communicating with said portions; a plurality of intake conduits respectively communicating with said crankcase and one of said portions of each one of said plurality of housing spaces; a plurality of discharge conduits respectively communicating with the other one of said portions of each one of said plurality of housing spaces and with said port; and motion transmitting means connected to said rotor shaft and to said crankshaft for rotating said basket means at a speed different from the speed of said crankshaft.

11. In an internal combustion engine, in combination, a cylinder formed with a port for admitting fluid to said cylinder; a crankcase; a crankshaft rotatably mounted in said crankcase; a piston reciprocable in said cylinder for rotating said crankshaft; a centrifugal separator having a rotor shaft spaced from said crankshaft, a rotor mounted on said rotor shaft, an intake duct communicating with said crankcase, and a discharge duct communicating with said port; and motion transmitting means connected to said rotor and to said crankshaft for rotating said rotor at a speed greater than the speed of said crankshaft.

12. In an internal combustion engine as set forth in claim 2, said motion transmitting means including a variable-speed transmission interposed between said rotor and said crankshaft for rotating said basket means at a plurality of selected speeds, at least one of said speeds being different from the speed of said crankshaft.

References Cited in the file of this patent
UNITED STATES PATENTS

1,303,207  Kelly et al.  May 6, 1919
2,547,327  King  Apr. 3, 1951
2,893,362  Dalrymple  July 7, 1959
2,959,164  Janeway et al. Nov. 8, 1960