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INTERNAL COMBUSTION ENGINE OPERATING ON A FOUR STROKE CYCLE IN WHICH THE SUPERCHARGING IS EFFECTED, FOR INSTANCE, BY A SUPERCHARGE AND THE INJECTION OF THE FUEL BY AN INJECTION PUMP

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Fig. 1

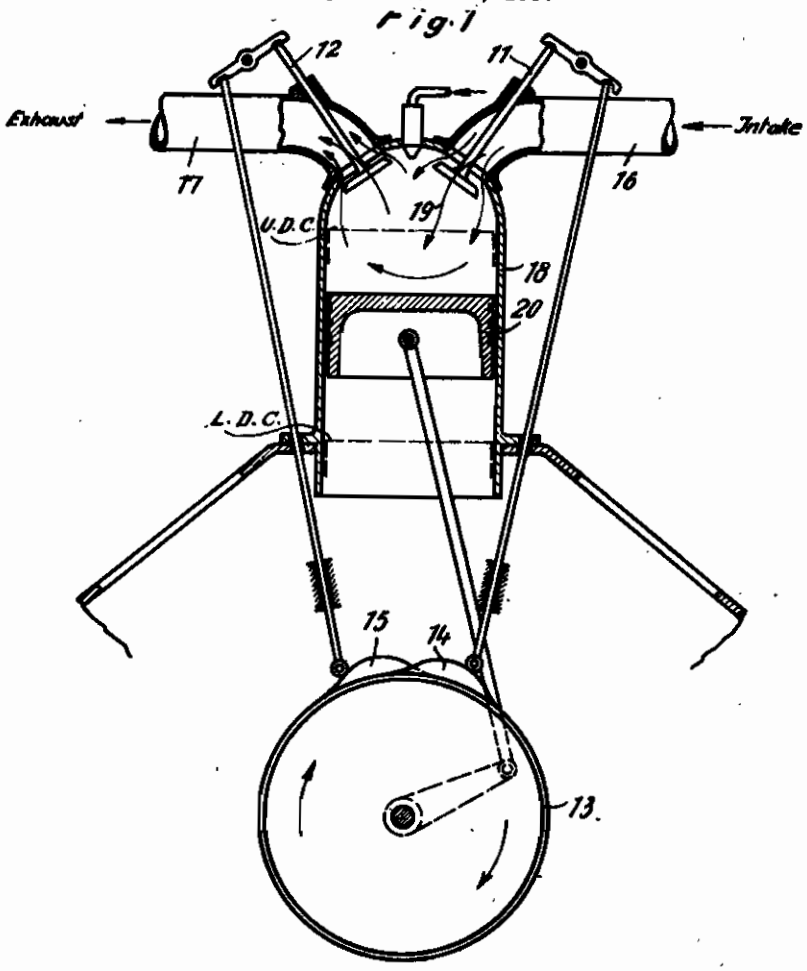
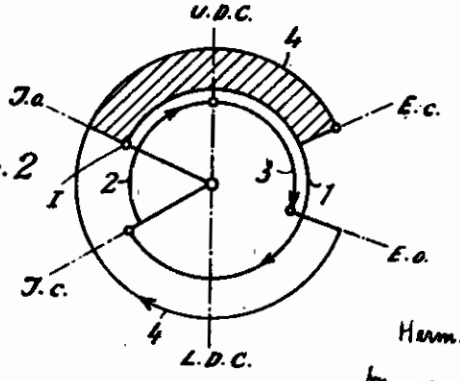


Fig. 2



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INTERNAL COMBUSTION ENGINE OPERATING ON A FOUR STROKE CYCLE IN WHICH THE SUPERCHARGING IS EFFECTED, FOR INSTANCE, BY A SUPERCHARGER AND THE INJECTION OF THE FUEL BY AN INJECTION PUMP

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This invention relates to an internal combustion engine operating on a four stroke cycle in which the supercharging is effected, for instance, by a supercharger and the injection of the fuel by an injection pump.

The power which may be obtained in the cylinder of an internal combustion engine during each power cycle is dependent upon the stress of the cylinder due to heat. This implies that even when the conditions for an increase in power are fulfilled the latter cannot be effected, since it would not be possible to adapt the cooling—regardless of whether a water or air cooling is involved—to the heat developed in the interior of the cylinder in such a manner that the material of the cylinder is not overheated. In this respect the conditions are particularly unfavorable in the case of an aero-engine in which only a limited space is available for the cooling device.

In the case of a two stroke internal combustion engine a considerable increase in the amount of heat exchanged during each power cycle has been made possible by scavenging the cylinder. At the end of the power stroke cooling air is caused to enter the cylinder in which it flows in a given direction, thus expelling the residual exhaust gases. This scavenging brings about an intensive cooling of the cylinder walls so that it is thus possible to attain cylinder powers which are a multiple of the powers of the four stroke internal combustion engines. The direct application of this method of scavenging developed for the two stroke engine to the four stroke engine encounters, however, such considerable difficulties that it has hitherto been impossible to carry this idea into practice.

By the present invention it is, however, possible to attain with relatively simple means considerable increases in power in a four stroke internal combustion engine in which the supercharging is effected, for instance, by a supercharger and the direct injection of the fuel by an injection pump. This is accomplished by the fact that the movements of the intake valve and the exhaust valve occur at spaced intervals so that the exhaust valve opens before the piston reaches the lower dead center and remains open beyond the upper dead center; i. e., during a portion of the movement of the intake valve towards the open position, which results in an overlapping of the open position of the valves before the piston has reached and after it has surpassed the upper dead center and therefore in an effective scavenging of the combustion chamber. The extent of the overlapping referred to the crank angle depends upon the operating conditions of the engine. An overlapping corresponding to a crank angle of about 80° is to be considered as the lower limit.

Here it is to be pointed out that also in the case of the internal combustion engines hitherto employed there results a certain overlapping of the movement of the exhaust valve towards the closed position and the movement of the intake valve towards the open position. This was, however, considered as an undesirable subordinate matter but had to be put up with, since it is practically impossible to suddenly close the exhaust valve at the end of the exhaust stroke which should remain if possible completely open till the end of the exhaust stroke and to suddenly open the intake valve at the beginning of the suction stroke. Owing to the control of both valves a certain overlapping of these two movements is unavoidable.

Furthermore, it is known to effect in four stroke internal combustion engines during the exhaust stroke beginning at the lower dead center and ending at the upper dead center a scavenging with cooling air after expansion of the exhaust gases. This scavenging is effected with the aid of an additional scavenging valve. The latter is opened only after the burnt gases have expanded; i. e., shortly before the piston reaches the upper dead center and remains open only until the piston reaches the upper dead center.

This presents the disadvantage that besides the use of further control parts, such as additional valves, the time available for an effective scavenging is so short owing to the late complete expansion of the burnt gases that an increase in power does not occur, since an effective inner cooling of the combustion chamber is not possible.

According to the invention the overlapping is, however, brought about intentionally and considerably increased as compared to the overlappings hitherto obtained. The purpose is, as above pointed out, to prevent an overheating of the cylinder by intensely cooling the interior of the cylinder so as to increase the power as well as to improve the fuel mixture, i. e. the contents of the cylinder, by a proper scavenging; in other words, to increase the power of the engine to a further extent.

Of considerable importance is, furthermore, the fact that it is possible to vary the magnitude of the overlapping in operation by certain simple means; for instance, by shiftable cam drums in the case of radial engines, one of said cam drums controlling the intake valves and the other the

exhaust valves. In this manner, a means is particularly obtained in order to adapt—together with other devices serving to control the power (for instance, a fuel pump, boost control, supercharger gearing, exhaust gas turbine, throttles etc.)—the operation of the engine and the condition of the cylinder to the requirements of operation. This possibility appears to be of particular importance, since as is well known the pressure conditions before and behind the supercharger and therefore also in the cylinder depends upon the altitude of flight. Since the overlapping of the movement of the control members (valves, slide valves etc.) may be varied, it is possible to take into consideration the variations of pressure in the cylinder resulting from the variations of the altitude of flight.

In the accompanying drawing is shown an embodiment of the invention in which the essential parts of the invention are shown in diagrammatic form.

Fig. 1 is a sectional view of a cylinder of a radial engine provided with its control members.

Fig. 2 is a graphical representation of the movements of the piston and valves.

As will be seen from the drawings, the control of the intake valve 11 and the exhaust valve 12 is effected, for instance, by a drum cam 13 through the cams 14 and 15 in such a manner that a current of cooling air 19 is forced by a blower (not shown) into the cylinder 18 in the direction as indicated by the arrows through the intake pipe 16 and passes through the still open hot exhaust valve 12 and the exhaust pipe 17 into the atmosphere, so that a considerable inner cooling and a proper scavenging of the cylinder is thereby possible. The cams 14 and 15 on the drum cam 13 are so shaped in this embodiment and displaced with respect to each other as to result in the following control periods for the intake valve and exhaust valve as is shown in Fig. 2.

Commencing from point I (Fig. 2) the intake valve is opened about 70° before the piston reaches its upper dead center. The exhaust valve itself was open as will be seen from the circular arc 4, for a time corresponding to about 65° after the piston has surpassed the upper dead center—cf. also the position of the piston in Fig. 1 corresponding to this position—so that a current of cooling air may be forced into the interior of the cylinder before the piston has reached and after it has surpassed the upper dead center through the open intake valve which closes only at a time corresponding to the circular arc 1 of about 70° after the piston has reached the lower dead center, and then passes through the still open hot exhaust valve 12 and the exhaust pipe 17 into the atmosphere. The injection of the fuel through the fuel nozzle 21 begins preferably at the same time or shortly thereafter and then follows the supercharging through the still open intake valve.

As soon as the intake valve is closed the mixture is compressed to the extent corresponding to the circular arc 2—compression stroke—and ignited, for instance, before the piston reaches the upper dead center. The power stroke represented by the circular arc 3 takes place with the valves closed up to about 70° before the piston reaches the lower dead center, the exhaust valve then opens in order to attain in due time a complete expansion of the burnt gases and remains open up to about 65° after the piston has reached the upper dead center as represented by the circular arc 4. The burnt gases are thus expanded upon the opening of the intake valve about 70° before the piston reaches the upper dead center so that the scavenging of the cylinder by the cooling air supplied by the blower (not shown) is effected up to about 65° after the piston has reached the upper dead center through the still open exhaust valve.

The crank path of about 135 to 140° represented in Fig. 2 by the hatched surface is available for the scavenging of the cylinder with cooling air, the overlapping when the piston has surpassed the upper dead center amounting in this embodiment to about 65 to 70°. With a four stroke internal combustion engine controlled according to this principle it is possible to attain an increase in power of about 10%.

If as above mentioned the overlapping of the open position of the valves amounts to about 70° before the piston reaches the upper dead center and 65° after the piston has surpassed the upper dead center, i. e. to 135°; this does not represent the limit value, since it is possible to vary the control periods to such an extent with respect to one another that, for instance, an overlapping of more than 140° may be attained as practical tests have shown. The movements of the intake valve and the exhaust valve towards the open position may preferably amount to a crank angle of 300 to 330°, the movement of the intake valve being preferably displaced with respect to that of the exhaust valve by 180° so that an overlapping angle of approximately 135° or more is obtained.

Depending upon the magnitude of this displacement it is possible, for instance, to vary the overlapping. As already above mentioned the magnitude of the overlapping may be varied in operation, for instance, if internal combustion engines of the radial type are involved, by the use of divided cam drums, one of which controls the intake valve and the other the exhaust valve. This displacement may be regulated either by hand or automatically in accordance with the corresponding operating conditions of the cylinder.

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