VI MEĐUNARODNI NAUČNO-STRUČNI SKUP
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Koziarski, C.

DISTRIBUTION MECHANISM FOR A HYBRID INTERNAL COMBUSTION ENGINE/ELECTRICAL MOTOR UNIT

ABSTRACT *The paper describes a new distribution system for the control of exhaust valves in direct injection engines, which was designed specially for application in vehicles operated in cities.*

The underlying idea of the presented mechanism is a new camshaft, which–apart of the known cams with the fixed raise angle–includes additional cams with the variable and large raise angles controlling the exhaust valves depending upon the ratio of the actual and maximum power. The engine that is fitted with the described mechanism is a combination of independent drive systems, the number of which is equal to the number of cylinders. Each cylinder may have different filling ratio and may operate individually.

The operation of the engine is as follows: On the intake stroke the piston is moving from the top dead centre to the bottom dead centre and the air is drawn into the cylinder through the intake valves. Before the closing of the intake valves the variable raise angle cams open the exhaust valves. The opening angle is inversely proportional to the filling ratio. In the next phase, the fuel is injected to the cylinder and its mixture with the air is being compressed during the displacement of the piston to the top dead centre. The ignition takes place just before the top dead centre. The power stroke follows and the piston travels till the bottom dead centre. Translating the body of the cams into its terminal position, the action of the cam with a large rise angle is being started and the exhaust valve stays opened during the compression, power and exhaust strokes

The possibility to eliminate the compression stroke makes it possible to start the engine using an electric machine instead of a starter. This machine may serve, apart from loading batteries, to the recuperative braking of the vehicle at crossroads, stops and traffic jams and to use this energy during the following acceleration, which is ecologically beneficent. The rotor of this machine may serve as the flywheel of the described internal combustion engine.

Czesław Koziarski dr hab. inż., Institut of Machines Design and Operation, Wrocław University of Technology, ul. Łukasiewicza 7, 50-371 Wrocław

The increased level of environmental contamination and poor efficiency are the two characteristic features of the internal combustion engines that are employed for the propulsion of city-operated vehicles. The level of contamination rises with the decrease in the quality of combustion, i.e. with the decrease in the temperature of combustion. This happens in situations where the filling ratio is being decreased in order to reduce the power. Additionally, to make ignition more reliable, the mixture of air and fuel must be made rich, which makes the purification process in the catalyst more difficult because less air is involved in the process. City operated vehicles face also the problem of energy losses during braking, which is deterrent not only to the economy of exploitation but is harmful to the environment too. To reduce braking losses, recuperating drive systems have been employed. The most popular is a hybrid system consisting of an internal combustion engine and electric motor, together with an additional accumulator called an internal combustion-electric motor unit. The motor that has been presented in [1] is well fitted to such application but it is a two-stroke engine, and its distribution system is inherent to that type of engines only.

The underlying idea of the presented mechanism is a new camshaft, which–apart of the known cams with the fixed raise angle–includes additional cams with the variable and large rise angles controlling the exhaust valves depending upon the ratio of the actual and maximum power. This mechanism is especially fitted to application in four-stroke internal combustion engines but may also be applied, after some modifications, to the control of the exhaust valves in a two-stroke internal combustion engine.

In the mechanism, there is a sliding sleeve mounted on the camshaft. The sleeve has three machined cams, which control, via pushers and rockers, the operation of the exhaust valves. The first cam has the rise angle that is variable along the axis of the camshaft, the third cam has a large rise angle and the second one couples together the first and the third. The displacement of the three cams along the axis of the camshaft is governed by the filling ratio and is executed by an hydraulic cylinder controlled by the accelerator pedal. The engine that is fitted with the described mechanism is a combination of independent drive systems, the number of which is equal to the number of cylinders. Each cylinder may have different filling ratio and may operate individually.

The operation of the engine is as follows: On the intake stroke the piston is moving from the top dead centre to the bottom dead centre and the air is drawn into the cylinder through the intake valves. Before the closing of the intake valves the variable raise angle cams open the exhaust valves. The opening angle is inversely proportional to the filling ratio. The variable rise angle cams perform, therefore, the same function as a throttle valve. In the next phase, the fuel is injected to the cylinder and its mixture with the air is being compressed during the displacement of the piston to the top dead centre. The ignition takes place just before the top dead centre. The power stroke follows and the piston travels till the bottom dead centre. The constant rise angle cams actuate the exhaust valve and the exhaust stroke follows. If the body of the cams is translated into its terminal position, the action of the cam with a large rise angle is being started. This cam couples together the variable rise angle and constant rise angle cams. As a result, the exhaust valve stays opened during the compression, power and exhaust strokes. The inlet of fuel is cut off at that time. To reduce the power of the engine, the variable angle cam opens the exhaust valve after the intake stroke has ended. This will reduce the filling ratio. The superfluous air is forced to the exhaust system, increasing the efficiency of the catalyst, when is of especial importance for ecology: the lesser is the filling ration; the worse is the composition of exhaust gases. In an engine with the proposed distribution system the filling ratio may be increased. This will improve not only the composition of exhaust gases but the efficiency of the engine too: with the reduced load one or more cylinders may be

non-active. Additionally, if the exhaust valves are opened during the three strokes, the idling piston is transformed into a pump, which presses air to the exhaust system, which increases the efficiency of the catalyst. The exhaust gases maintain the idling cylinder hot and ready for operation. Friction losses are reduced too. The other cylinders must develop in this situation higher power, which means that the efficiency is higher too. With the exhaust valves closed during the inlet stroke the fuel feed system is protected against the exhaust gases.

The possibility to eliminate the compression stroke makes it possible to start the engine using an electric machine instead of a starter. This machine may serve, apart from loading batteries, to the recuperative braking of the vehicle at crossroads, stops and traffic jams and to use this energy during the following acceleration, which is ecologically beneficent. The rotor of this machine may serve as the flywheel of the internal combustion engine. Due to the possibility of simultaneous propulsion of the vehicle using the engine and the machine, the mass of the engine may be significantly reduced.

The proposed embodiments of the invention are presented in Fig. 1 (cross-section) and in Fig. 2 (longitudinal section, side view) together with Fig. 3 (longitudinal section, bottom view). The mechanism consists of a cam sleeve 1 with a machined constant rise angle cam 2, variable rise angle cam 3 and a large rise angle cam 4 on it. The cams bear against the arm of a valve 5, which is supported on a hydraulic pusher or pin 6, from one side, and on the valve shank or on the end of a hydraulic pusher 7, from the other side. The cam sleeve 1 is free to translate using loosely fitted keys 8 on the camshaft 9, which is supported through a thrust-bearing ring 10 on a sliding bearing 11. The actuator via a fork 13 may shift the sleeve.

Another embodiment of the proposed invention is presented in Fig. 4 and 5. In this case the cams actuate directly the valve or its hydraulic pusher 15. Fig 4 presents a longitudinal section of this detail and Fig. 5, its cross-section and a longitudinal view. The mechanism is the same as in its first embodiment, but the valve arm 1 is here absent, and the cover 16 is designed as a guide for the hydraulic valve pusher and secures it against rotation.

The discussed mechanism in either of its two versions is mounted to the engine head 12. To secure the valve arm 5 against the side thrust from cams 3 and 4, the arm has the shape of an arc and has been provided with side guiding flanges whereas the hydraulic pusher 6 has a cylindrical end. The generatrix of the large rise angle cam 4 is of curved profile to reduce the necessary translation of the sleeve of cam 1. The fork 1 may engage the cam sleeve 1 through the key 8 individually or with all of them simultaneously.

In turbo-charged engines provided with the presented mechanism, blowing the air through the cylinders may cool the engine, and the heat recuperated may be used when filling cylinders with the air compressed in the turbo-compressor. The engine operates then on the air-base rule. The described distribution mechanism is designed primarily for low compression engines, but may also be employed in diesel engines, and in this case variable rise angle cams are not necessary.

The presented mechanism is a distribution mechanism with virtual cams [2,3,4]. Mechanical linkages govern its variable operational characteristic; therefore it is able to operate at higher operational speed than it is possible at present with other methods of control of valves.

The mechanism was described in a patent application and filed for examination as a property of the Wroclaw University of Technology.

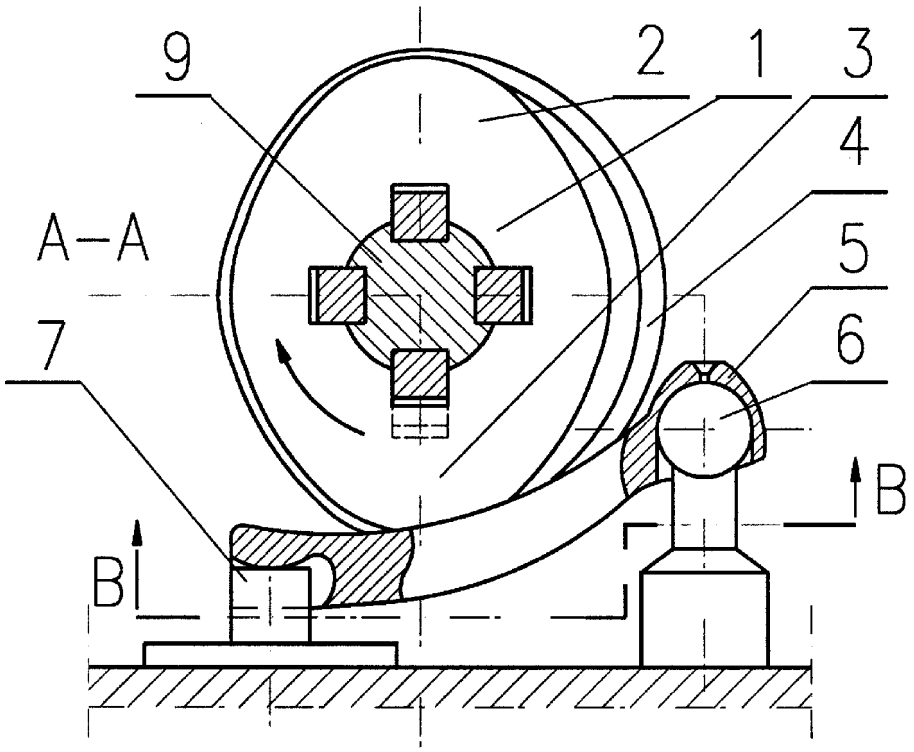

Fig.1

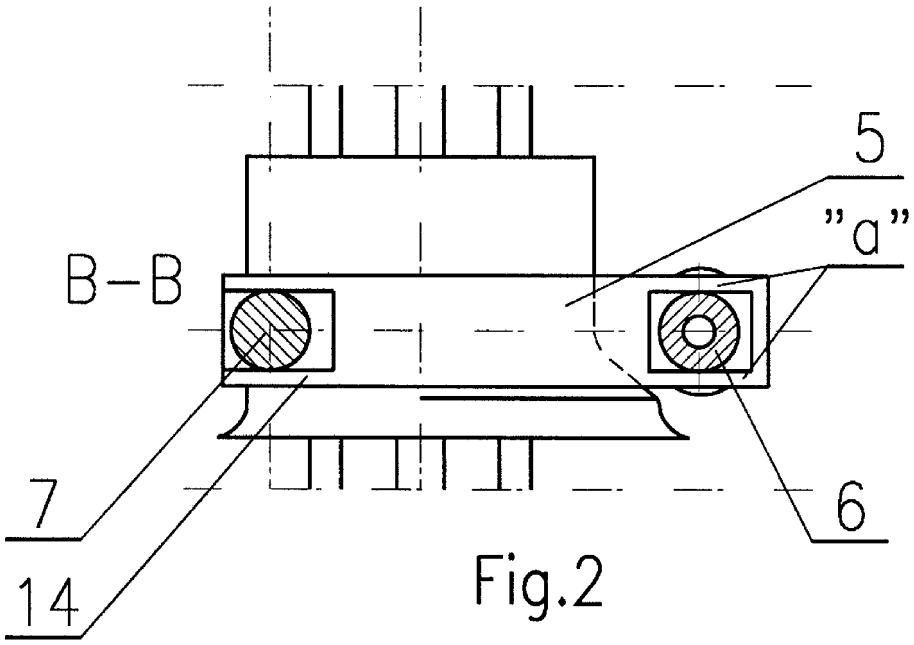

Fig.2

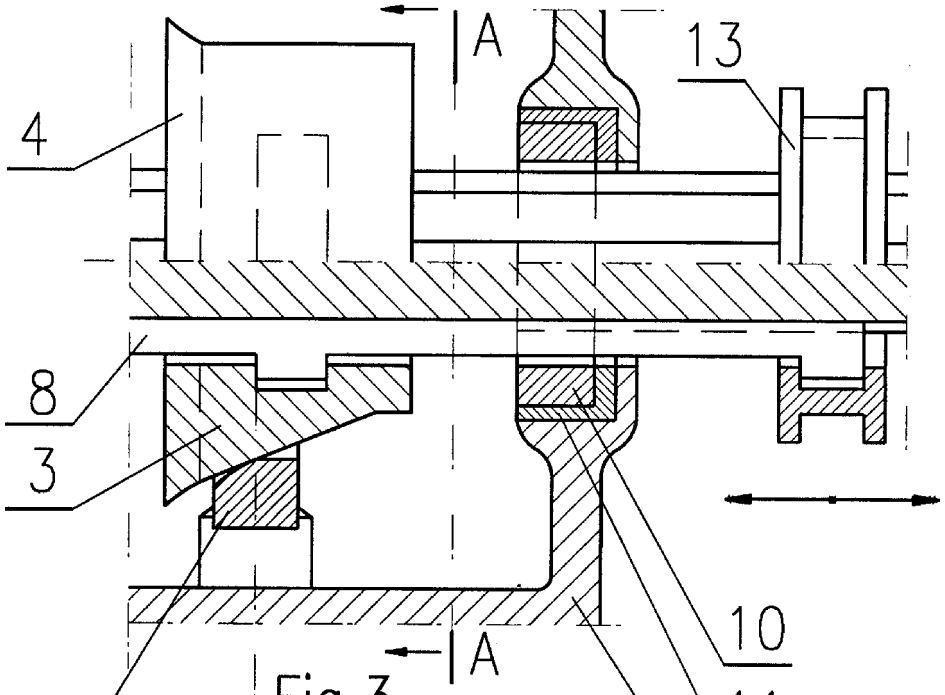

Fig.3

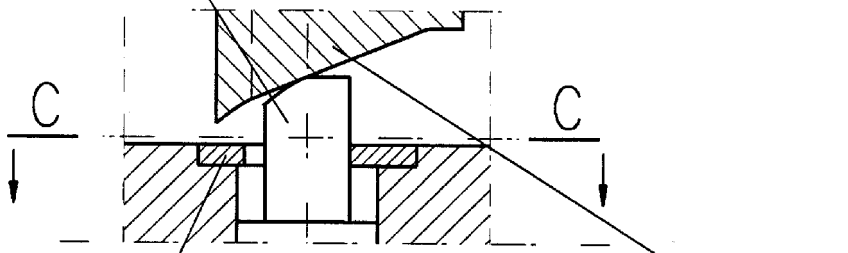

Fig.4

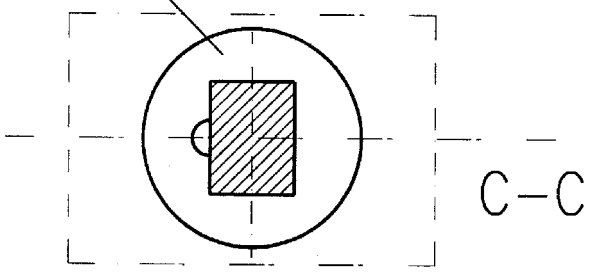

Fig.5

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