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(54) INTERNAL-COMBUSTION PISTON ENGINE "NAIDA"

(57) There is claimed an engine of the adiabatic type.

It is an object of the invention to enhance economical operation of the engine. The novelty of the invention consists in provision of two additional strokes for intracycle forced cooling of the engine (E) and injection of the air into cylinders. The engine comprises additional passages (AP) communicating the spaces of cylinders (C) and cooling jacket (CJ), AP overlap valves, a distribution device and its drive from a crankshaft with a gear ratio: 2: (S+2), where S is the original number of E strokes. CJ comprises volute chambers and is filled with air (A) or fuel-air mixture used in the capacity of a cooling medium (CM) for cooling and supercharging E due to a pumping action in two additional strokes. The engine can comprise injectors connected in series with admission P, the active gas paths thereof communicate these injectors via AP with CJ for injection of A into C at the expense of CM energy. There is provided a boost receiver connected with C and CJ spaces via pressure and discharge paths, with the controlled valves installed therein, for non-inertia increase of the supercharging pressure when E load abruptly changes and for facilitation of E starting by means of the supply of compressed A from the receiver into CJ. The rate of fuel consumption decreases by about 30 % in comparison with conventional engines.

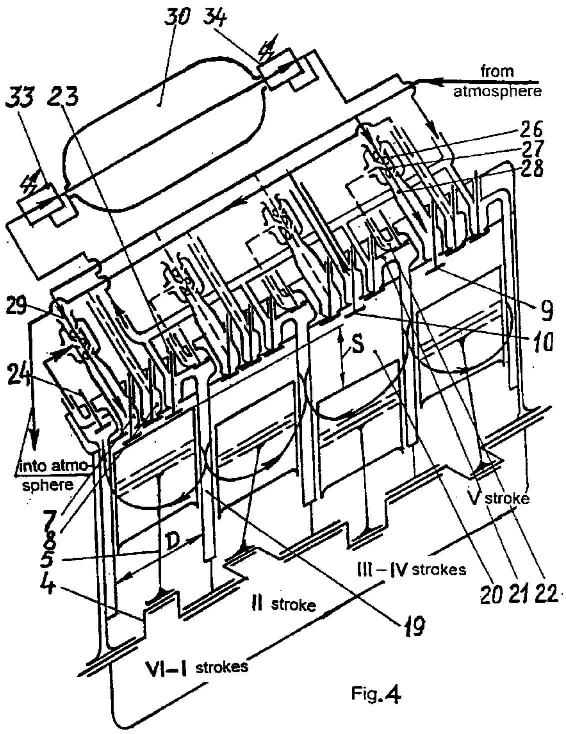

Fig.4

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Description

Field of Invention

[0001] The present invention relates to the field of mechanical engineering, and more specifically, to the field of engine building, and can be employed in the power plants of the automobiles, tractors, and other transport vehicles as well as in the stationary power installations.

Prior Art

[0002] The prior art constructions comprise R. Diesel piston-type two-stroke and four-stroke internal combustion engines with a thermo-dynamic cycle (diesel engines), e.g. two-stroke engine YaAZ 204, four-stroke engines: in-line engine D 260T, V-type engine YaMZ 240 B /R. 1, p. 322) as well as H. Otto engines with a thermo-dynamic cycle (gasoline engines: carburettor engines and direct-injection engines), e.g. Mercedes Benz C 230 /R. 9, p. 9-12/, with injection of the atmospheric air into the cylinders and with liquid cooling of the engine, comprising a body, one or several working cylinders with pistons located in the body or in the cylinder block, a crankshaft located in the body and hinged with the pistons by means of connecting rods, the pistons making reciprocating pumping actions in the cylinders when the crankshaft rotates, one or several cylinder heads with admission passages and admission valves located therein for supply of air (in the diesel engine) or fuel-air mixture (in the carburettor engine) into each cylinder, as well as with exhaust passages and exhaust valves located therein for release of the exhaust gases from the cylinders into the atmosphere, one or several distribution devices with control members and with valve actuating gears, e.g. camshafts with shaped cams and with tappets, push rods, rockers in combination with springs of the valves located in the body or in the cylinder heads, a drive for rotation of the distribution devices from the crankshaft made in the form of a gear or chain transmission /R. 1, p. 126/, a radiator located mainly separately from the body, and an engine cooling jacket made in the body or in the block and heads of the cylinders, with enclosure of the cylinders whose spaces form a common closed space, being hermetically sealed at an elevated pressure, which is filled with a cooling medium, a pump located in the body or in the engine cylinder block, with the drive of rotation from the crankshaft, intended for forced circulation of the cooling medium in the space of the cooling jacket and radiator, a fan installed in the vicinity of the radiator, mainly on the body, being rotated by the crankshaft for intensive removal of heat from the cooling medium in the radiator and its dissipation into the atmosphere by means of an air flow being produced, a compressor located, e.g. on the body, which is connected by means of an air path with the admission passages for injection of air into the cylinders and which is set in rotation due to power take-off from the engine crankshaft or due to utilization of the residual energy of the exhaust gases in the gas turbine of the turbo-supercharger, as well as a heat exchanger for cooling the air being injected into the cylinders, which is located in the vicinity of the fan or is provided with an additional cooling device /R. 5, p. 165-170/.

[0003] The working cycle of a two-stroke engine comprises the first stroke of admission into the cylinder with injection and compression therein of a charge of air or fuel-air mixture and the second stroke with burning, expansion of the working medium and working travel, release of the exhaust gases, and scavenge of the cylinders, being matched up with the piston travel.

[0004] The working cycle of the four-stroke engines is as follows: the 1st stroke - admission into the cylinder with injection of the atmospheric air or fuel-air mixture; 2nd stroke - compression of the air with supply of fuel and its self-ignition or compression of the fuel-air mixture and its forced ignition; 3rd stroke - burning, expansion of the working medium and working travel; 4th stroke - release of the exhaust gases into the atmosphere (with use of their residual energy for rotation of the turbo-supercharger or with other use of this energy, or without its use at all), with cylinder scavenge terminating in the 1st stroke.

[0005] During operation of the two-stroke engines, the full working cycle is accomplished in one turn, and during operation of the four-stroke engines, the full working cycle is accomplished in two turns of the crankshaft by opening and closing the admission and exhaust valves in accordance with the angle of turn of the crankshaft through the use of the distribution devices with the control members provided with definite shapes for this purpose and with definite mutual location, as well as through the use of the valve actuating gears being jointly actuated by the crankshaft through the medium of the distribution device rotation drive having a gear ratio: 2:S, where S is the number of the engine strokes.

[0006] Engine cooling is accomplished through removal of heat from the walls and heads of the cylinders by the cooling medium circulating in the space of the cooling jacket, with its subsequent transfer and dissipation via the radiator into the atmosphere.

[0007] The engine cooling conditions are adjusted (to prevent engine overcooling during its starting and operation at a partial load) by automatic disconnection of the fan and by selection of a small circulation pattern through the use of a thermostat /R. 1, p. 151-165/.

[0008] The carburettor engines are supercharged by supply of the compressed air either before or after the carburettor /R. 1, p. 287; R. 2, p. 169, Fig. 85). The supercharging pressure is adjusted at various loads of diesel and carburettor engines through the use of automatic control devices, e.g. through diversion of the exhaust gas flow direction to bypass the turbine nozzle diaphragm assembly /R. 1, p. 289/, and cooling of the air which is being injected (for increase of charge density) is accomplished by letting the air flow through a heat exchanger before its supply into the cylinders, with dissipation of the heat energy into the atmosphere /R. 5, p. 165-170/.

[0009] Selected as a prototype is the construction of a piston-type four-cylinder in-line diesel engine with turbo-supercharging and with a closed system of liquid cooling CMII-17KH/18KH /R. 3, p. 46, 47/ whose design and operation are most similar to the analogs described above.

[0010] The engine comprises a body with liner cylinders and pistons, a crankshaft located in the body and hinged to the pistons through the medium of connecting rods making reciprocating pumping actions when the crankshaft rotates, a cylinder head provided with admission and exhaust passages, admission and exhaust valves located in the cylinder head overlapping the respective passages, a distribution device comprising a camshaft with shaped cams and a valve actuating gear comprising tappets, push rods, rockers located in the body and in the cylinder head, said distribution device being connected with the crankshaft through the medium of a gear-type drive of rotation with a gear ratio of 1:2 for opening and closing the valves in accordance with the angle of turn of the crankshaft, thereby providing for admission of atmospheric air into the engine cylinders in the first stroke of admission, hermetic sealing of their working spaces in the second stroke of compression and in third stroke of working travel, and release of the exhaust gases in the fourth stroke. Additionally, the engine comprises a cooling jacket being hermetically sealed at an elevated pressure, which is provided in the body and in the head of the cylinders with enclosure of the latter, as well as a radiator whose spaces are filled with the cooling fluid, said spaces being interconnected by branch pipes, a built-in pump intended for forced circulation of the cooling liquid and a fan which are attached to the body and are provided with a belt drive from the crankshaft for cooling the fluid in the radiator, as well as a thermostat for adjustment of the cooling conditions. Additionally, the engine is provided with a turbo-supercharger located on the body thereof which is rotated by the exhaust gases and is connected by air paths with admission valves for injection of the air, thereby increasing the pressure and density of a charge.

[0011] The operation of such an engine has been described above.

[0012] The disadvantages of this construction include insufficiently high indicator of economical operation of the engine as well as an increased content of the toxic substances in the exhaust gases because of imperfection of the working cycle (incomplete combustion of the fuel, a high degree of the residual gases in the cylinders, and insufficiently high thermal efficiency of the engine) caused, in the general case, by shortage of the conditions and time provided in the working cycle for fine evaporation of the fuel and for a more thorough mixing of the components of the fuel-air mixture in combination with shortage of the time and piston travel in the working cycle for more complete utilization of the work of the working medium being expanded and for more complete cleaning of the cylinders from the exhaust gases as well as because of considerable losses of the heat via the cooling medium and with the exhaust gases into the environment comprising in the total 53 % of the heat produced during fuel combustion /R.2, p. 147, Table 9).

[0013] The employment of a turbo-supercharger with the automatic control of the pressure at which the air is injected into the cylinders in various engine operating conditions substantially improves the engine economical operation indicators and reduces the level of harmful releases into the atmosphere in comparison with the engines which are not supercharged but this is accomplished only through complication of the engine construction and without a considerable increase of the thermal and indicated efficiency because of the remaining heat losses into the cooling system which are not changed (23 %) /R. 2, p. 147, Table 9) and acquired pump losses in the turbo-supercharger. The need of utilization of the energy of the exhaust gases arises from incomplete utilization of the energy of the working medium being expanded in each working stroke of the pistons in the engine cylinders.

[0014] Another considerable disadvantage of such an engine consists in increased complexity of the construction caused by the irrational use of the pumping capabilities of own working cylinders which leads to installation of additional pumping units, such as a pump and a cooling system fan, a supercharging turbine and compressor, with their pumping losses and mechanical losses in their drives, which reduce the total efficiency by 5-10 % /R. 2, p. 183/.

[0015] Provision of the additional pumping units complete with their drives, as well as provision of a cooling system radiator, heat exchanger, and in some cases, compressor plant for production and accumulation of the compressed air feeding the pneumatic systems of the transport vehicles (e.g. in the brake drives, in the hydro-pneumatic boosters of various kinds of the actuators, in the car interior air conditioners, and in the pneumatic suspensions) considerably rises the price of the engine construction, increases the engine weight, overall dimensions, and operating costs, reduces engine reliability.

[0016] To raise the temperature of the engine after its starting in the cold season of the year to the operating values, there are required considerable expenditures of fuel energy and long time of idle running (of the order of 10 min) because of the need of warming not only the parts of the engine and its lubricants but also the cooling medium. Engine operation in unstable temperature conditions results in the decrease of the engine service life due to a rapid wear of the parts of the engine which continuously operates in the conditions differing from the rated conditions as regards amounts of clearances in the friction pairs and lubrication of the friction surfaces.

Object of Invention

[0017] It is an object of the present invention to raise the indicators of efficiency of a piston-type internal combustion engine by means of: improvement of its economical operation by lowering the fuel consumption, decrease of the level of harmful releases into the atmosphere, simplification of engine construction and reduction of its overall dimensions on this basis, reduction of the engine manufacturing and operating costs, enhancement of engine reliability and service life, facilitation of engine maintenance, including facilitation of engine starting in the cold season, through improvement of its working and thermodynamic cycles (more careful preparation of the mixture, improvement of scavenging and filling of the cylinders, more full utilization of the energy of the working medium being expanded in each working stroke, and decrease of the heat losses with the cooling medium, as well as through the use of the pumping capabilities of the working cylinders for accomplishment thereby of the auxiliary kinds of work for supercharging, warming and cooling the engine, production and accumulation of the compressed air within the cycle, in two additional strokes.

Summary of Invention

[0018] Conceptually the problem is solved by that an intra-cycle system intended for cooling and supercharging of cylinders before the beginning of the admission stroke and controlled by a common distribution device is provided in a piston-type internal combustion engine with a cooling jacket instead of an independent (external) cooling and supercharging system, said cooling jacket being hermetically sealed and filled with air or fuel-air mixture.

[0019] The system can comprise one or several additional passages between each cylinder and cooling jacket, said passages being provided with valves connected with a common distribution device.

[0020] The valves can be connected with the distribution device by means of additional control members, the ratio of the drive for rotation of the distribution device from the crankshaft being accordingly changed.

[0021] When the intra-cycle cooling system is provided, e.g. with two additional passages (inlet and outlet passages for the cylinder), a supercharging injector can be successively connected to the inlet passage. The injector can be located in the cylinder head, directly at the inlet of the cylinder.

[0022] The engine can comprise a receiver connected with the cylinders and cooling jacket via air ducts with the valves which are automatically controlled by the pressure transducers located in the admission passage and in the cooling jacket for improvement of engine pick-up and facilitation of its starting.

[0023] More specifically, the problem is solved by that substantial changes and amendments are introduced in the known engine comprising one or several working cylinders with pistons located in the body or in the cylinder block connected with the body, a crankshaft located in the body and hinged to the pistons by means of connecting rods, said pistons making reciprocating pumping actions in the cylinders during crankshaft rotation, one or several cylinder heads with admission passages for supply of the atmospheric air or fuel-air mixture into each cylinder and with exhaust passages for release of the exhaust gases from the cylinders, admission and exhaust valves located, e.g. in the cylinder heads with overlapping of the respective passages, one or several distribution devices, e.g. camshafts with control members comprising shaped cams and with valve actuating gears comprising, e.g. tappets with push rods, rockers and valve springs located, e.g. in the body or in the cylinder heads and connected with the crankshaft by means of a drive of rotation comprising, e.g. a gear or chain transmission, said valves being opened and closed in accordance with angle of turn of the crankshaft, thus providing for admission of the atmospheric air or fuel-air mixture into the cylinders in the first stroke of the working cycle, hermetic sealing of the working spaces of the cylinders during compression and working travel, and release of the exhaust gases from the cylinders after completion of combustion and execution of the expansion work by the gases, as well as an engine closed cooling jacket which is hermetically sealed when the pressure therein exceeds the atmospheric pressure, said cooling jacket located in the body or in the block and in the cylinder heads with enclosure of the cylinders being filled with a cooling medium, namely:

> the engine is provided at least with one additional passage per each working cylinder located, e.g. in the cylinder head which communicates the space of this cylinder with the space of the cooling jacket, and at least with one additional valve located, e.g. in the cylinder head, which overlaps this passage, being connected with the distribution device, and admits the cooling medium being injected and continuously exchanged in the cooling jacket in the process of engine operation from the cooling jacket into the cylinder in the first stroke of the working cycle, supplies under pressure a portion of the air taken from the atmosphere in the first additional stroke without supply of fuel or with simultaneous supply of fuel or its part (depending on the method of mixture preparation and method of ignition) from the cylinder into the cooling jacket in the second additional stroke, for which purpose the distribution device is provided with at least one additional control member and one additional valve actuating

gear, the drive for rotation of the distribution devices from the crankshaft having a gear ratio of: 2: (S+2), where S is the original number of the strokes, and the cooling jacket comprises one or several closed chambers which are made in the body or in the cylinder head with enclosure of the cylinders and which are hermetically sealed at an elevated pressure, said cooling jacket being preliminarily filled with air or fuel-air mixture, mainly at an elevated pressure, used in the capacity of a cooling medium.

[0024] For increase of supercharging efficiency, the engine is provided at least with one injector per cylinder, comprising an inlet, an active gas path with nozzles, a mixing chamber, and an outlet diffuser, which are connected in series with the admission passage, the active gas path thereof being connected via the additional passage with the cooling jacket so that the atmospheric air supplied over the admission passage is injected into the working space of the cylinder, with increase of the air temperature, rate of flow and pressure at the expense of the energy of the flow of the compressed and heated cooling medium moving from the cooling jacket and flowing via the nozzles into the mixing chamber in the first stroke of the working cycle, when the admission and additional valves are open.

[0025] For organization of an ordered movement of the flow serving as a cooling medium and compressed air being continuously exchanged in the cooling jacket or compressed fuel-air mixture, the internal surfaces of the cooling jacket and of the additional passages connecting the cylinder spaces with the space of the cooling jacket have a joint volute configuration and the communicating adjacent chambers have an opposite helical shape, thus providing for a directional movement of the cooling body being supplied into the cooing jacket tangentially to the external surfaces of the cylinders, with forced cooling of the surfaces exposed to the maximum thermal loads, which are adjacent with their working spaces and exhaust passages.

[0026] The volume of the space of the cooling jacket matches up the total working volume of the engine cylinders by the condition of achievement of the required supercharging pressure at the rated load of the engine and its rated speed of rotation in conformity with the formula:

$$\frac{V_{cj}}{V_c} = K\,\frac{P_{atm}}{P_S}\ ,$$

where:

V_{cj} is the volume of the cooling jacket,
V_c is the engine displacement,
P_{atm} is the atmospheric pressure,
P_S is the supercharging pressure,
K is the hydraulic loss coefficient.

[0027] For non-inertia supply of an additional mass of air which is necessary for combustion of an additional amount of fuel at a sudden increase of the engine load and for prevention of incomplete combustion of fuel accompanied with smoking and with release of the harmful oxides into the atmosphere, as well as for facilitation of engine starting and for possibility of an additional control of the cooling conditions of the engine, the latter is provided with a receiver connected, e.g. in parallel with the space of the cooling jacket, which comprises a chamber being hermetically sealed at an elevated pressure, a pressure path accommodating a pressure valve, e.g. a pneumatically controlled automatic pressure relief valve, which communicates the receiver space with the working spaces of the cylinders, as well as a discharge path accommodating a discharge valve, e.g. a pneumatically controlled automatic pressure relief valve, which communicates the receiver space with the space of the cooling jacket and supplies the compressed air from the working cylinders into the receiver after preliminary filling of the cooling jacket, accumulation of the compressed air in the receiver, and release of the compressed air from the receiver into the cooling jacket with the increase of the supercharging pressure and with simultaneous increase of the engine cooling intensity by the commands delivered to the respective valves, and at excessive pressures in the respective spaces.

Disclosure of Invention

[0028]

Fig. 1 is a sectional view and Fig. 2 is a top view of the exemplified construction of a piston-type in-line four-cylinder six-stroke (4+2) internal combustion engine with a closed cooling system.

Fig. 3 shows an exemplified construction of an engine with a supercharging injector.

Fig. 4 shows an exemplified pneumatic system with the directions of movement of the working and cooling media.

Fig. 5 illustrates mutual arrangement of the crankpins for the established sequence of work of the cylinders: 1-4-3-2.

[0029] The engine comprises a body 1 (Fig. 1) with liner cylinders 2, pistons 3, a crankshaft 4, connecting rods 5, a cylinder head 6 with admission passages 7 (Figs 2, 3, 4) and exhaust passages 8, admission valves 9 (Figs 3, 4) and exhaust valves 10 (Fig. 1, 4), two camshafts 11 and 12 (Fig. 1), sixteen valve actuating gears with tappets 13, push rods 14, rockers 15 and valve springs 16, two toothed wheels of a camshaft rotary drive 17 connected with a crankshaft gear 18 with a gear ratio: 2: (4+2), a closed cooling jacket 19 common for all cylinders, which is hermetically sealed at an elevated pressure and encloses the sleeves of the cylinders, said cooling jacket is filled, depending on the methods of mixture formation and ignition, with air or fuel-air mixture, mainly at an elevated pressure, and is connected with working spaces 20 of the cylinders by means of additional cooling passages 21 (Figs 1, 4) and additional supercharging passages 22 (Figs 3, 4), with additional valves 23 (Figs 1, 4) and 24 (Figs 3, 4) located therein, respectively, said valves being connected by the valve actuating gears with the camshaft 11 (Fig. 1), supercharging injectors 25 (Figs 3, 4) with active gas paths 26, mixing chambers 27, and diffusers 28 connected by their inlets 29 in series with the admission passages 7, whose active gas passages 26 communicate via additional supercharging passages 22 with the cooling jacket, as well as a receiver 30 with a pressure path 31 and a discharge path 32 accommodating a controlled automatic pressure valve 33 and a controlled automatic discharge valve 34, said receiver being connected in parallel with the space of the cooling jacket.

[0030] The engine operates as follows.

[0031] In the first stroke of the working cycle, when the piston 3 moves downward from TDC and the admission valve 9 and additional valve 24 (Figs 3, 4) are open, the cylinder is filled with a charge of the atmospheric air over the admission passage 7 and with a charge of the cooling medium (air or fuel-air mixture) fed from the cooling jacket over the supercharging passage 22, which communicate in the mixing chamber 27 of the injector 25. As a result, the compressed and heated cooling medium, while executing the work of expansion in the injector, liberates a part of its energy to the atmospheric air, thus increasing its pressure and rate of its flow and exchanging heat therewith, which promotes maintenance of a stable temperature and density of the total charge and, accordingly, full-valued filling of the cylinder. In the diffuser 28 of the injector, the total charge flow is retarded also with a certain increase of its pressure.

[0032] In the second stroke, when the valves are closed, the piston moves upward from BDC so that the air or fuel-air mixture in the working space of the cylinder is compressed, with injection of the automized fuel into the cylinder at the end of the stroke and its self-ignition (in the diesel engine) or with injection of the main portion of the fuel and forced ignition of the mixture (in the carburettor engine) like in the analogs.

[0033] In the third stroke, when the valves are closed, the fuel burns with expansion of the working medium and with downward working travel of the piston. In this case, due to increase of the piston travel relative to its diameter (S/D), with a greater expansion of the working medium and later, as compared with the analogs, opening of the exhaust valve, the energy of the working medium being expanded is more fully utilized, its temperature and cylinder outlet pressure are more substantially lowered, and the energy losses with the exhaust gases into the atmosphere are accordingly reduced.

[0034] At the beginning of the fourth stroke, when the piston passes by BDC, the exhaust valve 10 (Figs 1, 4) opens and the exhaust gases are displaced by the piston out of the cylinder into the exhaust passage 8, with the use of the gas residual pressure for overcoming the resistance to exhaust, like in the analogs.

[0035] In the first additional stroke, when the piston moves downward from TDC, the cylinder is at first scavenged with certain overlapping of the operation of the exhaust and admission valves at the beginning of the stroke, and then the atmospheric air is sucked into the cylinder via the admission passage 7 (Figs 3, 4), when only the admission valve 9 is open, like in the first stroke of the analogs, or the atmospheric air is sucked without the scavenge, or with the scavenge lasting for a shorter time, for re-circulation of the incomplete combustion products in the subsequent strokes. Admission of a new portion of the cooling medium from the atmosphere is accompanied with primary cooling of the cylinder whose internal surface is blown by the atmospheric air. In this stroke, there can be accomplished, e.g. preliminary preparation of the fuel-air mixture.

[0036] In the second additional stroke, when the additional valve 23 (Figs 1, 4) is open, the piston moves upward, thereby injecting air via the additional passage 21 into the cooling jacket with a certain excess of its pressure, or, for example, injecting air with an excess of its pressure and with simultaneous supply of a certain portion of the fuel for formation of more homogenized mixture in advance, or with continued homogenization of the mixture formed in the previous stroke. In this case, on the one hand, there is provided an opportunity of more thorough preparation of the mixture and more rational scavenge of the cylinder, with delivery of remaining fuel which has failed to react and the gases with incomplete oxidation of carbon and nitrogen into the cooling jacket for their subsequent more complete utilization in the process of repeated combustion and for the respective decrease of the ecologically harmful releases into the atmosphere, and on the other hand, the cylinder walls and its head are further cooled, with direction of the cooling medium flow tangentially to the external surface of the cylinder and with forced blowing of the surfaces of the engine parts which are exposed to the maximum thermal loads with a fresh portion of the cooling medium.

[0037] An ordered directional motion of the cooling medium in the cooling jacket is promoted by a respective helical shape and joint volute configuration of the additional cooling passages and communicating chambers enclosing the cylinder liners.

[0038] A complete working cycle of the engine cylinder is accomplished in three revolutions of the crankshaft (1080°). The approximate sequence of work of the cylinders of a four-cylinder engine, with mutual location of the crankpins in conformity with the diagram shown in Fig. 5, corresponds to the formula: 1-4-3-2. The engine working strokes are alternated uniformly, every 270° of the angle of turn of the crankshaft, which facilitates its counterbalancing /R. 8, p. 266/.

[0039] If the engine comprises one additional passage for each cylinder and one additional valve overlapping it, supercharging and cooling are accomplished by a flow of the air or fuel-air mixture in this passage in various directions: in one direction - for engine cooling, with opening of the additional vale in the sixth stroke, and in the opposite direction - for filling the cylinder with a new charge, with closing of this valve at the end of the first stroke, simultaneously with closing of the admission valve or somewhat in advance of its closing, thereby preventing the reverse flow of the air in the admission passage. Thus, cooling and supercharging are accomplished in each cycle with one opening of the additional valve, and stagnation of the cooling medium caused by the inertia of its mass, when the cooling medium is quickly returned from the cooling jacket, is overcome due to vortex-type organization of its flow movement and its elasticity which allow for the return of the energy spent for compression with the minimum energy losses for temperature rise, which are further also partially returned in the form of the gas expansion work in the injector.

[0040] When the engine comprises two additional overlap passages for each cylinder: the cooling passage and the supercharging passage which is not provided with the injector, in the first stroke of the working cycle the atmospheric air will flow into the cylinder via the admission passage 7 (Fig. 4) and the cooing medium will flow from the cooling jacket via the supercharging passage 22 independently.

[0041] To prevent the reverse flow of the atmospheric air in the admission passage, the additional valve 24 is opened with a certain delay relative to the opening of the admission valve 9 and is closed with a certain advance.

[0042] When the engine is started without an excessive pressure in the cooling jacket, at first the cooling jacket is filled with the compressed air by the command to the supply valve 34 from the receiver 30 connected in parallel, and if there is no excessive pressure in the receiver either, the engine is started and begins to operate without supercharging. In this case, the pressure in the cooling jacket grows up due to the excess of the air or fuel-air mixture supplied into the cooling jacket in the second additional stroke over its consumption from the cooling jacket for filling each cylinder in the first stroke (e.g. at a low engine loading, as well as in virtue of the fact that the cylinder is simultaneously filled by the air from the atmosphere). Filling of the receiver with the compressed air (without formation of the fuel-air mixture) is accomplished via the pressure path 31 by the command to the pressure valve 33, after the pressure of the cooling medium in the cooling chamber reaches the value required for the given loading conditions.

[0043] Accumulation of the compressed air in the receiver provides, on the one hand, for prevention of stagnation of the cooling medium in the cooling jacket and, accordingly, prevention of the hazard of engine overheating at a partial load, and on the other hand, it provides for making a reserve of the compressed air for its utilization when starting the engine and sharply increasing the engine load by bleeding it from the receiver via the discharge path 32 into the cooling jacket by the command to the discharge valve 34, with simultaneous rise of the supercharging pressure and achievement of non-inertia supply of an additional air mass for combustion of the additional fuel mass, with a rapid increase of power and prevention of incomplete combustion of the fuel, as well as, for example, for maintenance of the required pressure in the vehicle pneumatic system.

[0044] Since the working stroke in the cylinder is repeated every 1080° of the angle of turn of the crankshaft and cooling is accomplished during three strokes out of six strokes, the engine temperature conditions are less intensive in comparison with the analogs. Thus, the possibility of stabilization of the engine temperature in various operating conditions is facilitated and it becomes possible to cool the engine without dissipation of the excessive heat into the atmosphere. Bearing in mind that the cooling medium is contained in the cooling jacket at an excessive pressure (excessive density and heat capacity) and is being continuously exchanged, similar to the engines with the direct-flow cooling systems, it becomes possible to utilize the cooling medium with less heat capacity, without the need of its cooling to the original temperature, like in the analogs with loop circulation.

[0045] Since the engine is cooled by the air heated due to compression and the medium supplied for supercharging is heated in the cooling jacket as well, starting of the cold engine and its rapid heating to the operating temperatures are facilitated and fuel burning conditions are improved. A certain decrease of the charge density caused by heating and resulting probability of deterioration of cylinder filling are compensated by the increase of the supercharging pressure which is easily achieved during operation of the engine cylinders, as compared with the pressure produced in the bladed compressors, and by the decrease of the charge temperature in the result of endothermic vapourization processes realized in the cooling jackets when the fuel (or, e.g. fuel with water) is evaporated and fuel ignition is started in advance, e.g. in conformity with the antechamber type of ignition. Besides, the employment in the engine construction of a jet pump for injection of the atmospheric air into the cylinders at the expense of the energy of the preliminarily compressed and pre-heated cooling medium allows for conversion of the excessive thermal energy thereof into the kinetic energy of the atmospheric air flow in the admission passage and for the increase of its pressure, as well as for the heat exchange with this air flow, thereby maintaining an acceptable and stable temperature and density of the charge at various operating loads of the engine and at various speeds of its rotation, without reduction of engine cylinder filling efficiency in comparison with the analogs.

[0046] Automatic increase of the cooling intensity with the growth of the engine speed of rotation due to passage of a greater mass of the cooling medium through the cylinders and cooling jacket per unit time, including increase of the cooling intensity resulting from the rise of the supercharging pressure and density of the cooling medium, limits heating of the engine in the upper range of its working temperatures at increase of the load and at respective combustion of a greater amount of fuel (fuel enrichment) which also promotes maintenance of a stable working temperature of the engine.

[0047] Due to employment of engine construction providing for engine work in two additional strokes for complete ventilation of the cylinders, for cooling and supercharging of the engine, as well as due to utilization of the air or fuel-air mixture charge intended for combustion in the cylinders in the capacity of a cooling medium which is continuously exchanged and heated during compression and passage through the cooling jacket, the heat losses into the atmosphere via the cooling medium are eliminated, the conditions for preparation of the fuel-air mixture (including its preparation beyond the working space of the cylinders) are improved, the conditions for fuel burning and re-circulation of the exhaust gases are improved, the release of the harmful substances into the atmosphere is reduced, the thermal efficiency of the engine is enhanced, and the rate of fuel consumption is lowered, as compared with the analogs.

[0048] Thus, due to the fact that the heat liberated into the cooling medium is further used for the increase of the cooling medium energy and is not dissipated into the atmosphere, like in the analogs, the working cycle of the engine construction according to the invention is close with respect to the heat exchange conditions to an ideal working cycle of the adiabatic engine /R. 2, p. 150) which is characterized by absence of heat exchange with the environment in the process of expansion of the working medium.

[0049] The possibility of utilization of the compressed air being produced in the result of the pumping action of the working cylinders in two additional strokes for supercharging, ventilation and cooling of the engine, as well as for accumulation of this air in the receiver, makes it possible to give up employment of the duplicating pumping units with their drives, thereby increasing the mechanical efficiency of the engine, to clear the crankshaft nose-piece for power take-off (if necessary), to substantially cut short the costs for manufacture, maintenance and operation of the power plant.

[0050] A relative decrease, in comparison with the analogs, of the power-to-volume ratio because of the increase of the engine working cycle by two strokes is partially compensated by reduction of the irrational losses and by the respective increase of the full efficiency of the engine, while the remaining part of this decrease can be compensated for by a certain increase of the air or fuel-air mixture pressure which is easily achieved in the engine construction according to the invention and which substantially increases the engine power /R. 1, p. 287/.

[0051] The working process in the four-stroke (2+2) engine is similar, with an additional double travel of the piston, and accordingly with two additional cooling and supercharging strokes. The full working cycle of this engine is accomplished in two turns of the crankshaft, with the distribution device gear ratio of: 1:2.

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Claims

1. An internal combustion engine comprising a body, one or several working cylinders with pistons located in the body or in the cylinder block connected with the body, a crankshaft located in the body and hinged to the pistons by means of connecting rods, said pistons making reciprocating pumping actions in the cylinders during crankshaft rotation, one or several cylinder heads with admission passages for supply of the atmospheric air or fuel-air mixture into each cylinder and with exhaust passages for release of the exhaust gases from the cylinders, admission and exhaust valves located, e.g. in the cylinder heads with overlapping of the respective passages, one or several distribution devices, e.g. camshafts with control members comprising shaped cams and with valve actuating gears comprising, e.g. tappets with push rods, rockers and valve springs located, e.g. in the body or in the cylinder heads and connected with the crankshaft by means of a drive of rotation comprising, e.g. a gear or chain transmission, said valves being opened and closed in accordance with angle of turn of the crankshaft, thus providing for admission of the atmospheric air or fuel-air mixture into the cylinders in the first stroke of the working cycle, hermetic sealing of the working spaces of the cylinders during compression and working travel, and release of the exhaust gases from the cylinders after completion of combustion and execution of the expansion work by the gases, as well as an engine closed cooling jacket which is hermetically sealed when the pressure therein exceeds the atmospheric pressure, said cooling jacket located in the body or in the block and in the cylinder heads with enclosure of the cylinders being filled with a cooling medium, **characterized in that,**

the engine is provided at least with one additional passage per each working cylinder located, e.g. in the head of this cylinder, which communicates the space of this cylinder with the space of the cooling jacket and at least with one additional valve located, e.g. in the cylinder head, which overlaps this passage, being connected with the distribution device, and admits the cooling medium being supercharged and continuously exchanged in the cooling jacket in the process of engine operation from the cooling jacket into the cylinder in the first stroke of the working cycle, supplies under pressure through the pumping action of this working cylinder a portion of the air preliminarily taken from the atmosphere in the first additional stroke, without supply of fuel or with simultaneous supply of fuel or its part, into the cooling jacket in the second additional stroke, for which purpose the distribution device is provided with at least one additional control member and one additional valve actuating gear, the drive for rotation of the distribution devices from the crankshaft having a gear ratio of: 2: (S+2), where S is the original number of the strokes (number of double travels of the piston in the working cycle), and the cooling jacket comprises one or several closed chambers which are made, for example, in the body or in the block and cylinder heads with enclosure of the cylinders and which are hermetically sealed at an elevated pressure, said cooling jacket being preliminarily filled with the air or fuel-air mixture, mainly at an elevated pressure, used in the capacity of a cooling medium.

2. An engine according to claim 1, characterized in that it is provided at least with one injector per working cylinder, comprising an inlet, an active gas path with nozzles, a mixing chamber, and an outlet diffuser, which are connected in series with the admission passage, the active gas path thereof communicates via the additional passage with the cooling jacket so that the atmospheric air supplied over the admission passage is injected into this cylinder, with increase of the air pressure, rate of flow and temperature at the expense of the energy of the compressed and heated cooling medium moving from the cooling jacket over the additional passage and flowing via the nozzles into the mixing chamber in the first stroke of the working cycle, when the admission and additional valves are open.

3. An engine according to claim 1, characterized in that its cooling jacket has a configuration which forms one or several closed volute spaces jointly with the configuration of the additional passages, said spaces have a respective helical shape and are hermetically sealed at an elevated pressure, and the communicating adjacent chambers have an opposite helical shape, thus providing for a tangential direction of movement of the cooling body being injected into the cooling jacket relative to the external surface of the working cylinders, with forced blowing of the surfaces of the cylinders and their heads which are exposed to the maximum thermal loads and which are adjacent with the working spaces of the cylinders and exhaust passages.

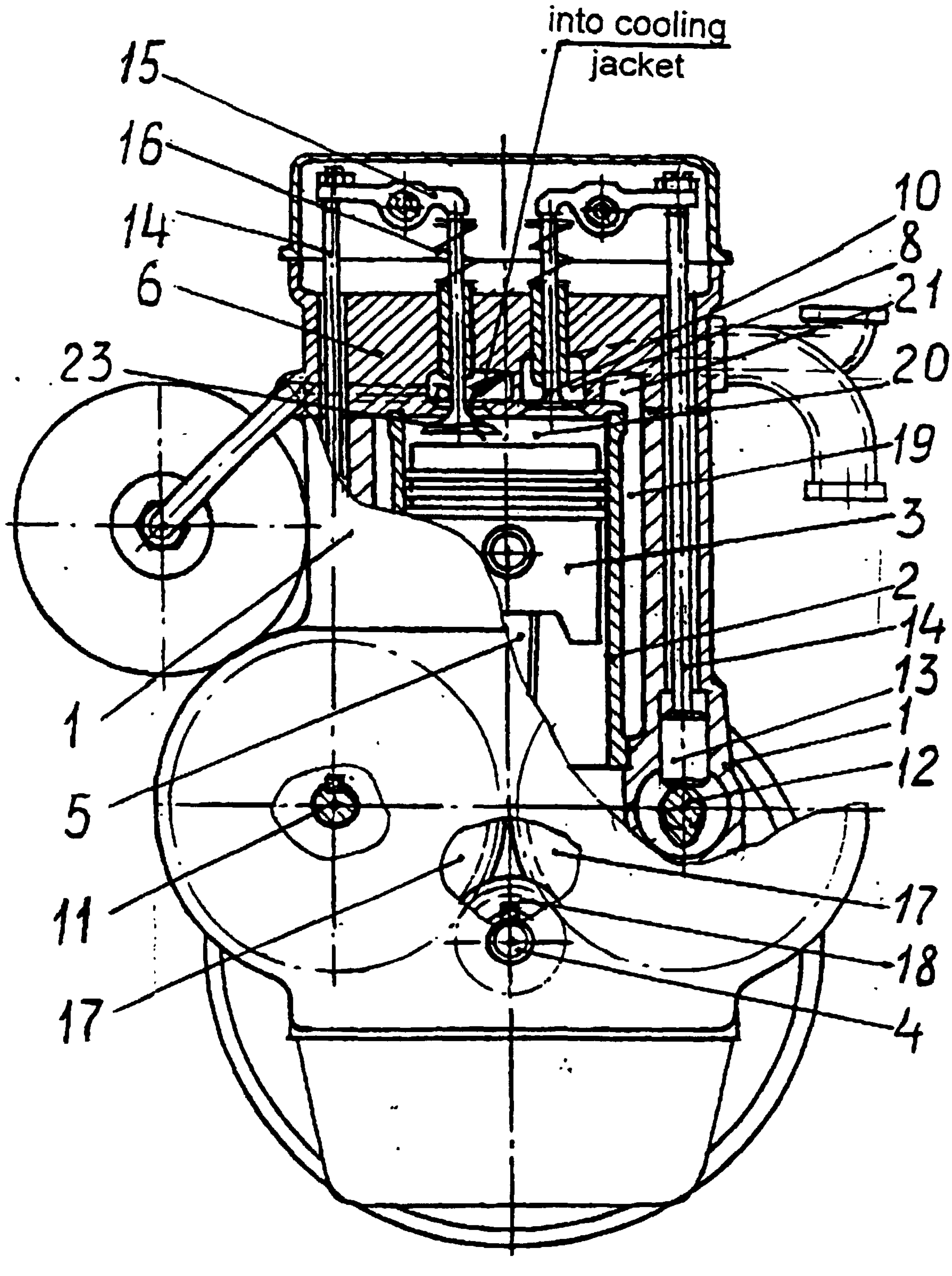
4. An engine according to claim 1, characterized in that the volume of the space of the cooling jacket matches up the total working volume of the engine cylinders by the condition of achievement of the required supercharging pressure at the rated load of the engine and its rated speed of rotation in conformity with the formula:

$$\frac{V_{cj}}{V_c} = K\frac{P_{atm}}{P_S} <$$

where:

V_{cj} is the volume of the cooling jacket,
V_c is the engine displacement,
P_{atm} is the atmospheric pressure,
P_S is the supercharging pressure,
K is the hydraulic loss coefficient.

5. An engine according to claim 1, characterized in that it is provided with a compressed air receiver connected, e.g. in parallel with the cooling jacket, which comprises a chamber being hermetically sealed at an elevated pressure, a pressure path communicating the working space of the receiver with the spaces of the cylinders, and a discharge path communicating the space of the receiver with the space of the cooling jacket, said paths accommodating, accordingly, pressure and discharge valves, e.g. controlled automatic relief valves, which supply the compressed air from the working cylinders into the receiver after preliminary filling of the cooling jacket and accumulation of the compressed air in the receiver by the control command to the pressure controlled automatic relief valve and additionally control the pressure and rate of flow of the cooling medium in the cooling jacket and, accordingly, the supercharging pressure and intensity of cooling by letting the compressed air flow from the receiver into the cooling jacket when starting the engine and when its load suddenly grows up by the commands delivered to the discharge controlled automatic relief valve, and at excessive pressure in the respective spaces.


into cooling
jacket
15
16
14
6
23
10
8
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2
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1
12
1
5
11
17
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4
17

Fig. 1

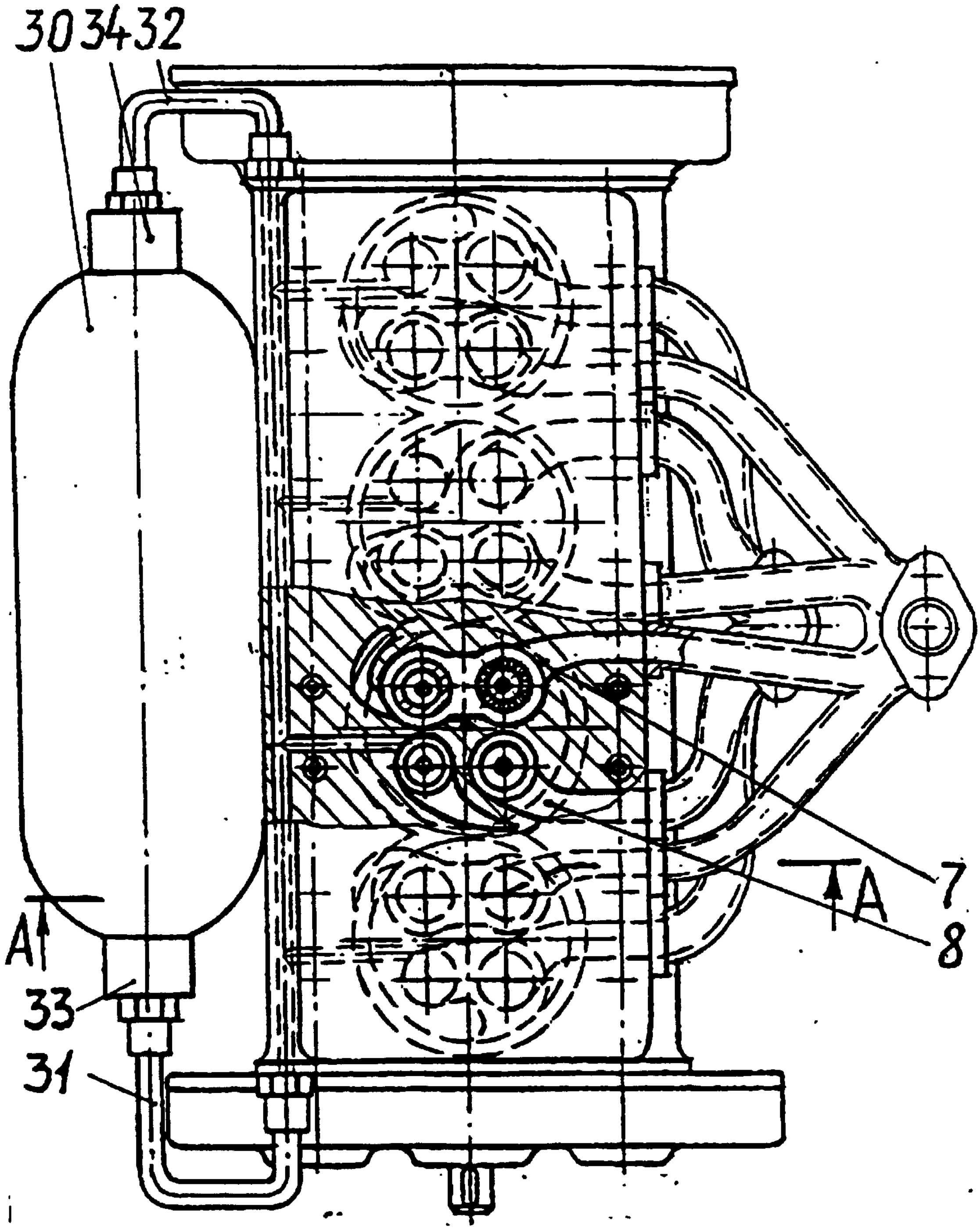

Fig. 2

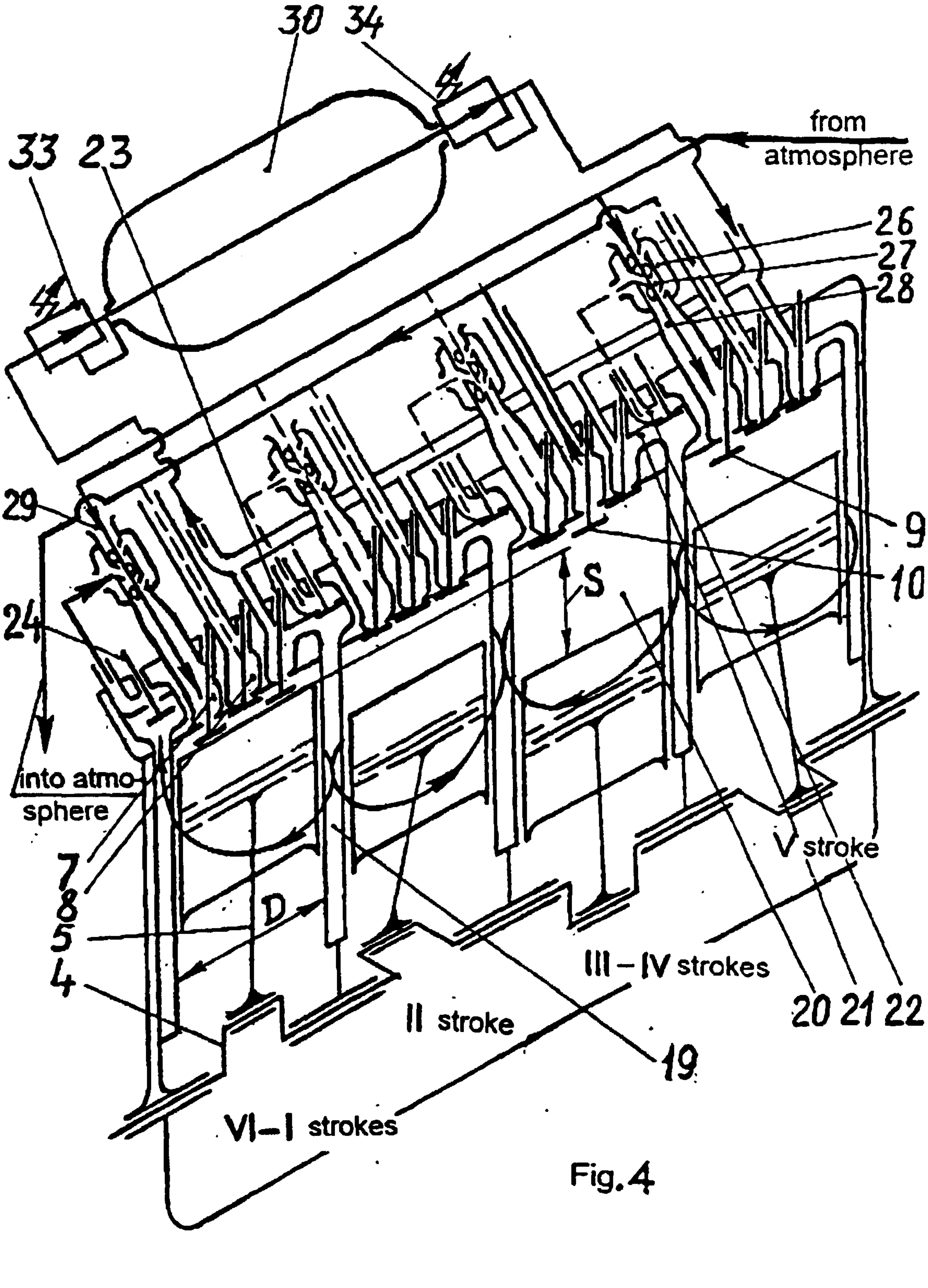
30
34
33
23
from
atmosphere
26
27
28
29
9
S
10
24
into atmo-
sphere
7
8
5
D
4
V stroke
III – IV strokes
20 21 22
II stroke
19
VI – I strokes

Fig.4

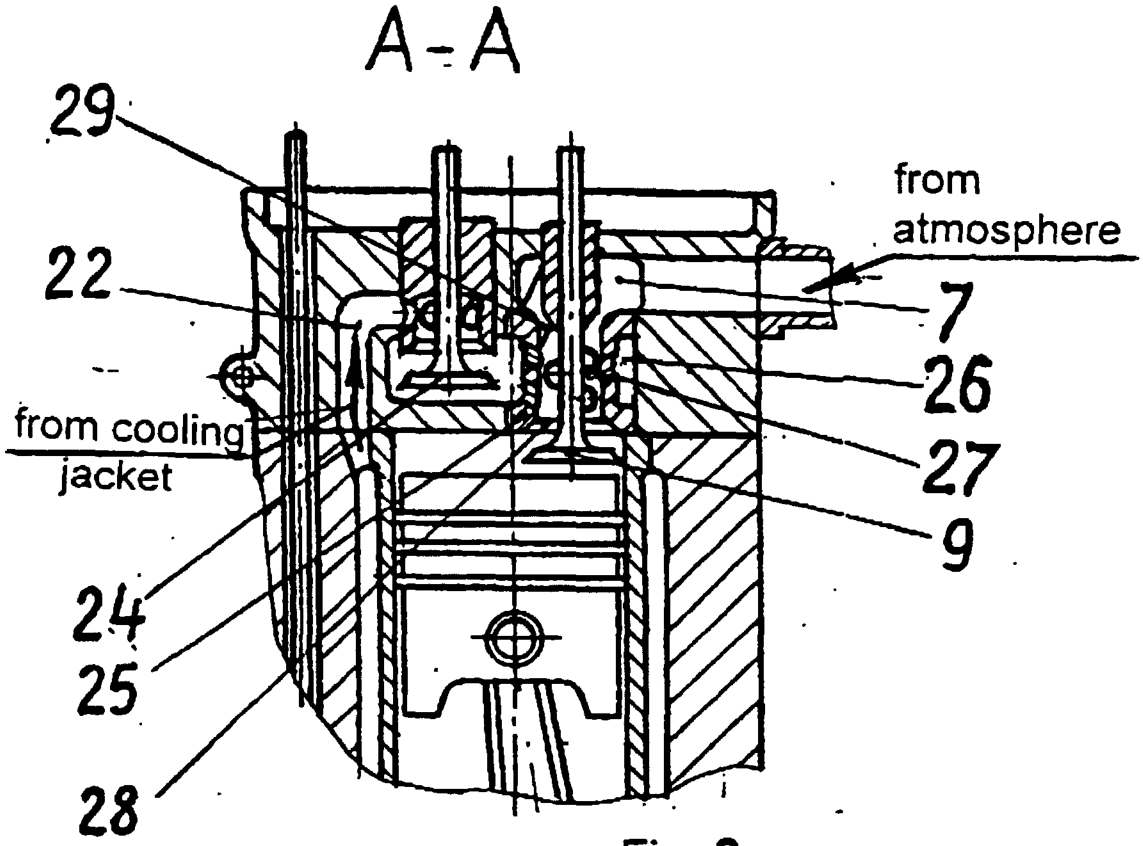
A-A
29
22
from cooling jacket
24
25
28
from atmosphere
7
26
27
9

Fig. 3

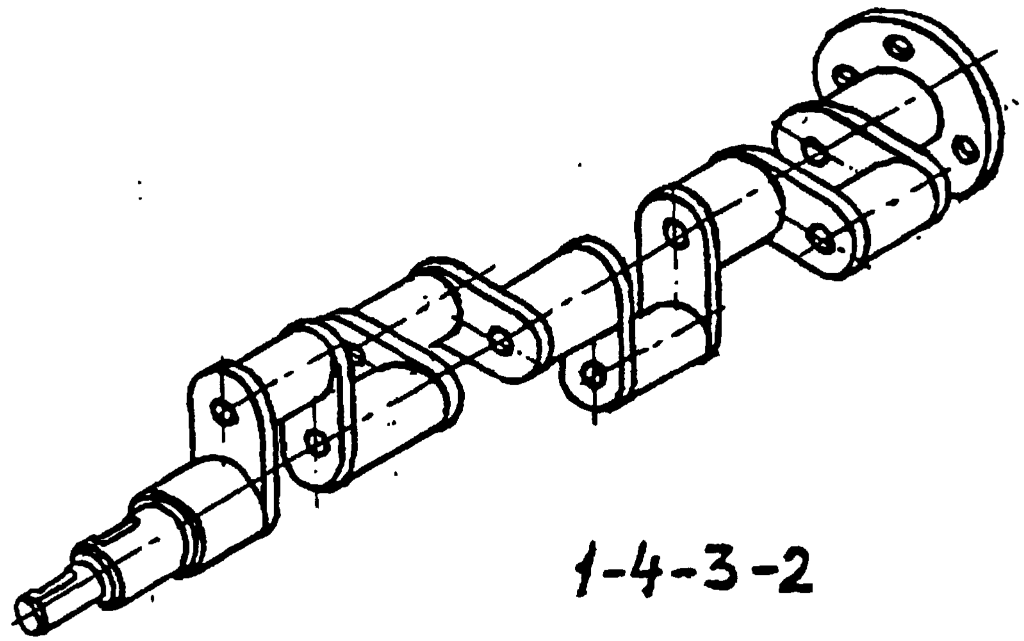
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Fig. 5