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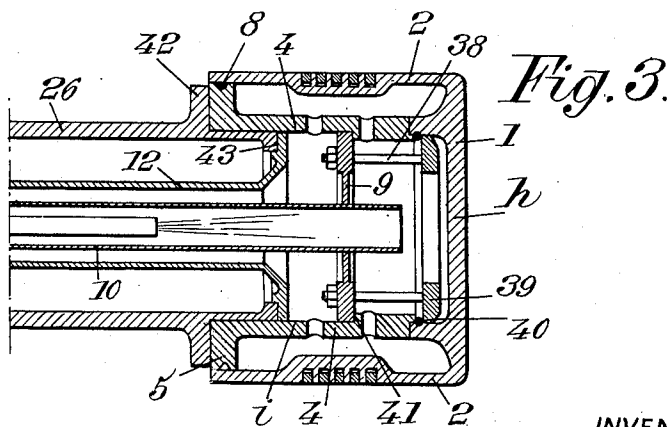
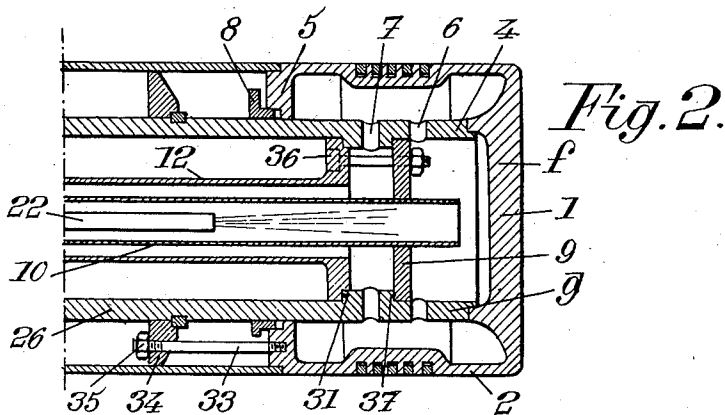
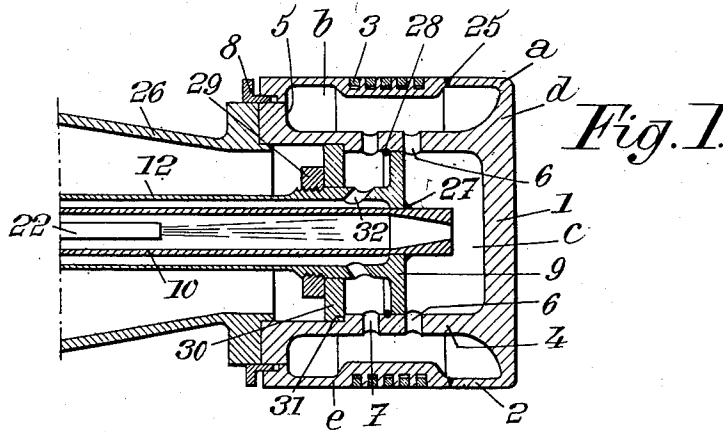
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## INTERNAL-COMBUSTION ENGINE PISTON

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## UNITED STATES PATENT OFFICE

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## INTERNAL-COMBUSTION ENGINE PISTON

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The present invention relates to internal combustion engine pistons and is more particularly but not exclusively concerned with free pistons for such machines, i. e. pistons the length of stroke of which depends upon the balancing of the motive and resistant energies to which it is subjected and not upon the operation of a mechanical system.

Free pistons are known which include, inside the portion of the cylindrical side wall thereof which adjoins the piston end wall and is fitted with packing rings, a cylindrical partition substantially coaxial with said side wall.

The object of our invention is to obtain in a simple manner an efficient cooling of the end wall of a piston of this kind, and to prevent breaks in the vicinity of the place where the piston end is connected to the side wall thereof.

According to our invention, in a piston of this type, the space between its cylindrical side wall and the cylindrical inner partition is closed at its rear end by a transverse partition, thus forming a chamber which is partly filled with a cooling liquid and inlet and outlet apertures for this liquid are provided in said cylindrical partition on either side of a transverse inner partition and at a distance both from the piston end wall and from said first mentioned transverse partition, front and rear pockets being thus created in said chamber in which is housed a mass of cooling liquid.

Preferred embodiments of the present invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example and in which:

Figs. 1 to 4 inclusive show, by way of example, four different embodiments of pistons made according to our invention, each of these figures being a piston axial section;

Fig. 5 is a diagrammatic sectional view of the left hand portion of an autogenerator having opposed free pistons with conduits for the inflow and the outflow of the liquid for cooling the motor piston belonging to the movable unit of said portion of the auto-generator.

Each of the pistons shown in the various figures and which constitutes a motor piston of a free piston system includes an end wall 1 the front face of which limits the motor space of the motor cylinder in which this piston is working. This piston end wall is made of relatively great thickness to enable it to support the high pressures which act thereon when the internal combustion engine is in operation.

The periphery of the piston end wall 1 is con-

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nected to a cylindrical wall portion 2 the outer surface of which cooperates with the cylindrical inner surface of the motor cylinder. Packing rings 3 are housed, in the usual manner, in this cylindrical wall. Part 2 is made of reduced thickness so as thus to maintain a certain elasticity which enables it to follow, up to a point, the expansions to which the piston is subjected by its heating during operation of the engine. The critical place, where breaks easily occur, is constituted by the circular junction zone *a*. Despite the elasticity of the side wall 2 of the piston, joint *a* and the surrounding portions must be very efficiently cooled. The way of obtaining this cooling will be hereinafter described.

As part 2, due to its reduced thickness, is not capable of transmitting the stresses exerted upon the piston end wall 1, a cylindrical partition is provided inside this wall 2 and substantially in coaxial relation therewith, this partition 4 being generally of greater thickness than wall 2 and having preferably a diameter equal to at least one half of the diameter of side wall 2, partition 4 being intended to transmit at least a great portion of the stresses acting upon the piston end wall.

In order to ensure cooling of the piston about zone *a*, according to an important feature of our invention, the space between side wall 2 and partition 4 forms a chamber *b* partly filled with a cooling liquid, for instance oil, and for this purpose, this space is closed at the rear by a transverse partition 5 located at a substantial distance from end wall 1 and even preferably at the rear of the zone in which packing rings 3 are located.

Inlet apertures 6 and outlet apertures 7 are provided in partition 4 for the cooling liquid, these apertures being located at a distance both from the piston end wall 1 and from rear partition 5. We thus obtain, in chamber *b*, front and rear pockets adapted alternately to receive, in the course of the reciprocating movement of the piston, a mass of cooling liquid which cannot escape through the inlet and outlet apertures of chamber *b*.

In order to permit free expansion of the cylindrical side wall 2 with respect to partition 4, partition 5 is made either rigid with only wall 2 (see Fig. 2 and Fig. 4), or rigid with only partition 4, or again partly with wall 2 and partly with partition 4 (see Fig. 1) and in all cases we provide packing means which make chamber *b* liquid-tight while allowing for a limited axial sliding

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of the rear end of wall 2 with respect to partition 4.

We further provide, inside partition 4 and between the two sets of cooling liquid inlet and outlet apertures 6 and 7, a transverse partition 9 which thus forms immediately behind the central portion of the piston end wall 1, a cooling liquid inlet chamber c. In order to feed liquid to this chamber c, a feed conduit 10 is provided, which opens into this chamber, the end of this conduit projecting preferably from partition 9 into chamber c so that, during the movement of the piston toward the right, a mass of liquid gathers about this projecting end and is thus prevented from flowing back into feed conduit 10.

The end of conduit 10 which penetrates into conduit c may be given the shape of a nozzle, as shown by Fig. 1. According to another embodiment illustrated by Fig. 4, we provide, at the outlet end of conduit 10, a deflecting plate 11 which radially deflects the cooling liquid which is being supplied in an axial direction. This deflection prevents the cooling liquid which is being fed from impinging directly against the center of the piston end wall.

In order constantly to evacuate a portion of the cooling liquid, conduit 10 is surrounded by an evacuation conduit 12 and the interval between conduits 10 and 12 is connected with the outlet apertures 7 of chamber b. The inflow of the cooling liquid through conduit 10 and its outflow through conduit 12 may take place in the way indicated by Fig. 5. This figure shows the left hand portion of an auto-generator having opposed free pistons and which includes on the one hand a motor cylinder 13 in which the motor piston according to the invention is working and on the other hand a compressor cylinder 14 divided into two chambers by a compressor piston 15 rigid with the above mentioned motor piston so as to form therewith a movable unit. The chamber located on the right hand side of piston 15 constitutes the compressor space proper, this space being provided with suction valves 16 and discharge valves 17, while the space located on the left hand side of this same piston constitutes a return energy pneumatic accumulator.

In order to ensure inflow and outflow of the cooling liquid, we fix, on the left hand wall 18 of cylinder 14, a tube 19 the inner end 20 of which coaxially surrounds tube 12, which is rigid with the movable unit, a stuffing box or other packing means 21 being provided between the end 20 of tube 19 and said tube 12. Furthermore, we fix to the cylinder, on the inside of tube 19 and coaxially therewith, a second tube 22 which extends into tube 10. The outer end of tube 19 communicates with a cooling liquid exhaust conduit 23, while the outer end of tube 22 is connected with a cooling liquid feed conduit 24. Of course, all these last mentioned tubes 19, 22, 23, and 24 are stationary and do not participate in the reciprocating movement of the movable unit.

The cooling liquid injected through tube 22 into tube 10 thus flows into chamber c adjacent to the central portion of the end wall 1 of the motor piston. This liquid then enters chamber b through apertures 6. The liquid, which only partly fills chamber b, forms therein a liquid mass which has, during the movement of the piston and due to the inertia of the liquid, a reciprocating movement, the velocity of which with reference to the piston is practically equal to the velocity of the piston itself. Consequently, oil is violently thrown against the piston end wall,

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which ensures a very efficient cooling, further reinforced by eddies formed inside the liquid mass. It should be noted that these movements of the liquid mass are particularly intensive in a free piston which is subjected, when in the vicinity of its dead center points, to high retardations and accelerations.

Besides, the shape of the inner face of the piston end wall 1 close to zone a is chosen in such manner as to obtain maximum eddying in this zone.

The liquid mass which is formed in chamber c undergoes analogous movements and also has an intensive cooling effect when it is thrown against the central portion of the piston end wall.

The excess of cooling liquid supplied through tube 10 is constantly evacuated through apertures 7 and the interval between tubes 10 and 12, so as thus to pass into tube 19 from which it flows out through conduit 23.

The motor piston being preferably made of steel, it is advantageous, in order to facilitate its manufacture, to make it of several elements. Thus, according to Fig. 1, this piston is essentially constituted by two elements d and e, portion d including end wall 1, partition 4, a portion of wall 2 and a portion of wall 5, whereas element e includes most of wall 2 and a portion of wall 5. The two elements d and e are fixed together by means of a weld joint 25. The whole of the motor piston thus constituted is fixed, for instance by means of bolts, to rod 26, which connects the motor piston with compressor piston 15. Wall 9 and tubes 10 and 12 may be fixed in the motor piston, for instance in the manner illustrated by Fig. 1, according to which tube 12 is rigid with wall 9 which also carries tube 10, for instance through a weld joint 27.

Partition 9 is itself applied against a circular abutment 28 of partition 4, by means of a nut 29 screwed on a threaded portion of tube 12 and applied against a plate 30 which bears against a shoulder 31 provided on the inner face of partition 4. Apertures 32 provided in tube 12 afford communication between the outlet apertures 7 of chamber b and the interval between tubes 10 and 12.

According to Fig. 2, the motor piston is constituted by elements f and g, element f including piston end wall 1, outer cylindrical wall 2 and transverse partition 5, whereas element g essentially includes inner partition 4, this partition, in the embodiment of Fig. 2, being constituted by the end of rod 26.

Element f is fixed on element g by means of bolts 33 one of the ends of which is screwed in wall 5 whereas the other end passes through a ring 34 mounted on rod 26, nuts 35 screwed on the free ends of bolts 33 being applied against ring 34.

According to Fig. 2, tube 12 is provided at its inner end with a flange 36 which is applied against a shoulder 31 of element g, under the pressure of bolts and nuts which apply partition 9, which carries tube 10, against another shoulder 37 formed on the inner wall of partition 4.

In the embodiment of Fig. 3, the element h of the motor piston includes end wall 1 and cylindrical wall 2, whereas the element i includes the inner partition 4 and wall 5. These two elements are assembled together by means of bolts 38 which urge toward each other a ring 39 bearing at 40 against element h and partition 9 which bears upon a shoulder 41 of partition 4. The whole of h and i is fixed, for instance by means of bolts,

on a flange 42 of rod 26, upon the end of which conduit 12 is also fixed at 43, while conduit 10, as in the preceding embodiment, is fixed in partition 9.

In the embodiment shown by Fig. 4, the motor is constituted by three main elements:

1. An element *j* which constitutes the central portion of the piston end wall;

2. An element *k* which constitutes the peripheral portion of the piston end wall and also side wall 2 and wall 5, this element further including a frusto-conical extension 44 which forms a housing for the element *j* of the piston end wall;

3. An element *l* which forms the inner partition 4 of the piston and includes a flange 45 through which the end of hollow rod 26 and an intermediate piece 46 acting as a support for conduit 12 are fixed, for instance by means of bolts.

The three elements *j*, *k* and *l* are connected together by means of bolts 47 screwed at one of their ends in element *j* and bearing, through nuts fixed on their other end, against partition 9 which bears against a shoulder 48 provided on element *l*, the inner edge of the frusto-conical portion 44 of element *k* being thus tightly held against elements *j* and *l*.

It should be noted that the expression "free piston" is meant to include not only a piston both of the dead center points of which are variable but also a piston only one dead center point of which, in particular the inner one, is variable.

In a general manner, while we have, in the above description, disclosed what we deem to be practical and efficient embodiments of our invention, it should be well understood that we do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

What we claim is:

1. An internal combustion engine piston which comprises, in combination, a cylindrical wall, an end wall transverse to the axis of said cylindrical wall, a cylindrical partition coaxial with said cylindrical wall on the inside thereof and extending from said end wall to a distance therefrom, a transverse partition extending from said cylindrical wall to said cylindrical partition at the end thereof located at a distance from said piston end wall, whereby an annular chamber for a cooling liquid is formed between said cylindrical wall, said cylindrical partition, said piston end wall and said transverse partition, a second transverse partition extending across said cylindrical partition and on the inside thereof at a place intermediate between the piston end wall and the first mentioned transverse partition, whereby a central chamber is formed between said cylindrical partition, said piston end wall and said second transverse partition, means for feeding cooling liquid into said central chamber, the cylindrical partition being provided with at least one inlet aperture connecting said central chamber with said annular chamber, said aperture being located at a distance from the piston end wall, said cylindrical partition being also provided with at least one outlet aperture located between said two transverse partitions and at a distance from the first transverse partition, and means for letting out cooling fluid from said second mentioned aperture.

2. An internal combustion engine piston which comprises, in combination, a cylindrical wall, an

end wall transverse to the axis of said cylindrical wall, a cylindrical partition coaxial with said cylindrical wall on the inside thereof and extending from said end wall to a distance therefrom, a transverse partition extending from said cylindrical wall to said cylindrical partition at the end thereof located at a distance from said piston end wall, whereby an annular chamber for a cooling liquid is formed between said cylindrical wall, said cylindrical partition, said piston end wall and said transverse partition, a second transverse partition extending across said cylindrical partition and on the inside thereof at a place intermediate between the piston end wall and the first mentioned transverse partition, whereby a central chamber is formed between said cylindrical partition, said piston end wall and said second transverse partition, an axial conduit extending through said second transverse partition and projecting therefrom to a distance inside said central chamber for feeding cooling liquid into said central chamber, the cylindrical partition being provided with at least one inlet aperture connecting said central chamber with said annular chamber, said aperture being located at a distance from the piston end wall, said cylindrical partition being also provided with at least one outlet aperture located between said two transverse partitions and at a distance from the first transverse partition, and an outflow conduit coaxially surrounding said first mentioned conduit for letting out cooling fluid from said second mentioned aperture.

3. An internal combustion engine which comprises, in combination, a frame, a motor piston mounted to reciprocate with respect to said frame and including a cylindrical wall, an end wall transverse to the axis of said cylindrical wall, a cylindrical partition coaxial with said cylindrical wall on the inside thereof and extending from said end wall to a distance therefrom, a transverse partition extending from said cylindrical wall to said cylindrical partition at the end thereof located at a distance from said piston end wall, whereby an annular chamber for a cooling liquid is formed between said cylindrical wall, said cylindrical partition, said piston end wall and said transverse partition, a second transverse partition extending across said cylindrical partition and on the inside thereof at a place intermediate between the piston end wall and the first mentioned transverse partition, whereby a central chamber is formed between said cylindrical partition, said piston end wall and said second transverse partition, an axial conduit rigid with said piston extending through said second transverse partition and projecting therefrom to a distance inside said central chamber, a second conduit coaxially surrounding said first mentioned conduit and rigid therewith, means rigid with said frame for feeding cooling fluid into the first mentioned conduit, the cylindrical partition being provided with at least one inlet aperture connecting said central chamber with said annular chamber, said aperture being located at a distance from the piston end wall, said cylindrical partition being also provided with at least one outlet aperture located between said two transverse partitions and at a distance from the first transverse partition, means for connecting said outlet aperture with the annular space between said two coaxial conduits, a conduit rigid with said frame engaging in a fluidtight fashion the outer wall of the second mentioned conduit, and means for the out-

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flow of cooling liquid from the third mentioned conduit.

4. An internal combustion engine piston according to claim 2 further including a transverse deflection plate mounted at the end of said axial conduit located in said central chamber so as radially to deflect the cooling liquid flowing out from said conduit.

5. An internal combustion engine piston according to claim 1 constituted by three elements assembled together, the first element forming the central portion of the piston end wall and having a frusto-conical peripheral edge, the second element forming the peripheral portion of said end wall, the lateral wall and the first mentioned transverse partition, said second element including a frusto-conical housing adapted to accommodate the peripheral edge of said first element, and the third element forming the cylindrical partition, said cylindrical partition being provided, on its inner face, with a shoulder adapted to cooperate with the second transverse partition to prevent displacement thereof with respect to said cylindrical transmission beyond a given point

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in the direction of the piston end wall, said piston further including rods for assembling said three elements together, said rods being each fixed at one end in said first mentioned element and being connected at their other end with said second transverse partition to pull said last mentioned partition against said shoulder.

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