

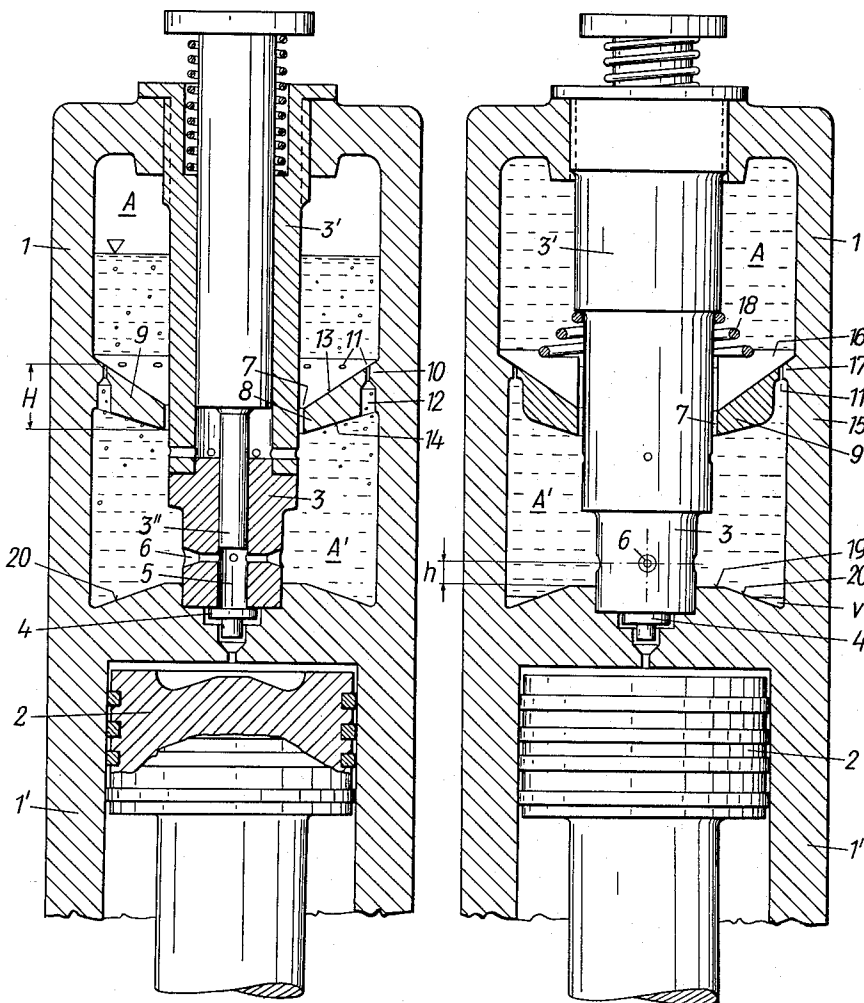
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FUEL CONTAINERS IN RECIPROCATING CYLINDERS
OF INTERNAL COMBUSTION ENGINES
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FIG. 1

FIG. 2



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FUEL CONTAINERS IN RECIPROCATING CYLINDERS OF INTERNAL COMBUSTION ENGINES

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This invention relates to a system for removing gas from the fuel in reciprocating fuel containers of internal combustion engines, more particularly fuel containers of internal combustion hammers, which containers communicate with the injection pump.

In internal combustion hammers and stampers, in which both the fuel container and also the members used for injecting the fuel into the working cylinder are accommodated in parts that jump during operation, the problem of the removal of gas from the fuel is particularly important, because the fuel is shaken together with air to a particularly large extent owing to the reciprocating movement of the fuel container, and any air or gas bubble involves the risk of trouble in operation. Experience has shown that filters placed in front of the fuel supply bores provided in the injection pump cannot obviate these defects.

According to the invention, the internal chamber of the fuel container is subdivided into two chamber parts disposed one above the other and communicating with one another through narrow passages; in certain cases the passages may be united to form a narrow annular gap. The fuel which is in the upper chamber part and which during operation is permeated by air owing to the continuous reciprocating movement, gives up its air bubbles on passing into the lower chamber part, so that the small air bubbles remain behind in the upper chamber part, and the liquid fuel which has passed through the narrow passages or through the annular gap into the lower chamber part and which completely fills this part, is free from air. Moreover the narrow passages prevent the fuel located in the lower chamber part from flowing upwards unchecked as soon as the hammer body during its rapid ascent has its upward movement retarded by picking up the hammer piston or by frictional resistances of the hammer body. Also, the subdivision of the internal chamber of the container, and the narrow passages, ensure that even during the abovementioned retardation of the upward movement the filling of the injection pump takes place under suitable liquid pressure.

In accordance with a further feature of the invention, the passages used for passing the fuel from the upper into the lower chamber part may be disposed in the bottom region of an intermediate wall extending at an inclination and separating the two chambers parts, and additional passages may be provided in the top region of this intermediate wall. This construction not only prevents air bubbles from getting from the upper into the lower chamber part but also at the same time ensures the separation of any air or gas particles that may have gotten into the lower chamber part in any way. For instance it is quite possible even if the internal combustion engine of the hammer is operating satisfactorily in other respects, that compressed air or combustion gases may occasionally get out of the combustion chamber, past the non-return valve of the injection pump and through the fuel supply bores of this pump, into the lower chamber part of the container. The air or gas bubbles expanding in this chamber part rise in the fuel to the top region of the intermediate wall and from there pass out through the additional narrow passages into the upper chamber part, whereby re-entry of these air or gas bubbles into the in-

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jection pump is prevented; this re-entry would cause trouble in operation. The passages disposed in the bottom region of the intermediate wall may advantageously be formed by a narrow annular gap located between the bottom end of the intermediate wall and a holder of the injection pump. The additional passages disposed in the top region of the intermediate wall are preferably formed as narrow bores merging into widened portions extending towards the lower chamber part. But the additional passages can also be united to form a narrow annular gap which widens towards the lower chamber part. The intermediate wall surrounding the holder of the injection pump and extending downwards towards this holder may advantageously have conical bounding surfaces. Alternatively, however, this wall may consist of a disc inserted into the fuel container and forming narrow gaps in combination with the holder of the injection pump and with the lateral boundary wall of the fuel container.

In order to ensure that any compressed air or combustion gases getting through during temporarily faulty operation of the non-return valve of the injection pump, can flow away unhindered into the upper chamber part, it is advisable to make the fuel supply ducts of the injection pump, which extends through the lower chamber part, lead directly from this lower chamber part, whereby the distance from the internal chamber of the pump to the fuel container is reduced to a minimum, in contradistinction to constructions used heretofore in which the communication between the fuel container and the internal chamber of the pump was usually established by means of different bores which were relatively long and in some cases bent at angles to one another. The bottom boundary surface of the lower chamber part may preferably have a region which descends towards the lateral boundary wall of that part and advantageously is of conical shape, and is downwardly offset, through a certain distance, with respect to the fuel supply bores of the injection pump. By means of this construction, maintenance of the flow of fuel to the supply bores of the injection pump is ensured even during the retardation that takes place during the last stage of the rapid ascent of the hammer body, since only a very small part of the fuel that completely fills the lower chamber part and is pressed against the intermediate wall during the retardation period, passes through the narrow passages into the upper chamber part, whereby a vacuum lasting only for a brief length of time is formed in the region of the lower boundary surface of the lower chamber part, but extends only over the preferably conically descending boundary surface region and is unable, because of the fact that this region is vertically offset with respect to the fuel supply bores, to spread as far as these supply bores.

Vertical sections through two embodiments of the invention chosen by way of example are shown in FIGURES 1 and 2 of the accompanying drawings.

In these drawings, 1 is a hammer body surrounding a fuel container and having a lower part 1' in which a piston 2 of an internal combustion hammer is guided. An injection pump 3 is secured, by means of a holder 3' screwed into the hammer body 1, in a cylinder head formed by the upper part of the hammer body. 3" is the piston of the injection pump. The injection pump, of which the axis coincides with that of the hammer body, and of the fuel container in the embodiments illustrated, may alternatively be arranged eccentrically, i.e. offset laterally. 4 is a non-return valve provided at the injection pump nozzle, and 5 is the internal chamber of the injection pump, which chamber is located between that valve and the pump piston 3"; fuel supply bores 6 lead into this chamber.

The internal chamber of the fuel container is subdivided

vided into two chamber parts A and A' which are disposed one above the other and communicate with one another through narrow passages 7. The passages may be formed by one or more narrow bores arranged for instance in a ring or may alternatively be constructed as a narrow annular gap. In addition to the passages 7 disposed in the bottom region 8 of the intermediate wall 9 separating the two chamber parts A and A' and extending at an inclination, additional narrow passages 11 are provided which are located in the top region 10 of this intermediate wall. In the embodiment illustrated in FIGURE 1, the passages 7 disposed in the bottom region 8 of the intermediate wall 9 are formed by a narrow annular gap located between the bottom end of the intermediate wall and the holder 3' of the injection pump 3, whereas the additional passages 11 located in the top region 10 of the intermediate wall 9 consist of a ring of narrow bores merging into widened portions 12 extending towards the lower chamber part A'. The intermediate wall 9 surrounding the holder 3' of the injection pump 3 and extending downwards towards this holder has conical bounding surfaces 13 and 14.

The large piston above and integral with pump piston 3'' is guided in the hollow cylindrical holder 3', so that the pump piston 3'' connected to this large piston is satisfactorily aligned. The pump piston 3'' therefore does not need to be guided in the cylinder of the injection pump 3, that is to say, this cylinder does not have to perform the function of maintaining the piston 3'' in correct alignment. The piston 3'' can therefore slide up and down in the pump cylinder, making sealing contact with the inside surface of the cylinder, and does not have to be supported by the pump cylinder against any transverse forces that may arise, since these forces are absorbed by the holder 3' surrounding the large piston integral with piston 3''. The pump piston 3'' therefore wears only to a practically negligible extent, and therefore continues always to ensure a constant injection pressure and therefore a correct quantity of injected fuel, even after this piston 3'' has been in use for a long time.

During upward movement of the said large piston, fuel is sucked into the annular space between the pump piston 3'' and the internal surface of the holder 3', through the transverse bores shown in the drawing, which are provided between the said annular space and the chamber part A'. During subsequent descent of the large piston, the pressure in said annular space rises, whereby the fuel that has been sucked in is mostly forced back into the chamber part A', but some of this fuel is forced upwards into the sliding clearance between the large piston and the holder 3'. This ensures very satisfactory lubrication of the large piston.

In addition to this, the said large piston has another special function. This large piston causes injection to occur, in the following manner.

The downward movement of the hammer body 1 is retarded as soon as the power piston 2 strikes against the pile that is being hammered. The air in the combustion chamber above the piston 2 is then compressed, and this brakes the further downward movement of the hammer body 1. But the large piston integral with the piston 3'' is slidable in the hammer body and tends to follow the force of gravity, i.e. to continue its descent. The strength of the spring, shown in the drawing, which bears at one end against the plate-shaped end of the large piston and at the other end against the holder 3', is made such that the spring permits relative displacement between the said large piston and the hammer body as indicated above, but subsequently brings the said large piston and therefore the pump piston 3'' back into the position, relative to the hammer body 1, which is shown in the drawing.

In the embodiment illustrated in FIGURE 2, the additional passages 11' are also united to form a narrow annular gap which widens towards the lower chamber

part A'. The intermediate wall consists of a disc 9' inserted into the fuel container and forming narrow gaps 7 and 11' in combination with the holder 3' of the injection pump 3 and with the lateral boundary wall 15 of the fuel container; the disc has ribs 16 which project beyond its outer periphery, and is supported, through the intermediary of these ribs, on a projection 17 formed on the lateral boundary wall 15 of the container. A compression spring 18 arranged for instance between the injection pump holder 3' and the ribs 16 secures the disc 9' in the position shown in the drawing.

The fuel supply bores 6 of the injection pump 3, which extends through the lower chamber part A', lead directly from this lower chamber part. The bottom boundary surface 19 of this chamber part has a region 20 which descends towards the lateral boundary wall 15 of this part and advantageously is of conical shape, and is downwards offset, through a distance h , with respect to the fuel supply bores 6.

The manner of operation of the apparatus is as follows:

When the fuel container is stationary, that is to say, when the hammer body in the present embodiments is stationary, fuel introduced into the upper chamber part A is freed from gas on passing through the narrow passages, so that only fuel that is completely free from air can get into the lower chamber part A', the fuel supply bores 6 and the internal chamber 5 of the pump and down to the non-return valve 4. Since the level of the liquid in the upper chamber part A then descends because of the consumption of fuel during the operation of the hammer, as a rule the upper chamber part is only partly full of fuel. By the retardation of the downward movement of the hammer body 1 and subsequent upward acceleration of this body, due to the compression and the ignition of the injected fuel before the impact of the hammer body, to the impact itself, and to the subsequent expansion of the combustion gases, the fuel in the chamber parts A and A' is forced with considerable pressure, by its own inertia, against the container walls surrounding the fuel, whereby air or gas bubbles in the fuel are urged rapidly upwards. Because of the inclined direction of the intermediate wall 9 of the disc 9', the rising air or gas bubbles in the lower chamber part A' are guided towards the top region of the intermediate wall or disc, and from there the bubbles pass through the additional narrow passages 11 or the narrow annular gap 11' into the upper chamber part A, and at the same time fuel flows from the upper to the lower chamber part through the narrow annular gaps 7. Furthermore, during the reciprocating movement of the hammer body and the consequent alternation between acceleration and retardation, the displacement of the air and gas bubbles towards the lateral boundary wall 15 of the lower chamber part A' is also assisted by the conical region 20 of the lower boundary surface 19 of the chamber A', which region is inclined downwards towards that boundary wall. As indicated in FIGURE 1, the liquid column H causes gas bubbles, which occasionally expand into the lower chamber part A' through the injection pump, to rise through the narrow passages 11 or 11'.

After expansion has ended, the hammer body is retarded by the piston friction and still more by picking up the piston, but this retardation of the hammer body mainly affects the fuel located in the upper chamber part A. When the magnitude of the retardation exceeds that of gravitational acceleration, the liquid level in the upper chamber part A is reversed, and intensive intermingling with air takes place. But as regards the fuel enclosed in the lower chamber part A', only a small portion of this fuel can pass through the passages 7 and 11 or 11' into the upper chamber part A, and at the same time a vacuum v (FIGURE 2) lasting only a brief period of time is formed; this vacuum is ring-shaped and surrounds the conically de-

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scending region 20 of the lower boundary surface 19 of the lower chamber part A' and does not extend as far as the fuel supply bores 6 of the injection pump 3, whereby the filling of the injection pump without air bubbles is ensured.

The liquid level in the upper chamber part A will have returned to normal before the hammer body 1 falls back, so that during the descent fuel can again flow from A to A' at the beginning of the compression period, whereby the lower chamber part A' is again completely filled with fuel and any air or gas bubble that may be present are forced through the additional passages 11 or 11' into the upper chamber part A. Therefore, however abrupt the alternation between acceleration and retardation may be, the apparatus according to the invention ensures steady uninterrupted feeding of the injection pump with fuel that is completely freed from gas, and consequently also ensures completely satisfactory operation of the equipment.

What is claimed is:

1. In an internal combustion engine, an upwardly and downwardly reciprocable power cylinder, a power piston slidably mounted in said cylinder, a cylinder head on said power cylinder above said piston, a fuel chamber formed in said cylinder head, a downwardly and inwardly inclined annular intermediate wall having an upper and a lower extremity and dividing said chamber into an upper chamber part above said wall and a lower chamber part beneath said wall, first permanently narrow passage means disposed adjacent said upper extremity and providing communication between said upper and lower chamber parts, second permanently narrow passage means disposed adjacent said lower extremity and providing communication between said upper and lower chamber parts, and an injection pump adapted to communicate with said lower chamber part and to inject fuel into said power cylinder.

2. In an internal combustion engine as claimed in claim 1, a holder extending through said intermediate wall and accommodating said injection pump, and a narrow annular gap located between said lower extremity of said intermediate wall and said holder and constituting said second permanently narrow passage means.

3. In an internal combustion engine as claimed in claim 1, narrow bores formed in said intermediate wall near said upper extremity thereof and merging into widened portions extending towards said lower chamber

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part, said bores constituting said first permanently narrow passage means.

4. In an internal combustion engine as claimed in claim 1, an annular gap widening towards said lower chamber part and constituting said first passage means.

5. In an internal combustion engine as claimed in claim 1, an upper and a lower frusto-conical bounding surface on said intermediate wall.

6. In an internal combustion engine as claimed in claim 1, an annular disc forming said intermediate wall, a holder accommodating said injection pump and extending through said disc, a first annular gap located between said disc and said cylinder head and constituting said first narrow passage means, and a second annular gap located between said disc and said holder and constituting said second narrow passage means.

7. In an internal combustion engine, an upwardly and downwardly reciprocable power cylinder, a power piston slidably mounted in said power cylinder, a cylinder head on said power cylinder above said power piston, a fuel chamber formed in said cylinder head and divided into an upper chamber part and a lower chamber part beneath said upper chamber part, said lower chamber part having a bottom surface which is adjacent to said piston and comprises a downwardly and outwardly inclined frusto-conical portion, and a top surface adjacent to said upper chamber part, passage means providing communication between said upper and lower parts, said passage means being at all times sufficiently narrow to prevent bubbles from passing from said upper part into said lower part, an injection pump having an injection cylinder and an injection piston accommodated in said injection cylinder and slidable relatively to said injection cylinder, and duct means disposed wholly above said bottom surface of said lower chamber part and adapted to provide communication between said lower chamber part and said injection cylinder, whereby retardation of said power cylinder during upward movement thereof will cause said injection cylinder to be filled with fuel under pressure.

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