Nov. 5, 1940. J. J. McCARTHY 2,220,609

INTERNAL COMBUSTION ENGINE

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Fig. 1

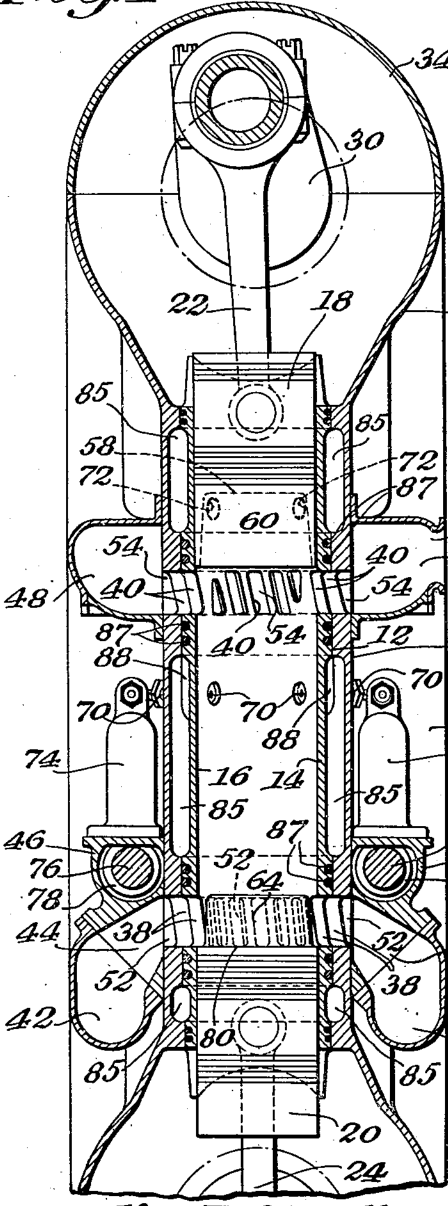


Fig. 2

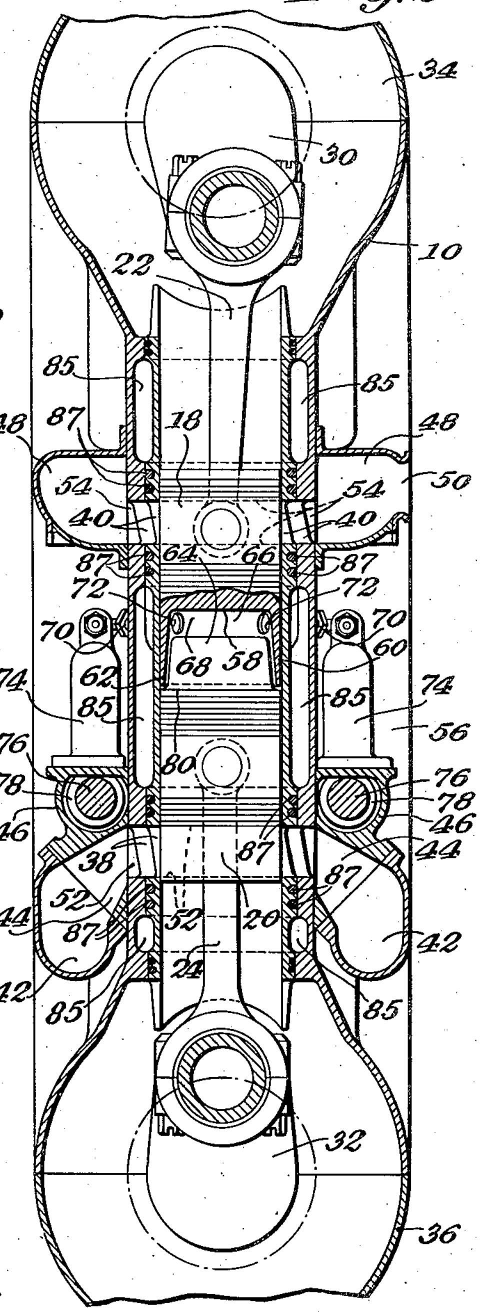


Fig. 1A

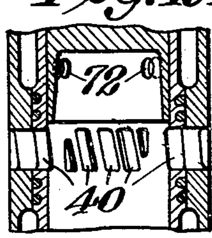
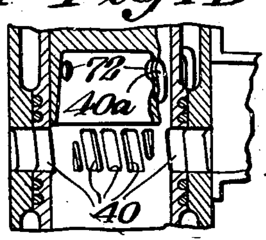


Fig 1B



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INTERNAL COMBUSTION ENGINE

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3 Claims. (Cl. 123—51)

This invention relates to internal combustion engines and more particularly to engines of the so-called "opposed piston type."

It is a well known fact that the crank case and the crank shaft bearings of an internal combustion engine of the highly efficient opposed piston type must be built strong in order to take the stresses of explosion. The main disadvantage therein resides in the large weight per horse power of the engine, whereas the trend is to reduce the weight per horse power.

It is the primary aim and object of the present invention to provide an internal combustion engine of the opposed piston type which has a small weight per horse power and can be manufactured at a low cost.

This and other objects of the present invention are accomplished by so forming the opposed pistons of a cylinder that they define a combustion chamber exclusive of the cylinder wall, wherefore the latter need not take the stresses of the explosion and the crank case as well as the crank shaft bearings may be constructed light in weight. More particularly, one of the pistons is provided with a cup-shaped extension open to the cylinder chamber and of an outside diameter substantially equal to the cylinder diameter, while the other piston has a projecting head piece which enters said cup and forms therein a combustion chamber when the pistons move through preassigned portions of a cycle including their inner dead center positions. Suitable provisions are also made for admitting air into the cylinder, for emitting the products of combustion therefrom and for forcing fuel into the combustion chamber.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation, and it is not intended to limit the invention claimed herein beyond the requirements of the prior art.

In the drawing:

Fig. 1 is a vertical section through a cylinder of an internal combustion engine of the opposed piston type which embodies the present invention.

Fig. 1A is a fragmentary sectional view of the engine, disclosing more particularly the location of the fuel openings in one of the pistons with respect to the exhaust ports in the cylinder.

Fig. 1B is another fragmentary sectional view of the engine, disclosing a modified arrangement of the exhaust ports in the cylinder.

Fig. 2 is a section similar to Fig. 1, showing the opposed pistons in a different position of their respective cycle, however.

Referring to the drawing, the reference numeral **10** designates a crank case, having one or more cylindrical bores **12**, each to receive a cylinder liner **14**. The engine is preferably a multi-cylinder engine with the cylinders in line, there being only one cylinder shown in the drawing because they are cross-sections through the engine. While the cylinders are formed by steel liners in the illustrated embodiment of the invention, making it possible to make the crank case of a light weight material, such as aluminum or an aluminum alloy, and to reduce the weight of the engine to a minimum, it is also fully within the purview of the present invention to cast the cylinders with the crank case and to omit the cylinder liners, in which case the engine becomes naturally heavier.

Inasmuch as all cylinders of the engine are identical, only one will be described hereinafter in detail and in connection with the opposed pistons therein. Slidable on the wall **16** of the cylinder **14** are two opposed pistons **18** and **20** which are drivingly connected in the usual manner by means of connecting rods **22** and **24**, respectively, with crank shafts **30** and **32**, respectively, which are suitably journalled in the crank case **10**. Covers **34** and **36** are applied to the top and bottom, respectively, of the crank case **10** in any suitable manner.

The cylinder liner **14** and the crank case **10** have aligned intake ports **38** and exhaust ports **40**. It will be noticed in Fig. 1 that these ports **38** and **40** are uncovered when the pistons **20** and **18**, respectively, are substantially in their outer dead center positions. The intake ports **38** are in permanent communication with two intake manifolds **42** on opposite sides of the cylinder which conduct air under pressure from a supercharger (not shown) to said intake ports by way of passages **44** which are provided in brackets **46**, interposed between said intake manifolds **42** and the crank case **10**. The exhaust ports **40** are in permanent communication with exhaust manifolds **48** which have a common discharge opening at **50**. The crank case **10** is suitably cored out to provide transverse passages **52** and

54 between adjacent cylinders which are in communication with the intake and exhaust ports 38 and 40, respectively, of adjacent cylinders and provide communication between the intake and exhaust manifolds 42 and 48, respectively, on opposite sides of the crank case. Thus, supercharged air conducted through the intake manifolds 42 has always access to all intake ports 38 of a cylinder, and the products of combustion may always be discharged through all exhaust ports 40 of a cylinder into one of the exhaust manifolds 48 and conducted from there to the common discharge opening 50.

The crank shafts 30 and 32 are connected in any suitable manner to operate in timed relation with each other. This may, for instance, be accomplished by a train of gears (not shown), mounted on an end plate 56 which is preferably integral with the crank case 10. The crank shafts 30 and 32 are preferably so angularly coordinated that the exhaust ports 40 are uncovered by the piston 18 before the intake ports 38 are uncovered by the piston 20, and said exhaust ports are covered by the piston 18 before said intake ports are covered by the piston 20. The products of combustion may then escape prior to the admission of supercharged air into the cylinder and the admitted air may thoroughly scavenge the cylinder before the exhaust ports are covered or closed, the air admitted into the cylinder after the closing of the exhaust ports being clean and available for combustion.

The engine so far described is of conventional construction and the present invention resides in the following construction of the remaining part of the engine. The piston 18 is provided on its head 58 with a cup-shaped extension 60 the rim 62 of which has an outside diameter that is substantially equal to the inside diameter of the cylinder 14. The piston 20 is provided with a projecting head piece 64 which enters the cavity 66 in the extension 60 of the other piston 18 in the manner shown in Fig. 2 and defines therein a combustion chamber 68 when both pistons 18, 20 are substantially in their inner dead center positions. Fuel is injected into the highly compressed air in the combustion chamber 68 at a selected point in each cycle of the pistons 18, 20. The fuel is conducted from fuel nozzles 70 in the cylinder wall into the combustion chamber 68 through openings 72 in the rim 62 of the cup-shaped extension 60 of piston 18, said openings aligning with said fuel nozzles when piston 18 assumes the momentary position shown in Fig. 2 during each cycle. The exhaust ports 40 in the cylinder liner 14 are so arranged that the fuel openings 72 in the piston extension 60 never communicate with said exhaust ports. This may be readily accomplished by so spacing the two adjacent exhaust ports between which each fuel opening 72 of the reciprocating piston passes that neither of said fuel openings ever communicates with said exhaust ports (Fig. 1A). The nozzles 70 are in communication with conventional fuel pumps 74 which in turn communicate in any suitable manner with a fuel supply (not shown). The fuel pumps 74 are mounted on the earlier mentioned brackets 46 which also provide journal bearings for shafts 76, having cams 78 for operating the fuel pumps. The cam shafts 76 are driven in any suitable manner in timed relation with the crank shafts 30, 32 so that the fuel pumps 74 force fuel through the nozzles 70 when the openings 72 in the cup-shaped extension 60 of piston 18 align with said nozzles (Fig. 2).

In order to hold an explosive charge of air and fuel comparable in quantity and pressure to a charge in the same cylinder between the heads of two conventional pistons, the combustion chamber is of a relatively large inside diameter in comparison with the cylinder diameter. Hence, the wall thickness of the cylindrical rim 62 on piston 18 is relatively small, the same being, however, strong enough safely to withstand the explosions in the combustion chamber 68. The cavity 66 is substantially cylindrical and preferably somewhat conical as shown in section in Fig. 2, and the projecting head piece 64 of piston 20 is preferably likewise conical and has a small clearance from the rim 62 when the pistons are at or near their inner dead center positions. Thus, no air can possibly be trapped between the head 80 of piston 20 and the adjacent end of the rim 62 on piston 18 and impede the movement of the pistons. Also, the clearance between the conical rim 62 on piston 18 and the conical projecting head piece 64 on piston 20 is at first considerable when said head piece just enters the cavity 66, wherefore the flow of air into said cavity is not greatly obstructed. However, this clearance becomes smaller and smaller as the projecting head piece 64 of piston 20 progresses into the cavity 66 in piston 18 until said clearance becomes so small at the time of combustion that the exploded charge cannot effectively reach the cylinder wall and induce stresses in the same. The projecting head piece 64 of piston 20 should enter the cavity 66 in piston 18 a considerable distance in order to obtain the above conditions, and the cavity 66 must accordingly be of a substantial depth and should preferably be more than one-third of the cylinder diameter. In order that practically all air in the cylinder is at the time of combustion present in the combustion chamber 68 and immediately available for the combustion, the pistons 18, 20 are so coordinated that the head 80 of piston 20 is then in close proximity too the adjacent end of the rim 62 on piston 18, leaving a negligible air gap therebetween.

The crank case 10 is also provided with a cored-out water jacket 85 which is open at the cylinder bores 12 and otherwise closed and continuous throughout the length of the engine from its inlet to its outlet (neither shown). At the cylinder bores 12, the water jacket 85 is closed by the liners 14 which are fitted into said bores in the manner shown in the drawing, there being suitable packings 87 provided in said liners to prevent leakage of cooling water from the jacket 85. The fuel nozzles 70 may be so tightly screwed or otherwise fitted into aligned and abutting bosses 88 of the crank case 10 and each cylinder liner that cooling water in the jacket 85 will not leak along the fuel nozzles 70.

Due to the decreasing clearance between the conical side wall of the cavity 66 in piston 18 and the conical periphery of the head piece 64 on piston 20 as said head piece moves into said cavity, air is forced at increased velocity into the combustion chamber 68 shortly before the combustion takes place. This secures the important advantage that the air which is forced into the combustion chamber 68 at such increased velocity intersects the fuel as it is injected into the combustion chamber through the openings 72 in the rim 62 of piston 18 and finely atomizes the injected fuel. Moreover, the air in the cylinder is forced into a combustion space the volume of which decreases more rapidly than the volume of a combustion space which is bounded by the cylinder wall, with the result that the air becomes highly compressed and the mixture of air and fuel is highly explosive. Thus, the present combustion chamber secures also the advantages of a pre-combustion chamber.

In the disclosed embodiment of the invention, the exhaust ports **40** are below the extension **60** of the piston **18** when the latter is in the position shown in Fig. 1. While the products of combustion in the cavity **66** are satisfactorily ejected through the illustrated exhaust ports **40** due to the difference in pressure in the cylinder chamber and in the exhaust manifolds **48** and due to the scavenging of said cylinder chamber and of said cavity **66** by the compressed intake air, at least one further exhaust port **40*a*** (Fig. 1B) may be provided in the cylinder liner **14** and crank case **10** which permanently communicates in any suitable manner with the exhaust manifolds **48** and communicates with a fuel opening **72** in the piston **18** substantially when the latter assumes the outermost position shown in Fig. 1, thereby providing for straight-through scavenging of the cylinder chamber and of the piston cavity **66**.

I claim:

1. In an internal combustion engine, the combination of a cylinder having in its wall a fuel duct and axially spaced intake and exhaust ports on opposite sides, respectively, of said duct; and two pistons slidable on the cylinder wall and operating in opposite directions in timed relation with each other, one of said pistons having on its head a cup sliding with its rim on the cylinder wall and having in said rim near the cup bottom a hole registering with said fuel duct substantially when said one piston is in its innermost position and registering with an exhaust port when said one piston is in its outermost position, and the other piston having a boss on its head adapted to enter said cup when said pistons move into their innermost position, said cup and said boss cooperating to form a combustion chamber, and the pistons covering the exhaust and intake ports, respectively, except when they are substantially in their outermost positions.

2. In an internal combustion engine, the combination of a cylinder having in its wall a fuel duct and axially spaced intake and exhaust ports on opposite sides, respectively, of said duct, one of said exhaust ports being farther distant from the intake ports than the remaining exhaust ports; and two pistons slidable on the cylinder wall and operating in opposite directions in timed relation with each other, one of said pistons having on its head a cup sliding with its rim on the cylinder wall and having in said rim near the cup bottom a hole registering with said fuel duct substantially when said one piston is in its innermost position and registering with said one exhaust port when said one piston is in its outermost position, and the other piston having a boss on its head adapted to enter said cup when said pistons move into their innermost position, said cup and said boss cooperate to form a combustion chamber, and the pistons normally cover the intake and exhaust ports, respectively, and uncover the same except said one exhaust port when the pistons are substantially in their outermost positions.

3. The combination in an internal combustion engine as set forth in claim 2, in which said one exhaust port is circumferentially located between the adjacent edges of two successive remaining exhaust ports, and said hole is of such size as to be out of registry with said remaining exhaust ports in any position of said one piston.

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