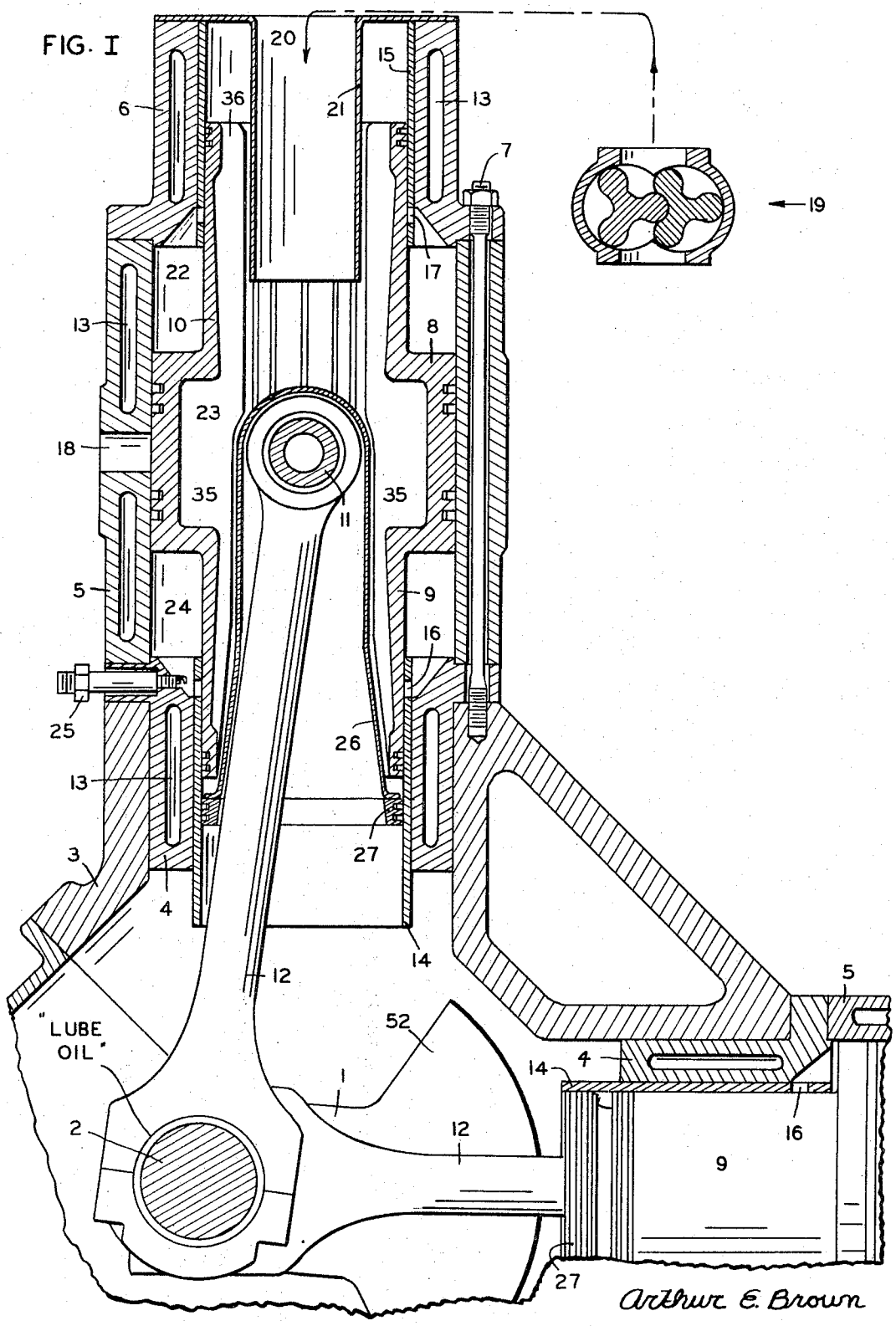
Sept. 12, 1967 A. E. BROWN 3,340,855

DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINE

Filed Aug. 16, 1965 3 Sheets-Sheet 1

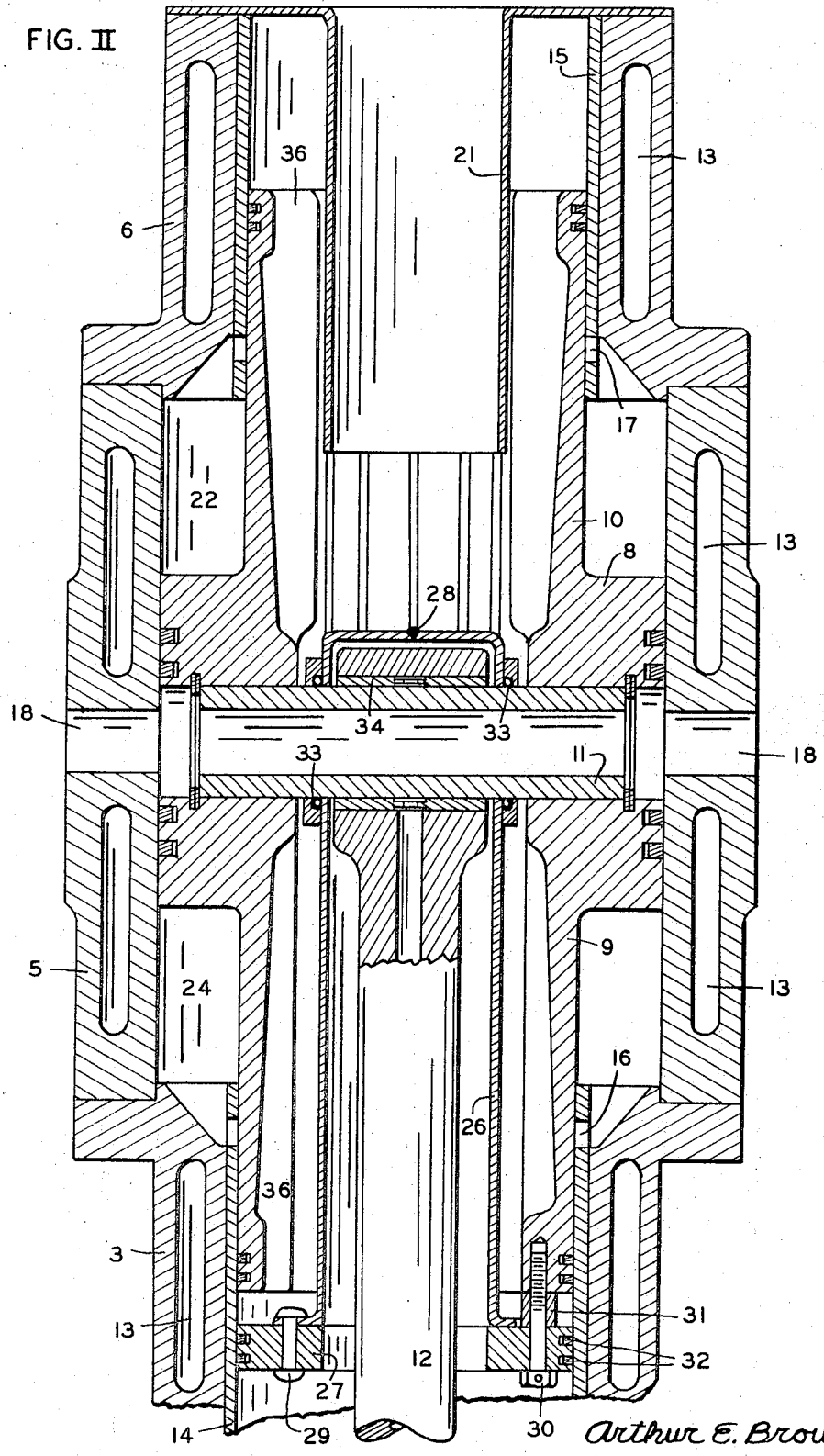
FIG. I



DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINE

Filed Aug. 16, 1965 3 Sheets-Sheet 2

FIG. II



Arthur E. Brown

Sept. 12, 1967 A. E. BROWN 3,340,855

DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINE

Filed Aug. 16, 1965 3 Sheets-Sheet 3

FIG. III

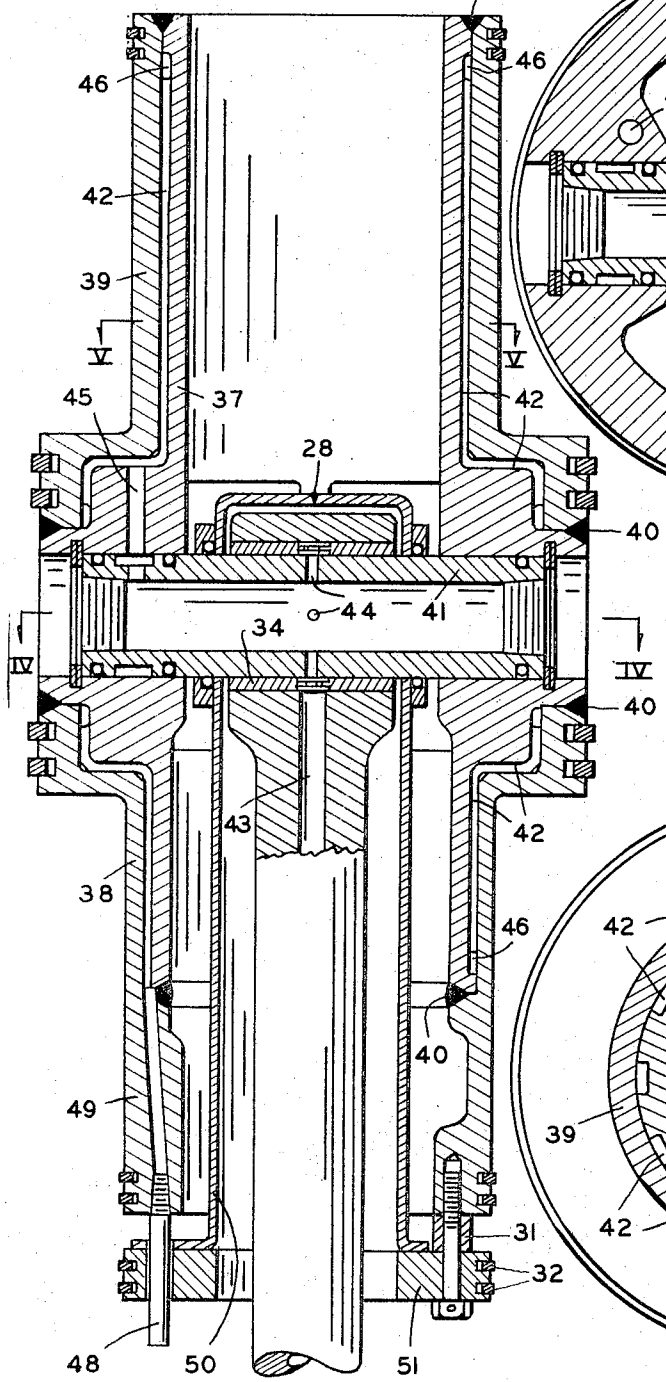


FIG. IV

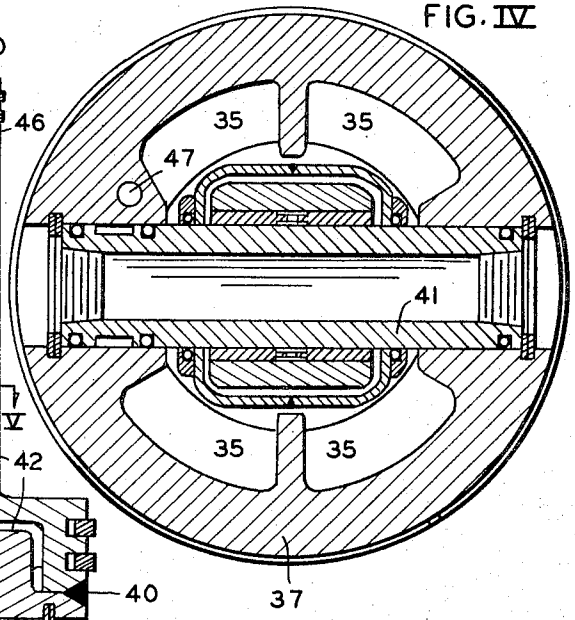
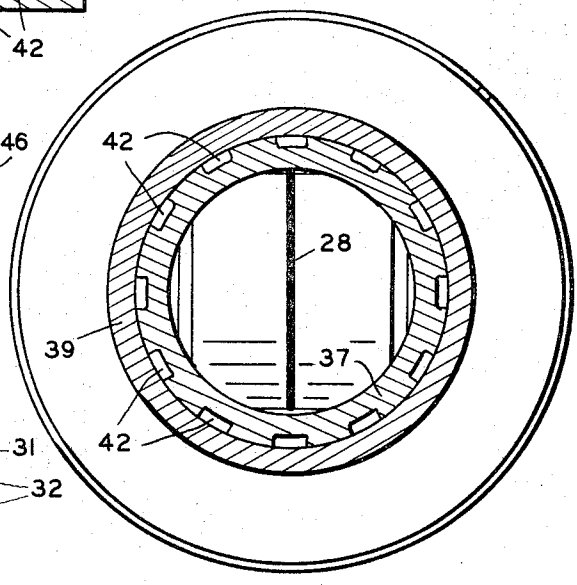


FIG. V



Arthur E. Brown

United States Patent Office 3,340,855 Patented Sept. 12, 1967

3,340,855

DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINE

Arthur E. Brown, 117 E. 5th St.,
Corning, N.Y. 14830

Filed Aug. 16, 1965, Ser. No. 479,775
8 Claims. (Cl. 123—61)

ABSTRACT OF THE DISCLOSURE

A reciprocating double acting stepped piston uncovers inlet ports and exhaust ports at each end of its stroke to obtain uniflow type scavenging operations. A partition member (located inside the piston structure) surrounds the small end of the connecting rod. The partition member and a sliding seal structure prevent intermixing of the scavenge air (separately supplied) and the lube oil in the crankcase. A special liquid cooling arrangement for the double acting stepped piston is shown.

The engine described in this invention is well suited for medium to large size applications, may employ either spark ignition or compression ignition, and may burn either liquid or gaseous fuel.

It is common practice to mix lube oil with fuel in two stroke engines of the type which use crankcase scavenging and this has proven to be a useful arrangement. It is desirable, however, to separate the lube oil from both the fuel and the scavenge air because of three reasons: (1) The lube oil consumption is reduced, (2) the lube oil is not diluted and therefore its viscosity is retained and its load carrying capacity in a journal type bearing is retained, and (3) there is less oil passing through the combustion chamber to cause plug fouling and detonation.

A principal object of this invention is to provide a particular type of double acting engine with means whereby the scavenging air does not pass through the inside of the crankcase and does not mix with oil laden air inside the crankcase. This permits the crankshaft and connecting rods to be lubricated with pure oil in a conventional manner and there is no danger of the crankcase lube oil being carried away by the scavenging air.

A principal advantage of this invention is that each engine cylinder has two power strokes per rotation of the crankshaft. The two cylinder engine shown in FIG. I therefore has the same number of power strokes per rotation as a conventional eight cylinder four stroke cycle engine. This permits the engine to have fewer cylinders for a given power output with a consequent reduction in cost, weight, and size compared to single acting engines.

Another object is to provide a double acting engine which does not require a cross head, cross head guide, piston rod, or stuffing box. The absence of these parts permits the engine to be more compact in overall size and lighter in weight compared to other double acting engines. Also, the elimination of the cross head and piston rod permits the engine to have less reciprocating weight and reduces cost compared to other double acting engines.

Another object is to provide a double acting engine in which a single inlet air connection and a single exhaust connection serves a double acting cylinder. This reduces the manifolding required and simplifies the engine in general.

An important advantage of the engine is that it has highly efficient uniflow type scavenging. The flow of scavenging air through each working chamber is orderly in character with less mixing, less short circuiting, and less eddy currents than is associated with cross flow or loop scavenging.

Another advantage is that the engine does not require inlet or exhaust poppet valves, power cams, power rollers, power rocker arms, or power push rods. The absence of these parts increases the reliability of the engine and reduces the cost.

Another principal objective is to provide a certain piston, connecting rod, and wrist pin combination that secures the following seven interrelated objectives simultaneously: (a) No loss of crankcase lube oil due to mixing with the scavenge air, (b) low uniform piston side wall pressure with no tendency for the piston to tilt in the cylinder, (c) minimum valve piston diameter, (d) adequate size for the wrist pin bearing, (e) adequate area for the flow of scavenge air through the piston, (f) low piston side thrust, and (g) low secondary inertia force.

Another object or advantage is that any high pressure combustion gas which may leak past the piston seal rings does not go into the crankcase where it would cause some sludging of the lube oil. Instead, any leakage of combustion gas goes back to inlet.

Another object is to provide air cooling means for the double acting piston.

Another object is to provide an alternate liquid cooled piston construction for use in this particular engine.

The side force on the pistons is low due to the relatively long connecting rods employed. The pistons have a large side wall area due to their long length. Thus, an advantage of this invention is that the side wall pressure on the pistons is low due to the large side wall area and low side force.

Engine designers are often faced with the problem of interference between counterweights and pistons when the latter are at bottom dead center. A fortunate advantage of this invention is that (due to the connecting rods being unusually long) this problem is not present.

Another object is to eliminate the need of several flanged and bolted joints for fastening the cylinder and cylinder heads. An accompanying object is to eliminate undesirable tension loads in the cast iron cylinder.

Another object is to provide a V type double acting engine having a unique combination of advantages (h) to (n) as will be subsequently described in detail.

These and other objects and advantages will be more apparent from the drawings and description.

FIG. I is a sectional view of a two cylinder 90 degree V engine. The section is taken through the axes of the cylinders and perpendicular to the axis of the crankshaft. One piston assembly is shown in section and a portion of the other piston assembly is shown in elevation.

FIG. II is a sectional view (drawn to a larger scale) of a portion of the engine shown in FIG. I. This view shows the cylinder, piston assembly, and related parts in a section view taken through the axis of one wrist pin.

FIG. III is a section view showing an alternate liquid cooled piston construction for use in the engine shown in FIG. I.

FIGS. IV and V are section views taken along the lines IV—IV and V—V respectively in FIG. III.

Throughout the description and claims, the front of the engine is defined as being nearer the crankshaft than the back.

Referring to FIGS. I and II, a crankshaft **1** having a crankpin **2** is rotatably mounted in the crankcase or frame **3**. A front cylinder head **4**, a working cylinder **5**, and back cylinder head **6**, are bolted to the frame by means of the long steel tension rods **7**. A double acting working piston **8** is reciprocable in the cylinder **5**. Reduced diameter front and back valve pistons **9** and **10** are integrally attached to the working piston. The valve pistons reciprocate within bores formed in their respective cylinder heads **4** and **6**. A wrist pin **11** and connecting rod **12** interconnect the piston and crankpin. The

working cylinder and the cylinder heads have liquid coolant passages **13**. The cylinder heads **4** and **6** are provided with liner sleeves **14** and **15** which have inlet ports **16** and **17** passing through their walls. A set of exhaust ports **18** pass through the wall of the working cylinder. When the piston approaches its bottom dead center position, the exhaust ports are uncovered by the working piston and the back inlet ports **17** are uncovered by the back valve piston **10**. Scavenge air (from any suitable scavenge pump **19**) enters the top of the back cylinder head at **20**, passes through the sheet metal tube **21**, makes a 180 degree turn, and then flows through the back inlet ports **17**. The back working chamber **22** is thus uniflow scavenged with the exhaust leaving at **18**.

When the piston approaches top dead center, the exhaust ports **18** and front inlet ports **16** are uncovered by the working piston **8** and front valve piston **9**. The scavenge air then passes through the tube **21** and hollow piston structure **23**, enters the front inlet ports **16** and uniflow scavenges the front working chamber **24** exhausting at **18**.

In the case of a spark ignition engine, one or more ignition plugs should be provided for each combustion chamber and a typical plug is shown at **25**. Fuel may be introduced either by a carburetor (not shown) or a fuel injector (not shown). In the case of a diesel engine, fuel injectors would be employed in place of the ignition plugs.

The purpose of the partition member **26** and seal structure **27** is to prevent intermixing of the scavenge air with the lube oil inside the crankcase. Without these parts, a considerable amount of lube oil (thrown off from the crankshaft) would become entrained in the scavenge air and the engine would have a high impractical rate of lube oil consumption. The partition member (made from two sheet metal stampings welded along the center line **28**) is attached at its front end to the seal structure **27** by means of rivets **29**. The seal structure is provided with expanding type seal and oil rings **32** which ride and seal inside the sleeve **14**. The wrist pin **11** passes through the back end of the partition member. Static oil seals **33** surround the wrist pin and they prevent the leakage of lube oil from the interior of the partition.

The annular space between the end of the front valve piston **9** and the seal structure **27** communicates with the inlet ports **16** when the pistons are at top dead center position so as to supply scavenge air through the ports **16**.

The crankshaft **1** and con rod **12** may be pressure lubricated or splash lubricated with lube oil as desired. The words "LUBE OIL" are shown in FIG. I to indicate a means for lubrication and to illustrate the presence of lube oil droplets or oil spray inside the crankcase.

The partition member **26** and seal structure **27** also perform a secondary function. Any leakage of high pressure combustion gas past the front valve piston **9** does not go into the crankcase where it would cause oil sludging. Instead, any combustion gas leakage is caught by the partition member and seal structure.

A feature of this invention is the arrangement of the piston, connecting rod, and wrist pin which secures the interrelated objectives (a) to (g) previously listed and next described in detail: (a) The partition member **26** prevents loss of crankcase lube oil as was described, (b) the working piston **8** rides with uniform side pressure in the cylinder bore and with no tendency to tilt in the cylinder bore. This objective is made possible by locating the wrist pin **11** at or near the longitudinal center of the working piston **8**. If the wrist pin was not located inside the working piston (as specified) then there would be a tendency for the working piston to tilt due to the off center sidewise push on the piston assembly, (c) it is required that the diameters of the valve pistons **9** and **10** be reduced to a minimum so as to obtain a maximum displacement of the working chambers **22** and **24** for a given diameter of the working piston **8**. This in turn minimizes the size of the partition member **26**. So as to prevent interference between the connecting rod and the partition member, the length of the connecting rod **12** is made unusually long in relation to the stroke of the pistons. With a long connecting rod, the maximum angular motion of the rod is less. The length of the con rod shown in FIG. I is 7.2 times the crank radius. The most common length of a conventional connecting rod is 4 to 5 times the crank radius. If a shorter rod were used, then the rod would have more angular motion and would interfere with the partition member when at the midstroke position of the pistons. (d) It is required that the wrist pin bearing **34** be sufficiently large in size so as to reliably withstand the forces imposed on it. By locating the wrist pin within the working piston (as described in item b above) there is more space available and it is possible to secure this objective. (e) It is required that there be adequate flow area for the passage of scavenge air through the piston (on its way to the inlet ports **16**) so as to avoid undue restriction of the scavenging air. This requirement is made difficult to attain because of the presence of an adequate wrist pin bearing **34**, the partition member **26**, and because it is required to minimize the diameter of the valve piston **9** as outlined above in item (c). However, by locating the wrist pin in the working piston as described in item (b) above it is possible to secure adequate flow area for the scavenging air around the wrist pin bearing and partition. The air flows at **35** (see FIGS. I and IV) around the wrist pin. (f) The long connecting rod required to secure objective (c) above also has the advantage that the side thrust on the piston is low due to the small angularity of the long connecting rod. (g) The long connecting rod also has the advantage that the secondary reciprocating inertia forces are low.

It is noted that the above objectives and advantages (b) through (g) are secured by locating the wrist pin as described in item (b), by employing an unusually long connecting rod **12**, and by providing passages **35** around the wrist pin.

COOLING OF PISTONS

The pistons shown in FIGS. I and II are cooled by the scavenging air which flows through them. The use of scavenging air is not an ideal way to cool pistons from the standpoint of maximum power output. However, it results in a simple construction. The calculated temperature rise of the scavenging air through the piston shown in FIGS. I and II is only 22 degrees F. to remove 4% (in heat energy) of the power output of the piston when at full load and with 100% excess scavenge air. With the cooling fins **36** shown the calculated temperature difference between the inside temperature of the piston and the scavenge air is 130 degrees F. to give the above rate of heat removal.

The purpose of the sheet metal tube **21** is merely to guide and direct the flow of scavenge air so as to more effectively cool the piston structure as the air flows through it. The tube **21** constrains the air which goes through the back inlet ports **17** to first pass along the cooling fins **36** on the back valve piston **10**.

Refer to FIGS. III, IV, and V which illustrate an alternate liquid cooled piston construction for the engine shown in FIG. I. The piston assembly is comprised of cast inner and outer shell structures **37**, **38**, and **39**. These parts are first machined and then assembled and welded at **40**. The inner structure **37** contains the wrist pin **41** and is provided with many grooves **42** cast in its outer surface. These grooves form passages for liquid coolant. In the embodiment shown, the liquid coolant is lube oil supplied under pressure through drilled hole **43** in the connecting rod. The oil lubricates the wrist pin bearing **34**, passes through drilled hole **44**, passes along the hollow interior of the wrist pin **41**, and then passes through drilled hole **45** so as to feed the network of grooves. The grooves run in axial directions and radial directions and are interconnected at their ends with cross over grooves **46** which run in the circumferential direc-

tion. A drilled hole **47** conducts the cooling oil from the back end of the piston assembly to the front end. A hollow tube **48** is threaded into the front valve piston **49**. The oil leaves the piston assembly through this tube and falls back into the crankcase. A partition member **50** and seal structure **51** are employed in the same manner as was described for the air cooled piston.

FASTENING OF CYLINDERS AND HEADS—FIG. I

A feature of this invention is that the cylinder heads **4** and **6** and the working cylinder **5** are fastened to the frame **3** with only a single set of steel tension rods **7**. Thus several flanged and bolted joints (normally associated with a double acting engine) are eliminated. This has the further related advantage that the cast iron working cylinders **5** are loaded only in compression without being subjected to undesirable tension loads. It is well known that cast iron is weak in tension but very strong in compression.

90 DEGREE V CYLINDER MOUNTING—FIG. I.

The concept of mounting cylinders in a 90 degree V is of course, well known. By arranging this particular type of engine in the form of a 90 degree V, a unique combination of many advantages are secured. These advantages are explained as follows:

(h) All rotating parts are balanced with the counterweights **52** opposite the crankpin **2**.

(i) Primary reciprocating inertia forces are balanced with the counterweights. This is a well known advantage of a 90 degree V cylinder mounting.

(j) The only unbalanced inertia forces are the secondary reciprocating forces. But these are quite low due to the fact that the connecting rods **12** are unusually long.

(k) The engine is very smooth running because there are four power strokes per rotation of one crankpin and these power strokes are evenly spaced every 90 degrees of rotation. This advantage is peculiar to the two stroke cycle double acting cylinders and is not obtained in a single acting engine.

(l) Each pair of double acting pistons and their crank are nearly balanced and are smooth running in their own right. This provides a freedom of design in the selection of the number of cranks desired for a particular engine.

(m) Two pistons drive one crankpin, yet the two pistons do not have their peak forces at the same time. In fact, they are 90 degrees out of phase and this reduces the peak vector sum of the forces on one crank pin.

(n) Reciprocating primary inertia forces are balanced at their source with a counterweight on each crank web. These forces need not be transmitted along the frame and crankshaft in order to achieve balance. This reduces bearing loads and reduces bending in the frame.

While the preferred embodiments of the invention have been described, it will be understood that the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

What is claimed is:

1. In a double acting two stroke cycle internal combustion engine, the combination of a crankcase, a crankshaft rotatably mounted in said crankcase, a working cylinder fastened to said crankcase, a front cylinder head and a back cylinder head fastened to said working cylinder, each cylinder head having a reduced diameter bore therein, a double acting working piston reciprocable in said working cylinder, a reduced diameter front valve piston and a reduced diameter back valve piston, said two valve pistons being attached to said working piston so as to form a reciprocating piston assembly, each valve piston being reciprocable in the bore of its respective cylinder head, said working cylinder having exhaust ports located in its wall, said working piston being adapted to uncover said exhaust ports near the end of each reciprocative stroke, means for supplying scavenge air, means for conducting said scavenge air through the interior of said back cylinder head, said piston assembly having a hollow interior, said piston assembly being adapted to conduct a portion of said scavenge air through its hollow interior, said working cylinder having within it an annular front working chamber and an annular back working chamber, said valve pistons being adapted to control the flow of scavenge air into said annular working chambers so as to scavenge the working chambers, each working chamber having a uniflow type scavenging operation exhausting through said exhaust ports, a connecting rod interconnecting said portion assembly and said crankshaft, said connecting rod being fastened to said piston assembly by means of an articulative joint (such as a wrist pin), said articulative joint being located within said working piston, one end of sad connecting rod being located within said working piston, a reciprocating partition member located inside said piston assembly and surrounding one end of said connecting rod, said partition member being fastened to and reciprocable with said piston assembly, a seal structure reciprocable within the bore in said front cylinder head, said seal structure being fastened to said partition member, means for lubricating said crankshaft with lube oil, and said partition member and said seal structure serving as a barrier to inhibit the intermixing of said scavenge air and said lube oil.

2. In a double acting two stroke cycle internal combustion engine, the combination of a crankcase, a crankshaft rotatably mounted in said crankcase, a working cylinder fastened to said crankcase, a front cylinder head and a back cylinder head fastened to said working cylinder, each cylinder head having a reduced diameter bore therein, a double acting working piston reciprocable in said working cylinder, a reduced diameter front valve piston and a reduced diameter back valve piston, said two valve pistons being attached to said working piston so as to form a reciprocating piston assembly, each valve piston being reciprocable in the bore of its respective cylinder head, said working cylinder having exhaust ports located in its wall, said working piston being adapted to uncover said exhaust ports near the end of each reciprocative stroke, means for supplying scavenge air, means for conducting said scavenge air through the interior of said back cylinder head, said piston assembly having a hollow interior, said piston assembly being adapted to conduct a portion of said scavenge air through its hollow interior, said working cylinder having within it an annular front working chamber and an annular back working chamber, said valve pistons being adapted to control the flow of scavenge air into said annular working chambers so as to scavenge the working chambers, said front valve piston having a controlling edge which alternately opens and closes the flow of scavenge air into said annular front working chamber, each working chamber having a uniflow type scavenging operation exhausting through said exhaust ports, a connecting rod interconnecting said piston assembly and said crankshaft, said connecting rod being fastened to said piston assembly by means of an articulative joint, said articulative joint being located (in a longitudinal direction) between said controlling edge and the back end of said working piston, a reciprocating partition member located inside said piston assembly and surrounding one end of said connecting rod, a seal structure reciprocable within the bore in said front cylinder head, said partition member being fastened to said seal structure, means for lubricating said crankshaft with lube oil, and said partition member and said seal structure serving as a barrier to inhibit the intermixing of said scavenge air and said lube oil.

3. In a double acting two stroke cycle internal combustion engine, the combination of a frame structure, a crankshaft rotatably mounted in said frame structure, a working cylinder fastened to said frame structure, a front cylinder head and a back cylinder head fastened to said working cylinder, each cylinder head having a reduced diameter bore therein, a double acting working piston

reciprocable within said working cylinder, a reduced diameter front valve piston and a reduced diameter back valve piston, said valve pistons being reciprocable in the bores of their respective cylinder heads, said valve pistons being fastened to said working piston so as to form a reciprocating piston assembly, a connecting rod interconnecting said piston assembly and said crankshaft, means for supplying scavenge air to the interior of said back cylinder head, said piston assembly having a hollow interior adapted to conduct said scavenging air, said piston assembly having cooling fins provided within its hollow interior, a tube fastened to the back end of said back cylinder head, said tube projecting inside the bore in said back cylinder head, said tube also projecting inside the hollow interior of said back valve piston, said tube being small enough in diameter so as to clear said cooling fins, and the purpose of said tube being to guide and direct the flow of said scavenging air so as to obtain better internal cooling of said piston assembly.

4. The combination recited in claim 1 wherein a wrist pin joins said connecting rod to said piston assembly, said wrist pin being located in said piston assembly, and said wrist pin passing through said partition member.

5. The combination recited in claim 1 wherein said reciprocating piston assembly is a composite structure made of an inner shell structure and an outer shell structure, said inner shell structure being located inside of said outer shell structure, said composite structure having internal grooves for the passage of liquid coolant, and means for conducting liquid coolant to and from said reciprocating piston assembly.

6. The combination recited in claim 5 wherein said liquid coolant is lube oil, a tube passing from said front valve piston through said seal structure, and said tube serving to drain said coolant back to the interior of said crankcase.

7. The combination in a double acting two stroke cycle internal combustion engine of a frame structure; a crankshaft rotatably mounted in said frame structure; a cast iron working cylinder; a front cylinder head and a back-cylinder head; each cylinder head having a reduced diameter bore; a double acting working piston reciprocable in said working cylinder; a reduced diameter front valve piston and a reduced diameter back valve piston; said valve pistons being attached to said working piston so as to form a reciprocating piston assembly; each valve piston being reciprocable in the bore of its respective cylinder head; a connecting rod interconnecting said piston assembly and said crankshaft; a set of steel tension rods passing through said back cylinder head, said working cylinder, said front cylinder head, and into said frame structure; said set of steel tension rods serving to fasten said cylinder heads and working cylinder to said frame structure without the need of extra bolted and flanged joints; and said set of steel tension rods serving to prevent undesirable tension loads in said cast iron working cylinder.

8. In a double acting two stroke cycle internal combustion engine, the combination of a frame structure, a crankshaft rotatably mounted in said frame structure, said crankshaft having a crankpin, a first working cylinder fastened to said frame structure, front and back cylinder heads fastened to said working cylinder, each cylinder head having a reduced diameter bore, a double acting working piston reciprocable in said working cylinder, a reduced diameter front valve piston and a reduced diameter back valve piston each reciprocable in the bore of its respective cylinder head, said valve pistons being attached to said working piston so as to form a reciprocating piston assembly, a first connecting rod connecting said piston assembly to said crankpin, said connecting rod being joined to said piston assembly by means of a wrist pin located in said working piston, a second similar double acting cylinder and second piston assembly mounted at substantially 90 degrees to the said first working cylinder, said second piston assembly being adapted to drive said crankshaft with a second connecting rod coupled to the same crankpin, said two connecting rods each having a ratio of length to crank radius of at least 6, said two working cylinders having a uniform firing order with power strokes spaced substantially every 90 degrees rotation of said crankshaft, counterweights attached to said crankshaft, and the moving parts of said engine being well balanced (but not perfectly balanced) because of the following reasons:

(a) said counterweights serve to counterbalance the rotating parts.

(b) said counterweights serve to counterbalance the reciprocating primary inertia forces.

(c) said engine having secondary inertia forces due to the reciprocating parts, said secondary inertia forces being unbalanced but said secondary inertia forces being unusually low due to the fact that said connecting rods are unusually long (having a ratio of length to crank radius of at least 6).

References Cited

UNITED STATES PATENTS

780,812	1/1905	Radovanovic	123—65
877,483	1/1908	Boyer	123—61
886,846	5/1908	Nicoll	123—61
1,132,386	3/1915	Rigaud	123—61

FOREIGN PATENTS

96,725	4/1924	Austria.
413,616	5/1910	France.
47,840	2/1929	Germany.
265,097	10/1913	Germany.
129,726	7/1919	Great Britain.
132,121	9/1919	Great Britain.
366,129	2/1932	Great Britain.

CARLTON R. CROYLE, *Primary Examiner.*

WENDELL E. BURNS, *Examiner.*