Sept. 21, 1965 A. E. BROWN 3,207,139

DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINES

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FIG. I

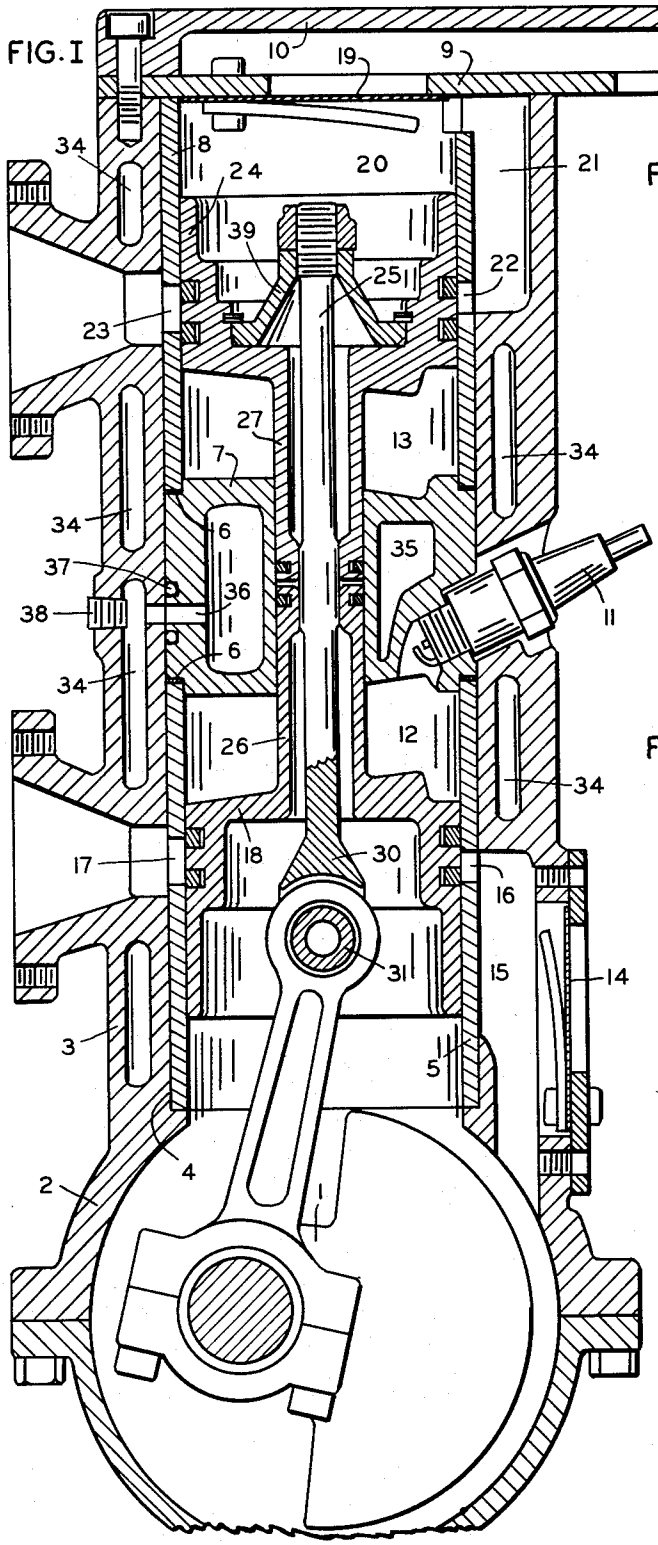


FIG. II

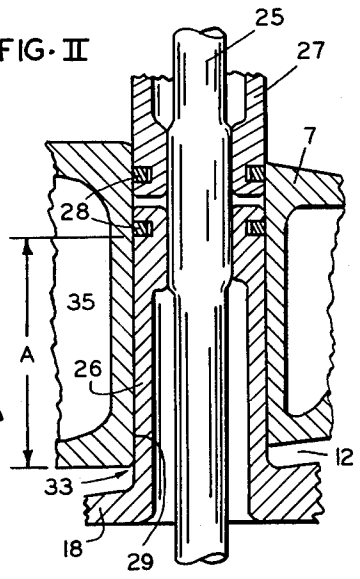
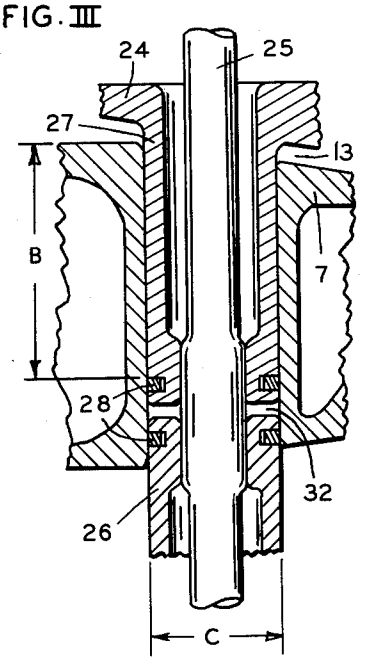


FIG. III



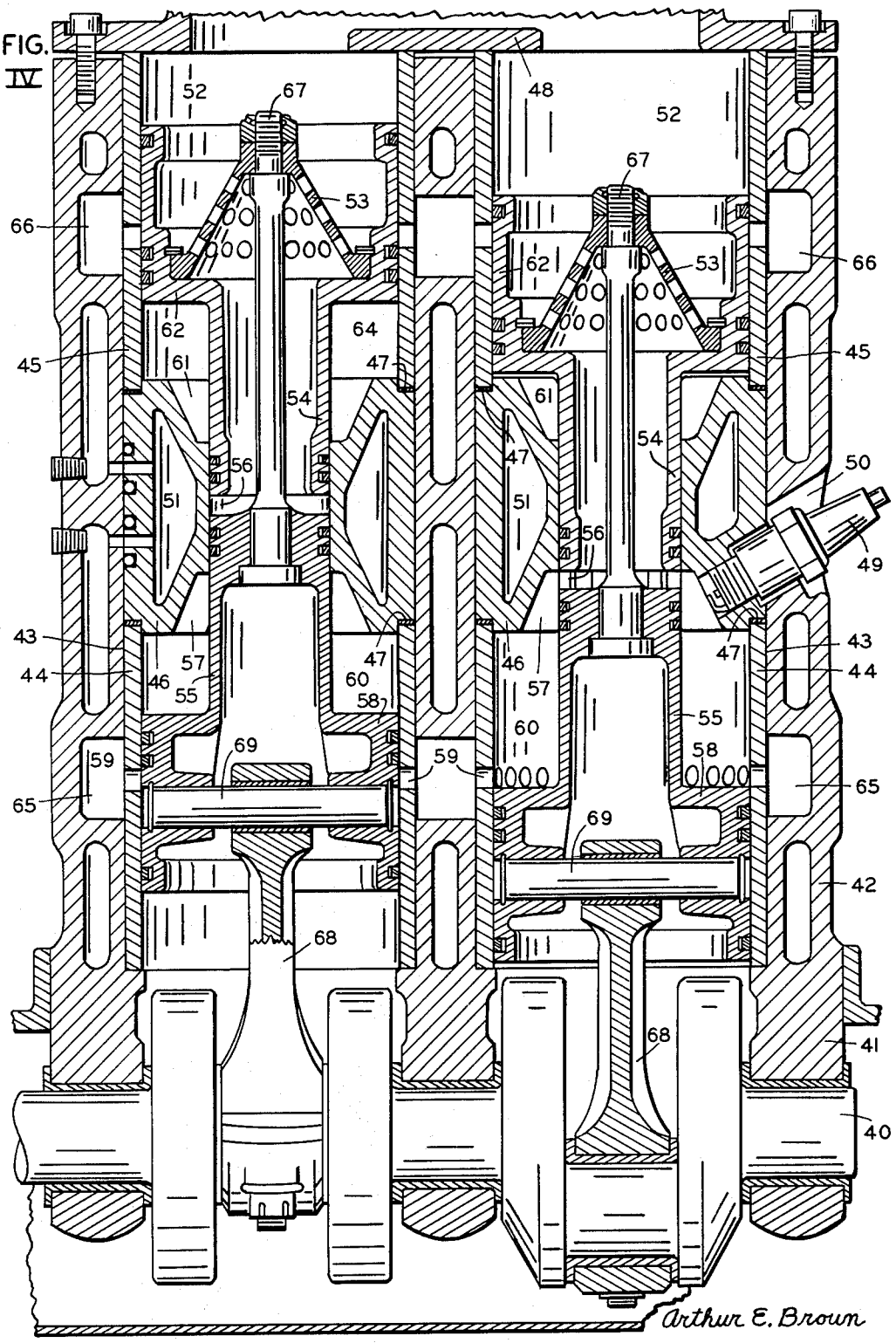
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DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINES

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FIG. IV

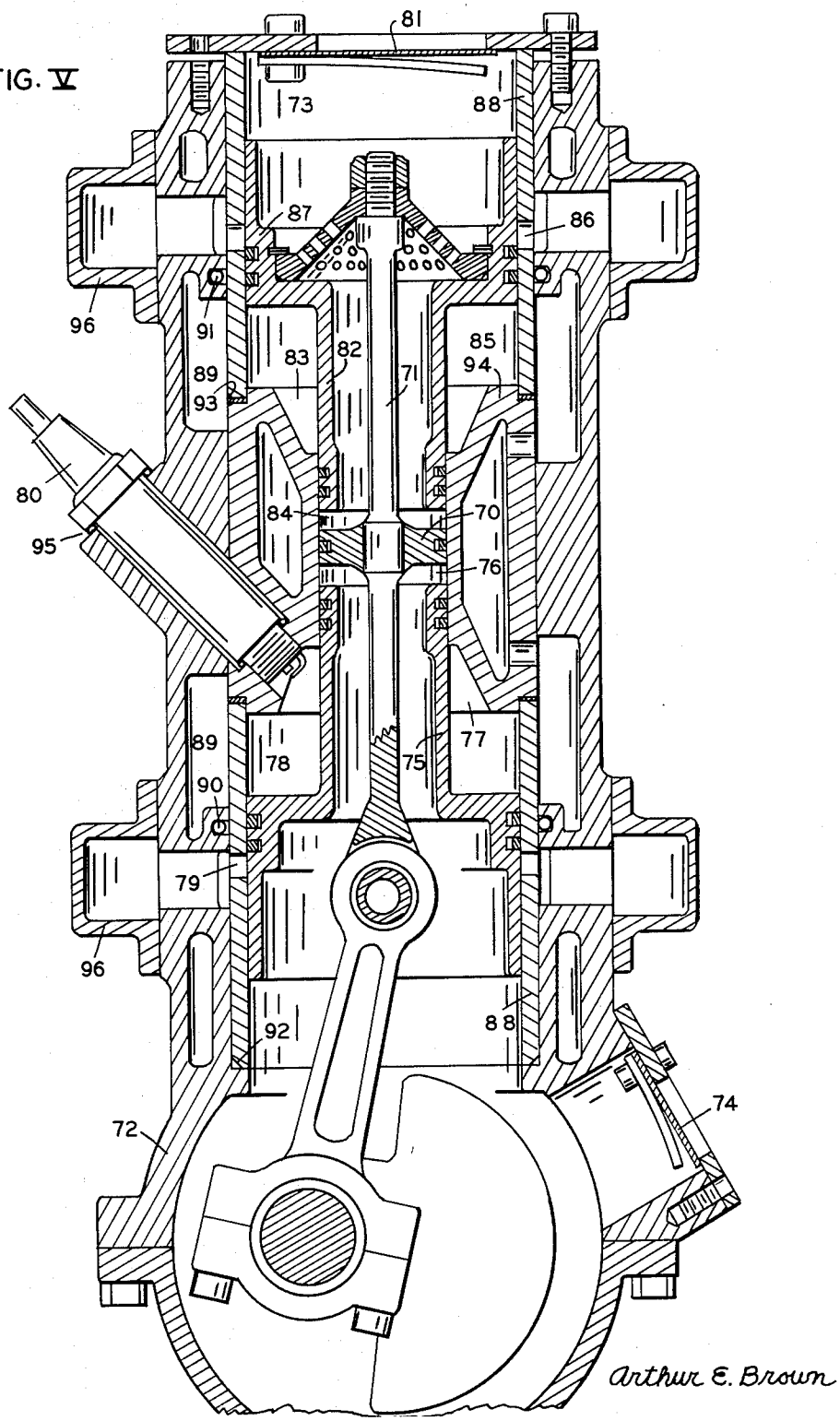


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DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINES

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FIG. V



Arthur E. Brown

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3,207,139

DOUBLE ACTING TWO STROKE CYCLE INTERNAL COMBUSTION ENGINES

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Filed Feb. 24, 1964, Ser. No. 346,964
10 Claims. (Cl. 123—57)

This invention relates to double acting two stroke cycle internal combustion engines.

In the past, commercial manufacture of double acting two stroke cycle engines has been mostly limited to the large slow turning engines of several thousand H.P.; and these engines have individually fabricated double acting cylinders, with individual heads on each end, all bolted to a lower frame structure which includes cross head guides. These prior engines are further characterized in that a conventional cross head, piston rod, and stuffing box is employed with each double acting piston. The cylinder generally contains in the walls intermediate its length both inlet and exhaust ports.

A main object of this invention is to provide a double acting engine in which the crankcase and cylinder block structure is formed as an integral casting similar to present day automotive single acting engines.

In single acting engines, the advantages of making the crankcase and cylinders a single cast structure is well known. These advantages are: (1) a lighter weight but more rigid structure, (2) more compact through elimination of flanged joints, (3) lower cost automatic machining of parallel cylinder bores in a transfer type machine, (4) less assembly cost, (5) fewer parts, and (6) better control of machining tolerances. This invention now secures the above six advantages in a double acting two stroke cycle engine.

Another object is to provide a double acting engine in which the cylinder bores can be machined from the top of the cylinder block with a boring operation similar to present single acting engines and in which each cylinder bore serves a double acting piston assembly.

Another object is to provide an improved reciprocating rod and rod seal construction for the embodiment shown in FIGS. I, II, and III.

An advantage of this invention is that the problem of misalignment between the front and back working cylinders (or liners) is eliminated. Concentricity is assured because of through boring of the cylinder block and elimination of bolted joints.

Another object is to provide a double acting engine that is economical to manufacture. This objective is achieved first, because the usual cross heads and cross head guides are not required; and second, because the cylinders and crankcase are formed as an integral casting and the cylinders bored in a manner similar to present single acting automotive engines all without the need of a bolted joint for the cylinders to the crankcase or a bolted joint intermediate the cylinder length.

An advantage is that the cylinders can be closely spaced in a multicylinder in line engine. This is made possible through the elimination of bolted joints in cylinders and crankcase.

Another object is to provide a double acting engine (without cross heads or cross head guides) in which the pistons can be removed without removing the crankshaft and in which all the pistons may be installed from the top and so that the main bearings need not be made small enough to clear the pistons.

An object is to provide removable and replaceable cylinder liners and seals for wet type liners.

Another object is to provide a confined gasket seal between the cylinder liners and the inserted head for sealing in combustion gas.

Another object is to provide a simple and effective

method of conducting liquid coolant from the cast cylinder block to an inserted cylinder head.

The engines described in this application and in my copending application (Serial No. 209,619, filed July 13, 1962, now Patent No. 3,159,147) have the following seven common advantages:

(1) The engine has two power strokes per rotation of each crank and connecting rod. Therefore, the two crank engine shown in FIG. IV can provide the same number of power impulses as an eight cylinder four-stroke single acting engine.

(2) The engine is able to operate at high speed without subjecting the connecting rod and bearings to high reciprocating inertia forces because the inertia forces are opposed at the end of each stroke by a gas pressure force.

(3) The load on the piston pin bearing is bi-directional (instead of unidirectional as in single acting two-stroke engines) and the load reversal aids its lubrication process.

(4) In the embodiment shown in FIGS. IV and V, the engines have uniflow type scavenging. This means the flow of scavenging air (or fuel-air mixture) through each working chamber is more orderly in character with less mixing, less short circuiting, and less eddy currents than are associated with cross flow or loop scavenging.

(5) In the embodiment shown in FIGS. IV and V, the engine has inherent free breathing, faster running characteristics made possible by uniflow scavenging which provides large port areas with minimum port height.

(6) The pistons remain cooler since each working piston (in an assembly) is exposed to combustion on one end only. Also, in FIGS. IV and V the flow of scavenging air through the pistons aids the cooling process.

(7) The engines are compact and light in weight because: (a) they are double acting without need of a cross head, (b) they are well suited to operate at high speed, and (c) in the FIGS. IV and V embodiments they have a high B.M.E.P. because of uniflow scavenging and short port height.

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

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

FIG. I is a sectional view of a cross flow scavenged double acting engine.

FIG. II is an enlarged partial section view of the engine shown in FIG. I and illustrates the rod seal parts when at top dead center.

FIG. III is the same as FIG. II except the parts are shown at the bottom dead center position.

FIG. IV is a sectional view of a two crank double acting uniflow scavenged engine. The section is taken through the axi of the cylinders and the crankshaft.

FIG. V is a sectional view of a double acting uniflow scavenged engine. This engine is self scavenged without the need of a separate scavenge pump.

Referring to FIGS. I, II, and II, the crankshaft **1** is rotatably mounted in the crankcase **2**, the upper half of which is cast integral with the cylinder structure **3**. A long cylindrical bore **4** is machined in the cylinder structure. Into this bore is stacked a front cylinder liner **5**, head gaskets **6** and **6**, inserted cylinder head **7**, and an identical back cylinder liner **8**. This stacked assembly of parts is held tightly in place by the valve plate **9** and inlet casting **10**.

A spark plug **11** is shown serving the front combustion chamber **12**. A similar plug (in another section plane) serves the back combustion chamber **13**.

Operation of the engine shown in FIG. I is as follows: Upward motion of the pistons draws air (or a fuel-air mixture) through the reed valve **14**. Downward motion partially compresses the air in the crankcase and near

bottom dead center the air passes through the by-pass **15**, through inlet ports **16**, and scavenges the front working chamber **12** with a counterflow scavenging action exhausting through exhaust ports **17** which are uncovered by the front piston **18**. A subsequent compression and power stroke then occurs.

Downward motion of the pistons draws air through the reed valve **19** into chamber **20**. Upward motion partially compresses the air in chamber **20** until at near top dead center, the air flows through the by-pass **21**, through inlet ports **22**, and scavenges the back working chamber **13** with a counterflow scavenging action exhausting through exhaust ports **23** which are uncovered by the back piston **24**.

The method of sealing the reciprocating rod **25** is a critical item because there is a two cycle combustion chamber on each side of the cylinder head **7** and hence a double heating effect and a double sealing requirement. Sealing is accomplished by providing each working piston **18** and **24** with an integral hollow sleeve **26** and **27** each of which carries an expanding type seal ring **28** located in a ring groove machined in the outer end of each sleeve. The expanding type seal rings **28** press out against and seal against the central bore **29** in the cylinder head **7** and thus prevent leakage of gas from one combustion chamber to the other. The length of the bore in the cylinder head is sufficiently long that the rings **28** never withdraw from the bore during their reciprocative stroke and are thereby retained in their grooves.

The sleeves also perform a shielding function in addition to their sealing function. That is, they surround the rod **25** and thus shield it from high temperature combustion gas.

The preferred combination is to make the pistons and their sleeves **26** and **27** of aluminum alloy and the rod **25** of high strength steel.

The function of the rod **25** and clevis **30** is to transmit the driving force of the back piston **24** to the piston pin **31** and the rod is made as small in diameter as practicable in order to keep down its reciprocating weight and also to permit the outer diameter of the sleeves to be small. With a small diameter rod, the tensile stress in the rod is high but by shielding the rod with the sleeves as described, the rod is kept relatively cool and its strength in service is retained.

The aluminum sleeves **26** and **27** are not called upon to transmit the force of combustion and hence high tensile strength for the sleeves is not a requirement. The function of the sleeves is only to shield the rod and carry the seal rings **28**. By making the sleeves and the pistons of an aluminum alloy there is the two fold advantage of less reciprocating weight and better conduction of heat away from the sleeves into the pistons where the heat is then dissipated through the cylinder walls to the coolant. It is noted that the two sleeves are separated by a gap **32** so as to allow for thermal expansion. The sleeves are heated to a higher temperature than the rod and (being made of aluminum) have a higher coefficient of expansion than the steel rod and hence expand more than the rod. The thermal expansion does no harm since each end of the sleeve is free to lengthen within the bore **29**.

The sleeves with their seal rings function in a unique and unexpected way next described. The seal rings alternately move away from each combustion chamber at the time of peak pressure and peak temperature, i.e., when the front piston **18** is at top dead center as shown in FIG. II, the pressure and temperature in the front combustion chamber **12** is at its peak; and at the same moment, the seal rings **28** have moved to the top position in their bore so that they are farther away (distance "A" in FIG. II) from the flame, pressure, and temperature in the front combustion chamber **12**. This means that the aluminum sleeve **26** serves as a buffer seal for the rings and thus protects the rings from high temperature combustion gas which must travel distance "A" along the clearance space **33** bore reaching the seal rings **28**. The gas will be at a much lower temperature and slightly lower pressure when it reaches the seal rings since it is cooled and throttled in the narrow clearance space **33** between the sleeve **26** and the water jacketed bore **29** in the cylinder head.

It is well known that overheating (a major cause of ring failure in a combustion engine) causes the lube oil in the ring grooves to coke up and stick the rings.

Alternatively when the back piston **24** is at bottom dead center, the flame, pressure, and temperature in the back combustion chamber **13** is at its peak, but the seal rings are again protected by virtue of the fact that they are at the opposite end of the bore in the cylinder head (at a distance B in FIG. III). This unique but simple action solves a difficult sealing problem where in a double acting two stroke cycle engine, heat on the sealing elements is otherwise severe because of the double heat flow.

It is noted that the outer diameter C of the sleeve **26** is made with a close running clearance within the cylinder head bore **29** so as to retain the advantage of the buffer seal effect described in the preceding paragraph.

The passages **34** are for liquid coolant. An annular coolant chamber **35** is provided in the inserted cylinder head. A drilled hole **36** conducts the coolant from passage **34** into the chamber **35**. An elastomeric ring **37** surrounds the hole and prevents leakage. The ring **37** fits in a groove machined on the outer diameter of the inserted cylinder head **7**. The groove does not surround the head **7** but merely extends locally around the hole **36**. The plug **38** seals up the outer end of the hole. Coolant leaves chamber **15** through a similar hole not shown. Cooling of the inserted head is important since it has a two stroke cycle combustion chamber on each end of it and is depended upon to aid the cooling process of the sleeves **26** and **27**.

The rod **25** is fastened to the back piston by means of the hollow steel cone **3**.

Referring to FIG. IV, the crankshaft **40** is mounted in the crankcase **41** to which is integrally cast a cylinder structure **42**. The cylinder structure has two parallel cylinder bores **43**. Into each bore is stacked a front cylinder liner **44**, an identical back cylinder liner **45**, an inserted cylinder head **46**, and soft metal head gaskets **47**. This stacked assembly of parts is held tightly in place by the inlet manifold **48**. The inserted common cylinder heads are thus supported in axial position within the cylinder bores by means of direct compression loading of the cylinder liners.

The FIG. IV engine requires a minimum of four spark plugs, at least one for each combustion chamber. It is noted that the spark plug **49** threads into and seats directly against the inserted head **46** through a clearance hole **50** in the side of the cylinder structure.

Liquid coolant is conducted into and out of the annular chambers **51** in the same manner as was described for FIG. I.

Operation of the engine shown in FIG. IV is as follows: Scavenge air (or a fuel-air mixture) is supplied through the inlet manifold from a scavenge pump (not shown) to the chambers **52**. The scavenge air then flows through the perforated cones **53** into the interior of the back valve pistons **54**. The front and back valve pistons **55** and **54** are separated by annular gaps **56**. Near bottom dead center, the front valve pistons **55** uncover the front inlet ports **57** (which are in the form of slots in the cylinder head) and the front working pistons **58** uncover the exhaust ports **59** in the front liners **44** so that the front working chambers **60** are scavenged with a uniflow type scavenging operation. Near dead center, the annular gaps **56** overlap the back inlet ports **61** and the back pistons **62** uncover the exhaust ports **63** formed in the back cylinder liners **45** so that the back working chambers **64** are scavenged with a uniflow type scavenging operation.

The cast in passages **65** and **66** serve as collectors or manifolds for the exhaust gas.

It is pointed out that the cylinder liners in each embodiment are unique in that they perform four functions simultaneously and these are; (1) The liners can be made of a special grade of cast iron (differing from that of the cylinder block) and therefore provide a hard long wearing surface, (2) if and when the liners wear out, they can be replaced without replacing the whole cylinder block, (3) the liners provide a convenient way of forming the exhaust ports by machining the ports in the wall of the liner, and (4) the liners now serve as a very convenient method of supporting the inserted cylinder head.

The liners also provide a convenient method of capturing the soft metal seals **47** or **6** in a confined space. That is, the seals are confined on all sides so that they cannot flow out of their sealing position under a high clamping pressure.

The front and back pistons **58** and **62** are interconnected by means of the tension rods **67** and perforated cones **53**. Conventional connecting rods **68** and piston pins **69** are provided.

The cylinder liners **44** and **45** are of the dry type.

Referring to FIG. V, the engine is provided with a disk **70** attached to the rod **71** so that the crankcase **72** and back pump chamber **73** can serve as scavenge pumps as the disk **70** prevents alternate flow of fuel air mixture from one chamber to the other during pumping.

The operation of the engine shown in FIG. V is as follows: Upward motion of the pistons draws air (or a fuel air mixture from a carburetor not shown) through the reed valve **74** into the interior of the crankcase. Downward motion of the pistons partially compresses the fuel air mixture in the crankcase so that when the pistons near bottom dead center, the precompressed mixture flows up through the hollow front valve piston **75**, through the annular gap **76**, through the front inlet ports **77**, and scavenges the front working chamber **78** with a uniflow scavenging operation exhausting through exhaust ports **79**. Upward motion of the pistons compresses the charge in the front working chamber where it is ignited by means of spark plug **80** and a subsequent power stroke occurs.

Similarly, downward motion of the pistons draws a fuel air mixture through the reed valve **81** into the back pump chamber **73**. Upward motion of the pistons partially compresses the mixture in the chamber **73** and near top dead center the back valve piston **82** begins to uncover the back inlet ports **83** so that the fuel air mixture flows through the back valve piston **82**, through the annular gap **84**, through the back inlet ports **83**, and scavenges the back power chamber **85** with a uniflow scavenging operation exhausting at the exhaust ports **86** which are uncovered by the back working piston **87**. Downward motion of the pistons compresses and then fires the mixture in the back power chamber **85** from a spark plug not shown.

The cylinder liners **88** are of the wet type along a portion of their lengths. The water passages **89** surround the liners and the cooling water flows directly against the cylinder liners. Elastomeric O rings **90** and **91** fit in internal grooves machined in the walls of the cylinder bore and prevent leakage of the coolant. The O rings are installed without being cut by sharp metal edges (during liner installation) because the bottom edges **92** and **93** of the cylinder liners are chamfered and the edges of the ports **79** and **86** are rounded and polished. Locating the O rings in the cylinder structure (instead of the liners) keeps the O rings cooler.

The long spark plug **80** threads into and seats against the inserted cylinder head **94** and is also sealed at **95** to prevent coolant leakage.

The exhaust manifolds or collectors **96** are fastened to the cylinder structure.

A feature of the FIG. V engine is that the liners (being of the wet type) are easier to remove and this is an advantage since it permits removal of the front piston without removing the crankshaft.

In FIGS. I, IV, and V, a front cylinder liner **5**, **44**, or **88** is shown for supporting the inserted cylinder head. An alternative but less preferred construction would be to let the inserted head **7**, **46**, or **94** rest against a step in the cylinder block bore instead of against a front liner. This alternative construction still employs the back cylinder liner **8**, **45**, or **88** in each case for retaining the inserted cylinder head.

The engine shown in FIGS. I and V can also be made multi-crank with an in line cylinder arrangement similar to FIG. IV.

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 cylinder structure fastened to said crankcase, said cylinder structure having within it a front working cylinder and a back working cylinder, a cylinder head inserted into the cylinder structure and located between said front and back working cylinders, said front and back working cylinders having respective front and back combustion chambers within them, said back working cylinder having within it a cylinder liner, a front working piston reciprocable in said front working cylinder, a back working piston reciprocable in said liner in the back working cylinder, said cylinder head having a central bore, said pistons being mechanically interconnected through said bore in the cylinder head so as to reciprocate in unison, a connecting rod for converting the reciprocating motion of said pistons to the rotary motion of said crankshaft, said liner having exhaust ports in its wall controlled by said back piston, said liner also serving to retain said common cylinder head in axial position within said cylinder structure, said engine being adapted to be cooled with a liquid coolant, said cylinder structure and said cylinder head having passages for the flow of said liquid coolant, passage means for conducting the flow of said liquid coolant into said cylinder head, an ignition plug for each of said combustion chambers, and each ignition plug being in firing communication with its respective combustion chamber.

2. In a double acting two stroke cycle internal combustion engine, the combination of a crankcase, a crankshaft rotatably mounted in said crankcase, a cylinder structure, said cylinder structure and at least part of said crankcase being an integral casting, said cylinder structure having at least one cylinder bore, a cylinder head inserted in said cylinder bore so as to divide the cylinder bore into a front working cylinder and a back working cylinder, a front working piston and a back working piston reciprocable in their respective working cylinders, said cylinder head having a central bore smaller in diameter than either of said working pistons, said two working pistons being mechanically interconnected through said bore in the cylinder head so as to reciprocate in unison, a connecting rod for converting the reciprocating motion of said pistons to the rotary motion of said crankshaft, retaining means for retaining said cylinder head in axial position within said cylinder bore, said retaining means being of sufficient strength to resist the force of combustion in said working cylinders, said retaining means being removable so as to permit removal of said cylinder head, and said cylinder head being removable so as to permit removal of said front working piston from said cylinder bore without removing said crankshaft from its position in said crankcase.

3. The combination recited in claim **1** including an inlet conduit bolted to the back end of said cylinder struc-

ture for conducting inlet air to said engine, and said inlet conduit being also adapted to press against the end of said cylinder liner and thereby retain the cylinder liner in axial position within said back working cylinder.

4. The combination recited in claim 1 wherein said cylinder structure is provided with passages for the flow of liquid coolant, and wherein said cylinder liner is of the wet type in which the liquid coolant flows directly against the outer surface of the liner.

5. The combination recited in claim 4 wherein a seal ring of resilient material is interposed between said liner and said cylinder structure for the prevention of leakage of the liquid coolant, and wherein said seal ring is located within an internal groove machined in the bore of said cylinder structure.

6. The combination recited in claim 1 wherein said front working cylinder is also provided with a cylinder liner and wherein said liner in the front working cylinder also serves to retain said cylinder head in axial position within said cylinder structure.

7. The combination recited in claim 6 wherein the two cylinder liners are identical in size so as to facilitate interchangeability and reduce the number of dissimilar parts.

8. In a double acting two stroke cycle internal combustion engine, a first cylinder and a second cylinder, a first unitary piston reciprocable in said first cylinder, a second unitary piston reciprocable in said second cylinder, said two cylinders being mounted in tandem, a cylinder head located between said two cylinders, said cylinder head having a bore smaller in diameter than either of said cylinders, a reciprocable rod passing through said bore in the cylinder head, said two unitary pistons being each fastened to said reciprocable rod so as to reciprocate in unison, said cylinders each enclosing a combustion chamber, one of said combustion chambers being located on one side of said cylinder head and the other combustion chamber being located on the other side of said cylinder head, each of said unitary pistons having a hollow sleeve extending into said bore in the cylinder head, each of said hollow sleeves having a ring groove machined in its outer diameter, an expanding type seal ring mounted in each of said ring grooves, said seal rings being adapted to ride inside and seal against said bore in the cylinder head, said bore in the cylinder head being of sufficient length that said seal rings never withdraw from said bore during their reciprocative stroke, said seal rings serving to prevent the leakage of combustion gas from each of said combustion chambers, and said hollow sleeves serving to shield said reciprocable rod from the flame and temperature in said combustion chambers.

9. In a double acting two stroke cycle internal combustion engine, the combination of a crankcase, a crankshaft rotatably mounted in said crankcase, a cylinder structure fastened to said crankcase, said cylinder structure having within it a front working cylinder and a back working cylinder, a cylinder head inserted into the cylinder structure and located between said front and back working cylinders, said front and back working cylinders having respective front and back combustion chambers within them, said back working cylinder having within it a cylinder liner, a front working piston reciprocable in said front working cylinder, a back working piston reciprocable in said liner in the back working cylinder, said cylinder head having a central bore, said pistons being mechanically interconnected through said bore in the cylinder head so as to reciprocate in unison, a connecting rod for converting the reciprocating motion of said pistons to the rotary motion of said crankshaft, said liner having exhaust ports in its wall, said exhaust ports being controlled by said back piston, said liner also serving to retain said common cylinder head in axial position within said cylinder structure, said engine being adapted to be cooled with liquid coolant, said cylinder structure being provided with passages for the flow of said liquid coolant, said cylinder liner being of the wet type in which said liquid coolant flows directly against the outer surface of the liner, said cylinder head having within it a passage for the flow of liquid coolant, passage means for conducting the liquid coolant into said cylinder head, an ignition plug having its ignition end fitted into said cylinder head, said ignition plug being in firing communication with said back combustion chamber, said ignition plug extending through a hole in the wall of said cylinder structure, a seal located around said ignition plug where the plug passes through said cylinder structure, and said seal serving to prevent leakage of said liquid coolant out of said cylinder structure.

10. In a double acting two stroke cycle internal combustion engine, a first cylinder and a second cylinder, a first piston reciprocable in said first cylinder, a second piston reciprocable in said second cylinder, said two cylinders being mounted in tandem, a cylinder head located between said two cylinders, said cylinder head having a bore smaller in diameter than either of said cylinders, a reciprocable rod passing through said bore in the cylinder head, said two pistons being each fastened to said reciprocable rod so as to reciprocate in unison, said cylinders each enclosing a combustion chamber, one of said combustion chambers being located on one side of said cylinder head and the other combustion chamber being located on the other side of said cylinder head, each of said pistons having a hollow sleeve extending into said bore in the cylinder head, each of said hollow sleeves having a ring groove machined in its outer diameter, an expanding type seal ring mounted in each of said ring grooves, said seal rings being adapted to ride inside and seal against said bore in the cylinder head, said bore in the cylinder head being of sufficient length that said seal rings never withdraw from said bore during their reciprocative stroke, said seal rings serving to prevent the leakage of combustion gas from each of said combustion chambers to the other, said hollow sleeves serving to shield said reciprocable rod from the flame and temperature in said combustion chambers, said pistons and said hollow sleeves being made of metal A, said reciprocable rod being made of metal B, metal A having a higher thermal conductivity than metal B, metal A having a higher coefficient of thermal expansion than metal B, metal A having a lower density than metal B, metal B having a higher unit tensile strength (in terms of pounds per square inch of cross sectional area) than metal A, and the ends of the two said sleeves being separated by a gap so as to allow for thermal expansion of the hollow sleeves relative to the reciprocable rod.

References Cited by the Examiner

UNITED STATES PATENTS

874,634	12/07	St. Germain	123—41.72
1,088,334	2/14	Edgar	92—151
1,149,521	8/15	Hunter	123—41.72
1,298,468	3/19	Derihon	123—57
1,634,249	6/27	Lindequist	123—57
1,900,133	3/33	Schaeffers	123—57
2,154,249	4/49	Porter	123—59

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