

[54] **SCAVENGE PORTING SYSTEM**

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[51] Int. Cl. **F02b 33/04**

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123/73 AV, 73 AC, 73 AD, 73 AE, 73 EF,
73 B, 73 BA, 73 C, 73 CA, 73 CB, 73 CC, 73
D, 73 DA, 73 E, 73 A; 137/512.15**

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[57]

ABSTRACT

In a two cycle internal combustion engine of the type which utilizes the underneath side of the power piston as a scavenge pump piston, the improvement which consists of extra height, piston valved scavenge ports which are additionally valved by reed valves located in the transfer passageway close to the scavenge ports, in order to increase the scavenge gas mass flow through capability of the cylinder, improve the scavenge gas flow pattern, or both.

10 Claims, 6 Drawing Figures

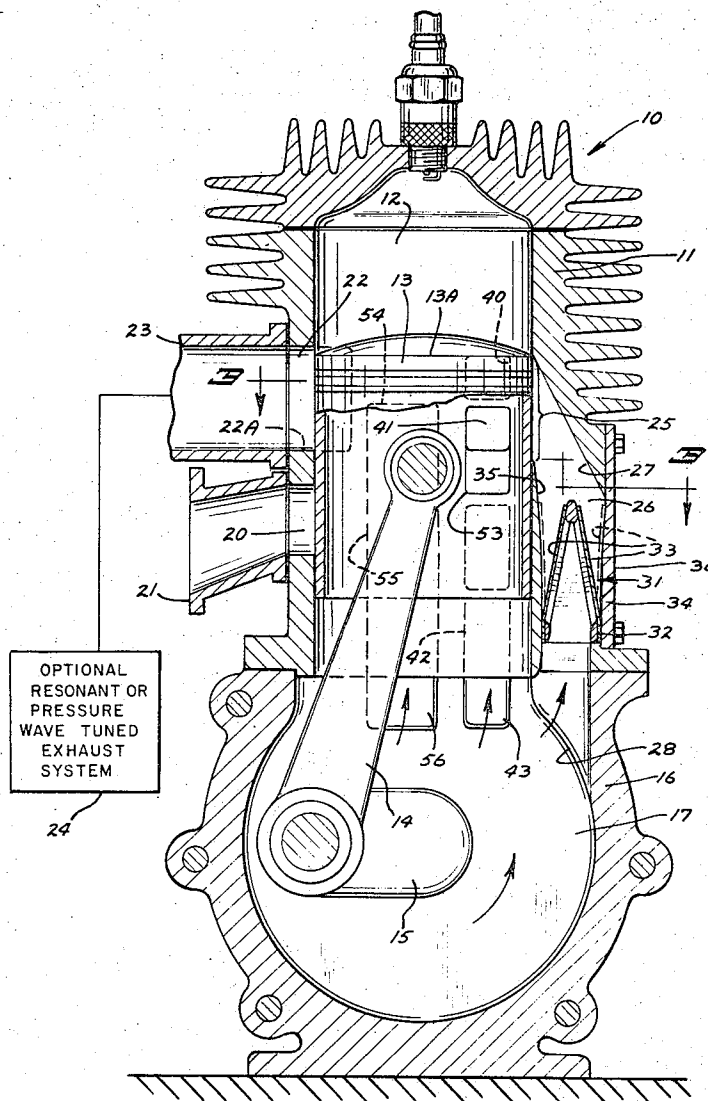
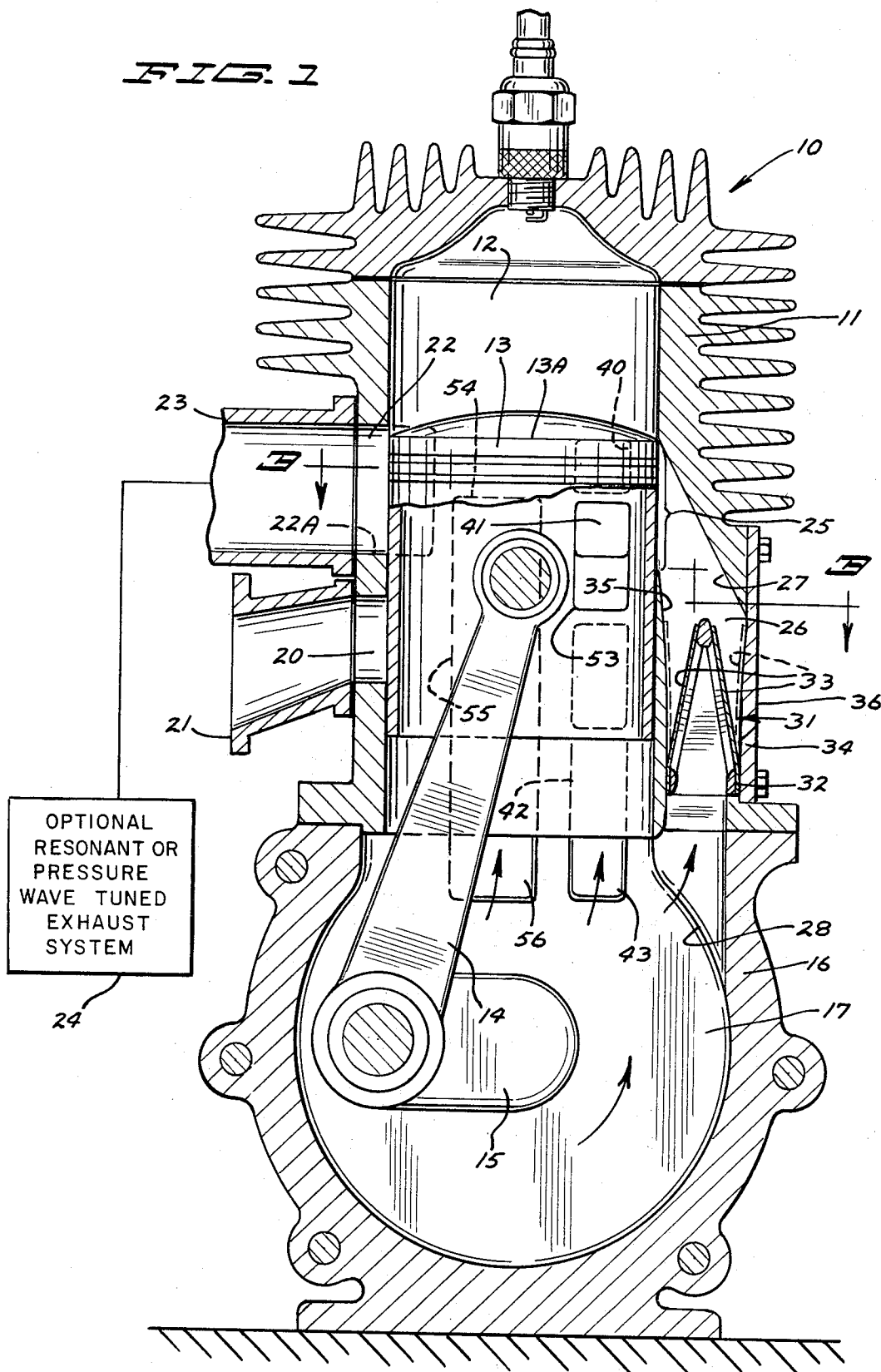
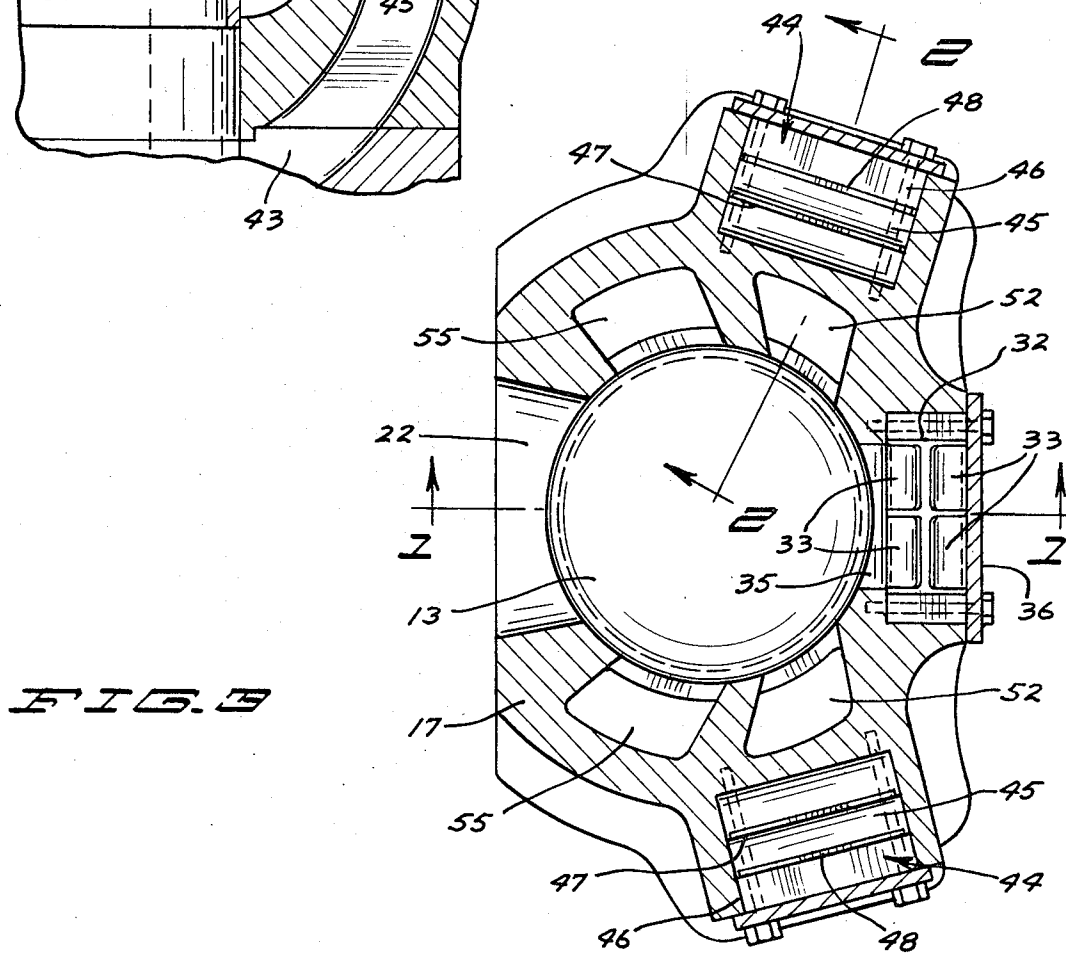
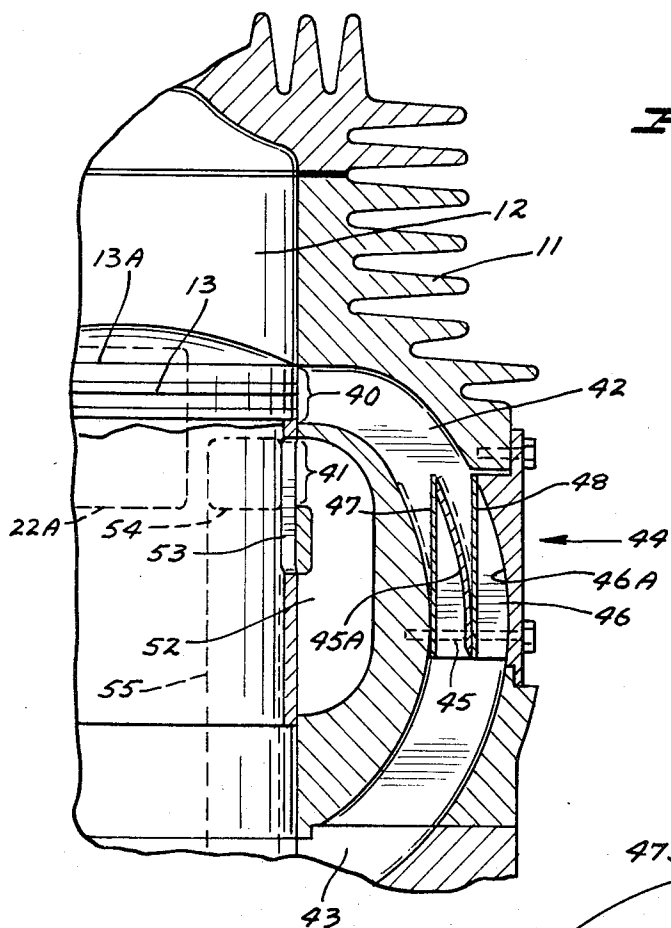


FIG. 1





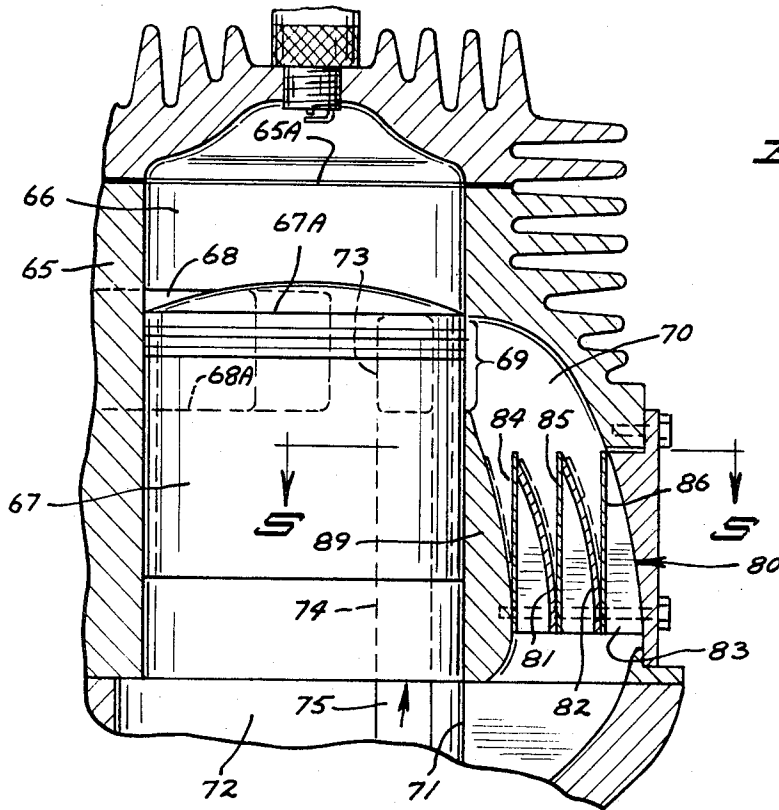


FIG. 4

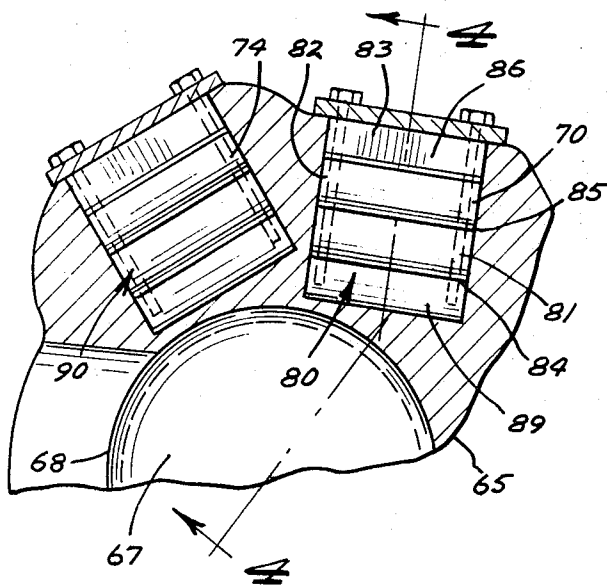


FIG. 5

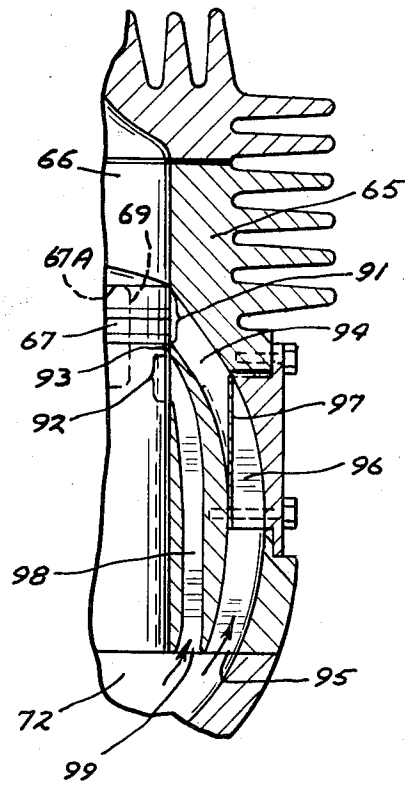


FIG. 6

SCAVENGE PORTING SYSTEM

BACKGROUND OF THE INVENTION

TERMINOLOGY

In describing two cycle engines, terminology can be confusing as regards "intake port", "inlet port", "scavenge port", "transfer port", etc. In particular, the terms "inlet port" and "intake port" are used to describe both the power cylinder scavenge ports and the scavenge pump inlet ports. Also, the term "transfer port" is used to describe both the power cylinder scavenge port and the port at the opposite end of the transfer passageway opening into the scavenge pump system. Confusion is the result. To reduce such confusion, for the purposes of this patent the terminology will be employed as follows:

The last port through which the scavenge and charging medium passes on its way into the power cylinder, will be referred to as a scavenge port.

the passageway which connects each scavenge port with the scavenge pump will be referred to as a transfer passageway.

a port located at the opposite end of each transfer passageway from the scavenge port, which port connects the transfer passageway with the scavenge pump system at the opposite end from the scavenge port, will be referred to as a crankcase outlet port.

Any port which opens from atmosphere into the scavenge pump system to feed or charge the scavenge pump will be referred to as an intake port or inlet port.

Also, the terminology "upper dead center", "lower dead center", "top dead center", "bottom dead center", "upper" or "top" cylinder or crankcase portion or area, "bottom" or "lower" cylinder or crankcase portion, etc., will be used in this patent to refer to an engine so oriented as to have the cylinder longitudinal axis located in a generally vertical plane with the cylinder head uppermost or on top, and the crankshaft and crank chamber located in an area generally directly underneath or at the lower or bottom end of the cylinder.

FIELD OF THE INVENTION

The field of the invention is that of the two cycle, reciprocating piston type internal combustion engine having the scavenge ports located in that section of the cylinder wall situated nearest to the bottom dead center position of the power piston head, and utilizing the underside of the power piston as a pumping piston for the scavenge pump system.

DESCRIPTION OF THE PRIOR ART

In my copending U.S. Pat. application Ser. No. 224,756, filed Feb. 9, 1972 for Two Cycle Engine Scavenge Ports, there is disclosed the improvement to the subject type of engine consisting of a scavenge port or ports of extra height but having normal effective port timing as to opening to the scavenge pump system, the necessary additional timing control being effected with the aid of a port or ports located in the piston side wall. This is a very effective system for increasing the scavenge gas mass flow through capability, improving the scavenge gas flow pattern within the power cylinder, or both.

U.S. Pat. No. 3,046,958 issued July 31, 1962 to F. N. Bard et al. discloses an internal combustion percussive device based on a two cycle engine in which the energy imparted to the piston by combustion of the fuel-air charge is transmitted to the work load by percussion of the piston directly against a tool or anvil. In the Bard et al patent the scavenge port opening and closing in the power cylinder wall is controlled by the reciprocating movement of the piston head timing edge in cooperation with the adjacent piston side wall area, and additional control of the transfer passageway opening to the scavenge port and to the scavenge pump system is exercised by means of a reed type valve located in the transfer passageway. The system as illustrated and described, however, neither serves to increase the scavenge gas mass flow through capability of the cylinder, not to provide an efficient scavenge gas flow pattern.

As illustrated, in Bard et al the height of the scavenge port opening, as measured from the upper edge to the lower edge of the port, amounts to only about 14 percent of the piston stroke as scaled from the drawing. However, the upper edge of the scavenge port is located above the timing edge of the piston head (with the piston in bottom dead center position) by a distance equal to approximately 28 percent of the piston stroke. Thus half of the potential gas flow area available between the timing edge of the piston head with the piston at the bottom dead center position, and the upper edge of the scavenge port, is wasted. The scavenge gas flow through capability is thereby decreased instead of increased. Further, the longitudinal sectional view in Bard et al. does not illustrate either the scavenge or exhaust port extending any distance radially around the cylinder wall. Thus the usual peripheral area around the cylinder wall, available for scavenge and exhaust ports is not illustrated as being used. Again the gas flow through capability of the ports and cylinder appears the opposite of being increased or maximized. Finally, there is no teaching in the description that even hints at increasing or maximizing the gas flow through capability.

Also, the scavenge gas flow pattern through the power cylinder bore of Bard et al is not improved in any way by the illustrated arrangement, but is in fact very inefficient. The scavenge gas flow is aimed directly across the cylinder toward the exhaust port, which will result in very poor scavenging and maximum short circuiting of the fresh charge out of the cylinder via the exhaust port. Even the domed portion of the piston head does not project into or tend to interrupt the straight line scavenge gas flow path leading directly from the scavenge port across to the exhaust port.

The Bard et al patent thus offers no teaching as to increasing or maximizing the scavenge gas mass flow through capability of the port system or of providing even a normally efficient scavenge gas flow pattern within the cylinder.

U.S. Pat. No. 3,499,425 issued Mar. 10, 1970 to D. E. Gommel shows in FIGS. 7, 8 and 9 an engine which also has the scavenge port piston timed, with additional valving being provided by means of reed valves situated within the transfer passageway. The system as illustrated and described therein does nothing, however, to increase or maximize the scavenge gas flow capability or provide a more efficient scavenging pattern of gas flow within the power cylinder. As to increasing or

maximizing the mass gas flow capability through the ports and cylinder, the great majority of cylinder wall area around the port belt is shown as being totally devoid of ports. Thus no effort is illustrated which is aimed at utilizing even the normal maximum circumferential area available for gas flow porting. It might be argued that high gas flow capacity is suggested by the somewhat unusually high scavenge port which scales on the drawing at a height of some 29 percent of the stroke. However, the corresponding depth of transfer passageway illustrated scales at only some 17 percent of the stroke, which would tend to negate any flow rate advantage of the high port. Finally, FIG. 9 of Gommel quite clearly illustrates that when the reed valves are in the fully opened position the flow through the open ends of the opposing valves is not only obstructed by head on "bucking" of the gas streams one against the other, but also by blocking of the transfer passageway cross section by the open reed valves, with the result that the gases can flow only via a tortuous and obstructed path that serves to reduce the mass rate of scavenge gas flow instead of increasing it. Also, there is no hint given in the description of any aim or attempt toward increasing or maximizing the rate of gas flow.

As to improving or making more efficient the scavenge gas flow pattern within the cylinder, nothing in either FIGS. 7, 8 and 9 or in the accompanying description of Gommel suggests such an outcome.

SUMMARY OF THE INVENTION

The invention consists of the use of extra height scavenge ports, as described and illustrated in my said co-pending application Ser. No. 224,756, filed Feb. 9, 1972, but with the necessary additional valving control supplied by reed valves located in the transfer passageway(s) close to the extra height ports, instead of by piston side wall ports. The reed valves are located generally parallel to the normal direction of gas flow with their outlet ends oriented toward the scavenge ports. The outlet area of the reed valves when the reeds are in fully opened position is preferably made at least equal to the corresponding scavenge port flow area as measured perpendicular to the flow and is made greater when feasible. The reeds are provided with suitable stops to limit the height of opening and permit the proper opening curvature or shape so as to return them to the closed position on their seats without undue shock or stress, resulting in maximum reed life. The extra height scavenge ports, additionally controlled by reed valves, are provided in order to increase the mass rate of gas flow capability out of the piston underside scavenge pump system and thus increase the mass air flow through capability of the cylinder with resulting increased power output capability. The extra height scavenge ports may also be utilized to provide a more efficient scavenge gas flow pattern in the work cylinder spent gas content, as by releasing the scavenge gases into the cylinder at a point nearer to the cylinder head area or by providing a scavenge air stream of desirably larger cross-sectional area in relation to the cylinder bore cross-sectional area.

In particular, the extra height scavenge ports of the invention are useful in short stroke engines having cylinder bore to stroke ratios greater than in the 1:1 to 1.25:1 ratio range which has usually produced the highest power output per cubic inch of power piston dis-

placement in prior art engines which have been limited to use of normal height scavenge ports only. In such engines, when piston area has been increased without corresponding increase of piston stroke, a scavenge port system flow through capability in relation to piston area has automatically declined (with any given port layout and timing) and thus air pumping capability has not increased along with the increased piston area. At the same time the inherently reduced ratio of scavenge gas flow stream cross-sectional area to piston head area generally results in a less favorable scavenge gas flow pattern within the spent gas cylinder contents, resulting in even less favorable power output together with poorer thermal efficiency particularly in the case of fuel mixture scavenged engines. The additional scavenge port flow area afforded by the use of extra height scavenge ports overcomes these difficulties inherent in the usual short stroke engines.

It is of course understood that cylinder exhaust flow capability and also scavenge pump system intake flow capability must be designed to complement the increased scavenge port system flow capability made possible by use of extra height scavenge ports, if maximum engine power increase due to increased air handling capability is to be realized. However, suitable complementary increases in exhaust flow capability and scavenge pump system inlet flow capability can usually be made without departing from the general teachings of the present state of the art. A special form of the exhaust port used for increasing exhaust flow capability in combination with a particularly popular and useful scavenge port arrangement which may include extra height scavenge ports is described and illustrated in my co-pending application Ser. No. 233,588, filed Mar. 10, 1972, entitled "Two Cycle Engine with Auxiliary Exhaust Ports."

The additional scavenge port timing control offered by the reed valves of the subject invention as opposed to the additional piston side wall control port valving of my co-pending application Ser. No. 224,756 justifies the slight mechanical complexity added by the reed valve system, for several reasons. First, the reed valves provide a variable valve timing automatically responsive to different engine operating conditions, as opposed to the fixed timing of the piston side wall control port system. This variable timing is particularly useful when rpm-tuned exhaust systems are utilized to cause earlier effective closing of exhaust port systems via gas pressure waves, when the exhaust port systems feature mechanically late closure which would otherwise result in undue loss of fresh charge gases out of the cylinder during the port closing phase of piston motion. Such arrangements work well as long as the engine rpm does not fall much below the rpm-tuned range of the exhaust system. However when the engine rpm falls too low, the exhaust pressure wave enters the cylinder when the scavenge ports are still open to the scavenge pump system, resulting at the least in interference with transfer of fresh charges between scavenge pump and power cylinder. Contaminated hot gases can also be blown back into the scavenge pump system with known results as to deterioration of engine operation. Finally, particularly when piston valved scavenge pump intake systems are utilized in combination with fuel-air mixture intake devices, extremely over-rich fuel-air mixtures result and cause objectionable irregular engine running, misfiring, etc. This result occurs because when

the too early arriving exhaust pressure waves interfere with transfer of fresh gas charges into the cylinder, the charges then blow back out through the piston controlled scavenge pump inlet port when it opens, and thence out through the fuel introduction device causing the well known fuel "spit back." Worse yet, the same inlet air passes through the fuel inlet device as much as three times and picks up fuel each time, causing an extreme over-rich mixture condition with attendant misfiring, sparkplug fouling, and other objectionable operating conditions. The variable timing provided by the reed valves tends to act as a check valve to prevent reverse flow through the transfer passageways under such conditions, resulting in greatly improved engine operation.

Another advantage of the reed valve additional control is that it tends to reduce the gas volume trapped in the transfer passageway between the closed additional valving device and the scavenge port. Particularly when rpm-tuned exhaust pressure waves are utilized to bring about earlier effective exhaust port closure, an additional portion of the cylinder fresh charge gases may be forced back into the part of the transfer passageway located between the additional control valve cutoff point and the scavenge port outlet, and thus result in some reduction of the fresh gas charge mass trapped within the power cylinder bore. With the reed valve(s) placed close to the extra height scavenge ports, the passageway valve available for such blow back of fresh charge volume can be reduced in comparison to the transfer passageway volume extending all the way down to a piston side wall control port.

Another advantage of the reed valve type additional extra height scavenge port control system is that it checks reverse flow of heated combustion gases before it can reach the piston skirt which is already subjected to high thermal loading and consequent marginal lubrication conditions. With the piston skirt side wall control port, of course there is no mechanical barrier which intervenes between hot combustion gases flowing back down into the transfer passageway and the piston skirt or side wall.

It is an object of the present invention to provide increase over the normal flow capability available through prior art scavenge port systems having only normal height scavenge ports. It is also an object of the invention to make possible a scavenge gas flow pattern of improved efficiency.

These objects are achieved in the disclosed embodiments of the invention through the use of extra height scavenge ports with reed valves located close to the associated ports and which are designed and oriented so as to minimize flow eddies, sudden changes in flow direction, and flow resistance through the transfer passageways.

The illustrated reed valve and extra height scavenge ports are especially desirable when used in combination with short stroke engines.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view taken as on line 1—1 of FIG. 3 illustrating a two cycle engine having extra height scavenge ports and utilizing reed valves in the transfer passageways associated with these extra height scavenge ports in accordance with the present invention;

FIG. 2 is a fragmentary vertical sectional view taken as on line 2—2 in FIG. 3;

FIG. 3 is a transverse sectional view taken as on line 3—3 in FIG. 1;

FIG. 4 is a fragmentary vertical sectional view of a modified form of the present invention in an engine having a 1.5:1 bore to stroke ratio;

FIG. 5 is a fragmentary sectional view taken as on line 5—5 in FIG. 4; and

FIG. 6 is a fragmentary vertical sectional view of a further modified scavenge port and transfer passageway configuration.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1, 2 and 3, a two cycle internal combustion engine illustrated generally at 10 includes a cylinder block 11 having a cylinder bore 12 defined therein. A piston 13 is mounted for reciprocating movement in said cylinder bore. The piston is connected with a piston pin to a connecting rod 14, which in turn is connected at its lower end to a crankshaft 15 mounted in a crankcase 16. The crankcase defines an interior chamber 17 which in the form of the invention shown is utilized as a scavenge pump chamber. The underside of the piston 13 is open to the chamber 17 and acts as a scavenge pump piston.

The fresh charge gas inlet to the crank chamber 17 can be through any desired valving arrangement, for example reed valves or rotary valves, or as shown, an inlet port 20 which is valved by the lower portions of the side wall of the piston 13 may be used as the inlet valve arrangement. A suitable connecting tube 21 leads to a carburetor or other suitable charge inlet device.

The cylinder has an exhaust port 22 leading to an exhaust pipe 23 that in turn can be connected to a suitable exhaust system 24 such as a resonant or pressure wave tuned exhaust system.

A plurality of scavenge ports are defined in the cylinder wall and these scavenge ports are connected by transfer passageways to the crank chamber 17. The scavenge ports as shown include an extra height opposite scavenge port 25 located in that portion of the cylinder wall opposite from the exhaust port 22. The extra height scavenge port 25 is connected to a transfer passageway 26. The transfer passageway 26, as shown, has a steeply upwardly inclined wall 27 adjacent the scavenge port 25 which directs fresh charge gases flowing through the transfer passageway 26 into the cylinder bore in an upwardly directed flow path toward the distal end of the cylinder, or in other words, away from the end of the cylinder adjacent the bottom dead center position of the piston timing edge 13A. The bottom dead center position of the piston timing edge is on a level in the cylinder with the bottom line 22A of the exhaust port 22 in the form shown. The extra height ports have an upper edge at least substantially 30 percent of the piston stroke as measured from a reference level defined by the piston timing edge in bottom dead center position of the piston to the distal edge of the port. As shown herein, the extra height ports have distal edges spaced from the reference level a distance equal to substantially 45 percent of the piston stroke.

The transfer passageway 26 which connects to the extra height opposite scavenge port 25 is open to the crank chamber 17 through a crankcase outlet port 28. The extra height scavenge port 25 is covered and un-

covered by the piston in the course of its normal stroke. When the port 25 is uncovered, flow through the port 25 and through passageway 26 is additionally controlled by a reed valve assembly 31 placed in the transfer passageway. The reed valve assembly includes a valve cage 32 that has passageways defined there-through. A plurality of reeds or valve leaves 33 are held at the lower end of the cage 32, and in normal position the upper portions of the reeds rest against corresponding portions of the cage as shown in solid lines in FIG. 1 and serve to close the internal passageways through the case. The reeds 33 are made of springy or resilient material, for example spring steel, and whenever the gas pressure at the scavenge port 25 and in the upper portion of transfer passageway 26 is sufficiently less than the pressure at the crankcase outlet port 28, the reeds 33 will move away from their solid line position and open the passageways through cage 32. When the reeds 33 move to their dotted line positions shown in FIG. 1 the reed valve assembly reaches its maximum opening. When closed, the reed valve assembly 31 prevents reverse flow of gases from the scavenge port 25 through the transfer passageway 26 to the crankcase outlet port 28. The reed valve assembly 31 is, as shown in FIG. 3, of sufficient lateral width to have two reeds 33 on each side of the valve cage.

When port 25 is uncovered during a power stroke of the piston and pressure in cylinder bore 12 has blown down through the exhaust port 22 to a level sufficiently different from the pressure in the scavenge pump system the reeds 33 will move away from their seats on cage 32. When the valve assembly is at its maximum opening, the reeds are in their dotted line positions supported against the curved back stop surfaces indicated at 34 and 35. Due to pressure differential between the chamber 17 and bore 12 fresh charge gases will flow from the crankcase outlet port 28 through the openings in the cage 32 and then out through the upper portions of the transfer passageway 26 and scavenge port 25 into the cylinder bore 12.

The reed valve assembly 31 comprises an additional valving means for the extra height scavenge port 25 apart from the piston 13. The piston 13 will uncover the upper portions of the extra height scavenge port 25 during the power stroke before the pressure in cylinder bore 12 has blown down to a suitable level for scavenging, and the reed valve assembly 31 will remain closed to prevent blow back into the scavenge pump system. The reeds automatically open when the pressure in the cylinder bore drops a sufficient amount in relation to the pressure in chamber 17. Downward piston movement increases the pressure of the fresh charge gases which were drawn into chamber 17 through port 20 as the piston previously moved toward top dead center position.

The reed valve assembly 31 is held in place by means of suitable cap screws. A cover plate 36 is also fastened in place by cap screws to cover the opening the cylinder block used for installing or removing the reed valve assembly 31. The cover plate may also be used to exert clamping pressure on the fixed ends of the reeds. The reed valve assembly 31 is selected in size so as to provide a maximum flow area at least equal to and preferably greater than the minimum area of the transfer passageway 26 as measured in a plane perpendicular to the flow in the region of surface 27.

As shown perhaps best in FIG. 2, the cylinder wall also has a pair of side extra height scavenge ports 40 defined therein. The side extra height scavenge ports 40 are positioned, as shown, alongside the opposite scavenge port 25 and are located above, i.e. spaced toward the distal end of the cylinder from, a pair of side normal height scavenge ports 41 provided in the cylinder wall. The extra height side scavenge ports 40 open to transfer passageways 42 defined in the cylinder block. The transfer passageways 42 at their lower ends terminate in crankcase outlet ports 43 that are open to the chamber 17 of the scavenge pump system. As shown, the distal or upper edges of the extra height side scavenge ports 40 are substantially on the same level in the cylinder bore 12 as the upper edge of the extra height opposite scavenge port 25. The lower edges of ports 40 are defined by the walls separating the ports 40 from normal height ports 41.

A reed valve assembly 44 is mounted in transfer passageway 42. The assembly 44 includes first and second reed valve assembly portions 45 and 46 and associated reeds 47 and 48. The reed valve assembly portions 45 and 46 define interior flow passageways as shown, that are closed by the valve reeds or leaves 47 and 48 with the reeds in their normal solid line position shown in FIG. 2. The reeds, when closed, seat against surfaces surrounding the outlets of the flow passageways in the valve assembly portions.

When the extra height scavenge ports 40 are uncovered and the pressure at the crankcase outlet port 43 is sufficiently different from the pressure in the upper portions of the transfer passageway 42 (above the valve assembly 44) the valve reeds 47 and 48 will be moved to a valve open position and fresh charge gases will flow through the passageways 42 and out through ports 40. The reeds automatically open in response to pressure differentials, and likewise also automatically close to prevent reverse flow in direction from the extra height scavenge ports 40 toward the crankcase outlet ports 43 through the passageway 42.

When the reeds 47 and 48 are fully opened as shown in dotted lines they are supported on curved surfaces that correspond generally to the normal curvature of the reeds in their open positions. The support surface for reed 48 is an outer surface of valve assembly portion 45, and the support surface for reed 47 is one of the surfaces defining passageway 42. The support surfaces for the reeds are oriented so as to provide a smooth gas flow path toward the scavenge port 40. The internal surfaces 45A and 46A of the passageways through the valve assembly portions generally conform to the curvature of the supporting surface for the reeds in the reed open positions and contribute further toward a smooth gas flow path toward scavenge port 40.

The normal height scavenge ports 41, which are below the extra height scavenge ports 40, open to transfer passageways 52. The passageways 52 communicate with the scavenge pump system through a crankcase outlet port and a window or opening 53 in the piston, which aligns with the associated crankcase outlet port during portions of the piston stroke. Timing of the flow through ports 41 is controlled in the usual manner by the piston timing edge and the upper portions of the piston. If desired, additional normal height side scavenge ports 54 may be provided and as shown such ports are positioned in the cylinder wall between the scav-

enge ports 41 and the opposite sides of exhaust port 22. Scavenge ports 54 open to transfer passageways 55 which open directly into the chamber 17 through crankcase outlet ports 56. The normal height scavenge ports 54 are also valved in the usual manner by the piston. The portion of the cylinder wall below ports 41 which separate the piston from transfer passageway 52 can be removed if desired without affecting operation of the engine.

As shown, the valve assembly portions 45 and 46 are held in place in the cylinder block with suitable cap screws, and are inserted or removed through a provided opening leading to their respective transfer passageway 42. The cover for this provided opening is formed as part of valve assembly portion 46.

The reed valve assembly 44 provides a maximum flow area through the valve at least equal to and preferably greater than the area of scavenge port 40. Also, the reed valve is designed and oriented so as to provide a smooth, even and direct gas flow path leading to scavenge port 40.

While two different forms of reed valves have been shown, of course other types of reed valves can be utilized. It should be noted that the reed valves in the present devices are located in the transfer passageways close to the extra height ports in order to minimize the volume of the transfer passageway between the reed valve and the associated scavenge port.

The engine shown in FIGS. 1, 2 and 3 has a 1:1 bore to stroke ratio, and in FIGS. 4, 5 and 6, an engine having a 1.5:1 bore to stroke ratio is illustrated. As has already been explained, the use of extra height scavenge ports is especially advantageous in engines utilizing high bore to stroke ratios, such as 1.5:1.

Referring to FIG. 4, the engine shown fragmentarily has a cylinder block 65, with an internal cylinder bore 66 in which a piston 67 is slidably mounted for reciprocating movement. The piston is connected to a connecting rod (not shown) in the normal manner, and many of the conventional details are omitted from FIG. 4. Bottom dead center position of the piston is reached when the piston head timing edge 67A is at the same level as the lower edge 68A of exhaust port 68. The upper dead center position of timing edge 67A coincides with the edge 65A of the mating surface between the cylinder block 65 and the cylinder head.

In this form of the invention, the cylinder has an exhaust port 68 leading therefrom, and as shown in FIG. 4 a first pair of extra height side scavenge ports 69 are provided in the cylinder. The extra height side scavenge ports 69 extend from a level along the level of the piston timing edge 67A in bottom dead center position of the piston continuously up to their upper or distal edge, as shown substantially 45 percent of the piston stroke. The ports 69 open to transfer passageways 70 that in turn open through crankcase outlet ports 71 to a chamber 72 forming a part of the scavenge pump system. The underside of the piston 67 again is used as a scavenge pump piston.

In addition to the extra height side scavenge ports 69, the engine as shown has extra height side scavenge ports 73 opening into transfer passageways 74 that connect to crankcase outlet ports 75 in the chamber 72. The extra height side scavenge ports 73 extend continuously from the bottom dead center level of the piston timing edge 67A to the upper or distal edges of the ports 73, which, as shown, are spaced up from the level

of the piston timing edge in bottom dead center position a distance equal to approximately 45 percent of the piston stroke.

The extra height side scavenge ports 69 and 73 and their associated transfer passageways as shown are positioned so that the walls of the transfer passageways adjacent the respective ports are aimed in directions such that the flow from the respective scavenge ports is intended to provide for efficient scavenging in the known manner whereby the gas flow streams from the opposed pairs of side scavenge ports meet and combine to form a single gas stream which proceeds upwardly along the section of cylinder wall located opposite from exhaust port 68.

As illustrated in FIG. 4, a reed valve assembly 80 is mounted in the transfer passageway 70. In this particular instance, the reed valve assembly 80 includes three valve assembly portions 81, 82 and 83 defining flow passageways, and having valve reeds or leaves 84, 85 and 86, respectively, associated therewith so as to close the valve passageways when the reeds are in their solid line positions. The valve assembly portions are held in place with suitable cap screws.

The sum of the cross-sectional areas of the individual flow channels through the valve assembly portions is greater than the cross-sectional area of the transfer passageway at the scavenge port 69. Thus the reed valve assembly 80 constitutes a minimal obstruction to flow of fresh charge gases through the transfer passageway 70 during engine operation.

The transfer passageway wall 89 has a curved surface that forms a backstop for the valve reed 84 in its full open position, and the adjacent valve assembly portions 81 and 82 form backstop surfaces for the valve reeds 85 and 86 so that the reeds will be supported when in their respective full open positions. Likewise, the surfaces defining the flow passageways through the respective valve assembly portions are so designed and oriented as to direct the flow through the valve assembly in a desired smooth flow path through the transfer passageways with a minimum of sudden changes in direction, turbulence or disrupting eddies. The reed valve assembly 80 is located in the transfer passageway close to the scavenge port in order that the volume in the passageway between the reed valve assembly and its associated scavenge port is kept to a desirable minimum.

After the piston 67 uncovers the extra height scavenge port 69 during the power stroke, the reed valve assembly 80 will remain closed until the pressure in the cylinder bore 66 has blown down via exhaust port 68 and the pressure at the crankcase outlet port 71 is sufficiently different from the pressure at the extra height scavenge port 69 to cause the reeds to open. When the reeds open fresh charge gases will flow from the scavenge pump system into the cylinder because of the pressure differential between the scavenge pump and the cylinder bore.

In FIG. 5, it can be seen that the transfer passageway 74 has a reed valve assembly 90 therein which is constructed in a substantially identical manner to the reed valve assembly 80.

A modified scavenge port and transfer passageway arrangement is shown in FIG. 6. The arrangement of FIG. 6 may be used as an opposite extra height scavenge port in the engine of FIG. 4, or may be used for side extra height scavenge ports if desired. The scav-

enge port arrangement of FIG. 6 includes an extra height scavenge port 91, and an underlying normal height scavenge port 92. These ports 91 and 92 are separated by wall 93. The extra height scavenge port 91 opens to a transfer passageway 94 that communicates with crankcase outlet port 95. A reed valve assembly 96 is located in transfer passageway 94. Reed valve assembly 96 is a single reed valve assembly having a reed 97, which, when fully open, is supported back against the surface of the wall 93 as shown in dotted lines. The reed valve assembly is fastened into the cylinder block with suitable cap screws. Normally the reed is in its solid line closed position. It is of course to be understood that this modified form is not limited to the illustrated single reed valve assembly; multiple reed valves may also be used.

The normal height scavenge port 92 opens to a transfer passageway 98 that communicates with a crankcase outlet port 99 leading to the scavenge pump chamber 72 (when used with the engine of FIG. 4). The valve of normal height scavenge port 92 is controlled in the normal manner by the piston 67 and the piston timing edge 67A.

Fresh charge gases will not flow from the scavenge pump system chamber 72 to the cylinder 66 through the port 91 until the pressure in the cylinder has blown down through the exhaust port to a level which permits the reed 97 to move to open position. The valve reed 97 automatically closes to prevent flow from the cylinder back into the scavenge pump system. The reed valves are automatic, pressure responsive valves, so that as soon as the pressure in the cylinder bore has blown down to a suitable level the valves will automatically open and permit fresh charge gases to flow into the cylinder bore.

The use of reed valves has been illustrated in combination with engines having two different particular bore to stroke ratios, but of course the reed valves can be used with the extra height scavenge ports regardless of the bore to stroke ratios.

Also, it should be noted that the type of engine ignition does not affect the operation of the invention, in that the engine can have spark ignition or can be a compression ignition or a glow plug ignition engine. Fuel injection through the cylinder head (or elsewhere also can be utilized if desired. The scavenge pump intake valve system also can be of any desired type.

Two types of extra height scavenge ports have been shown. In one type, the extra height scavenge port is superposed over a normal height scavenge port. The extra height port has an additional valving means comprising the reed valve, while the normal height port is valved only by the piston. The transfer passageway for the underlying normal height port is therefore unobstructed. All reed valves provide some flow obstruction, so for a minimum of obstruction the use of conventional piston valved, normal height scavenge ports underlying the extra height ports is preferred. This configuration also reduces the size and complexity of the reed valves necessary because the reed valves only control the flow through the extra height ports.

On the other hand, the type of extra height port that is continuous from the bottom dead center level of the piston timing edge up to the distal edge of the port and which uses one large reed valve eliminates the need for a divider wall to separate the transfer passageways, as is needed with separated extra height and normal

height ports. It should also be noted that with the reed valve assembly used for the continuous port, (such as reed valve assembly 80) the valve at all times protects against reverse flow from the cylinder through the transfer passageway and into the scavenge pump system.

The extra height scavenge ports tend to improve the scavenge gas flow pattern within the cylinder because the scavenge gases emanate from the ports closer to the distal end of the cylinder, thereby aiding in clearing the spent combustion gases from this end of the cylinder. As previously mentioned, the extra height scavenge ports also tend to provide for a greater cross-sectional area of the scavenge gas flow stream, which is particularly important in short stroke engines.

In all forms of the invention (utilizing the extra height scavenge ports) the scavenge ports are substantially continuous or open from the upper edges of the extra height ports down to the level of the piston head timing edge with the piston in bottom dead center position, in order to provide maximum utilization of the cylinder wall area available for scavenge ports and thus aid in maximizing the scavenge gas flow through capability. The divider walls used in some of the illustrated forms of the invention for dividing the scavenge ports into extra height ports with underlying normal height ports do not occupy any substantial amount of cylinder wall area that could otherwise be used for scavenge port area.

It should also be noted that in all forms of the invention the reed valve assemblies are located close to the extra height scavenge ports and are so oriented and designed as to provide a smooth gas flow path directed toward the associated scavenge ports with a minimum of changes in flow direction and hence a minimum of turbulence and flow disrupting eddies.

Finally, the embodiments shown have the upper edges of the extra height scavenge ports terminating on a level in the cylinder no higher than the level of the upper or distal edge of the exhaust port. This insures that the exhaust gas pressure and temperature to which the reeds are subjected will not be high enough to cause damage to the reeds.

What is claimed is:

1. A two cycle engine having a cylinder and a power piston with a piston head timing edge and an underside, and which utilizes the underside as a piston of a scavenge pump system and which has scavenge ports located in a first portion of the cylinder adjacent a reference line along the piston timing edge with the piston in bottom dead center position, said cylinder having a distal end towards which the piston moves during the compression stroke, transfer passageway means leading from said scavenge pump system to the scavenge ports, said passageway means being elongated and extending close to the cylinder and generally in the same direction as the axis of said cylinder from the underside of said piston to the scavenge ports, said scavenge ports in said cylinder extending from substantially adjacent said reference line toward the distal end of the cylinder and being covered and uncovered by said piston timing edge as the piston reciprocates in the cylinder, significant portions of at least some of said scavenge ports being uncovered by said piston when the distance between the piston timing edge and the reference line is not less than substantially 25 percent of the piston stroke, and reed valve means in said transfer passage-

way means for said some scavenge ports to substantially prevent reverse flow from said cylinder to said scavenge pump system, and to permit flow from said scavenge pump system into the associated transfer passageway means and then to said some scavenge ports 5 in response to pressure differentials, said reed valve means extending generally longitudinally of said passageway means and including at least one reed member having a supported lower end and a pressure responsive upper end that is movable generally transverse of said 10 passageway means to an open position to permit flow from the scavenge pump system, and means positioning said upper movable end substantially above the bottom of the piston when the latter is in bottom dead center position so that said upper movable end is adjacent said 15 scavenge port means, said reed member in an open position guiding flow toward the associated scavenge ports.

2. The combination as specified in claim 1 wherein said reed valve means comprises surface means forming a smoothly curved surface to guide flow from said scavenge pump system to the associated scavenge port means, said reed member being positioned to move in direction to guide flow toward said scavenge port means as the reed valve member opens. 20

3. The combination as specified in claim 1 wherein said reed valve member comprises a blade like valve member movable from a closed to an open position, and said transfer passageway means is defined by wall surfaces in said engine, a portion of said wall surfaces being positioned adjacent said reed valve means and shaped to support and stop at least one of said blade like valve members in its open position in a shape conforming to the general curve of the blade like member in an unsupported open position. 25

4. The combination as specified in claim 1 wherein said reed valve means comprises a body member mounted in said passageway means, and having a plurality of flow channels through said body member, separate blade like resilient members positioned adjacent 40 each of said channels and movable to a closed position to prevent reverse flow through the associated flow channels and yieldingly movable under pressure differentials to an open position to permit flow from the scavenge pump system to said scavenge port means. 45

5. The combination as specified in claim 1 wherein

the reed valve means include flow passageways having a total effective flow path cross sectional area with the reed valve means fully open that is at least equal to the effective minimum flow path cross sectional area through the associated transfer passageway means without the reed valve means in the associated transfer passageway means.

6. The combination as specified in claim 1 wherein at least one of said some scavenge ports extends from a distal edge thereof continuously toward a level corresponding to said reference line.

7. The combination as specified in claim 1 wherein said cylinder has port means including first scavenge port means of no greater than normal height and second extra height scavenge port means, said first scavenge port means opening to separate transfer passageway means from the transfer passageway means for the second scavenge port means, said first scavenge port means being positioned between said second scavenge port means and said reference line, communication between the scavenge pump and the cylinder through said first scavenge port means being controlled by the piston and the piston head timing edge, and wherein said reed valve means is associated with the second scavenge port means and not with said first scavenge port means. 30

8. The combination as specified in claim 7 wherein said first and second scavenge port means at least partially overlap in circumferential relationship.

9. The combination as specified in claim 1 and in which there are separate passageway means open to separate portions of said some scavenge port means to divide at least some of said scavenge port means into separate portions which at least partially overlap circumferentially in the cylinder, said reed valve means being positioned in at least some of said separate transfer passageways. 35

10. The combination as specified in claim 1 wherein said cylinder is defined by a wall having a circumference, an exhaust port leading from said cylinder and defined through said wall, and said scavenge ports being defined in said wall to occupy a major portion of the circumference of said wall adjacent said reference line other than the portion of the circumference adjacent the reference line occupied by said exhaust port. 40

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