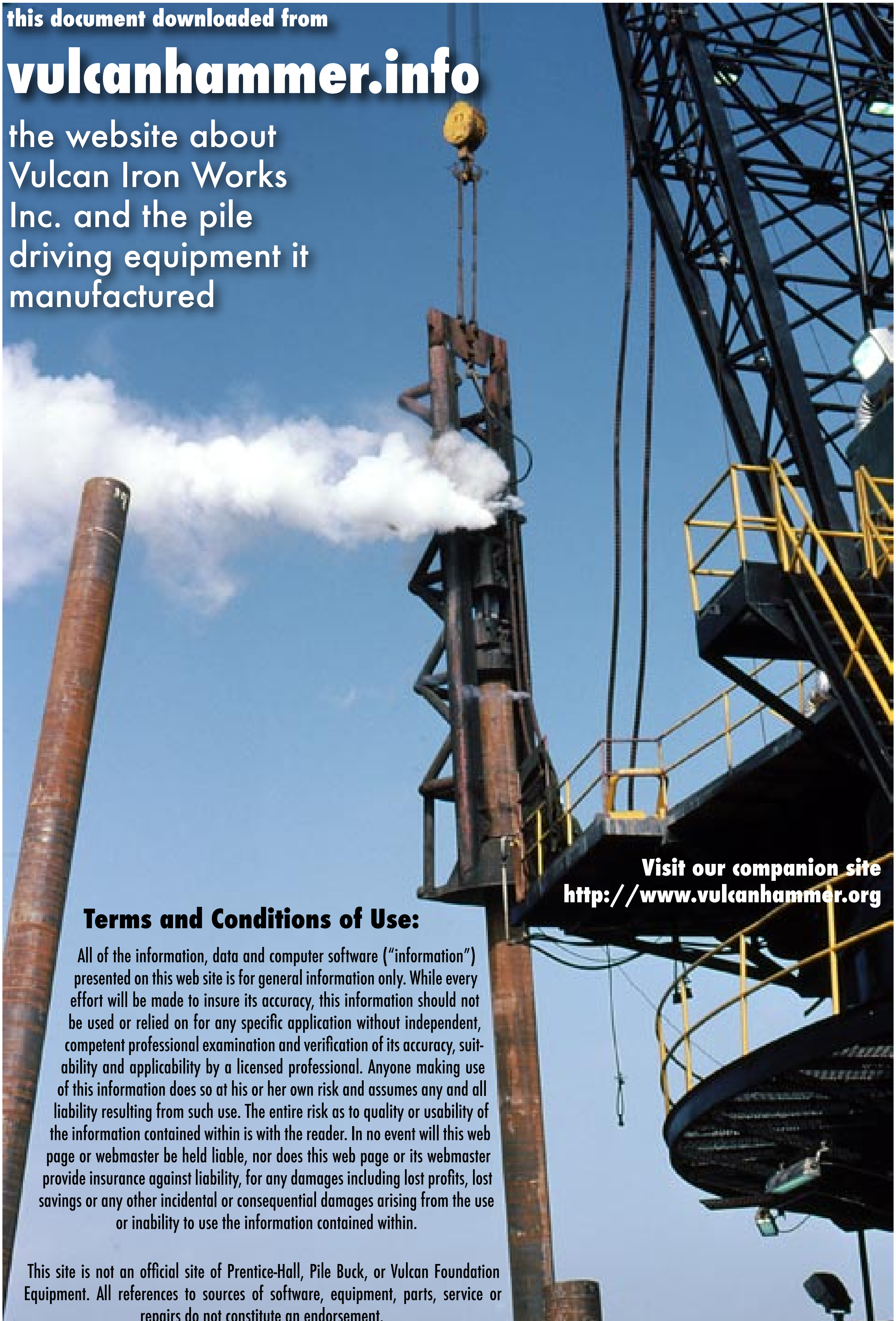

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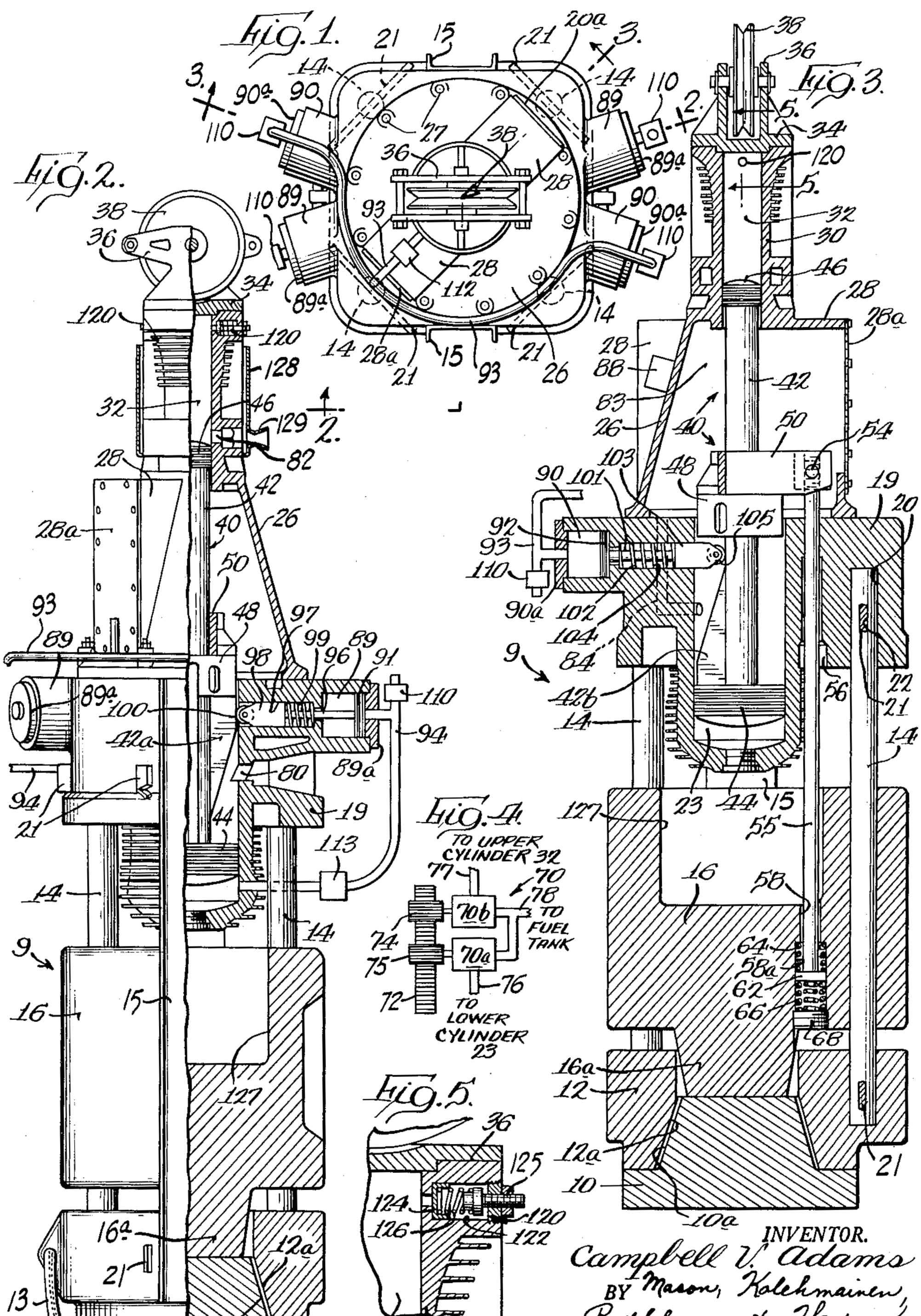
PILE DRIVING HAMMER

Filed Dec. 29, 1959



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PILE DRIVING HAMMER

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This invention relates to a power or percussion type hammer such as pile driving hammers, and more particularly to pile driving hammers of the internal combustion compression-ignition type.

Although the power hammer of the present invention in the preferred embodiment is particularly well adapted for pile driving and is of the compression-ignition powered type, it will be apparent to those skilled in the art that the invention is not limited to such an application or embodiment. Compression-ignition powered pile driving hammers have certain inherent advantages over pile driving hammers which are powered by steam, compressed air, or other fluids but have heretofore encountered considerable difficulty in obtaining sufficient compression pressure to cause ignition of injected fuel when attempting to initiate starting thereof in soft soils and further in failing to ignite injected fuel due to insufficient compression pressure during continuous operation whenever the pile being driven penetrates a soft stratum of soil. Inability to obtain required compression pressure for ignition results from an embedment movement of the pile when pressure in the combustion chamber, acting between the decending ram and slidably inserted lower head of the cylinder resting on top of the pile, exceeds that offered by the resistance of the soil opposing movement of the pile. Other inherent limitations are also imposed in combining a heavy ram with a high frequency of blows without detrimentally affecting the maximum force of the blow. It will be appreciated that in double-acting pile driving hammers only the dead weight of the stationary parts thereof resists the upward thrust, and such dead weight must be commensurate with the energy to be produced. One of these limiting factors is concerned with the maximum total weight of the apparatus, which is limited within certain classes, for practical purposes, by the capacity of available handling equipment which is employed with existing steam and compressed air powered pile driving hammers. Another well-known factor is that with a given, limited weight of ram, a heavy blow requires extended travel of the ram, whereby the frequency of the blows is reduced, although this limitation has been partially overcome by some prior art developments. Still another limitation on the capacity of compression-ignition powered pile driving hammers concerns the difficulty in obtaining effective scavenging or otherwise providing adequate air for complete fuel combustion in what is necessarily a two-stroke cycle, particularly in view of weight and size limitations of the over-all machine.

A compression-ignition powered pile driving hammer constructed in accordance with the present invention avoids any theoretical limitation on the force or frequency of the pile driving blows while observing the prescribed weight and size limitations. It also provides adequate air for fuel combustion without significant increase in weight or size.

Accordingly, it is an object of the present invention to provide an improved power hammer of the internal combustion type which is capable of delivering heavy low velocity blows at high frequency with a conventional ram of relatively heavy weight with respect to the total weight of the power hammer.

It is another object of the present invention to provide a double-acting compression-ignition hammer which is readily convertible to a single-acting hammer.

It is a further object of the invention to provide an improved power hammer of the internal combustion type in which burned gases are properly scavenged.

It is a still further object of the invention to provide an improved power hammer of the internal combustion type in which additional air for combustion is obtained through supercharging.

Another object of the invention is to provide an improved compression-ignition powered pile driving hammer having various of the advantageous characteristics specified above.

A further object of the invention is to provide an improved power hammer of the internal combustion type having various of the advantageous characteristics specified above while being light in weight, small in size, reliable in operation and inexpensive to manufacture.

A further object of the invention is to provide an improved power hammer of the internal combustion type having various of the advantageous characteristics specified above and capable of positive starting and uninterrupted functioning regardless of intensity of soil resistance opposing the pile during embedment thereof by the power hammer.

Further features of the invention pertain to the particular arrangement of the elements of the power hammer, whereby the above outlined and additional features thereof are attained.

The invention, both as to its oragnization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification, taken in connection with the accompanying drawing, in which:

FIG. 1 is a top plan view of a compression-ignition powered pile driving hammer constructed in accordance with the present invention;

FIG. 2 is an elevational view partially in section taken generally along the line **2—2** of FIG. 1;

FIG. 3 is an elevational cross-sectional view taken in the direction of the arrows along the line **3—3** of FIG. 1;

FIG. 4 is a fragmentary diagrammatic view of suitable fuel injection means for the hammer of the present invention; and

FIG. 5 is an enlarged fragmentary sectional view taken on line **5—5** of FIG. 3.

As indicated above, the present invention is well adapted to a compression-ignition powered pile driving hammer, and the invention is illustrated in such an application herein but could readily be arranged for spark or other forms of ignition. It will be apparent to those skilled in the art, however, that the invention is not limited to such use but is of broad applicability.

Referring now to the drawing, there is illustrated a compression-ignition powered pile driving hammer generally indicated at **9**, comprising an anvil **10**, this anvil being arranged to rest on, be secured to, or otherwise engage the upper end of a pile or similar device, not shown in the drawing. A base **12** encircles an upwardly protruding central portion of the anvil, the anvil and the base having tapered sides **10***a* and **12***a*, respectively, whereby the base **12** may readily be placed in proper, centered position with respect to the anvil **10**. In order that the anvil may be moved with the hammer **9** it is suitably connected thereto by a flexible member such as the rope **13** which rope provides the necessary play between the anvil **10** and base **12**.

For the purpose of relating the base **12** to the remainder of the apparatus **9**, there are provided a plurality of vertically disposed columns or guide members **14** having their lower ends secured to the base **12**. The hammer **9** also includes vertically disposed guides **15**. The columns **14** serve as guides for the reciprocal movement of a ram **16**. Preferably, the guide members **14** are circular in cross section, the ram **16** having openings therethrough which freely receive the guide members **14** whereby the ram is confined to linear movement along the length of the guide members. The lower end of the ram has a central protrusion **16a** of such proportions that it extends partly through the base **12** and engages the central raised portion of the anvil **10**.

The guide members or columns **14** also serve, at least in part, to support the substantially stationary portion of the engine which powers the ram **16**. More specifically, an engine block **19** is provided with downwardly directed recesses **20** for securing the upper ends of the columns **14**. The engine block **19** is secured to the columns **14** in any suitable manner as by suitable key means **21** extending through aligned openings in the engine block **19** and in the columns **14**, such an opening **22** in the columns **14** being visible in FIG. 3 of the drawing. Preferably, the lower ends of the columns **14** are secured to the base **12** in a similar manner and similar key means **21** are employed. The engine block **19** defines therein a cylinder **23** having a closed lower end and an open upper end.

To enclose the open upper end of the cylinder **23** and to provide another cylinder, there is provided a generally conical housing **26** which is secured to the top of the engine block **19** by a plurality of bolts **27** (FIG. 1). While this housing **26** is generally conical in form, it is preferably provided with two portions **28** having open faces closed by cover plates **28a**. These cover plates may be removed to permit inspection and maintenance of interior portions of the engine.

Extending upwardly from the housing **26**, and preferably integral therewith, is a second engine block **30** which defines a single upper cylinder **32** of substantially smaller bore than the lower cylinder **23**. The lower end of the cylinder **32** is open while the upper end is closed by a cylinder head **34**. Extending upwardly from and preferably integral with the cylinder head **34** are a pair of arms **36** which rotatably support a head sheave **38**. It is intended that the entire pile driving hammer, including the anvil **10**, be moved to and from operative position atop a pile by means of a suitable hoisting rope or the like which engages the head sheave **38** in a conventional manner.

In order to reciprocate the ram **16**, piston means **40** are provided including a piston rod **42**, a lower piston **44** and an upper piston **46**, the two pistons **44** and **46** being cooperable with the cylinders **23** and **32**, respectively, and preferably being provided with suitable piston rings, as is commonly the case.

For the purpose of relating the piston means **40** to the ram **16**, a collar **48** is secured to the piston rod **42** in any suitable manner and, in turn, has secured thereto a yoke **50**. As illustrated, the respective ends of the yoke **50** are connected by any suitable means such as the pins **54** to the rods **55**, only one of said rods being visible in FIG. 3 of the drawing. As further illustrated, the two rods **55** and their connection with the rest of the apparatus are identical, so a detailed description of one will suffice. Thus, each of the rods **55** extends through an opening **56** in the engine block **19** and through an opening **58** in the ram **16**, which opening **58** includes a portion **58a** of larger diameter.

To connect the rods **55** to the ram **16a**, a head **62** is secured to or formed on the lower end of each rod **55**, these heads **62** being freely slidable within the enlarged portions **58a** of openings **58**. Springs **64** and **66** are arranged above and below the head **62** in each enlarged portion **58a** of the opening **58**, the lower spring **66** being confined by a plug **68** which is threadedly received in the lower end of the opening portion **58a**. It will now be seen that the ram **16** will be caused to move with the piston means **40**, the springs **64** and **66** providing a resilient connection therebetween whereby the jar of the impact of the ram **16** against the anvil **10** will be softened as far as transmission thereof through the rods **55** to the piston means **40** is concerned.

Suitable fuel injecting means **70** must be provided for injecting fuel alternately into the closed ends of the cylinders **23** and **32** as the corresponding piston **44** or **46** reaches or closely approaches and/or recedes from the end of its compression stroke. Since these fuel injecting means may be of conventional form, they are illustrated only diagrammatically in FIG. 4 of the drawing. They may be actuated by any suitable means such as cams, or, as shown, a rack **72** movable with the piston means **40** or the cross head **50**. As illustrated in FIG. 4, a pair of pinions **74** and **75** cooperate with the rack **72** and drive the fuel pump **70a** for the lower cylinder **23** and fuel pump **70b** for the upper cylinder **32**. In the event cams are used in place of rack **72**, suitable cam followers and associated linkage would replace pinions **74** and **75**. Suitable conduits **76**, **77** and **78** connect the fuel injecting means respectively to the cylinders **23** and **32**, and to a fuel tank, not shown in the drawing but contained within the hammer **9**. It will be appreciated that suitable means will be provided to insure the necessary quantity of fuel at the proper time.

For the purpose of permitting the escape of gaseous combustion products as the corresponding piston **44** or **46** approaches the end of its power stroke, exhaust vents **80** and **82** are provided. Means are also provided for scavenging the lower cylinder **23**, that is, for substantially replacing the residue of gaseous combustion products with clean air. These scavenging means include the housing **26** which serves as a storage chamber for containing air to be compressed therein. Since the cylinders **23** and **32** open into the chamber **83** defined by the housing **26**, the open end portions of these cylinders comprise a portion of the storage chamber. Upon each upward stroke of the piston means **40** the volume of the storage chamber is decreased by an amount equal to the length of the stroke of the piston means multiplied by the difference between the cross-sectional areas of the two cylinders **23** and **32**. Air pressure within the storage chamber is accordingly increased by a proportionate amount. It has been found that a pressure of the order of several pounds per square inch gauge is thereby obtainable within the housing **26** in the illustrated embodiment of the invention.

Air at this pressure is fed to the cylinder **23** from the housing **26** through a passage **84** in the engine block **20**. The passage **84** opens into the cylinder **23** just below the piston **44** when the latter is in its uppermost position, whereby air may pass from the housing **26** to the closed end of the cylinder **23** only at the end of the power stroke of the piston **44**. Attention is directed to the fact that the exhaust vent **80** should be uncovered by the piston **44** to permit substantial exhaustion of gaseous combustion products substantially simultaneously with the uncovering of the cylinder port of the passage **84**. It should be understood that valve means may be included in passageway **84** which are actuated at the proper time if desired rather than employing the piston **44** as a valve member.

A one-way valve **88** is arranged on the wall of the housing **26** to permit entrance of air into the housing during the downward stroke of the piston means **40**. This one-way valve may be of conventional construction and, accordingly, is not disclosed in detail herein. It will be understood that this valve prevents the flow of air out of the housing **26** during the upward stroke of the piston means **40**. Means may also be provided to store a portion or all of the scavenging air and divert the same to upper cylinder **32**. Separate means may also be provided for scavenging cylinder **32** as described hereinafter.

In accordance with the present invention, supercharging means are provided to accelerate the piston means in both directions by injecting compressed air into both of the cylinders **23** and **32** during the compression strokes of the corresponding pistons **44** and **46**. As illustrated, a reciprocating type of supercharging means is provided, arranged radially around the axis of the cylinders 23 and 32. These supercharging means include cylinders 89 and 90 formed within the engine block 19, and pistons 91 and 92 arranged therein. In the illustrated embodiment of the invention two cylinders 89 and pistons 91 are provided for supercharging the lower cylinder 23, and two cylinders 90 and pistons 92 are provided for supercharging the upper cylinder 32. One or more of these cylinder-piston units or additional cylinder-piston units arranged in tandem thereto could be used for scavenging the cylinder 23 or 32 or both.

Each cylinder 89 is closed by a plate 89*a* suitably secured to the engine block 19, while each cylinder 90 is closed by a plate 90*a* similarly secured. Suitable piping 93 connects the closed ends of two opposed cylinders 90 to each other and to the closed end of the upper cylinder 32, this piping being shown in part in FIGS. 1 and 3. Similar piping 94, shown schematically and in part in FIG. 2, connects the closed ends of the other two opposed cylinders 89 to the closed end of the lower cylinder 23.

In order to perform the supercharging action for the lower cylinder 23 in timed relation with piston means 40, each piston 91 has a piston rod 96 which extends into a recess 97 formed within the engine block 19 and has an enlarged head 98 secured thereto which is freely slidable within the recess 97. A coiled spring 99 arranged within the recess 97 resiliently urges the entire piston assembly including piston 91 inwardly. The inner end of the head 98 rotatably supports a roller 100 which is arranged to bear against a cam 42*a* secured to the piston rod 42.

Similarly, each piston 92 has a piston rod 101 which extends into a recess 102 formed within the engine block 19, and has an enlarged head 103 secured thereto which is freely slidable within the recess 102. A coiled spring 104 arranged within the recess 102 resiliently urges the entire piston assembly including piston 92 inwardly. The inner end of the head 103 rotatably supports a roller 105 which is arranged to bear against a cam 42*b* secured to the piston rod 42. It will be understood that there will be a cam 42*a* for each piston 91 and a cam 42*b* for each piston 92, or, in other words, two cams 42*a* and two cams 42*b*. It will be understood that piston unit 40 may include means such as a cam groove or the like for positively moving pistons 91 and 92 in both directions whereby springs 99 and 102 may be dispensed with.

As was mentioned above, some of the supercharging cylinders may be employed as scavenging cylinders. If desired, however, additional cylinders arranged in tandem with the supercharging cylinders may be employed. In such case, the pistons of these tandem cylinders would be driven by extensions on the piston rods 96 and 101. The necessary conduits and valves would of course be provided for conveying air at the desired pressure to the respective cylinders. The supercharging means have been described as piston type pumps but it should be understood that rotary pumps driven by a rack on piston unit 40 might equally well be employed for performing the supercharging action and scavenging action when combined therewith.

It will be apparent upon reference to FIG. 3 that upward movement of the piston means 40 causes each cam 42*b* to move its associated piston 92 such that air is forced from the associated cylinder 90 through the piping 93 and into the closed end of the upper cylinder 32, this occurring during the compression stroke of the associated piston 46. It will also be appreciated that an identical cam 42*b* is arranged on the opposite side of the piston rod 42 for actuating the opposed supercharger piston 92 such that the two opposed superchargers force air through the piping 93 into the closed end of the cylinder 32 during upward movement of the piston means 40.

The cams 42*a*, one of which is illustrated in FIG. 2, drive the other two opposed superchargers in like manner but in opposite phase relationship. Thus, the illustrated cam 42*a* may be seen to move the associated piston 91 during downward movement of the piston means 40, whereby air is driven through the piping 94 into the closed end of the lower cylinder 23 during the downward or compression stroke of the piston 44.

In order to permit the entrance of air from the atmosphere to recharge the superchargers, a one-way valve 110 is provided for each of the cylinders 89 and 90. Since these valves may be of conventional form, they are not described in detail herein. It will be understood that the valves 110 open to permit the entrance of air into the associated cylinders 89 or 90 when the associated pistons 91 or 92, respectively, have completed their supercharging operation, and are closed when the pressure within the cylinders 89 or 90 is raised by movement of the pistons 91 and 92. Preferably, the valves 110 are arranged closely adjacent the associated supercharger cylinders 90, as shown, to reduce line pressure drop during the recharging strokes of the supercharger.

One-way valves 112 and 113 are also provided in the piping 93 and the piping 94 closely adjacent the respective power cylinders 32 and 23 to permit passage of air into the power cylinders and to prevent reverse flow of air or gaseous combustion products during the power stroke of the associated power cylinder.

From the above description it will be appreciated that with the supercharging means described above arranged in horizontal positions no appreciable reaction to the vertically movable piston means 40 is involved, which is very desirable. This would also be true if rotary pump type superchargers were employed.

In order to permit the development of a large amount of power by the upper cylinder 32 and piston 46 during each power stroke of the piston means 40, it is preferred that the fuel injecting means 70 be arranged to inject the fuel into the cylinder 32 during any portion of the power stroke of the piston 46. While this is recognized as being relatively inefficient in terms of fuel consumption, this relatively unimportant disadvantage is greatly outweighed by the fact that greater power, and hence a heavier blow, can be obtained due to the achievement of a higher mean effective pressure without the creation of excessive initial gas pressure within the cylinder 32.

In the illustrated embodiment of the invention, means are provided for further distributing gas pressure over the full power stroke of the piston 46 whereby additional fuel may be burned and more power may thereby be developed during each stroke of the piston 46 due to the achievement of a higher mean effective pressure without the creation of excessive initial gas pressure within the cylinder 32. Such means may include a suitable expansion chamber in the form of an annulus or the like surrounding the cylinder 32 at the upper end or, as shown in the illustrated embodiment, may comprise several expansible chambers 120 (best shown in FIG. 5), or a combination of an annulus as mentioned above combined therewith, each comprising a cylinder 122 and a piston 124. One end of each cylinder opens into the closed end of the cylinder 32, and a heavy spring 126 urges each piston 124 toward that end of the cylinder 32. The springs 126 are of such strength that they resist outward movement of the pistons 124 until the gas pressure within the cylinder 32 approaches the maximum safe or desired pressure. They then yield and permit outward movement of the pistons 124. Preferably adjustable means 125 are provided to adjust the spring tension to any desired value. Storage means are thereby provided for storing air without affecting the dead weight of the device which comprises expansible chambers opening into the closed end of the cylinder 32, the springs 126 providing resilient and adjustable expansible chambers.

In the operation of the illustrated embodiment of the invention, it is intended, as previously indicated, that the anvil 10 loosely secured to the base 12 by means 13 be placed on the upper end of a pile to be driven. Also, as previously noted, the lower end of the pile driving hammer, namely, the base **12**, is readily centered on the anvil **10** by virtue of the sloping faces **10***a* and **12***a* of the anvil **10** and the base **12**. Operation of the pile driving hammer may be initiated by lifting the ram **16**, with an automatic engaging and releasing device, this being readily accomplished by the same hoist employed to lift the pile driver into operating position, or hydraulic manipulations, or by any other means operable from the ground. This causes automatic firing of the gases in upper cylinder **32** to initiate the operation.

Preferably the upper piston **42** and cylinder **32** are used for controlling the power developed or intensity of the blow by varying the amount of the fuel supplied thereto, while the lower cylinder is operated to develop a substantially constant power just sufficient to always project the ram **16** upwards to the full length of the compression stroke. Consequently, the fuel adjustment for the lower cylinder **23** may remain fixed after initial adjustment to suit fuel being used or other requirements.

As the ram **16** drops against the anvil **10**, the piston **44** compresses air in the closed end of the cylinder **23** and fuel is injected by the fuel injecting means **70**. Additional air is injected by two opposed superchargers through the piping **94**, the cams **42***a* actuating those two opposed superchargers during the downward movement of the ram **16** and the piston means **40**. The air in the lower end of the cylinder **23** is thus heated to such a temperature as to cause ignition of the injected fuel with the resultant upward force on piston **44** pulling ram **16** along.

As the piston means **40** are thus driven upwardly, the ram **16** is lifted in preparation for a powered pile driving stroke. It should be noted that the over-all length of the apparatus is considerably shortened by the fact that the ram **16** is recessed as indicated at **127** to receive the lower end of the cylinder **23** when the ram is thus lifted and which also by displacing air in such recess **127** increases the velocity of the air flowing past the cylinder which preferably is provided with cooling fins, as shown, thereby improving heat dissipation. The same effect occurs when the ram moves in the other direction. Increased cooling of power cylinder **32** can be provided by encasing the fins on the outside thereof with a shield **128** open at the upper end and inducing air to flow therebetween at an increased velocity and volume by arranging means for utilizing the energy of exhaust gases from this cylinder to aspirate the air over the fins. As illustrated, a Venturi device **129** associated with the shield **128** is located in alignment with exhaust gas vent **82** whereby the flow of exhaust gases through Venturi **129** causes cooling air to flow along the outside of cylinder **23**.

As the piston means **40** rises, those superchargers comprising cylinders **89** which serve the lower cylinder **23** are recharged, the cam **42***a* of FIG. 2 permitting the supercharger pistons **91** to move inwardly, the one-way valves **110** permitting the entrance of air, and the associated one-way valve **113** preventing the entrance of gaseous combustion products. At the same time air pressure within the housing **26** rises by virtue of the effective reduction in the volume of the chamber **83** defined by the housing **26** and the open ends of the cylinders **23** and **32**, the cylinder port of the passage **84** opening to the open end of the cylinder **23** at first and then being covered by the piston **44** or controlled by suitable separate valve means if desired.

As the piston means **40** approach maximum height, the exhaust port **80** is uncovered such that gaseous combustion products may be exhausted. Subsequently, the cylinder port of the passage **84** is rendered effective and scavenging air from the housing **26** flows into the closed end of the cylinder **23** to scavenge the same.

Upward movement of the piston means **40** also compresses air in the upper cylinder **32** and causes operation by the cams **42***b* of those superchargers comprising

cylinders **90** which serve the upper cylinder **32**. An adequate quantity of air is thereby compressed within the closed end of the upper cylinder for burning of a large charge of fuel. The fuel pump **70***b* injects fuel which is ignited by the high temperature of the air compressed within the cylinder **32**.

Whether or not fuel is injected over a substantial portion of the power stroke of the piston **46**, if sufficient fuel is injected to cause momentary excessive pressure the pistons within the expansible chambers **120** will recede, against the action of the springs **126**, to relieve the pressure. If an annulus shaped chamber of larger diameter than cylinder **32** is provided at the closed end of this cylinder it will initially relieve such pressure. Moreover, the springs **126** may be adjusted not only to relieve the explosive force within cylinder **32** but also to limit the compression force to a predetermined value. As the piston **46** moves downwardly the pressure within the upper cylinder decreases, whereupon the springs **126** force the pistons **124** back to their normal positions. The energy stored in the expansible chambers **120** or other suitable cylinder volume controlling means is thereby returned to the cylinder **32** and serves to drive the piston means and the ram more forcibly downward.

Downward movement of the piston means **40** is accompanied by recharging of those superchargers which serve the upper cylinder **32**, recharging of the chamber defined by the housing **26** through the one-way valve **88**, and actuation of those superchargers which serve the lower cylinder **23**. As the piston **46** approaches the end of its downward stroke, the exhaust vent **82** is uncovered by the piston, and the gaseous combustion products are permitted to escape. If desired, one or more of the supercharging cylinders may be employed to scavenge the cylinder **32**.

A power hammer of the internal combustion type has now been disclosed which is capable of delivering blows of great frequency and forcefulness. It will be apparent that the force of each blow is not limited by the force of gravity (the weight of the ram and other moving parts, and the length of the drop), but is the sum of the gravitational effect and the force of the power stroke of the upper cylinder. Neither is the frequency of the blows deliverable by the power hammer described above limited by the force of gravity, since both the upward and downward strokes are powered.

It will also be seen that the power hammer described above is provided with superchargers which assure adequate air for combustion of large quantities of fuel. This solves a major problem in this inherently two-stroke cycle apparatus while adding insignificantly to the weight and size of the machine. Still further, scavenging means are provided for the necessarily large bore, ram-lifting cylinder **23** and small bore cylinder **32**, again without adding significantly to the weight or bulk of the machine. Furthermore, starting is initiated and power output controlled by means of power cylinder **32**.

To those skilled in the art, it will be apparent that the machine disclosed has numerous features making it inherently small in size and light in weight for any desired rating in terms of force and frequency of blows deliverable thereby. At the same time the machine is fundamentally reliable in operation and inexpensive to manufacture.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various changes and modifications may be made therein, and it is intended to cover in the appended claims all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a power hammer of the internal combustion type including a cylinder and piston means reciprocally mounted therein, a ram, guide means interrelating said

cylinder means and said ram and confining said cylinder means and said ram to linear relative movement in a direction parallel to the longitudinal axis of said cylinder, drive means interconnecting said piston means and said ram, fuel injecting means actuatable upon predetermined movement of said piston means for injecting fuel into said cylinder, means for igniting said fuel solely in dependence upon producing sufficient pressure in said cylinder, and supercharging means actuatable upon movement of said piston means for supercharging said cylinder during the compression stroke of said piston means.

2. In a power hammer of the internal combustion type including a cylinder and piston means reciprocally mounted therein, a ram, guide means interrelating said cylinder means and said ram and confining said cylinder means and said ram to linear relative movement in a direction parallel to the longitudinal axis of said cylinder, drive means interconnecting said piston means and said ram, fuel injecting means actuatable upon predetermined movement of said piston means for injecting fuel into said cylinder, means for igniting said fuel solely in dependence upon producing sufficient pressure in said cylinder, supercharging means actuatable upon movement of said piston means for supercharging said cylinder during the compression stroke of said piston means, said supercharging means including cylinder means and a piston, the longitudinal axis of said cylinder means being perpendicular to the longitudinal axis of said cylinder means.

3. In a power hammer of the internal combustion type, cylinder means including axially aligned cylinders having their facing ends open and their other ends closed, piston means having a piston at two opposed ends thereof receivable respectively within said cylinders, a ram, guide means interrelating said cylinder means and said ram and confining said cylinder means and said ram to linear relative movement in a direction parallel to the common axis of said cylinders, drive means interconnecting said piston means and said ram, and fuel injecting means actuatable by relative reciprocatory movement of said piston means and said cylinder means for injecting fuel into the closed ends of said cylinders alternately.

4. The combination as specified in claim 3 wherein supercharging means are provided for injecting air into the closed ends of said cylinders during the compression stroke of the associated piston, said supercharging means being actuatable by relative reciprocatory movement of said piston means and said cylinder means.

5. The combination as specified in claim 3 wherein supercharging means are provided for injecting air into the closed ends of said cylinders during the compression stroke of the associated piston, said supercharging means including a cylinder and piston for each of said first-mentioned cylinders, said supercharging cylinders being mounted on said cylinder means and having their axes perpendicular to the common axis of said first-mentioned cylinders, and wherein cam means are provided for actuating said supercharging means in response to relative reciprocatory movement of said piston means and said cylinder means, said cam means including cam elements mounted on said piston means and cam followers mounted on said supercharging pistons.

6. The combination as specified in claim 3 wherein said cylinders are of substantially different bores, and scavenging means are provided for clearing gaseous combustion products from the larger of said cylinders when the associated piston is near the end of its power stroke, said scavenging means including a chamber enclosing the open ends of both of said cylinders, conduit means connecting said chamber to said larger cylinder, valve means permitting air flow from said chamber to said larger cylinder only when the associated piston is near the end of its power stroke, and one-way valve means permitting air flow into said chamber from the atmosphere during the compression stroke of the piston associated with said larger cylinder.

7. The combination as specified in claim 3 wherein storage means are provided for limiting compressive pressure to a predetermined amount and for relieving the explosive force within the closed end of at least one of said cylinders and storing the energy thereof until the associated piston has partially completed its power stroke.

8. In a power hammer of the internal combustion type, cylinder means including axially aligned power cylinders of substantially different bores having their facing ends open and their other ends closed, piston means having a piston at two opposed ends thereof receivable respectively within said cylinders, a ram, guide means interconnecting said cylinder means and said ram and confining said cylinder means and said ram to linear relative movement in a direction parallel to the common axis of said cylinders, drive means interconnecting said piston means and said ram, fuel injecting means actuatable by relative reciprocatory movement of said piston means and said cylinder means for injecting fuel into the closed ends of said cylinders, scavenging means for clearing gaseous combustion products from said cylinders when the associated pistons are near the ends of their power strokes, said scavenging means including a chamber enclosing the open ends of both of said cylinders, conduit means connecting said chamber to the closed end of said larger cylinder, valve means permitting air flow from said chamber to the closed end of said larger cylinder only when the associated piston is near the end of its power stroke, and one-way valve means permitting air flow into said chamber from the atmosphere during the compression stroke of the piston associated with said larger cylinder, supercharging means for injecting air into the closed ends of said power cylinders during the compression stroke of the associated piston, said supercharging means including a cylinder and piston for each of said power cylinders, said supercharging cylinders being mounted on said cylinder means and having their axes perpendicular to the common axis of said power cylinders, and cam means for actuating said supercharging means in response to relative reciprocatory movement of said piston means and said cylinder means, said cam means including cam elements mounted on said piston means and cam-followers mounted on said supercharging pistons.

9. In a power hammer of the internal combustion type, a power cylinder having one closed end, piston means receivable within said cylinder, a ram, guide means interconnecting said cylinder and said ram and confining said cylinder and said ram to linear relative movement in a direction parallel to the axis of said cylinder, drive means interconnecting said piston means and said ram, fuel injecting means actuatable by relative reciprocatory movement of said piston means and said cylinder for injecting fuel into the closed end of said cylinder, means for igniting said fuel solely in dependence upon producing sufficient pressure in said cylinder, and scavenging means for clearing gaseous combustion products from said cylinder when said piston means is near the end of its power stroke, said scavenging means including a chamber enclosing the open end of said cylinder, conduit means connecting said chamber to the closed end of said cylinder, valve means permitting air flow from said chamber to the closed end of said cylinder only when said piston means is near the end of its power stroke, and one-way valve means permitting air flow into said chamber from the atmosphere during the compression stroke of said piston means.

10. In a power hammer of the internal combustion type, a power cylinder having one closed end, piston means receivable within said cylinder, a ram, guide means interconnecting said cylinder and said ram and confining said cylinder and said ram to linear relative movement in a direction parallel to the axis of said cylinder, drive means interconnecting said piston means and said ram, fuel injecting means actuatable by relative reciprocatory movement of said piston means and said cylinder for in-

jecting fuel into the closed end of said cylinder, means for igniting said fuel solely in dependence upon producing sufficient pressure in said cylinder, and storage means for limiting the compressive pressure to a predetermined amount and for relieving the explosive force within the closed end of said cylinder and storing the energy thereof until said piston means has partly completed its power stroke, said storage means comprising an expansible chamber opening into the closed end of said cylinder, and means resiliently urging said expansible chamber toward contracted condition.

11. In a compression-ignition power pile driving hammer, cylinder means including axially aligned power cylinders having their facing ends open and their other ends closed, piston means having a piston at two opposed ends thereof receivable respectively within said cylinders, a ram, guide means interconnecting said cylinder means and said ram and confining said cylinder means and said ram to linear relative movement in a direction parallel to the common axis of said cylinders, drive means interconnecting said piston means and said ram, and fuel injecting means actuatable by relative reciprocatory movement of said piston means and said cylinder means for injecting fuel into the closed ends of said cylinders alternately when the associated piston is close to the closed end of the cylinder.

12. In a compression-ignition powered pile driving hammer, an anvil for engagement with a pile, said anvil having a lower portion and a raised central portion, a base arranged to rest on said lower portion of said anvil and encircle said raised central portion thereof, upper and lower axially aligned cylinders supported on said base, said cylinders having their facing ends open and their other ends closed, a ram, guide means extending between said base and said cylinder means for confining said ram to reciprocating movement and permitting impingement of said ram on said anvil, piston means having a piston at two opposed ends thereof receivable respectively within said cylinders, means connecting said piston means to said ram and permitting an impingement of said ram with said anvil when the lower piston of said piston means approaches the closed end of said lower cylinder, and fuel injecting means actuatable by relative reciprocatory movement of said piston means and said cylinder means for alternately injecting fuel into the closed ends of said cylinders.

13. The combination of claim 1 wherein cam means on said piston means actuates said supercharging means.

14. The combination of claim 1 wherein storage means are provided for limiting the compressive pressure and for relieving the explosive force within the closed end of said cylinder until the piston means has partially completed its power stroke.

15. The combination of claim 7 wherein said storage means comprises an expansible chamber opening into the closed end of said cylinder, and adjustable means resiliently urging said expansible chamber toward contracted condition.

16. The combination of claim 7 wherein said storage means comprises an annulus connected to the closed end of said cylinder.

17. In a compression-ignition power pile driving hammer, cylinder means including axially aligned power cylinders having their facing ends open and their other ends closed, piston means having a piston at two opposed ends thereof receivable respectively within said cylinders, a ram, guide means interconnecting said cylinder means and said ram and confining said cylinder means and said ram to linear relative movement in a direction parallel to the common axis of said cylinders, drive means interconnecting said piston means and said ram, and fuel injecting means actuatable by relative reciprocatory movement of said piston means and said cylinder means for injecting fuel into the closed ends of said cylinders during a portion of the power stroke.

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