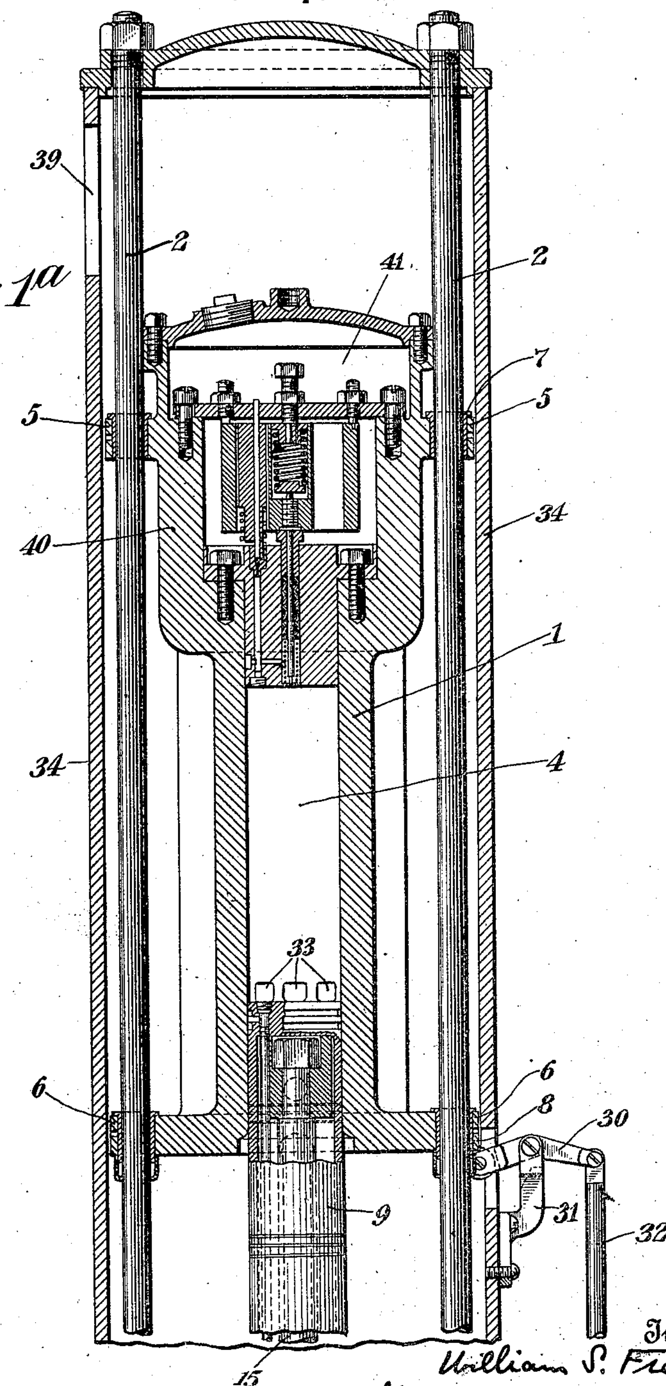
April 5, 1927. 1,623,402

W. S. FRANKLIN

PUMP AND INTERNAL COMBUSTION ENGINE THEREFOR

Filed Sept. 23, 1920 5 Sheets-Sheet 1

Fig. 1a



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April 5, 1927.

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1,623,402

PUMP AND INTERNAL COMBUSTION ENGINE THEREFOR

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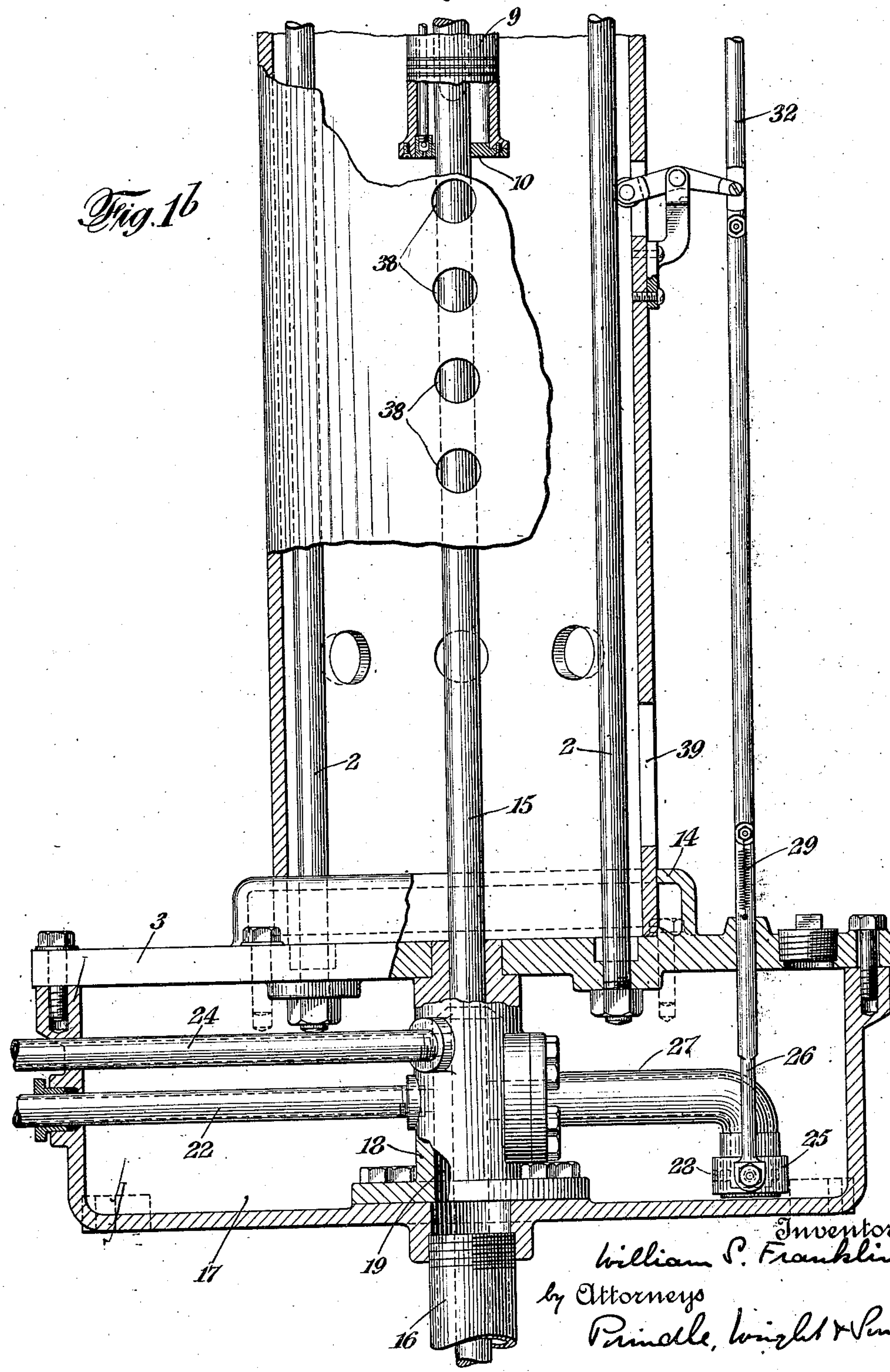
Fig. 1b



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PUMP AND INTERNAL COMBUSTION ENGINE THEREFOR

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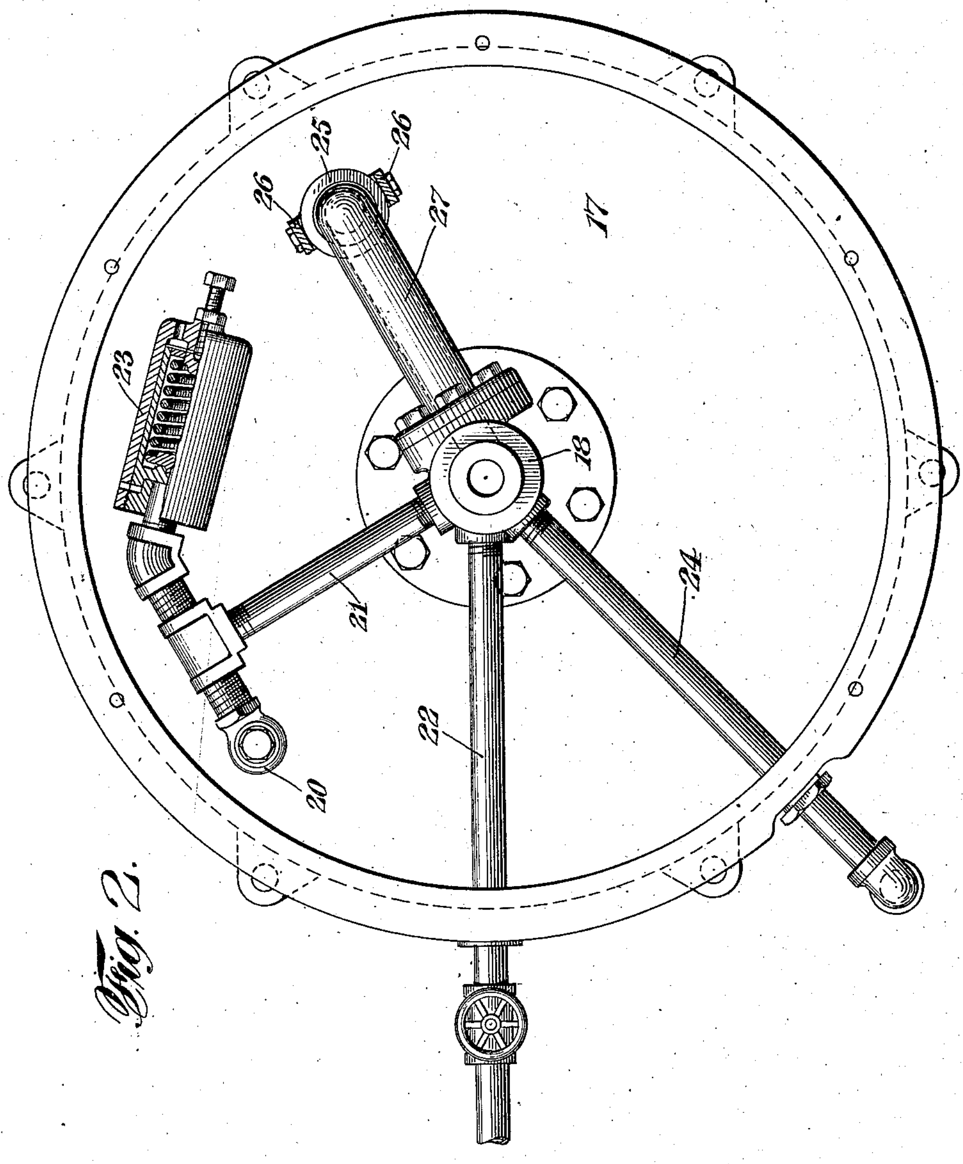

Fig. 2.

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PUMP AND INTERNAL COMBUSTION ENGINE THEREFOR

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Fig. 4.

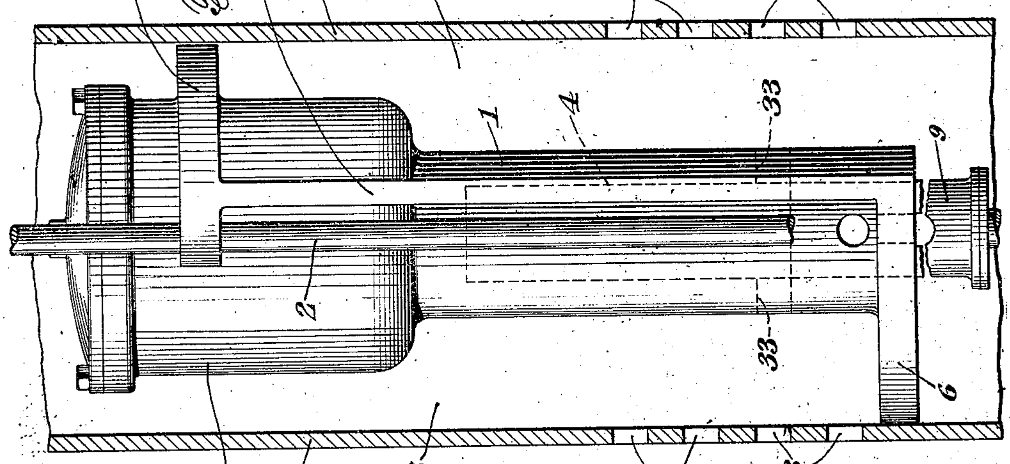
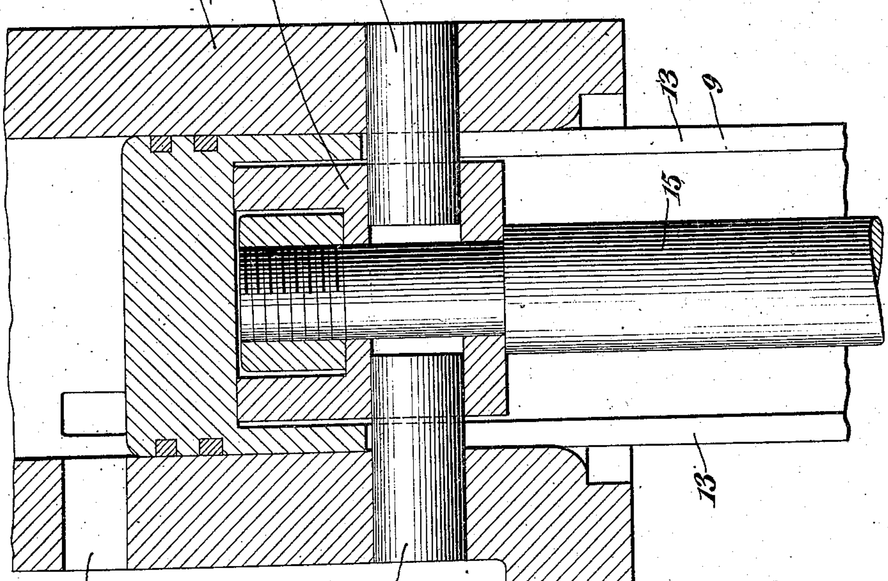


Fig. 3.



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PUMP AND INTERNAL COMBUSTION ENGINE THEREFOR

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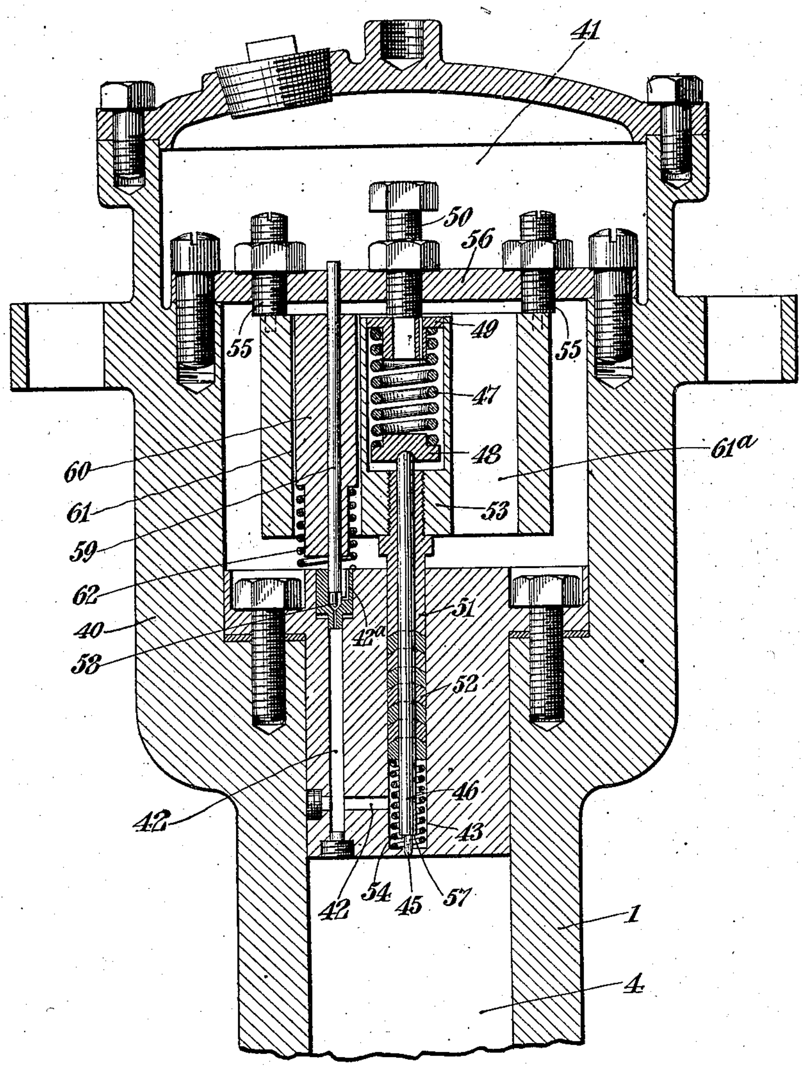
Fig. 5.



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Patented Apr. 5, 1927. **1,623,402**

UNITED STATES PATENT OFFICE.

WILLIAM S. FRANKLIN, OF CAMBRIDGE, MASSACHUSETTS.

PUMP AND INTERNAL-COMBUSTION ENGINE THEREFOR.

Application filed September 23, 1920. Serial No. 412,154.

The invention has for an object to provide an engine, preferably of the internal combustion type, which may be operated to produce very small amounts of power, which will run at a low operating cost and with very little attention and repairs. Such an engine may be used, for example, to furnish the power for small domestic refrigerating machines when electric power is not available, the unusual demands of which device will be apparent when it is considered that only about one-fifteenth (1/15) horse-power is required to yield the equivalent of one hundred and fifty pounds (150 lbs.) of ice per day. It will also be obvious that, to be suitable for such service, the engine should be capable of running for long periods without requiring adjustments or repairs, or frequent attention.

The invention also includes simple and reliable fuel feeding and scavenging devices suitable for an engine of the above character.

Another object of the invention is to combine such an engine with a fluid pump so as to form a rugged, compact construction which cannot be readily injured, which is simple in installation and operation and in which the fluid pressures produced by the pump are suitably controlled during operation of the engine.

Further objects and advantages of the invention will be in part obvious and in part specifically pointed out in the description hereinafter contained, in which is disclosed one embodiment of the invention; such embodiment, however, is to be considered merely as illustrative of its principle.

In the accompanying drawings—

Figures 1[a] and 1[b], taken together, show a vertical section of a pump and internal combustion engine made in accordance with the invention;

Fig. 2 is a plan view of the fluid reservoir shown at the bottom of Fig. 1[b], with its cover-plate removed;

Fig. 3 is a vertical, sectional view of a portion of the engine piston and cylinder, showing the connection between the two;

Fig. 4 is a view showing the engine cylinder within its casing, the latter appearing in section;

Fig. 5 is a vertical, sectional view of the cylinder head showing particularly the fuel feeding devices carried thereby.

The engine comprises generally a movable member of comparatively large weight, which is urged toward a position at rest, in such manner that the expansive force of the fluid within the engine cylinder, moves said weight against the action of the force which tends to maintain it in its position at rest, and thus imparts energy to the movable member.

In the embodiment shown in the accompanying drawings, the cylinder 1 of the engine is utilized as the movable member of large weight, and such cylinder is slidable upon a plurality of guides 2 extending from a base member 3 for the combined pump and engine. Thus the action of gravity in the present instance, constantly urges the cylinder 1 toward the base member 3, and the energy imparted to the cylinder 1 through the action of an expansive fluid within the cylinder chamber 4, may be utilized to perform useful work. In the present instance, the cylinder is provided with upper and lower flanges 5 and 6, respectively, having bearings 7 and 8, respectively, for receiving the guides 2, so that the cylinder may slide freely up and down thereon.

The piston 9 of the engine is slidably mounted within the cylinder 1 previously described, and in the present form, not only does the cylinder 1 move upwardly, but the piston 9 moves upwardly with it as soon as the cylinder has moved upwardly a distance equal to the travel permitted between the cylinder and piston.

Upon downward movement of the cylinder (and piston, if the latter is constructed to move therewith), the piston is utilized to bring the cylinder to rest. In the present form, the lower head 10 of the piston comes into engagement with the base 3 of the apparatus, so that the cylinder 1 is brought to rest by the resulting compression of the gases in the cylinder chamber 4 after the piston 10 has come into engagement with the base 3.

If desired, shocks between the cylinder 1 and piston 9 may be avoided by providing a cushioning pocket between the two. As shown (see Fig. 3), the piston 9 slides over a block 11 suitably supported from the cylinder 1,—for instance, by a pair of pins 12 passing through the cylinder and block and through slots 13 in the walls of the piston. With a construction of this nature, when the piston and cylinder approach the ends of their paths of relative travel, a cushioning air pocket will be formed between the block 11 and the respective piston head so as to absorb any shocks which otherwise might be developed between the members. A dash pot 14 filled, for example, with oil may also be placed between the base 3 and the cylinder head 10 of the piston in order to relieve undue shocks when the piston head comes against the base after downward movement of the piston.

The engine is preferably of the internal combustion type, and, if it is assumed that the cylinder and piston be at their lowest positions with the piston head 10 against the base 3 and an explosive gaseous mixture suitably ignited within the cylinder chamber 4, the force of the explosion will first raise the cylinder 1 against the action of gravity until it has traveled upward a distance equal to the relative travel permitted between the cylinder and piston; the momentum of the cylinder will then carry the latter and also the piston upward for a further distance, during which time the gases within the cylinder chamber are exhausted, and a fresh charge of air supplied by suitable means, certain forms of which will be later described.

The cylinder and piston then travel downwardly under the action of gravity until the piston head 10 comes into engagement with the base 3, after which further downward travel of the cylinder compresses the air within the cylinder chamber and the engine is ready for a repetition of the cycle.

In the apparatus illustrated, the motion imparted to the heavy cylinder is utilized to operate a fluid pump,—for example, of the type employed to operate the diaphragm compressors used in refrigerating machines. The pump plunger 15, reciprocates within the pump barrel 16 (see bottom of Fig. 1^b), the latter being associated with the base member 3 (see Fig. 1^b). As shown, the base member 3 contains a reservoir 17 supplying the fluid to be pumped and the plunger 15 slides within a hollow post 18 bolted to the bottom of the reservoir 17, and having an annular chamber 19 communicating with the pump barrel 16. The pump plunger 15 is suitably connected with the movable member of the engine, being shown in the structure illustrated as bolted to block 11 (see Fig. 3), so that it follows the movement of the heavy cylinder 1. In the present form the working stroke of the plunger 15 occurs during the downward fall of the cylinder 1, and as the cylinder moves upwardly carrying the plunger 15 with it, the fluid to be pumped is drawn from reservoir 17 into pump barrel 16 through an inlet check valve 20 of suitable construction (Fig. 2) connected to the annular chamber 19 by means of a pipe 21. When the downward movement of the cylinder and plunger begins, check valve 20 closes and useful work is performed in forcing the fluid to be pumped through a delivery pipe 22. A pipe 24 for draining the pumping fluid whenever desired may also be connected to the hollow post 18.

In case the pump is to be used for purposes such as to operate a diaphragm compressor, it is desirable to control the pressure of the oil or liquid pumped to prevent it from exceeding a predetermined amount. For this purpose a relief valve 23 (Fig. 2), the structure of which it is not deemed necessary to describe in detail, may be employed so as to permit the fluid pumped to flow back into reservoir 17 when a certain pressure is exceeded.

In order to facilitate proper compression of the fresh gas to be employed in the succeeding cycle of the engine, the engine may also be released from its load during the portion of the return stroke in which compression of the gas takes place. In the present form, the fluid pressure within the pump barrel 16 is released after cylinder 1 has moved downwardly on its return movement for a predetermined distance, so that the remaining fall of the cylinder is practically unimpeded except for the work done in compressing the gas. Figs. 1^b and 2 show a simple arrangement adapted to perform this function. A sleeve valve 25 connected to a forked arm 26 slides over the end of a pipe 27, having one or more openings 28 which communicate with the reservoir 17 when the sleeve 25 is in elevated position. A coil spring 29, however, normally maintains the sleeve valve closed, but after the cylinder 1 has moved downwardly a certain distance a rocker arm 30 carried by a bracket 31 is engaged by the surface of the cylinder and lifts a rod 32 connected to the arm 29, thus opening valve 25 and permitting the oil or fluid to flow back into reservoir 17 during the remaining downward movement of the cylinder and plunger without impeding the resulting compression after piston head 10 has come into engagement with base 3, to any substantial extent. When the cylinder rises again, coil spring 29 returns valve 25 to closed position as soon as the cylinder passes above rocker arm 30.

If desired, the motion of the movable member of the engine may be utilized to effect proper exhaust and scavenging of the cylinder chamber 4, without materially adding to the structure of the engine. As shown in Figs. 1^a and 4, cylinder 1 may be provided with a plurality of exhaust ports 33 which are uncovered by piston 9 during upward movement of the cylinder 1, and after the piston and cylinder have just about reached the end of their travel relative to each other, and baffle plates such as the flanges 5 and 6, are provided which will force fresh air into the cylinder chamber through ports 33 after the exhaust gases have passed out. An enclosing housing or casing 34 may also be provided for the cylinder 1 to facilitate the scavenging action. In the present form the flanges 5 and 6 are disposed on opposite sides of the cylinder 1 and respectively adjacent one or more of the ports 33, and a plurality of longitudinal ribs 35 on cylinder 1 extend between the flanges or baffle plates 5 and 6 in such a way as to divide the space within casing 34 into a pair of chambers 36 and 37 (Fig. 4), the chamber 36 being located in general above the chamber 37. Exhaust openings 38 may be located in the walls of the casing 34 at such an elevation that they will be substantially opposite to the ports 33 at the time when the exhaust of the engine taking place, thus permitting the bulk of the exhaust gases to pass out from within casing 34. As the cylinder 1 then moves upwardly, the flanges or baffle plates 5 and 6 will produce a certain amount of air pressure within the chamber 36 and rarefaction within the chamber 37. A draught of fresh air for the next explosion of the engine will therefore pass into the cylinder chamber 4 through such ports 33 as are in communication with the chamber 36, and will pass out of the cylinder chamber through such ports as are in communication with the chamber 37 so as to thoroughly scavenge the cylinder chamber. If desired, holes 39 may be provided adjacent the upper or lower ends of the casing 34, to prevent such draft of air from becoming excessive. Upon the return movement of the cylinder by gravity, all of the ports 33 will be closed when piston head 10 engages with base 3, and compression of the fresh air within the cylinder chamber will begin.

It is preferred to employ an internal combustion engine of the type wherein ignition of the explosive mixture is effected by compression sufficient to raise the temperature of the explosive mixture to the ignition point, on account of its simplicity, although it will be obvious that this is not essential. The engine illustrated is also designed to operate upon fuel oil, and is provided with a simple device for feeding the oil or other fluid into the cylinder chamber at the proper time. It is preferred to operate the fuel feed upon the inertia principle as by a weight moving in general with the main movable member 1 of the engine, but yieldably supported thereby, so that the acceleration of the movable member 1 will cause the weight to move relative thereto at the proper time to supply fuel to the cylinder chamber.

In the present construction, the cylinder head 40 contains a fuel supply reservoir 41 which may be replenished from time to time in any desired manner, there being a duct 42 (Fig. 5) leading from said reservoir to a chamber 43 separated from the cylinder chamber 4 by a valve 45. The valve 45 is carried upon a valve rod 46, the latter being resiliently urged to move the valve 45 to closed position, for instance by a coil spring 47, bearing against a disk 48 on the end of the valve rod, at its lower end, and engaging a collar 49 at its upper end, which collar may be moved by an adjusting screw 50 to vary the pressure of the spring.

The valve rod 46 is surrounded by a sleeve pump 51 provided with suitable packing 52, and connected to a weight 53 within the fuel supply reservoir 41. A spring 54 lies beneath the sleeve pump 51 and under normal conditions presses up on the latter to a sufficient extent to hold weight 53 up against a plurality of stops 55, carried by a plate 56 extending across a portion of the fuel reservoir 41. When the downward movement of the cylinder 1 is checked by compression, however, the inertia of the weight 53 causes the latter to move downwardly relative to the cylinder, and advance sleeve pump 51 to exert high pressure upon the fuel contained within the fuel pump chamber 43. This pressure acts upon the shoulder 57 beneath the valve rod 46, thus raising valve 45 and permitting fuel to be injected into cylinder chamber 4.

A further valve 58, carried by a valve rod 59, may also be employed to shut off connection between the duct 42 and the fuel supply reservoir at the time when valve 45 is open. In the specific structure shown this valve rod 59 is fixed to a weight 60 located within a recess 61, in weight 53 previously described, a complementary recess 61^a being provided to balance weight 53 properly about its longitudinal axis. A coil spring 62 bears upwardly upon the weight 60 with sufficient force to maintain the valve 58 elevated from its seat under normal conditions in such manner that the fuel may flow from supply reservoir 41 through bypass 42^a to the duct 42. However, when the downward movement of the cylinder 1 is retarded by compression as previously described, spring 62 becomes insufficient to hold up valve 58 against the inertia action of weight 60, with the result that valve 58 closes at the same time that valve 45 opens, permitting sufficient pressure to be brought about in chamber 43 to inject the fuel into the cylinder chamber 4. When normal conditions are restored in the cylinder, valve 58 again opens, and weight 53 and sleeve pump 51 are elevated by spring 54, with the result that valve 45 closes, and more fuel runs into fuel pump chamber 43.

The engine is stopped by closing the valve in delivery pipe 22 (Fig. 1^b) which causes heavy cylinder 1 to move downwards very slowly (due only to leakage of oil from pump barrel 16) so that a rod, or other suitable tool, may be thrust into casing 34 underneath the heavy cylinder 1 to bring the latter to a dead stop in an elevated position, without undue shock.

When the engine has been stopped as above stated, to start it, it is only necessary to remove the rod which supports the heavy cylinder 1 and open the valve in delivery pipe 22.

If the engine should stop because of exhaustion of fuel supply, the heavy cylinder will come to rest in extreme lower position. To start the engine under these conditions, rod 32 may be uncoupled, sleeve valve 25 closed, and the heavy cylinder raised to elevated position, after which the rod 32 will be reconnected and the heavy cylinder 1 released to fall by its own weight, and thus start the engine.

An engine of the above nature may be constructed to operate over long periods of time with very little attention or repair. The motion of the moving parts may be made comparatively slow, and as no rotating members are necessarily required, lubrication becomes comparatively easy. The parts of the engine may also be made heavy and strong, and will be little liable to injury owing to the fact that strains are taken up by the base member 3, which may be readily constructed and supported to resist them adequately. The engine may also be readily operated to supply but very little amounts of power since the distance the movable member of the engine is moved may be regulated as desired, so that only small amounts of energy will be delivered to or given up thereby.

The engine is also well adapted for ignition by compression, since preignition merely increases the dash pot effect of compression, and stops the falling cylinder more quickly, nor need the stroke of the engine be exactly constant; and if an unusually high compression is developed within the cylinder, it merely acts to accelerate the upward movement of the latter without doing any harm. The high pressure incident to ignition by compression furthermore will not injure the cylinder due to its heavy and strong construction, nor is overheating of the cylinder liable to occur, since the engine may operate very slowly with large exposure of cylinder surface.

While a specific embodiment of the invention has been described, it is obvious that many changes may be made without departing from its principle as defined in the following claims:

1. An internal combustion engine having piston and cylinder members, one of said members being slidably carried by the other and being constantly urged by a constantly acting force toward a position against a fixed abutment, the other member being also slidably mounted, means for supplying an explosive mixture within said chamber to move the piston relative to the cylinder member and both of said members relative to said fixed abutment to impart energy to said members, and means for utilizing energy thus imparted to said members to perform useful work.

2. An internal combustion engine having piston and cylinder members, one of said members being slidably carried by the other and being constantly urged by a constantly acting force toward a position against a fixed abutment, the other member being also slidably mounted, means for supplying an explosive mixture within said chamber to move the piston relative to the cylinder member and both of said members relative to said fixed abutment to impart energy to said members, means for utilizing the energy thus imparted to said members to perform useful work, and a portion of the return movement of said members to compress fresh gas within the cylinder chamber.

3. An internal combustion engine having piston and cylinder members, one of said members being slidably carried by the other and being constantly urged by a constantly acting force toward a position against a fixed abutment, the other member being also slidably mounted, means for supplying an explosive mixture within said chamber to move the piston relative to the cylinder member and both of said members relative to said fixed abutment to impart energy to said members, means for utilizing the energy thus imparted to said members to perform useful work, and means for releasing the engine from its load during the return movement of said members when the slidably carried member has engaged the fixed abutment, whereby the return of the other member to its position adjacent the fixed abutment will compress fresh gas within the cylinder chamber.

4. An engine having piston and cylinder members, one of said members being slidably carried by the other and constantly urged by a constantly acting force toward a position against a fixed abutment, the other member being also slidably mounted, and means for admitting to and exhausting from the cylinder chamber an expansive fluid.

5. An engine having a fixed base, a cylinder mounted to slide up and down thereon, a piston carried by said cylinder and slidable to a limited extent with regard thereto, said piston engaging said base when the cylinder is in lower position, means for admitting to and exhausting from the cylinder chamber an expansive fluid, to elevate said cylinder, and means for utilizing the potential energy thus imparted to said cylinder, to perform useful work.

6. An internal combustion engine having a fixed base, a cylinder mounted to slide up

and down thereon, a piston carried by said cylinder and slidable to a limited extent with regard thereto, said piston engaging said base when the cylinder is in lower position, means for supplying an explosive mixture to the cylinder chamber to elevate said cylinder, and means for utilizing the potential energy thus imparted to the cylinder, to perform useful work.

7. An internal combustion engine having a fixed base, a cylinder mounted to slide up and down thereon, a piston carried by said cylinder and slidable to a limited extent with regard thereto, said piston engaging said base when the cylinder is in lower position, means for supplying an explosive mixture to the cylinder chamber to elevate said cylinder, and means for utilizing the return movement of the cylinder to perform useful work and compress a fresh charge of gas within the cylinder chamber.

8. An internal combustion engine having a fixed base, a cylinder mounted to slide up and down thereon, a piston carried by said cylinder and slidable to a limited extent with regard thereto, said piston engaging said base when the cylinder is in lower position, means for supplying an explosive mixture to the cylinder chamber to elevate said cylinder, means for utilizing the initial portion of the return movement of the cylinder to perform useful work, and the latter portion of such movement to compress a fresh charge of gas within the cylinder chamber, and means for releasing the engine from its load while the gas is being compressed.

9. A fuel feeding device for internal combustion engines, comprising a weight moving in general with the main movable member of the engine but yieldably supported therefrom, a valve between the fuel supply and the cylinder chamber, and means whereby the inertia action of said weight changes the position of said valve when the rate of movement of said movable member changes to a predetermined extent.

10. A fuel feeding device for internal combustion engines, comprising a weight moving in general with the main movable member of the engine but yieldably supported therefrom, a fuel feeding pump associated with the engine, and means whereby the inertia action of said weight will operate said pump to force fuel into the engine cylinder when the motion of the movable member is retarded by compression in the engine cylinder.

11. A fuel feeding device for internal combustion engines, comprising a valve adapted to close communication between an oil pump chamber and the engine cylinder chamber, a weight moving in general with the main movable member of the engine but yieldably supported therefrom, an oil pump associated with said pump chamber, and means whereby the inertia action of said weight will operate said pump to open said valve and force fuel into said cylinder chamber, when the motion of the movable member is retarded by compression in the engine cylinder.

12. A fuel feeding device for internal combustion engines, comprising a main movable member for the engine having a fuel pump chamber therein, a valve rod passing through said chamber urged to close communication between the pump chamber and the cylinder chamber, and a fuel pump comprising a reciprocable sleeve surrounding said valve rod and a weight yieldably supported by the movable member connected to said sleeve, whereby the inertia action of said weight will operate said sleeve to move the valve rod and force fuel into the cylinder chamber and draw further fuel into the pump chamber when the rate of motion of the movable member is retarded and accelerated.

13. A fuel feeding device for internal combustion engines, comprising a main movable member for the engine having a fuel reservoir and a fuel pump chamber therein with a fuel duct leading therebetween, a weight moving in general with said movable member but yieldably supported therefrom, means whereby the inertia action of said weight feeds fuel from said pump chamber to the cylinder chamber and permits fuel to be drawn into the pump chamber when the rate of movement of the movable member is retarded and accelerated, and an inertia-controlled valve for opening and closing the duct between the fuel reservoir and the pump chamber.

14. An internal combustion engine having a heavy, movable member associated therewith and urged toward one position by a constantly acting force, means for supplying an explosive mixture within the cylinder chamber to move said member against the action of said force to another position, means for utilizing the energy imparted to said member to perform useful work and a portion of the return movement of said member to compress fresh gas within the cylinder chamber, a weight yieldably supported by said movable member, and means operated by the inertia action of said weight for feeding fuel to the cylinder chamber during compression of gas within the cylinder chamber.

15. An internal combustion engine comprising relatively slidable cylinder and piston members, the slidable member being constantly urged toward the other member by a constantly acting force, means for supplying an explosive mixture within the cylinder chamber to move the slidable member relative to said other member and thus impart energy to the slidable member, means

for utilizing energy imparted to said slidable member to perform useful work, and a portion of the return movement of said movable member under the action of said constantly acting force to compress fresh gas within the cylinder chamber, a weight yieldably supported by said movable member, and means operated by the inertia action of said weight for feeding fuel to the cylinder chamber during compression of gas within the cylinder chamber.

16. An engine having relatively movable cylinder and piston members, the piston being hollow, and a block located within the piston and supported from the cylinder adapted to co-operate with the head of the piston to form a cushioning pocket for the relative movement between the piston and cylinder.

17. An engine having relatively movable cylinder and piston members, the piston being hollow and having its side wall slotted, a block within the piston connected to the cylinder by pins extending through said slots, whereby the pins limit the relative movement between the cylinder and piston and the block co-operates with the heads of the piston to form cushioning pockets at the ends of the path of relative motion of the cylinder and piston.

18. An internal combustion engine comprising cylinder and piston members relatively movable to a limited extent, the cylinder having a port opened when the two members are near the outward limit of their relative travel, and a baffle-plate associated with the movable member adapted to force air into the cylinder chamber through said port.

19. An internal combustion engine comprising cylinder and piston members contained within a casing and relatively slidable to a limited extent, the cylinder having a port opened when the two members are near the outward limit of their relative travel, and a baffle-plate extending between the movable member and the wall of the casing adapted to force air into the cylinder through said port.

20. An internal combustion engine comprising cylinder and piston members relatively movable to a limited extent, the cylinder having a plurality of ports opened when the two members are near the outward limit of their relative travel, and baffle-plates associated with the movable member adapted to produce air pressure adjacent one of said ports and a rarefaction adjacent another of said ports, whereby an air draft will be produced within the cylinder chamber.

21. An internal combustion engine comprising cylinder and piston members contained within a casing and relatively slidable to a limited extent, the cylinder having a plurality of ports opened when the two members are near the outward limit of their relative travel, transverse baffle-plates located respectively above and below said exhaust ports and extending between the movable member and portions of the casing wall adjacent said ports, and longitudinal ribs connecting said baffle-plates to divide the space between the movable member and the casing into separate air chambers, whereby the movement of the movable member will produce air pressure adjacent one of said ports and a rarefaction adjacent another to cause an air draft within the cylinder chamber.

22. In combination, an internal combustion engine, comprising relatively slidable cylinder and piston members, the slidable member being constantly urged toward the other member by a constantly acting force, means for supplying an explosive mixture within the cylinder chamber to move the slidable member, a fluid pump plunger deriving motion from said movable member adapted to pump fluid during the return movement of said movable member under the action of said constantly acting force, and means for releasing the pressure in the fluid pump chamber after said member has traveled a predetermined distance in its return movement, and means whereby fresh gas is compressed within the cylinder chamber only during a remaining portion of such return movement.

23. In combination, a base member having a fluid reservoir and a pump chamber therein and vertical pump plunger working within said chamber, and an internal combustion engine comprising a heavy cylinder mounted to slide up and down above said base member, a piston slidably mounted within said cylinder, said piston being engageable with said base, whereby further downward movement of the cylinder when the piston is so engaged will compress gas within said cylinder, means for supplying an explosive mixture within the cylinder chamber to elevate the cylinder, said pump plunger being connected to said piston.

24. In combination, a base member having a fluid reservoir and a pump chamber therein and a vertical pump plunger working within said chamber, and an internal combustion engine comprising a heavy cylinder mounted to slide up and down above said base member, a piston slidably mounted within said cylinder, said piston being engageable with said base, whereby further downward movement of the cylinder when the piston is so engaged will compress gas within said cylinder, means for supplying an explosive mixture within the cylinder chamber to elevate the cylinder, said pump plunger being connected to said piston, and means for opening communication between

the fluid reservoir and pump chamber substantially when the piston is in engagement with the base.

25. An engine comprising relatively movable piston and cylinder members, the movable member being urged toward the other member by a constantly acting force, means for producing gaseous pressure within said cylinder to actuate the movable member away from the other member, and means operable during each stroke of the movable member for exhausting the gases from within the cylinder and admitting a fresh charge of gas thereto while the movable member is near the outer limit of its travel away from the other member.

26. An engine comprising relatively movable piston and cylinder members, the movable member being urged toward the other member by a constantly acting force, means for producing gaseous pressure within said cylinder to actuate the movable member away from the other member, means operable during each stroke of the movable member for exhausting the gases from within the cylinder and admitting a fresh charge of gas thereto while the movable member is near the outer limit of its travel away from the other member, and means for utilizing the energy imparted to said member to perform useful work and a portion of the return movement of said member to compress fresh gas within the cylinder chamber sufficiently to produce ignition thereof.

27. An engine comprising relatively movable piston and cylinder members, the movable member being urged toward the other member by a constantly acting force, means for producing gaseous pressure within said cylinder to actuate the movable member away from the other member, the cylinder having ports therein adapted to be uncovered by the piston when the members are near the outer limit of movement relative to each other.

28. An engine comprising relatively movable piston and cylinder members, the movable member being urged toward the other member by a constantly acting force and being variable as regards its length of stroke, means for producing gaseous pressure within said cylinder to actuate the movable member away from the other member, the cylinder having a port therein adapted to be uncovered by the piston when the members are near the outer limit of movement relative to each other whereby the gases within the cylinder may be exhausted, means for supplying a fresh charge of gas through said port also when the members are near the outer limit of movement relative to each other on the return movement, said abovementioned force acting during the return movement of the movable member to compress the fresh charge sufficiently to produce ignition thereof.

In testimony that I claim the foregoing, I have hereunto set my hand this 24th day of August, 1920.

WILLIAM S. FRANKLIN.