May 6, 1924.

1,493,418

G. C. ARROWSMITH

STEAM PUMPING ENGINE

Filed March 15, 1918 3 Sheets-Sheet 1

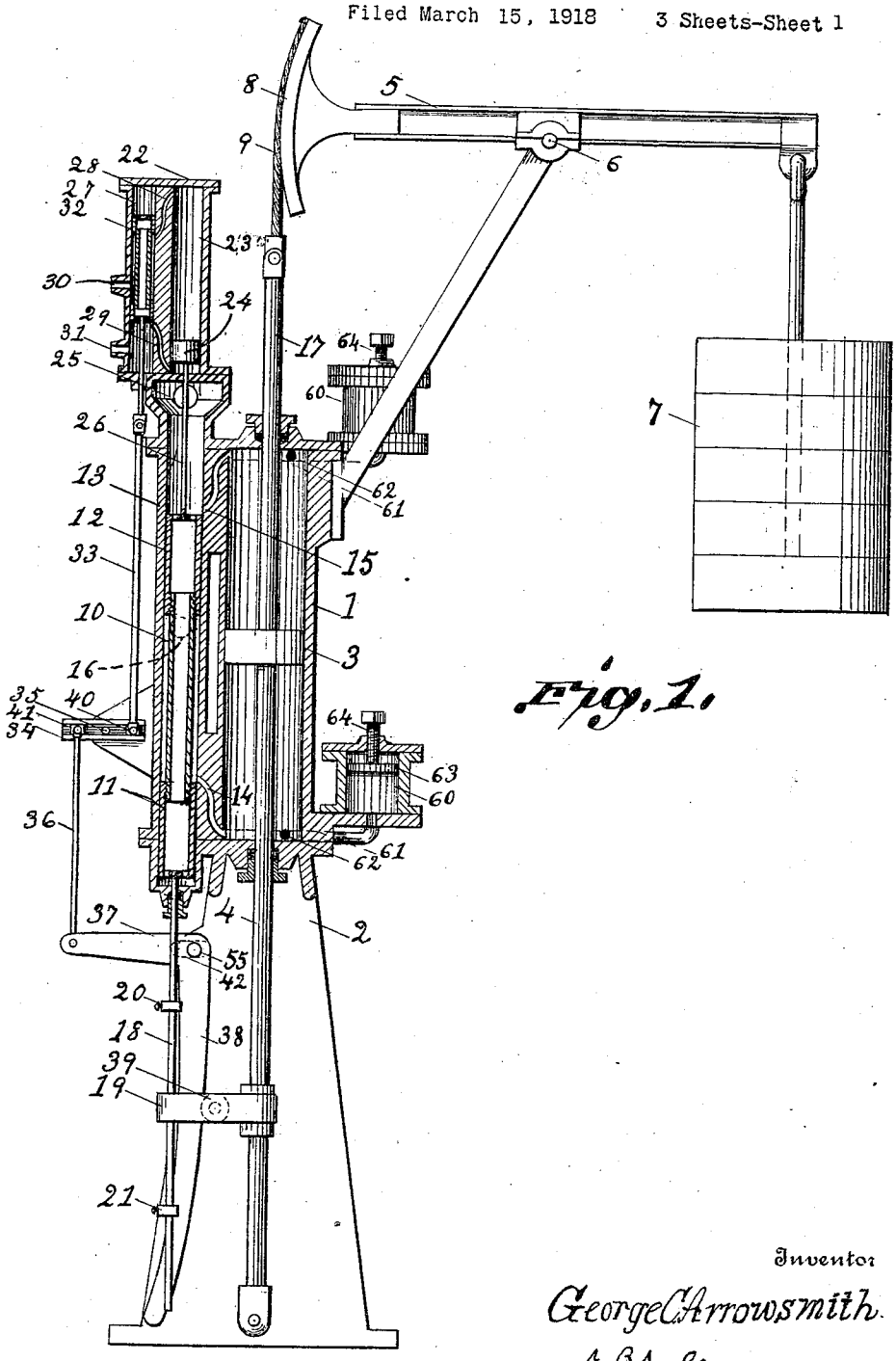


Fig. 1.

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Fig.2.

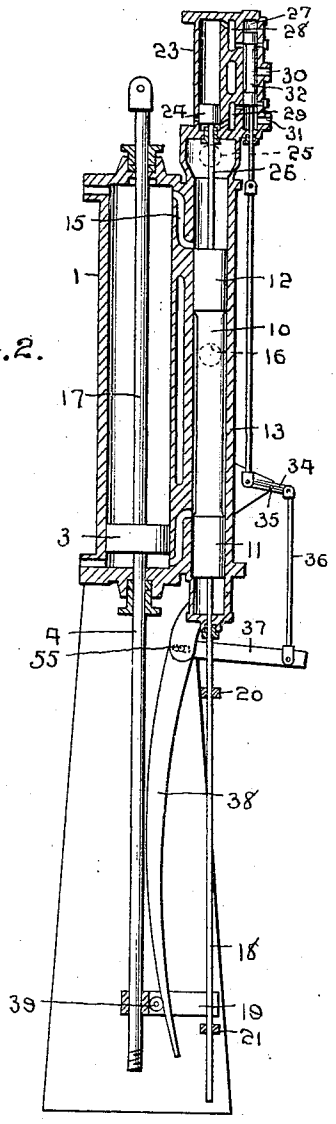
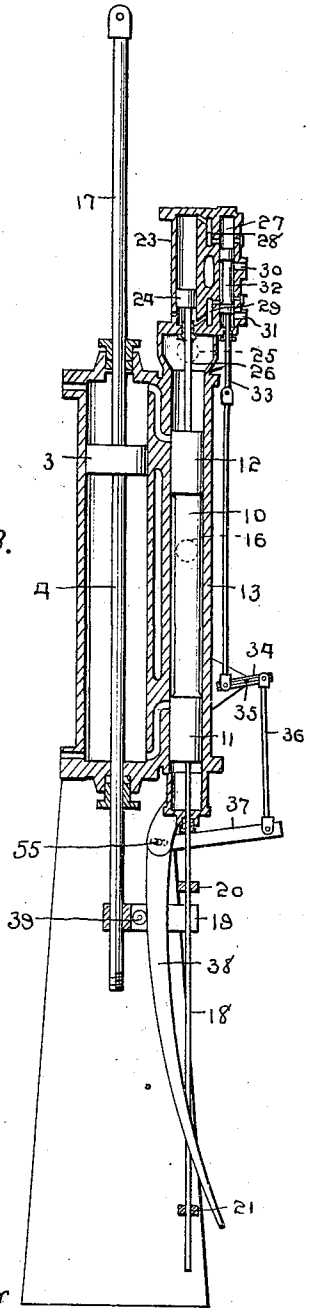


Fig.3.



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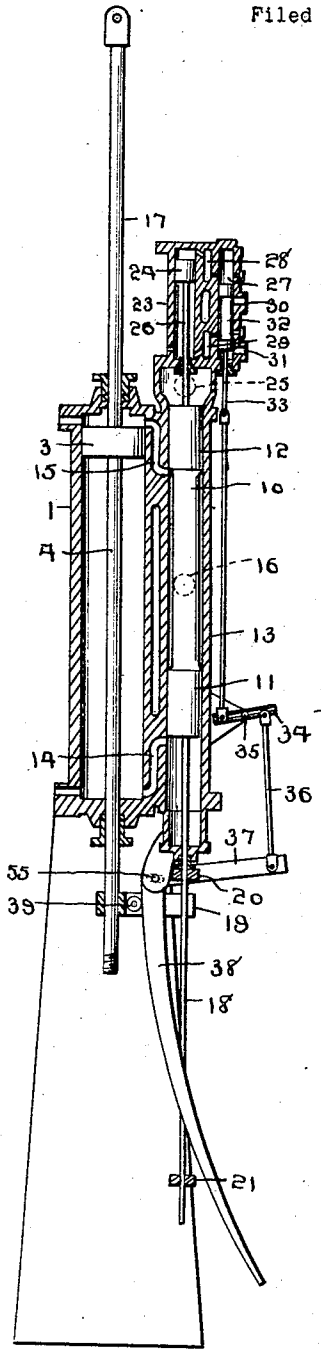


Fig. 4.

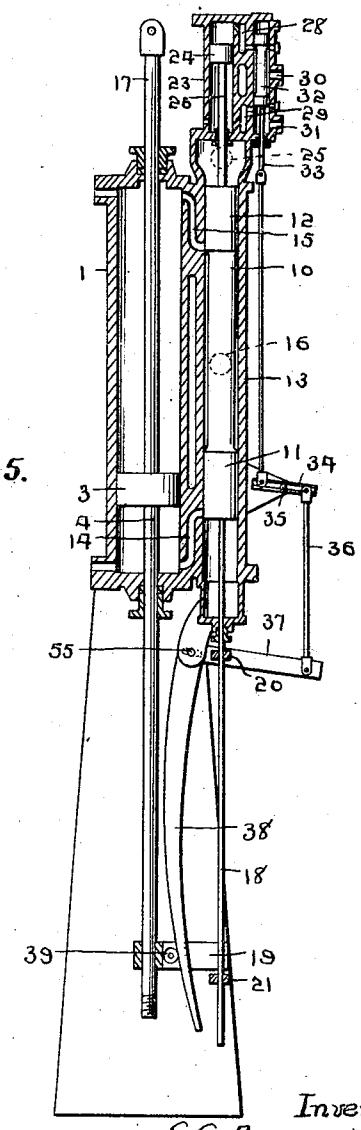


Fig. 5.

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Patented May 6, 1924. 1,493,418

UNITED STATES PATENT OFFICE.

GEORGE C. ARROWSMITH, OF VENITA, WASHINGTON.

STEAM PUMPING ENGINE.

Application filed March 15, 1918. Serial No. 222,764.

To all whom it may concern:

Be it known that I, GEORGE C. ARROWSMITH, a citizen of the United States of America, residing at Venita, in the county of Benton and State of Washington, have invented certain new and useful Improvements in Steam Pumping Engines, of which the following is a specification.

This invention relates to steam engines that act directly upon pumps without intermediate levers or other gearing, by connecting the piston of the engine with the plunger rod of the pump. Its object is to do more pumping in a given time, and with less consumption of fuel, and to lessen the wear and tear on the engine and pump.

To this end my invention consists in the construction and combination of parts forming a steam pumping engine, hereinafter more fully described, and particularly stated in the claims, reference being had to the accompanying drawings, in which:—

Fig. 1 is a central, vertical section partly in side elevation, of a complete steam pumping engine according to the invention, and viewed from one side;

Figs. 2, 3, 4 and 5 are similar views viewed from the opposite side and showing the parts in different positions which they assume during the working of the pumps. In these views the counterweight is omitted.

The steam cylinder 1, mounted on a base 2, is provided with a reciprocating piston 3, and a piston rod 4, that is adapted to be connected directly with the plunger rod of the pump to be operated. A lever 5, fulcrumed at 6, carries on one end, a weight 7, and at the other end a circular segment 8, to which one end of a chain or rope 9, is secured. The other end of the chain or rope is attached to the rod 17, that connects with the piston 3. A cylindrical slide valve comprising the body 10, and the heads 11 and 12, is tubular throughout its length and is mounted in the valve-chest 13, to slide longitudinally. Steam ports 14 and 15, communicate between the valve-chest 13, and the engine cylinder 1. The dotted circle 16, represents the steam inlet port, and 25 the exhaust port. A rod 18, attached to the valve 10, passes freely through the arm 19, that is secured upon the piston rod 4. Two lugs 20 and 21, are adjustably secured upon the rod 18, one at each side of the arm 19, and at a distance apart less than the reciprocating stroke of the piston 3, whereby each stroke will shift the valve 10. A relatively small auxiliary engine 22, having a steam cylinder 23, and piston 24, is connected by its piston rod 25, directly with the valve 10. The valve chest 27, communicates with the cylinder 23, by steam passages 28 and 29, its inlet port being at 30, and the exhaust at 31.

The valve 32, is connected by a rod 33, with a lever 34, which is pivoted at 35, to a bracket of the engine frame. The other end of the lever 34, is connected by a rod 36, with the horizontal arm 37, of an elbow lever the other arm 38, of which hangs vertically beside the piston rod 4. A wheel 39, is mounted on the arm 19, to roll upon the arm 38. The rods 33 and 36, are pivotally connected with the lever 34, by means of bearings 40 and 41, which are radially adjustable along the lever to control as may be desired, the movement of the valve 32. To further aid in this adjustment, the pivot 55, of the elbow lever is mounted in a slot 42, in the bracket to permit variation of the arm 37, relatively to the path of the roller 39. For economy of construction, the valve heads 11 and 12, are hollow cylinders that may be readily turned to fit the bore of the valve chest, and the body 10, may be common water pipe screw-threaded into the heads, by which means the length of the whole valve may be adjusted to register with the passages 14 and 15. This valve being tubular permits the passage through it of exhaust steam to the port 25, when the valve is in the upper position. The valve 32 is of similar construction to the valve 10.

A storage chamber 60, communicates with the clearance space beyond the end at 61, of the piston stroke, by passage 62, and has a piston 63, that may be adjustably located by a screw 64, so that if an earlier cutoff is desired this chamber will provide the extra space for enough air to prevent its being compressed beyond the normal steam pressure by the piston in completing its stroke.

The operation is illustrated in Figs. 2 to 5, inclusive, and referring to Fig. 2 it will be seen that steam piston 3 is just starting up from rest.

Steam is admitted to steam chest at 16 and enters into cylinder 1 by port 14 under piston 3. Piston 3 starts to move upward to point in cylinder shown in Fig. 3 where

it has reached its maximum velocity. In the meantime piston rod arm 19, by roller 39, has moved upward along curved lever 38, pushing it outward and thus raising lever 37 and rod 36 and turning motion plate, or lever 34, so that with its connection 33 it has moved pilot valve 32 down so that it is opening to steam through port 29 to underneath pilot piston 24 on main valve stem. Piston 24 starts upwards, moving piston valve 10 which closes main port 14 to steam under main steam piston 3 and port 15 to exhaust above piston 3. Also at this point piston arm 39 has travelled upward until it nearly engages with collar 20 on main valve stem 18.

As before stated, main piston 3 is travelling upward at its maximum velocity and I have just shown that steam pilot piston 24 by main piston valve 10 has closed main steam ports 14, 15 to steam and exhaust. At this point steam underneath main piston 3 begins expansion and space in main cylinder 1 above main piston 3 begins compression.

As main piston 3 is travelling at its maximum velocity so also is the counterweight 7 of Fig. 1, travelling downwards and pump rod and water column is also traveling upwards at its maximum velocity.

Leaving the pistons and valves in their respective positions, Fig. 3 for a moment, I will now take up the action of rod, water-column and counterweight. These all bear a specific relation to one another in that the counterweight equals the combined weight of the pump-rod complete and one-half the water-column, and where, for instance, if the water-column weighs 5,000 pounds and the rod 2,000 pounds, the counterweight would weigh 4,500 pounds.

So, by mathematics, it is known that by the admission of steam at a certain pressure under main piston, at the point shown in Fig. 3, the piston 3, pump-rod 4, and water-column have reached a stated velocity upward, and also the counterweight 7 has reached a stated velocity downward. From this stated velocity, together with the known value of stored energy of the counterweight of 4,500 pounds moving downwards and that of the rod and water-column of 7,000 pounds upwards, it is apparent that if there was no steam to assist, or compression to retard, the piston and pump rod would move upward a certain specific distance before coming to rest.

Now, returning to Fig. 3, I left main steam piston 3 at a point where steam under it was just beginning to expand and compression above it take place. Then taking the stored energies of the three positive elements before mentioned, together with the known values of the expanding steam minus the value of compression, it is obvious that the steam piston will come to rest at a point later than if there had been only stored energy due to the velocity imparted.

And as I predetermined the operations per minute at which I want this pump to run in the first place, I have, from the above, calculated the length of the heads 11 and 12 of main piston valve 10 to cut off steam at proper point, and as this valve travels at approximately the same speed as main piston 3, I make that valve the same length as the predetermined point of cut-off from the end of the stroke, and which feature is essential, and directly calculated for the duty any of these units are built to do and for the economy they obtain.

Fig. 4 shows steam piston 3 at upper end just at rest; main piston valve 10, which is hollow, allowing exhaust from under piston 3 through port 14; and head 12 positioned to admit steam through port 15 above main piston 3, at this time the space above piston 3 contains steam already compressed to, or nearly to, admission steam pressure, as heretofore explained.

Fig. 5 shows main piston 3 passed downward and to its maximum velocity to a relatively equal distance from lower end of stroke in exactly the same time and manner as on up stroke of Fig. 3, then by action of piston rod arm 19, and its roller 39, the curved lever arm 38 is allowed to travel inwards, and through valve motion plate 34 and its rods 33 and 36, moves pilot piston valve 32 to point where steam is being admitted through port 28 to top side of pilot cylinder piston 24, and which closes main ports 14 and 15, by piston valve 10, to steam and exhaust, the parts finally arriving in the position shown in Fig. 2.

The two strokes of this pump head are balanced. Referring to example given, we have a water-column of 5,000 pounds, a rod of 2,000 pounds, so accordingly the counterbalance will weigh 5,000 pounds divided by two plus 2,000 pounds, equals 4,500 pounds, and assuming a stroke of 3 feet, we have for duty upstroke: (5000 plus 2000) minus 4500 equals 2500 pounds.

For down stroke we then have: 4500 minus 2000 equals 2500 pounds.

For energy applied per operation we have: $2500 \times 3 \times 2$ equals 15000 foot pounds, and accomplished by the right use of steam with expansion and compression in clearance spaces, as efficient a machine as it is possible to make for the duty to be done, and with this type the power applied is to water duty and friction only, viz, 5000 pounds of water raised 3 ft. per operation.

Also this type brings the pump rod to rest at end of each stroke in a gentle manner, as from foregoing description, the piston begins to slow up from point of steam cut-off and gradually comes to rest on compression.

The function of the auxiliary engine is threefold; first, it starts the cutoff valve moderately and without shock, yet permits the full time designed for expansion at each stroke; secondly, it protects the valve 11, 12, and connections from the injury that would result from being struck by the arm 19, running at the full speed of the piston; thirdly, it will carry the valve 11, 12, across the ports independently of action on the lug 20, even if, from a lowering of steam pressure or the lack of sufficient energy stored in the counterbalance the piston 3, fails to complete its full stroke, thus permitting continuity of action under varying conditions of power and load.

In practice I have found it economical to use a counterbalance 7, equal in weight to one half that of the water column raised, plus the weight of the piston, plunger and connections and the difference of the resistance of friction in the up and down strokes. This amount of weight is found sufficient to continue the raising of the piston aided by the momentum of the load, after the steam is cut off, thereby compressing the volume of air and gas that is shut in ahead of the piston by the valve at the point of cut off. The compressed gases operate not only as a cushion absorbing the momentum of the heavy load at stopping, but accumulating power to aid the new inlet of steam in starting the return stroke. By means of a common throttle valve the engineer may control the auxiliary engine to vary the cut-off within certain limits, and these limits may be extended by means of the adjustments 34 and 38, described, so as to nearly eliminate the shock and wear on the pump and engine usual to this kind of work. By raising the counterbalance at each downward stroke, power is stored therein to aid the next uplift and the half of the load unbalanced assists the downward stroke. Thus, the engine consumes considerably less than the usual steam power required for the amount of water raised.

The valve heads 11, and 12, are designed to be, each as long as the stroke of the piston after the cut-off, and this length has to be determined by careful computation for each engine, taking into account the bore of the cylinder 1, the practicable steam pressure to be had; the stroke of the piston 3; the bore of the pump to be operated; the greatest probable height of the lift, and other elements known to affect the work. The auxiliary engine 22, with its means for adjustment; the auxiliary chamber 60; and the counterbalance with its adjustable weights 7, are designed to cover the various contingencies of water pumping with a double acting steam engine attached directly to the plunger rod of a single acting pump. Less expense for engine, service, and upkeep to do a given amount of pumping, are the objects attained by this invention.

I claim:

1. A pumping engine including a cylinder having ports for conducting steam toward and away from its opposite ends, a piston member arranged in said cylinder, a piston rod member connected to the piston member and provided with means to facilitate attachment of the same to a pump rod, a pivotally mounted lever operatively connected to said rod member, a counterweight carried by said lever and adapted to move said piston member toward one end of said cylinder to aid in lifting the fluid pumped by a pump operated by the engine, a main valve for controlling said ports and arranged to simultaneously open or close said ports, an auxiliary engine having a piston operatively connected to said valve, a control valve for the auxiliary engine, means operatively connecting the valve of the auxiliary engine to one of said members in such manner as to permit the auxiliary engine piston to move the main valve and close the ports of the engine cylinder while the piston member of the cylinder is approaching either end of its stroke and to maintain said ports closed until the piston member is in close proximity to either end of its cylinder, and other means operatively connecting the main valve to one of said members and constructed to permit the positive shifting of the main valve by the last mentioned member subsequently to the operation of the valve of the auxiliary engine by said last mentioned member.

2. A pumping engine as claimed in claim 1 in which the means connecting the valve of the auxiliary engine to one of said members includes a double ended lever, a link connecting one end of said double ended lever to the valve of the auxiliary engine, another link extending from the opposite end of said lever, a bell-crank lever having one of its arms connected to one end of the last mentioned link, and an arm fixed to the piston rod member and provided with a roller engageable with the other arm of said bell-crank lever.

3. A pumping engine including a vertically arranged main cylinder having ports for conveying fluid motive power to and discharging said motive power from the opposite ends of said cylinder, a piston arranged in the cylinder and having a piston rod extending through both ends of the cylinder, a pivotally mounted lever provided at one end with a counterweight and at its opposite end with a curved segment, a flexible connection connecting said curved segment and the upper end of the piston rod, the lower end of said piston rod being provided with means to facilitate attachment of the same to the pump rod of a well pump,

a main valve cylinder communicating with said ports and having an inlet arranged substantially midway between its ends and having an exhaust port arranged near one of its ends, a main valve arranged in the valve cylinder and of a length sufficient to simultaneously close or open all of the ports of the piston cylinder, an auxiliary engine having a piston connected to the main valve, a valve for the auxiliary engine, means connected to the valve of the auxiliary engine and to said piston rod adapted to shift the valve of the auxiliary engine shortly after the piston of the main cylinder reaches mid-stroke and before said last mentioned piston reaches the end of its stroke, whereby said main valve is shifted to close the ports of the main cylinder and the counterweight compresses the motive fluid above the piston while the motive fluid below the piston is expanding, and means connected to the piston rod and to the main valve for causing positive shifting of the main valve by the piston rod subsequently to the operation of the auxiliary engine valve by said piston rod.

4. A steam pumping engine comprising a cylinder, piston, piston rod, and valve; an arm on the piston rod; an auxiliary engine comprising a cylinder, piston and valve, and a rod connecting the last mentioned piston with the first named valve; a lever pivoted in a fixture and having radially adjustable bearings; a rod connecting one of the bearings with the auxiliary engine valve; a rod hung upon the other bearing and a connection comprising a pivoted lever between it and the aforesaid arm.

5. The combination with a steam pumping main engine including a valve, piston and piston rod therefor, of an auxiliary engine provided with a valve and valve rod, independent and variable connections between the valves of each engine including an arm carried by the piston rod of the main engine, and lugs adjustably secured upon the valve rod of the main engine, a lever having a curved arm, a roller on the first named arm arranged to engage the curved arm, another lever pivoted to the frame of the engine, and rods connecting the ends of the last mentioned lever respectively with the first mentioned lever and with the valve of the auxiliary engine.

In testimony whereof I affix my signature in presence of two witnesses.

GEORGE C. ARROWSMITH.

Witnesses:

N. S. WALLER,

D. E. WALLER.