STEAM - PUMPS.

A
Compilation of Notes
on
Steam Pumps,
by
F. T. Sargent.

May 10, 1875.

Steam Pumps.

A pump is a device for lifting a fluid by the motion of a piston working in a cylinder, the piston driving the fluid; where-as in the Steam Engine the piston is the part driven.

There is an old Egyptian tradition which states that Danaus, having displeased Egyptus, king of Egypt; was obliged to flee for his life, and accompanied by his fifty daughters they went to Argos, where it is said he dug wells, and by means of pumps he and his daughters supplied the city with water; this was about the year 1485 B.C.

It is much more probable that Ctesibus, a mechanician of Alexandria who lived 224 B.C, was the first to invent the pump, which as discribed by Hero 150 B.C. "consisted of two single acting pistons in as many cylinders, which raised the water on the up stroke and expelled it on the down stroke into a chamber which was connected with both pumps."

Among the first practical applications of steam of which we have any account, was made by the Marquis of Worcester for raising water, about 1630, this device is generally considered as being a Steam Engine but it was really nothing more than a Steam Pump; as will be seen from the following discription by the Marquis himself, in his Century of Inventions; he says, "I have invented an admirable and forcible way to drive up water by fire; not by drawing or sucking it upwards, for that must be, as the philosopher terms it, intra sphaeram activitatis, which is but at such a distance. But this way hath no bounder if the vessel be strong enough. For I have taken a piece of whole cannon, whereof the end was burst, and filled it three-quarters full of water, stopping and screwing up the broken end, and also the touch-hole, and making a constant fire under it; within twenty four hours it burst, and made a loud crack. So that, having a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a constant fountain stream forty feet high.

One vessel of water rarified by fire driveth up forty of cold water, and a man that tends the work has but to turn two cocks; that one vessel of water being consumed, another begins to force and refill with cold water, and so successively; the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim between the necessity of turning the said cocks."

Fig. 2.

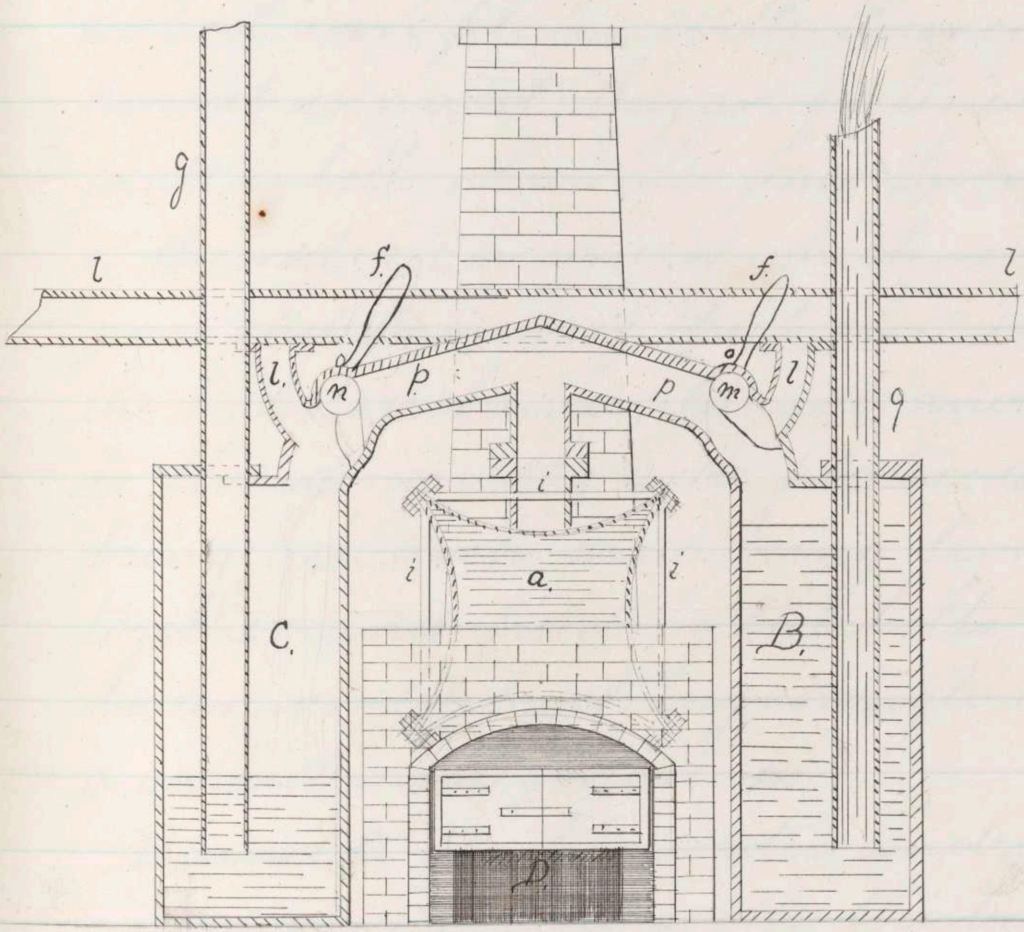


Fig. 1. Shows the Marquis of Worcester's engine. the boiler, a, is composed of arched iron plates, with their convex side turned inward; they are fastened at the joints by bolts which also pass through the ends of the rods, i, i, a series of which rods extend from end to end of the boiler. The ends of the boiler are hemispherical, and fastened to flanges on the side plates: Each plate being an arch, and being firmly bolted together and held by the bolts, i, i. the boiler would be strong enough to stand a considerable pressure.

B. and, C. are two water and steam tight cisterns connected with the boiler, a, by means of the pipes, p, p, and with the reservoir from which the water is to be drawn, by the pipes, l, l, near the junction of the pipes, p, and. l, there is placed a two way-cock, m, n, by means of which, p, and l, are put in communication with the cisterns, B, and C, by changing the handles, f, o. g, g, are two tubes through which the water is raised to the vessel placed above for receiving it; these tubes reach nearly to the bottom of, B, and C, and are open at both ends.

Fire having been kindled under the boiler, a, in the furnace, D, the cock, n, is placed in the position shown in the fig., the water will have access from the reservoir to the vessel, C, which being filled, the handle, f, is turned back closing the pipe, l, and opening, p, the steam then enters through, p, and having no other way of escape, exerts a pressure on the surface of the water and drives it up the pipe, g, to a height due the pressure of the steam; during this operation the cock, m, having been so placed that communication between the boiler, and, B, is shut off and, l, opened, B, is filled with water, by the time, C, is emptied, and the cocks being changed, the operation continues filling and emptying, B, and C, alternately.

The "one thing needful" for this

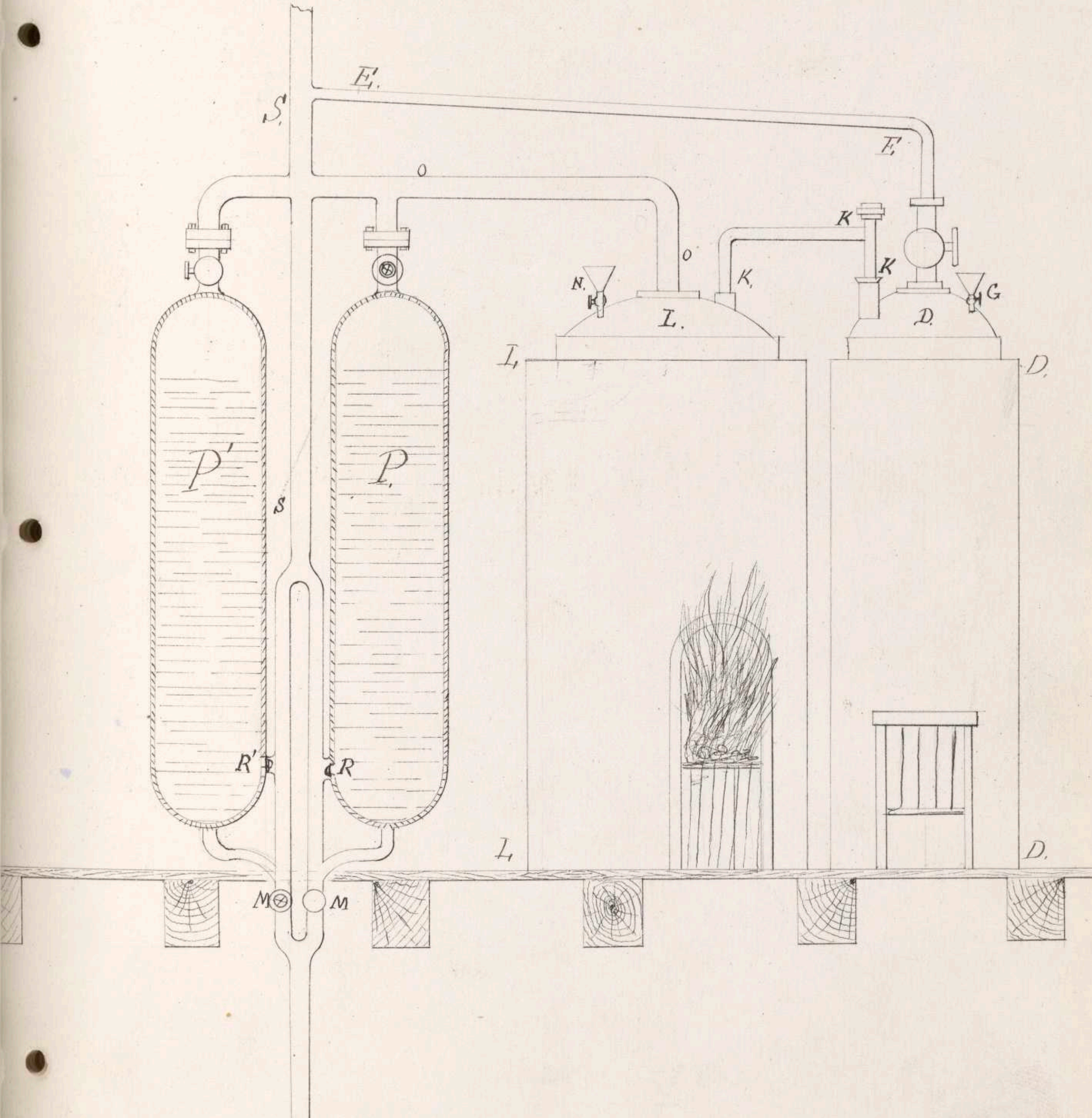
contrivance to be complete, was an arrangement for changing, m, and n, automatically.

The necessities of the mining operations in Cornwall drew the attention of practical men to some means of drawing off the water in the mines; and Capt. Thomas Savery devised a machine for that purpose. It being a combination of the pump of Worcester, and a law of Nature, whereby water rises to fill a vacuum, produced by the condensation of steam; this occurred in 1699.

Savery's machine consisted of two boilers; under each of which a fire is built; and two large cylinders which are alternately filled, and emptied of water.

Fig. 2. is a representation of Savery's machine. Before the fire is lighted; the two gauge-pipe cocks, G, and N, belonging to the two boilers are opened, water is poured in until the larger boiler, L, is two-thirds full, and the small one, D, entirely full; the cocks are then closed, and the fire under the large

(Fig 2.)



boiler is lighted. As soon as the water in, I, begins to boil the cock in the pipe that connects, I, and the vessel, P, is opened, thus allowing the steam in, I, to pass through, O, into, P, pushing out all the air before it through the valve, R. After all the air is driven out the cock in the pipe of the vessel is closed and that of the other vessel, P,' is opened until the air is driven out of, P' through the cock, R', up the pipe, S. In the meantime a stream of cold water (supplied by a pipe connected with discharge pipe, S, but not shown.) is passed over the outside of the vessel, P, which by condensing the steam within, created a vacuum and the water in the well is driven up the suction pipe by the pressure of the atmosphere, opening the valve, M, and filling the vessel, P.

The cock in the pipe of the vessel, P, is then opened, the steam exerts a pressure on the surface of the water thus forcing it out of the discharge.

pipe, S.

The two vessels or cylinders, P. and P.' are used in order that one may be emptied while the other is being filled. The pipe, H, is for the purpose of carrying water from the pipe, S. to the boiler, D.

The boiler I, is kept supplied with water by driving it from, D to I, through the pipe, K. by generating steam in, D.

This same principle of Saverys, with modifications and improvements, has within a few years been applied, resulting in the Steam Pump known as the Pulsometer; to be described further on.

The objections to the practicable working of the engine of Savery, was, that they were unable to raise water more than 60 ft. and this would cause the employment of a great many in a mine of any great depth, which would incur too great an expense; in case one engine broke down, the others could not be used; and the high pressure necessary for raising the water 60 ft., was dangerous in those days, as their boilers were but imperfectly made. Newcomen who was contemporary with Savery invented an engine which was capable of raising water out of a mine "however deep," and could be placed on the surface of the ground near the mouth of the shaft. thus causing less risk from accident: The use of steam of a pressure greater than the atmosphere was not required; and there was a greater saving of fuel; and when the duty on coal for ~~one~~ engine, alone, amounted to £850 pr. year it was no small item. The first engine of N— was set up about 1712; from that date till 1758 there were not more than two or three "fire engines" in existance; about 1758 however, the duty on coal having been taken off the number began to increase; and this has been going on until at the present day it would be nearly as much of an undertaking to count them, as it would to find a man, whose ancestors, did not come over in the May-flower.

From 1720 when Beighton applied the hand gearing, until the time of Smeaton 50 years later, the engine received no improvements. In 1775 Smeaton built an engine having the parts in so much better proportions than those that preceded it, that he increased the duty 50%. This engine had a cylinder 72" diameter 9½ ft. stroke, water load of 7⅔ lbs per. sq. in. and raised the water 306 feet.

Before the beneficial effects of the changes of Smeaton, were fully felt. Watt appeared with his great improvements and immediately took the lead; his first engine being erected in 1776. His changes in the Pumping Engines making it a new machine.

A few of the many improvements due to him are condensing the steam by means of a separate vessel, or condenser as it is called.

Keeping the steam at a high temperature in the cylinder by means of a steam jacket.
Exhausting the condensed steam by the air pump.
The substitution of the expansive force of steam for the atmospheric pressure.
The adoption of the cutting off of steam before the end of the stroke.
The introduction of double acting engines.
The invention of the parallel motion, and many other useful inventions.

As regards the use of the expansive force of steam an Engineer John Hornblower is entitled to a share of the honor of discovering this principle, the manner of its application however was different. Watt shut off communication between his boiler and cylinder before the stroke was completed, letting the steam expand during the remainder.
Hornblower on the contrary used two cylinders of different capacities, letting the steam into the smaller one at full pressure, and then allowing it to expand in the larger cylinder.

being in fact the originator of the compound principle.

Neither Hornblower nor Watt during their own time derived much advantage from their expansion principle; its failure being due to the low pressure steam used by them.

About 1785 Watts single acting pumping engine was brought to such a degree of perfection, that the same description of engines built at the present time have received very little change in their general features. He seldom made his engine cylinders larger than 63 inches diameter; and when more power was required than this size would give, he used his double-acting engine, which was applied by having a double column of pumps in the mine shaft, one being worked by the descending, the other by the ascending stroke; this method has not been found as advantageous for pumping as the single acting, and Cornish Pumping Engines are seldom built double acting.

About the year 1806 Trevithick proposed the substituting high-pressure steam in the then existing Boulton & Watt pumping engine and expanding it down to a low-pressure before condensation; it was not until the year 1812 that he found means to put his ideas into practice, building the first Cornish engine, that is, the first condensing engine working with high-pressure steam expansively, and having the present form of Cornish boilers.

The cylinder was 24 inches diam. with 6 feet stroke, the pumps had the same length of stroke, and raised a load of 20 lbs. per sq. in the steam pressure in the boiler was above 40 lbs, and the engine cut off at 1/10 stroke.

In 1806 Woolf who was contemporary with Trevithick, applied high-pressure steam to the double-cylinder engines of Hornblower thus doing for the latter, what Trevithick had done for Watts engine.

About 1813 he built a single acting pumping engine on this principle, the larger cylinder being 45 inches diam, the smaller about one fourth the area of the larger; the duty of this engine was 52.3 millions, on one occasion during a trial the duty went as high as 70 millions.

On account of the expense and difficulty of management of Woolf's engines they gradually began to be disused at the mines, being replaced by the simpler form of single acting Boulton & Watts.

From 1821 to the present time the main improvements have been in a more extended use of the expansive force and earlier cut off of the steam, using higher pressure, and increased boiler surface in proportion to the water evaporated, and fuel consumed, and greater care to prevent loss of heat by radiation.

The constant improvement in the engines, pumps, and boilers has gradually raised the average duty from 29 millions in 1821 to 129 millions in the case of the Leavitt Engine at Lynn, in 1874.

But Steam Pumps were not to be limited in their use and application to the mere draining of mines; but on the contrary as the manufacturing industries of the world increased and the introduction of steam power became general; the wants and needs of people increased in a "geometrical progression," and among these many wants the Steam Pump was found to supply its full proportion, and the demand for this machine has become so general, that one can scarcely go into a building of any considerable size, and certainly not into a manufacturing establishment without seeing one or more, either in use as feed pumps, for the boiler or in connection with a stand pipe to be used in case of fire. In sugar refineries in tannerys, distillerys, soap factories &c. besides their use for fire, they are employed for pumping acids, oil, - paper-pulp, syrup, thick beer mash, gas tar, muddy water &c. In fact it is almost impossible to mention any liquid, however thick or thin, hot or cold, that cannot be raised by means of the steam pump; and discharging from one, to several thousand gallons per. minute.

No sooner however, did its use and application become general, than like every thing else, hundreds of people went into their manufacture. But the devices and methods first employed, and arrangements adopted were very clumsy, imperfect, and so unreliable as to prove a source of constant annoyance, expense and inconvenience and besides this, they had the disadvantage of sometimes compelling people to use the engine which furnished the power of an establishment simply to run the pump, as it not unfrequently happens that water or other liquid is required, or steam Boilers supplied when it is not neassary, or disirable to work the general machinery.

The necessities of the case demanded a machine that would not only be able to do the work required, but must be simple in its construction and reliable and positive in its operation, at the same time being a complete machine in itself, entirely independent of all connection with any other machinery.

In order to meet these requirements many attempts have been made, with varying success, resulting in a great many different styles and kinds, each manufacturer making his a little different from his neighbors, and; human nature-like, each thinks his "the best steam pump in the market" as of-course it is.

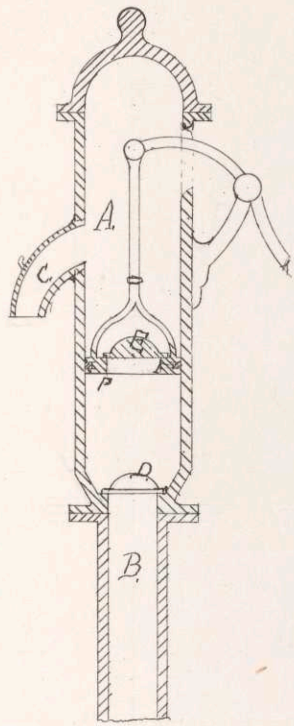
It is not my intention to describe all the different kinds and styles of Steam Pumps that have ever been invented and made and "tried and given perfect satisfaction", since the days when Adam was a boy, nor could I do it were that my desire, but simply to take a few of the many, and point out their peculiar differences, and the advantages claimed for them.

Pumps are divided into suction or lifting pumps, force pumps, rotary and centrifugal pumps; they are either single or double acting, and have either a piston, or bucket as it is sometimes called, or else a plunger.

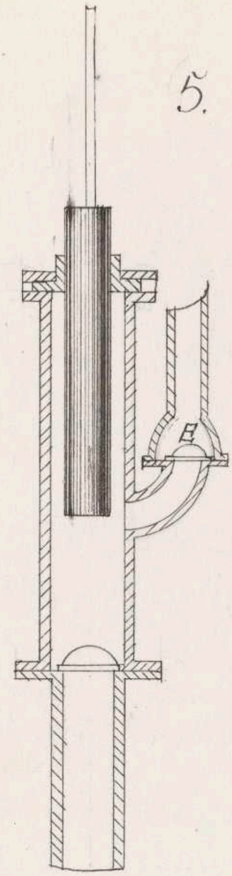
The rotary and centrifugal pumps are not steam pumps strictly speaking as they are driven by some power entirely seperate, and independent of them selves. But in as much as the same laws, and principles, are involved in the common force, and suction hand, as in the Steam Pump perhaps a short discription of their mode of operation will not be out of place.

The principle upon which the suction pump depends is as follows; the pump consists of the cylinder, A. Fig. 3. connected at the bottom with the pipe

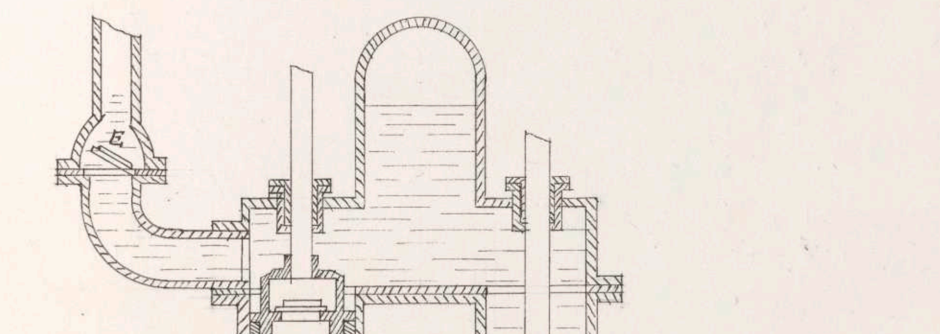
3.



5.



4.



B. which extends down into the water in the well. Near its top is the discharge spout, C. In the cylinder, A. there are two valves, D and E, D being fastened at the entrance of B to the cylinder, A and, E, forming part of the piston, F. The piston, F accurately fits the barrel A in which it is free to move, the valve, E closes an opening in the piston, F; both valves open upwards.

To understand the action, we will suppose the piston to be at the bottom of the cylinder; on moving it up, the valve, E, is kept closed by the atmospheric pressure above, and thus prevents any air entering; but this rarifies the air in, A, and causes less pressure on, D, from above than is exerted by the air in the suction pipe, B; the valve, D, consequently opens, and air from, B, enters, A. So when the piston reaches the top, a volume of air equal to the contents of, A, has been removed from

B; the piston now descends, the valve, D. is closed, and the air in, A. becomes compressed; when the density of this becomes greater than the external air, the valve, E. opens and allows its escape. This process is repeated until A and, B. are entirely freed from air; during this action however motion has been given to the water at the foot of the suction pipe, on account of the pressure exerted by the atmosphere on the surface of the water in the well, and when, B. is entirely freed from air the water rises to a level with D. By the next upward stroke of the piston, the cylinder being emptied of air, the water follows the piston, and fills the cylinder as it filled the suction pipe; the pressure produced by the next downward stroke, closes the valve, D, and forces the water confined in, A. through the valve, E.

The next upward stroke lifts

this water and discharges it out at the spout, C.

In the same manner each succeeding upward stroke discharges a volume of water equal to the contents of the cylinder, allowing for leakage of the valves and piston.

The Force pump is very similar to the suction pump, the main difference being that the valve, E, instead of being fixed on the piston is placed in the discharge pipe; the piston itself being solid. Figs 4 + 5 represent two varieties of force pump.

The water is forced into the cylinder of the pump through the suction valves, by the atmospheric pressure; and the pressure of the piston on the downward stroke, forces it through the valve, E, to any height that may be required.

Fig. 5 represents a pump with a description of piston, known as a plunger; it being a solid cylinder which merely drives out that quantity of water which is displaced by its volume. It was invented in 1806 by Capt. Lean. This form of piston has the advantage of not wearing the cylinder, as it does not require to fit very snug.

When the water is discharged only on the downward stroke, it is very irregular in its motion and takes place in a series of rushes. In order to obtain a continuous discharge various methods have been devised, the most common being the use of an air tight receptacle fixed on the discharge pipe: the water forced into this compresses the air, which, acting like a spring, forces the water out during the up stroke.

Another, and better method, and the one most universally used is the double acting pump; by this arrangement equal volumes of water are forced into the discharge pipe by both the up and the down stroke, thereby causing the flow to be continuous. The air chamber is also used to prevent sudden shocks or jars.

The Knowles Steam Pump is direct and double acting; built at their works in Warren, Mass. These pumps are made in sizes varying from two inches diam and four inches stroke, water cylinder, to 84 inches diameter and ten feet stroke, and are applicable to all kinds of work, from feeding boilers to supplying cities, are capable of raising water to any desired height, can be run slow or fast, and may be used equally as well for gritty, thick or hot liquids, as for clear spring water.

They are as simple in their construction as is possible, and all the parts are interchangable, so that in case of one portion breaking, it can be easily replaced, at small expense.

The pumps are both vertical and horizontal, and the steam and water pistons, are at opposite ends of the same rod, thus doing away with cranks, connecting rods, fly-wheels and cross-heads, necessarily reducing the friction to a minimum; it has no dead points and will start at any point of the stroke.

In the smaller sizes the steam and water cylinders and frame connecting them are all in one casting, the steam chest is secured to the cylinder by the common bolt, the water cap, however, in which the water valves are placed, is secured by hinge bolts, thus enabling the valves to be got at easily, by simply loosening the nuts; in the large sizes the water valves are got at by means of a hand hole.

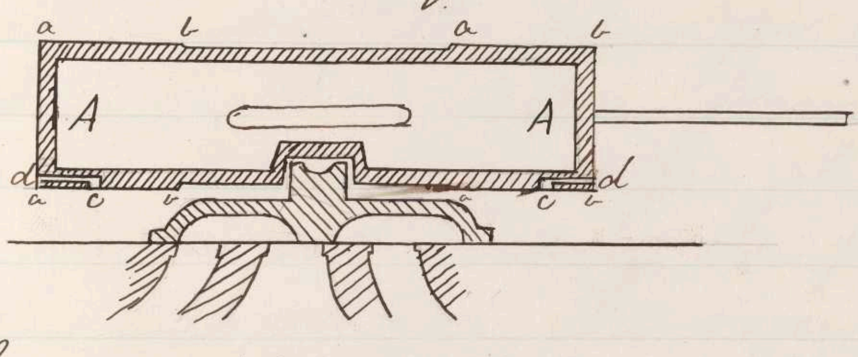
The steam piston is fitted with a spring-ring packing, and is capable of adjustment by means of screws; the piston rod is made of composition.

The water piston is fitted with composition rings and heads, or with leather rings, or a patent fibrous head, according to the nature of the work to be done; in the small sizes this piston is self-adjusting and works equally well in either hot or cold water.

The pumps built for mining purposes or where heavy work is required are made either single or double acting, and with a plunger; the latter class of pumps have a full size plunger working in two opposite water cylinders. Some of the larger plunger pumps have a cut off attachment by means of which the speed is diminished as it approaches the end of the stroke, where it stops for an instant, giving the valves time to seat quietly and entirely, thus getting rid of any pounding.

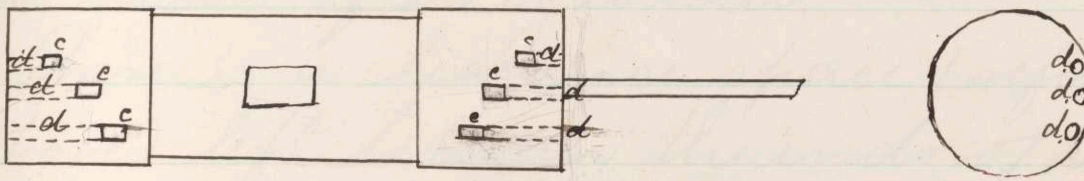
The water valves are ordinary poppet valves, which move vertically to and from their seats, and are guided by a central vertical stem which coincides with the axis of the seat; these valves are generally made of rubber and are kept on their seats when water is not passing by means of spiral springs.

The main steam valve, is an ordinary flat B. slide valve, completely steam balanced, and is without lap or lead, and driven by an auxiliary steam engine, as it were which is placed directly above, and connected with the slide valve by means of a wing on the top of the latter which works in a slot in the former.



This auxiliary steam engine is simply a cast iron plunger A. (see fig above) made hollow to ensure lightness, ground so as to fit its cylinder at the bearing parts a b. a b. perfectly steam tight.
There are three rectangular steam ports cut in its lower face at each end: one is shown in section above ~~at each end~~ at c.c. corresponding to three similar

ports in the cylinder; and at a distance from each other depending upon the size of the plunger.



The relative positions of the ports are shown above. Three holes d.d.d. are bored ~~out~~ at each end of the plunger, to meet the three ports c.c.c thus forming three distinct steam passages at each end ~~one~~; the middle one being the passage for the live steam, the one nearest the end of the plunger that for the exhaust steam, and the other the cushioning passage which is so arranged that it admits a small amount of steam to the clearance space a little before the plunger has completed its stroke; thus retarding its motion slightly and giving the pump valves sufficient time to seat themselves quietly, and at the same time prevent the plunger from pounding, or hitting the heads of its cylinder.

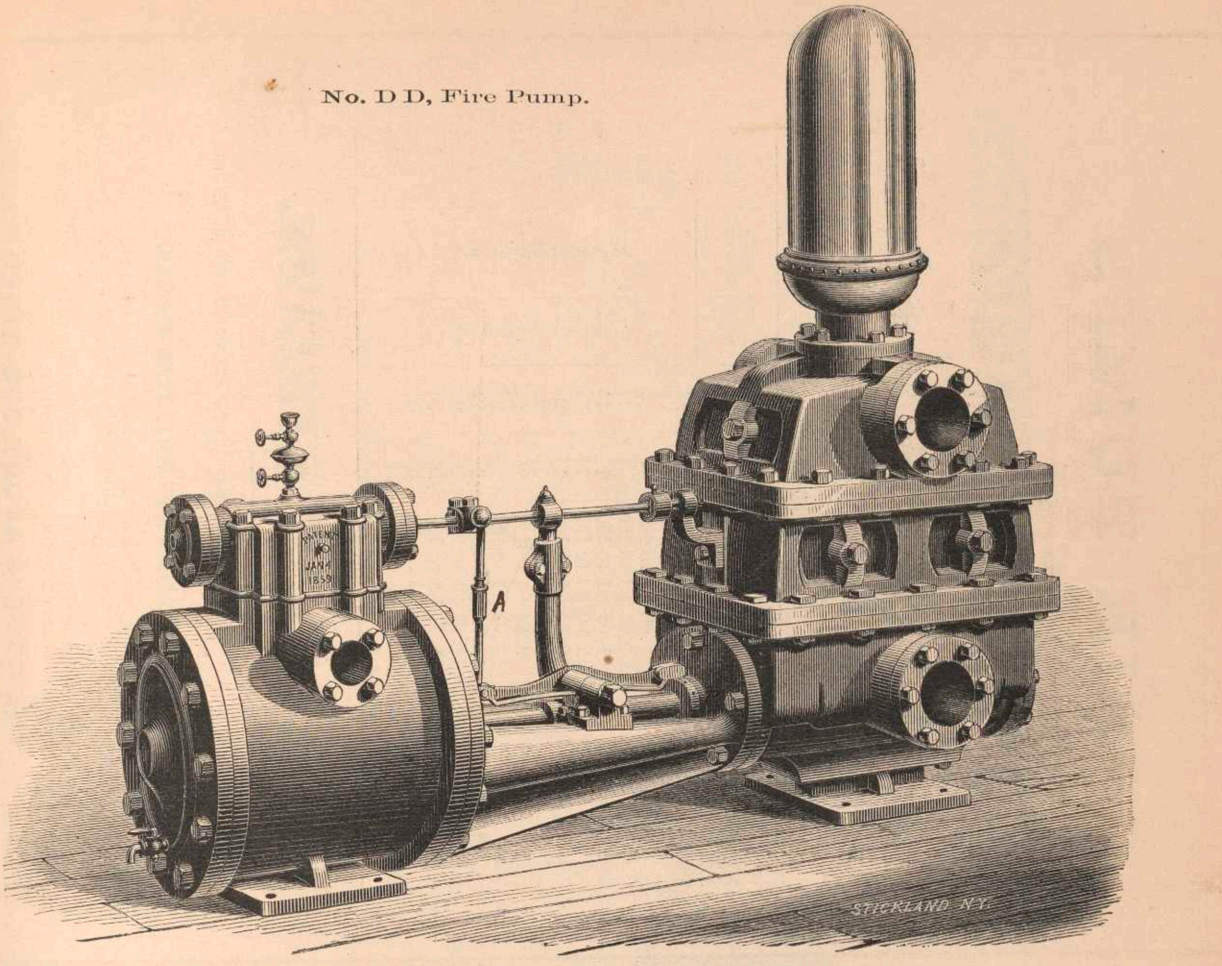
There is a clearance space (referred to above) left between the ends of this plunger, and the ends of its cylinder; the rod of the plunger passes out through a stuffing box and has a position on the outside, directly above and parallel to the piston rod of the pump. By a suitable arrangement this rod receives a slight rotary motion at the end of each stroke, which brings the middle or steam port of the plunger over its port opening in the seat; steam is thus admitted to the clearance space, and by its expansive force moves the plunger, and this in turn moves the steam valve. The exhaust port at the other end of the plunger is opened, at the same time as the steam port, and this operation being repeated at the end of each stroke of the piston, the main steam valve receives the required motion for admitting steam, to the steam cylinder, and allowing the exhaust steam to escape, at the proper time.

By refering to the tracing of "Knowles", the arrangement of its parts and its mode of operation is readily understood.

Suppose as is shown that the piston is going from left to right, the water valves will be as seen; the lower left hand one being the suction, opens, as does the upper right hand discharge; when the piston is near the end of its stroke, the tappet arm attached to the piston rod strikes against the stop fastened to the valve rod and by the peculiar form of the tappet arm and stop the valve rod receives a slight rotary motion towards you; this brings the passage shown in the left hand end of the auxiliary cylinder, into communication with one in the seat of this cylinder admitting live steam to the space between the plunger end, and end of its case, throwing the valve to the right, and changing the valve, so as to allow steam to the right hand end of the main cylinder; the same motion that admits steam to one end of the plunger opens the exhaust at the other end; when the plunger is near the end of its stroke, a third passage admits steam serving as a cushion.

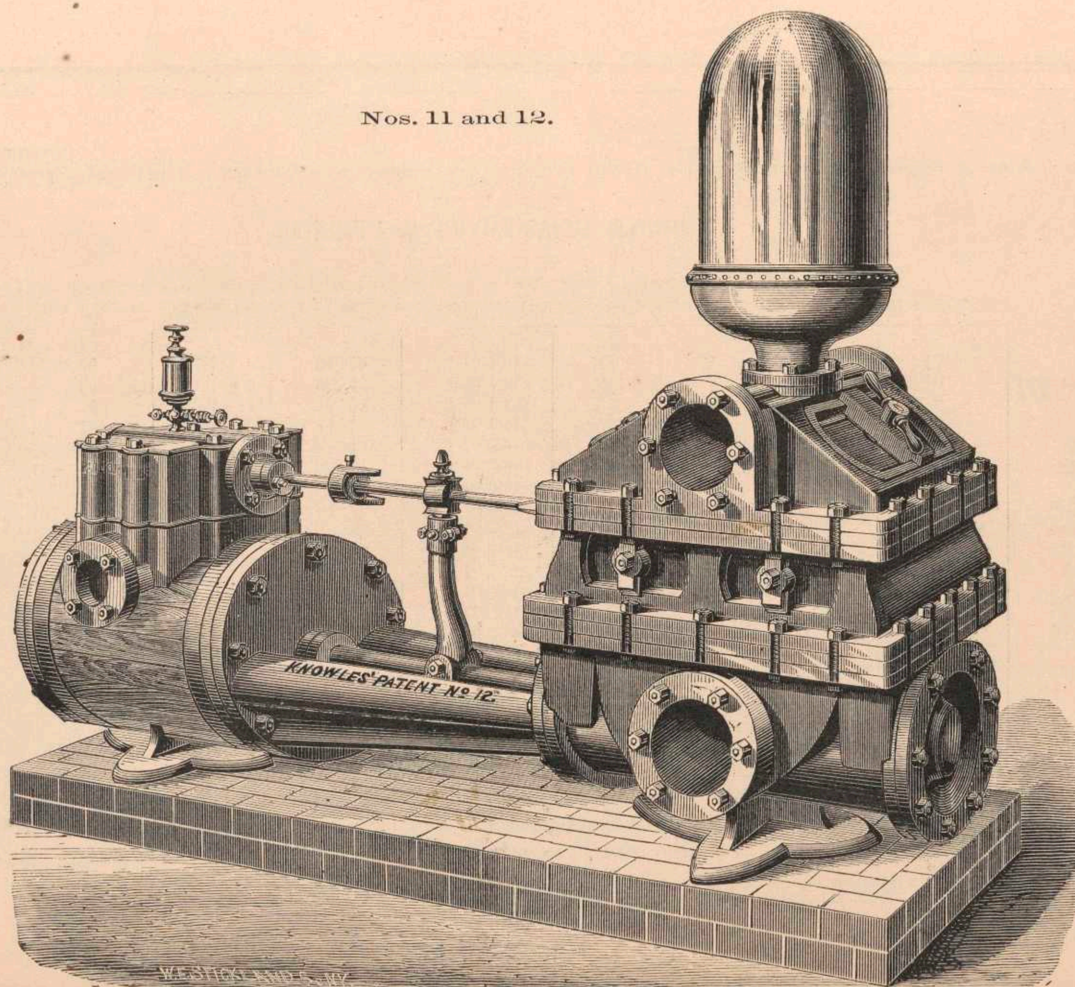
The same operation being repeated at the end of each stroke a continuous stream of water is discharged. Of course the rotary motion of the plunger alternates in its direction of motion being alternately towards you ~~left~~ and from you.

No. D D, Fire Pump.



The above cut shows a new method of giving the rotary motion to the valve plunger; it is simply a lever pivoted at the centre, and raised and lowered alternately by a stud on the piston rod; the rod A connected at one end to the valve rod imparts the motion to the plunger.

Nos. 11 and 12.



All Steam Pumps are to a certain extent alike; for instance every pump in the market according to its circular;- and in place of practical knowledge and experience we must accept such statements; is the "simplest," "the most durable," "will run slower or faster than any other," requires less steam than any other for the same duty;" "will start at any point of the stroke, and has no dead points," "will pump all kinds of liquids," "is superior in workmanship and material to any pump made," "is the only pump made in which all the parts are made actually interchangable and to fit," and all these pumps have many other points of similarity and equal value.

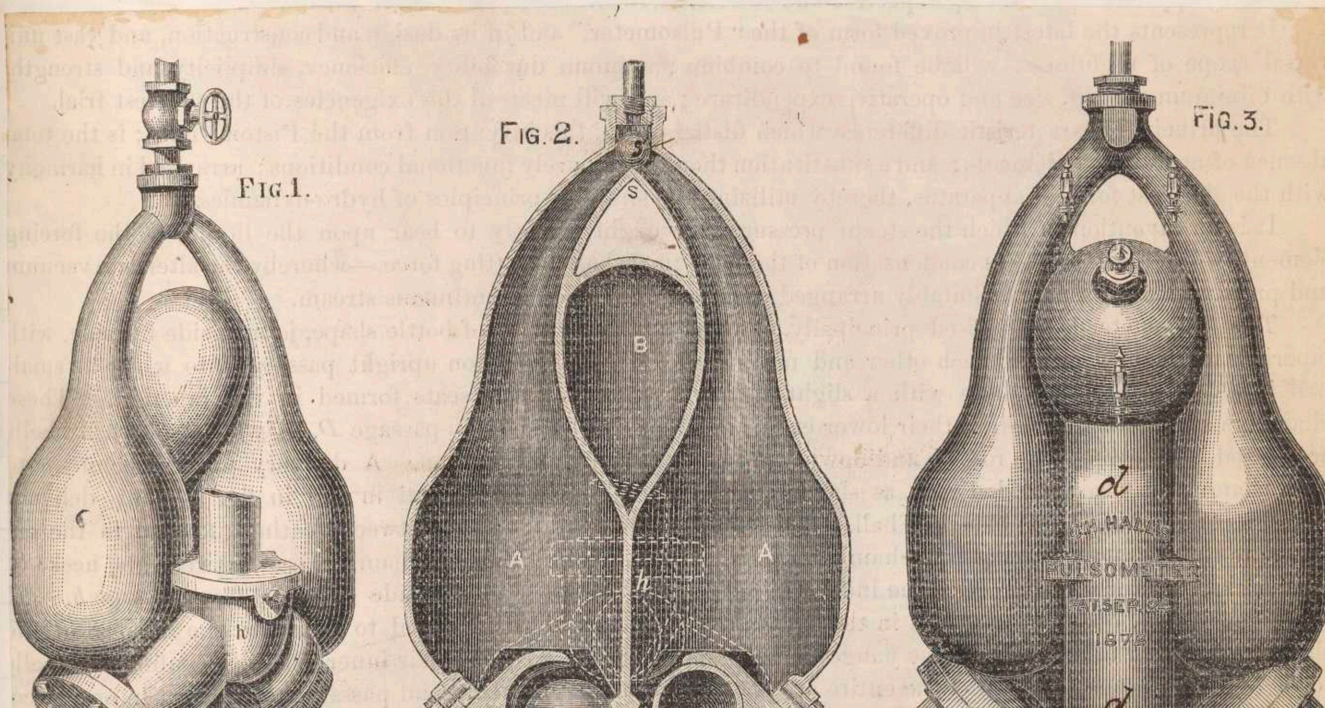
In fact, the only differences between them seem to be in the arrangement of parts, the external appearance and the arrangement for changing the direction of the stroke.

I shall not, therefore, attempt to describe all the "good qualities" of these pumps, but simply give a short description of their valve motion and the manner in which they work.

The Pulsometer.

A Steam Pump without cylinders, pistons, piston-rods, stuffing-boxes, cams eccentrics, tappet-rods,- tappets, cranks, slide-valves or fly wheels. and consequently requiring none of the repairs incident to the presence of the above mechanism such as reboring cylinders, repacking piston-rods, refacing slide valves oiling journals and slides &c; is the negative definition of the Pulsometer.

Positively speaking it is a form of Steam Pump "in which the steam pressure is brought directly to bear upon the liquid" acting as a piston for forcing the water, while the subsequent condensation of the steam creates a vacuum thus "furnishing the lifting force; "whereby the alternate vacuum and pressure within a pair of suitably arranged chambers, produces a continuous stream; utilizing the simplist principles of hydro-dynamics" by means of one of the simplist forms of machine.



"The Pulsometer is comprised principally of two chambers, A A, (see fig. above) of bottle shape, joined side by side, with tapering necks bent towards each other and united at S. forming a common upright passage, into which a small ball is fitted, losely however, so as to be free to oscillate with a slight rolling motion between seats formed in each neck at their junction. These chambers are also connected, at their lower ends, with a vertical induction passage D. in which spherical shells are seated, and arranged to roll up and down with a limited amount of motion. A delivery passage, common to both chambers is also provided at h, as shown in dotted section in fig. 2. and in full in fig. 1. This delivery passage contains a spherical shell or ball, (shown dotted in fig. 2.) which oscillates from side to side, between seatings, formed in the entrance to the passages, leading into the chambers A A, B represents an air chamber, cast between the necks of the chambers A A, and connects with the induction passage, on the side opposite from the passage h, as shown in fig. 3. ab d d, Bb, represent flanges covering openings in the bottom of chambers A A.

arranget to facilitate the removal of the shell valves when necessary.

These flanges have studs or guards cast on their inner faces, to confine the shells to their proper range of motion; the entire apparatus, with all its chambers and passages, being cast in one piece.

There is a small air check valve screwed into the neck of each of the chambers A A, and one into the vacuum chamber B, so that their stems hang downward as shown in fig. 3. Two little milled nuts with a rubber disc between, to pro~~vent~~duce friction, are screwed on their stems.

A pin is screwed into chamber h, at a, and projecting internally above the delivery valve, holds it from lifting upward, any farther than is necessary. Vent plugs are inserted in the flanges b b. to draw off the water from chambers, to prevent freezing, when the pump is not in use.

The operation of the Pulsometer is as simple as its construction; the suction pipe and chambers being filled with water, the pump is ready for work.

Now if steam be admitted at the top through the steam pipe H, it will pass into which-ever chamber the position of the ball S' will permit, and as it enters the chamber directly above the water, it presses upon and forces it out past the discharge-ball valve, and through the discharge pipe, with a force, and to a height due to the pressure of the steam in the boiler. When the steam has depressed the water line so that the outlet leading to the discharge becomes exposed to the steam; the steam which has filled the chamber suddenly escapes, and mingling by impulsion and agitation, with the water, condenses immediately; and produces a nearly perfect vacuum.

The ball at the junction of the necks of the chambers, having a limited range of motion, rests at a point from which it is drawn with the slightest impulse. Now, while steam is entering the left-hand chamber, with a steady, uniform flow, this ball will keep the position shown in the fig. because the pressure of the steam from above, tends to hold it against whichever seat it is first inclined towards; but as soon as the vacuum in the left hand chamber is formed, its equilibrium is distroyed, and it is instantly drawn from its right-hand seat into its left-hand one, and stops the further entrance of steam to the left-hand chamber.

The steam then enters the right-hand chamber, expelling the water therefrom. But at the same time the vacuum produced in the left-hand one, causes it to immediately fill with water; the ball-valve near the bottom, rolls out of its seat, permitting the water from the suction pipe to enter, but falls back, as soon as the chamber is full; and is then ready for the succeeding round of operations as described above."

"The ball-valve in the discharge chamber H, vibrates between its two seats in a manner similar to the steam ball, and simply checks the back flow of the water, after it has been expelled from each chamber."

"The intermediate chamber B connects directly with the suction pipe and contains air in its upper part, which serves to cushion the ramming action of the water, as it rushes into each chamber alternately. The small check valve screwed into this chamber lifts when a partial vacuum is produced and allows a little air to enter, but closes against its return, while the two air-valves in the neck of the chambers allow a small quantity of air to enter above the water, to prevent the steam from agitating it on its first entrance"; the quantity of air admitted may be regulated by means of the milled nuts on the stem of the air-valves.

It will be seen that this combination of chambers, with these four balls, gives all that is required for a double acting steam pump, having two chambers which fill and empty alternately, thus drawing and forcing a constant stream.

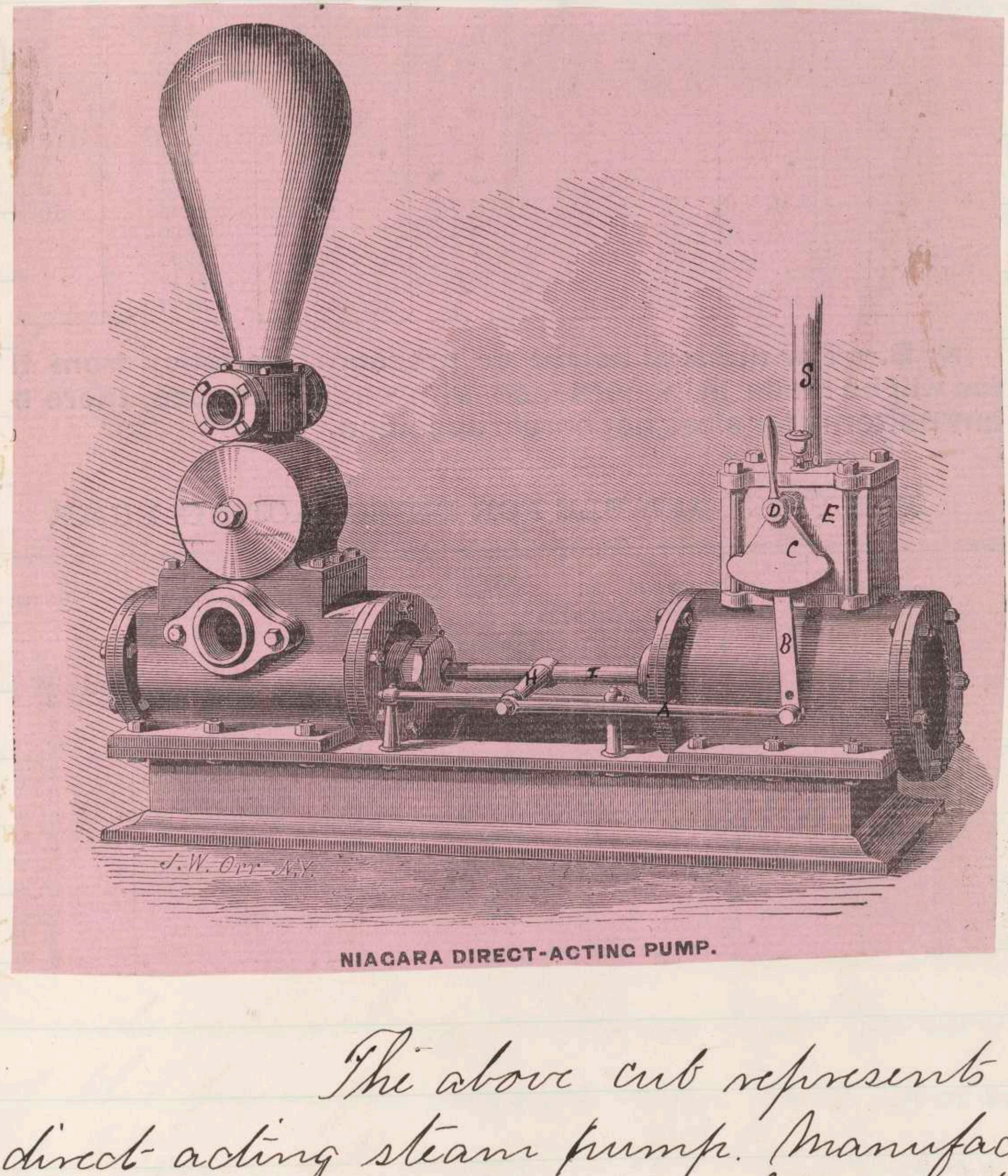
Owing to the peculiar form of the large chambers, the steam on its entrance, comes in contact with a small surface of water only, gradually expanding, as the surface is depressed, thus preventing agitation of the water-surface, and condensation of the steam.

The conditions upon which

the proper action of the Pulsometer depends, are similar to those which pertain to the ordinary double-acting steam pump.

For some classes of work; such as pumping where the water is very muddy or gritty, or where quick sand is to be raised, and in digging for foundations and excavating, where these troublesome elements occur; the Pulsometer on account of its great strength, simplicity and requiring no care or oiling of any of its parts, can be used more economically, and with less danger of any of its parts getting broken, or deranged; than any other steam pump.

Niagara Steam Pump.

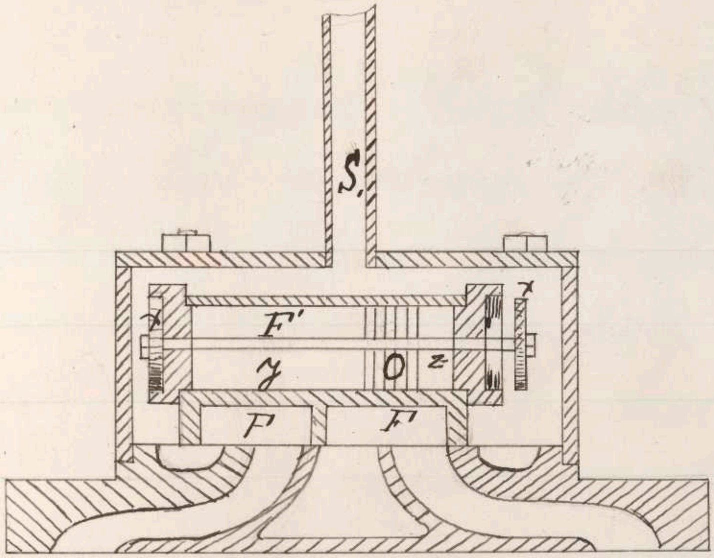


NIAGARA DIRECT-ACTING PUMP.

The above cut represents a direct-acting steam pump. Manufactured by Chas. B. Hardick, Brooklyn L. I. known as the Niagara steam pump.

The principal peculiarity of this pump, is the manner in which the steam valve is operated, and the shape of the water valves, these latter being rectangular, parallelopipeds, made hollow for lightness.

The steam valve is operated by the connecting rod A. (see fig. on preceding page) attached at one end to the cross head H; which is bolted on to the piston rod I. and the other end to the the outside lever B. which is fastened to the rocking shaft D. under the "Shifter" C. The rocker shaft D. extends through, into the Steam Chest E. and has attached to it on the inner side of the Steam Chest, an inside lever, which fits into a small auxillary Slide Valve (neither the inside lever nor the auxiliary valve is shown in the cut) which it will be understood is reversed at every stroke of the pump. insuring free admission of Steam at every stroke to the main Cylindrical Steam Valve F. (see fig. on next page.



The piston F' is free to move, ~~however~~ back and forward upon its rod, this rod is fastened to the steam chest and is kept stationary, the two discs x.x. preventing the pistons travling too far. The piston F' carrying the main valve F.F. glides back and forth on its rod, and thus causes the valve to slide on its seat opening and closing the steam passages to the cylinder.

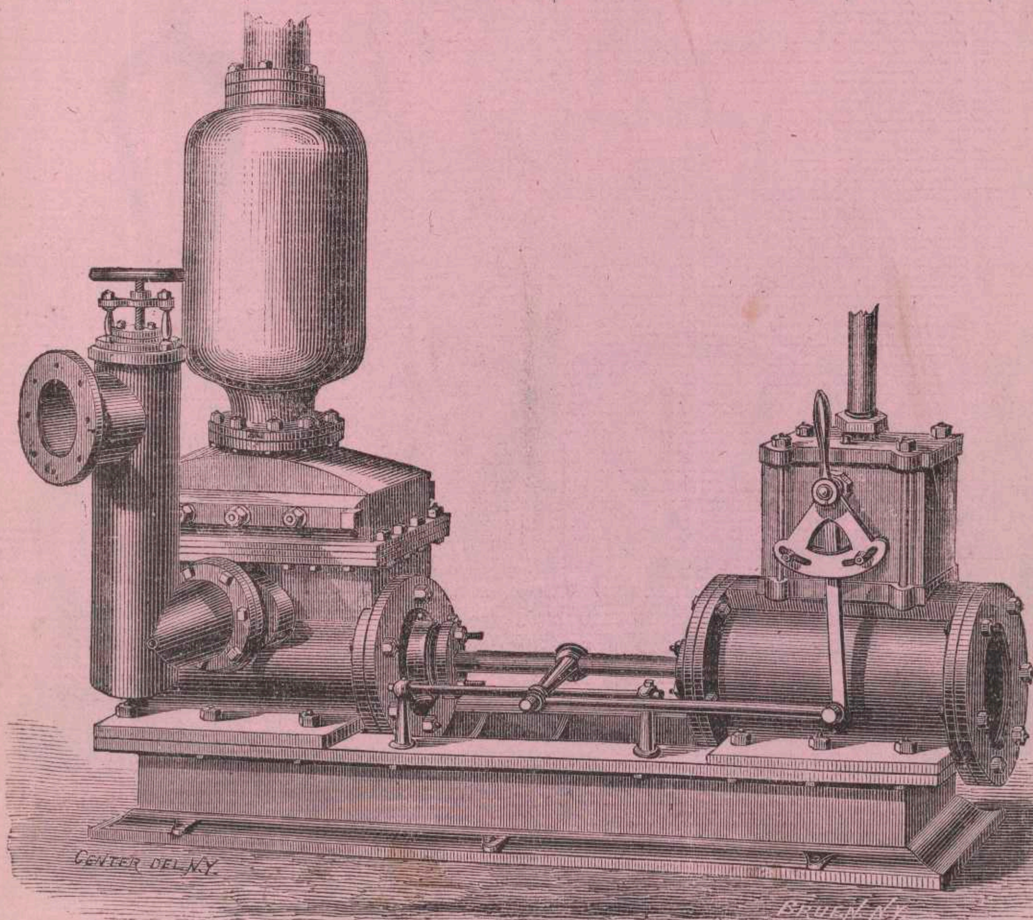
The Steam Valve is of the B form as is see by the figure above; the steam entering by the pipe S.

The auxillary valve spoken of as being actuated by the rocker & lever is so arranged that the motion imparted to it by the motion of the piston, causes it to open and close alternately; openings in the piston F,' thus allowing steam first into the hollow of the piston y. where by its expansive force it causes F' to move. The part marked O being rotating to the possition shown, and then the steam in y. is exhausted and the space z. filled thus giving the required motion; y. and z. being alternately filled and discharged of steam.

The water valves are rectangular parallelopipeds, rising vertically and being kept in place by guides, and a spring on the top, these valves can be taken out and cleaned very easily; the accessibility of the valves is apparent by a glance at the cut on the page where it will be seen. To extract the water valves it is only necassary to to remove one nut; each of the four faces of the valves is a planed surface so that each of the four faces may be successively used. These valves are usually made of metal, and faced with leather, or rubber.

6

The Niagara Direct-Acting Agitator and Steam Pump.



The Improved Niagara Pump.

After John Hardick had invented his so-called Niagara Steam Pump just discribed, and had manufactured hundr- of them, Mr. A. Loretz applied certain changes to the manner of regulating the motion of the steam valve, producing the pump which is now to be considered. As the only difference between this pump and the one last discribed is the valve, that is all that I will speak of.

NIAGARA STEAM PUMP.

The valve is a circular slide valve, which has also the function of a piston, and is attached to a valve stem or piston rod which extends through a stuffing box in the ends of the steam chest. It is operated by a tappet on the piston-rod, attached directly between

the steam and pump cylinders.
It is operated by steam admitted to, and exhausted from the spaces between its ends and the ends of the steam chest; which steam-chest also answers the purpose of an auxilliary steam-cylinder. The induction and eduction of the steam to the spaces between the ends of the circular slide valve and the ends of the steam chest are accomplished by ports formed in the walls of the steam-chest and leading down to the piston rod to which the circular slide-valve is attached. In this piston-rod are also formed passage-ways for the steam, so placed that when the valve-stem or valve piston rod is moved slightly at the end of the stroke of the principal piston, which operates the pump, the steam exhaust from one end of the cylindrical slide-valve, and enters the space at the other end, its action being to

immediatility set the cylindrical slide valve over into position, to permit of the proper induction of steam on one side of the principal steam-piston and allow the steam to exhaust from the other side.

The movement required to bring the passage-ways formed in the piston-rod into conjunction with the ports or passage ways formed in the walls of the steam chest, is very slight indeed, and is of especial advantage when the pump is required to work very slow; and since in this pump the steam pressure throws the valve over before the piston-rod has brought it half way, this pump will not stop on its centres, for when the steam is turned on it is bound to start, and with a velocity in proportion to the amount and pressure, so by increasing the diameter of the cylindrical slide-valve, the force of the action of the steam upon its ends is increased.

By looking at the small cut accompanying this descriptio it will be seen, that the design is excellent, and all the parts are separate which is a great advantage in case of breakage.

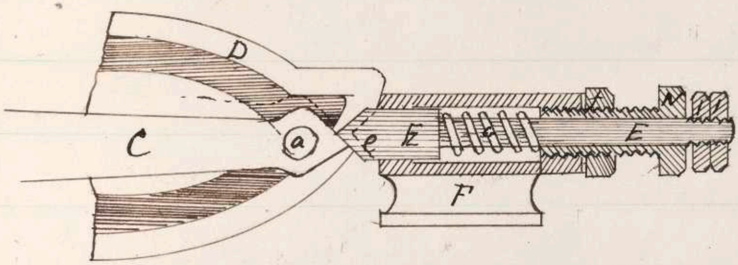
Dayton Steam Pump.

One of the latest improvements in Steam Pump is that known as the Dayton Cam Pump. The principal feature of this pump is the manner of working the steam valve by means of a cam bolted to the piston rod and moving with it.

The steam valve is a plain slide valve; the steam chest is on the side of the cylinder, instead of on the top as in most of the Pumps. The valve rod extends out through the stuffing box and as connected with a crank-arm, the shaft of which turns in a bearing bolted to the pump frame just in front of the Steam cylinder. On the other end of this short shaft, there is keyed a long crank-arm having a stud bolted to its free end, which works in the groove of a cam which is fastened to the piston rod and moves with it; the cam having such a shape that the stroke is slowed down at each end; giving plenty of time for the water cylinder to fill completely, and the water valves to close quietly before the return stroke, insuring a full stream at each stroke, and preventing the pump piston from striking against the water when the cylinder is but partially filled.

It is impossible for the steam valve to be thrown in such a position as to shut off steam and stop the pump.

There are no small steam passages to fill up with dirt and grease, as is often the case with some of the pumps whose steam valve is "steam moved" by means of an auxillary steam valve, but the valve being of the simplest form i.e. a plain slide valve, is not very liable to get out of order. The valve is adjustable on the outside by a left handed screw. By simply slacking the jam nut, the valve can be changed so that the Pump will run perfectly uniform in any kind of work required of it.



The above fig. shows a sectional view, with spring shown in full, of a simple device for throwing the valve, after the Piston has exhausted its efforts. It consists of the following parts: Fixed support or pocket F; Plunger E; Spring G; Adjustable head N.

"In the operation of this device, the cam D, near the termination of its stroke, brings the V shaped or pointed end of lever C. against the V shaped end of Plunger E, forcing it back to dotted lines e, contracting the spring against the adjustable head N.

The reaction of the spring after the points have passed each other, and the presence of the inclined faces of the points serve to move the lever C. and its valve sufficiently to partially open the steam port for the return stroke.

The object of making the head N adjustable is, that the spring G may be made stronger or weaker, or within the control of the engineer. Should the Plunger E not react sufficiently after the points have passed each other, all that is necessary is to loosen the jam nut, and screw N. in a little further, which tightens the spring. In altering the head N, the checks nuts I I on Plunger E should also be altered so as to maintain ¼ inch lap of the points of the lever and plunger.

The Wright Plunger Pump.

The principal point to be noted in this pump, is the arrangement of the bucket plunger, and its mode of operation; there is nothing peculiar about the steam cylinder and valve, the latter being an ordinary slide valve driven by an eccentric.

The bucket plunger is composed of two cast iron cylinders, the larger one being below, and packed with composition rings; the water cylinder in which it acts is made twice the area in comparison to the steam cylinders of the ordinary forms of double acting steam pumps, the object being to dispense with half the number of water valves, as the quantity of water discharged on the upward stroke, is thrown out through an opening in the top of the pump cylinder, and does not pass through the valve opening.

Water is drawn in on the up stroke through a suction valve near the bottom of the cylinder filling the latter; the down stroke forces the contents out through the discharge valve half the discharged liquid passing into the air chamber, the other half flowing up, by means of a passage into the upper part of the cylinder enclosing the small part of the plunger. The reason why half of the water is forced out, is because the small part of the plunger takes up that proportion of the interior volume of the cylinder.

On the next upward stroke, the water around the plunger is forced out through a passage and into the air chamber, thus filling the pump, and at the same time refilling the cylinder.

Thus after a few strokes a steady stream may be kept up, as the quantity of water taken into the cylinder through the suction valve on the up stroke is double that forced out through the discharge passage on the same stroke.

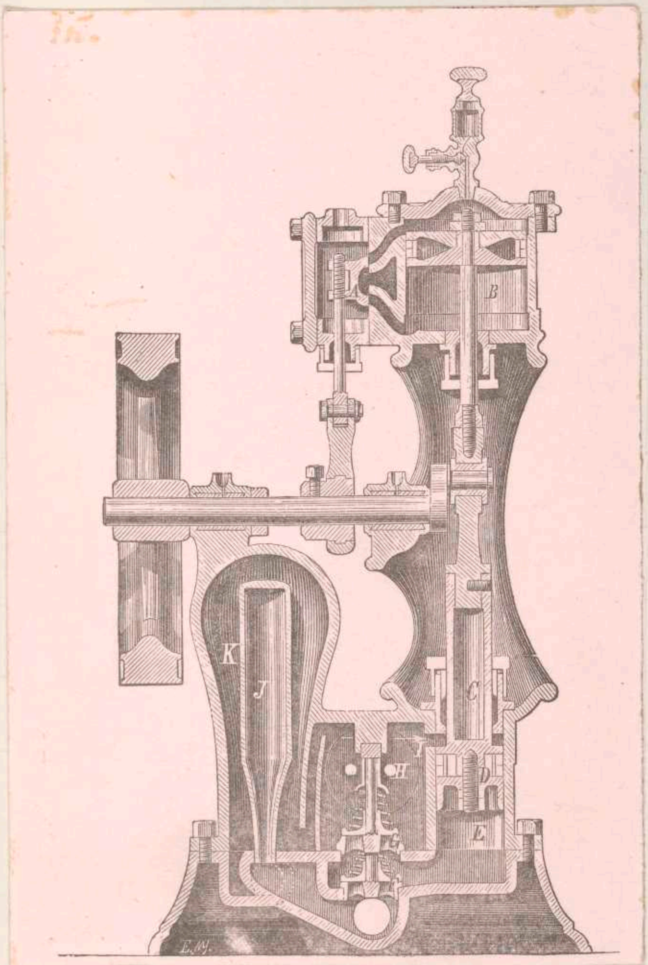
Another reason for constructing the water cylinders in the proportion as above, is that while a large portion of the power is required to discharge the water, but little is needed to draw it through the suction valves. The fly wheel is operated by a crank, which works by means of a sliding block in a slotted cross-head; to the latter, both the steam piston and bucket plunger are connected by their piston rods. This mode of crank does away with connecting rods, and thus economizes room. The pump barrel and steam cylinder are both in the same vertical line; the former being below the latter.

The water valves are the ordinary poppet valve; they may be removed from the pump when necessary by simply unscrewing a single nut and withdrawing a key which is inserted by hand, and is prevented from being driven out, by having its end rest against the hand hole cover. The removal of this key allows the discharge valve and seat to be taken out thus giving access to the suction valves underneath.

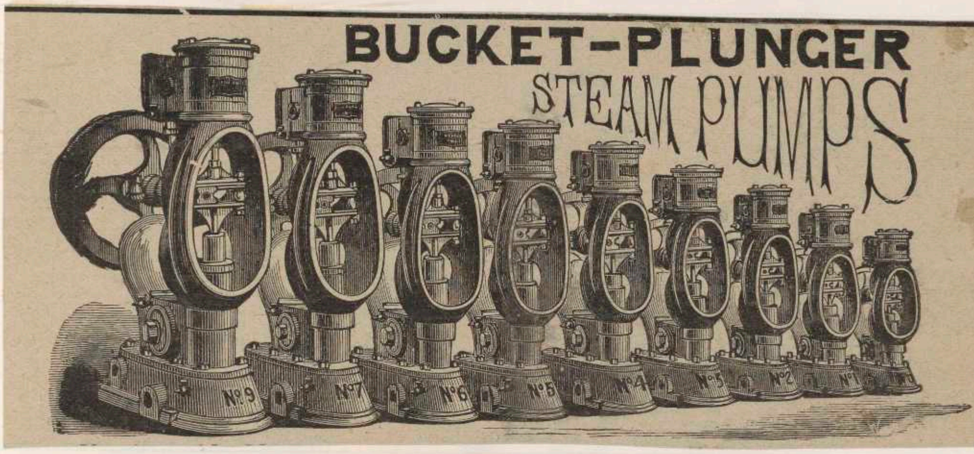
The crank shaft, crank, and pin are in one continuous forging. On the end of the crank shaft there is keyed a heavy fly wheel in order to cause the crank to move with a uniform velocity and by its momentum to carry it through its dead points.

The great objection to the use of a crank, and necessarily a fly wheel, aside from the extra expense, over the direct connection of steam and water piston, is that in case the water valves become choked, or the suction pipe broken, or from any other cause the water is prevented from entering the water cylinder; the momentum of the fly wheel could not be overcome for several strokes at least, and there being no resistance to the progress of the water piston, it would cause a severe pounding and jar to the entire pump, if not the breaking of some of its parts.

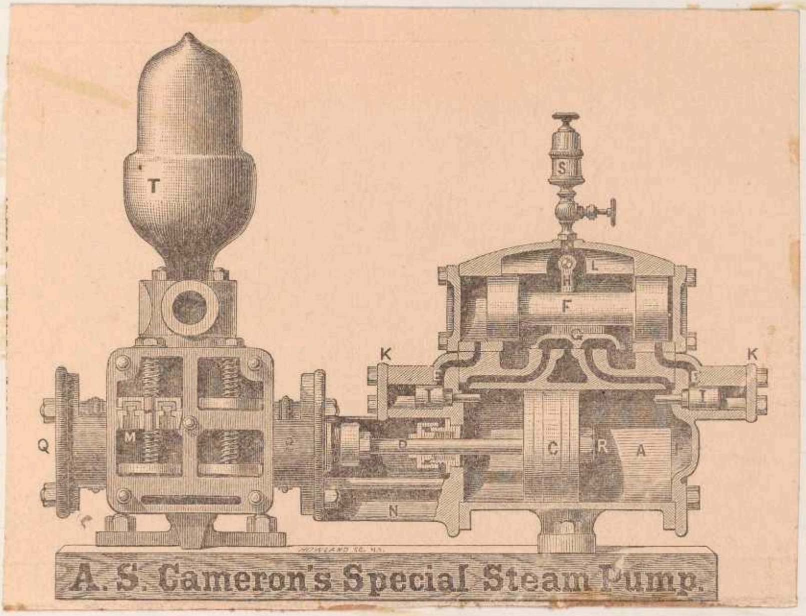
Aside from this, however crank and fly wheel pumps, are so constructed that the water piston can be disconnected from the rest of the machine, leaving a simple and effective stationary engine, that can be used for a variety of purposes requiring not a very great amount of power.



From the accompanying cut the operation of the pump will be easily understood "A is the steam valve, and B the steam cylinder; C is the upper and small portion, and D the lower and large portion of the plunger connected thereto. E is the water cylinder F the suction valve, and G the discharge valve, H is a hand hole for access to the water valves. I is a passage in the upper end of the water cylinder, through which water is taken in on the down, and discharge on the up stroke. J is the vacuum, and K the air chamber.



The Cameron Pump.



The "Cameron Steam Pump" is a direct double acting pump, having this advantage over most of the other forms, that its steam valve is entirely independent of any external cams, rods, levers, tappets &c., as in some; nor is the valve in the cylinder, and forming a part of it as is the case with the Eickemeyer, and Cope and Maxwell steampumps, but on the contrary, is controlled entirely by means of two small reversing valves acted upon directly by the steam piston, at each end of the stroke. These valves are cylindrical in form, and have short rods extending into the cylinder as shown in the fig. on the preceedy page.

In the fig. refered to A, is the steam cylinder shown in longitudinal section; C the piston, and D, the piston rod, passing through stuffing boxes and connected at the other end directly to the water piston; I, the steam chest; and F the plunger, which acts as an auxiliary engine to move the main slide valve G, which is of the B form; H is a starting lever connected to F and operated from the outside by means of a handle not shown; I, I, are the reversing valves spoken of above; and K, K, are the bonnets over them; N, is the body piece connecting the steam and water cylinders; B is the water cylinder shown with the side of the water valve chest removed, exhibiting the arrangement of these valves which are ordinary poppet valves, as seen at M which shows a section of the valve together with its seat; T, is a cast iron air chamber; the water valve chest is on the side as will be seen.

To understand the operation of this pump we will suppose the Steam Piston, C, moving from right to left; when it arrives at the left hand end of the cylinder it strikes the end of the rod on the reversing valve I, it opens and the space at the left hand end of the plunger F is exhausted of its steam by the passage, E, which communicates with the exhaust pipe.

The steam inside the steam chest exerts a pressure on the right hand end of the plunger F, throwing it over to the left, together with the slide valve G; thus causing the motion of the piston C to be instantly reversed.

The same operation is repeated at the end of each stroke, thus causing a continuous motion.

The reversing valves, I, I, are closed by a pressure of steam on their larger ends, the steam being conveyed by an unseen passage direct from the steam chest.

One great advantage this pump has, is the fact that the steam, and water cylinders, may be placed as near each other as desired; thus economizing room which is desirable in some situations.

So many small passages, as this pump has, however, are objectionable, as they are liable to be filled with dirt, ~~and~~ necessitating the stopping of the pump.

The Blake Pump.

One of the best known forms of Steam Pump in this vicinity is that made by Geo. F. Blake & Co., of Boston,

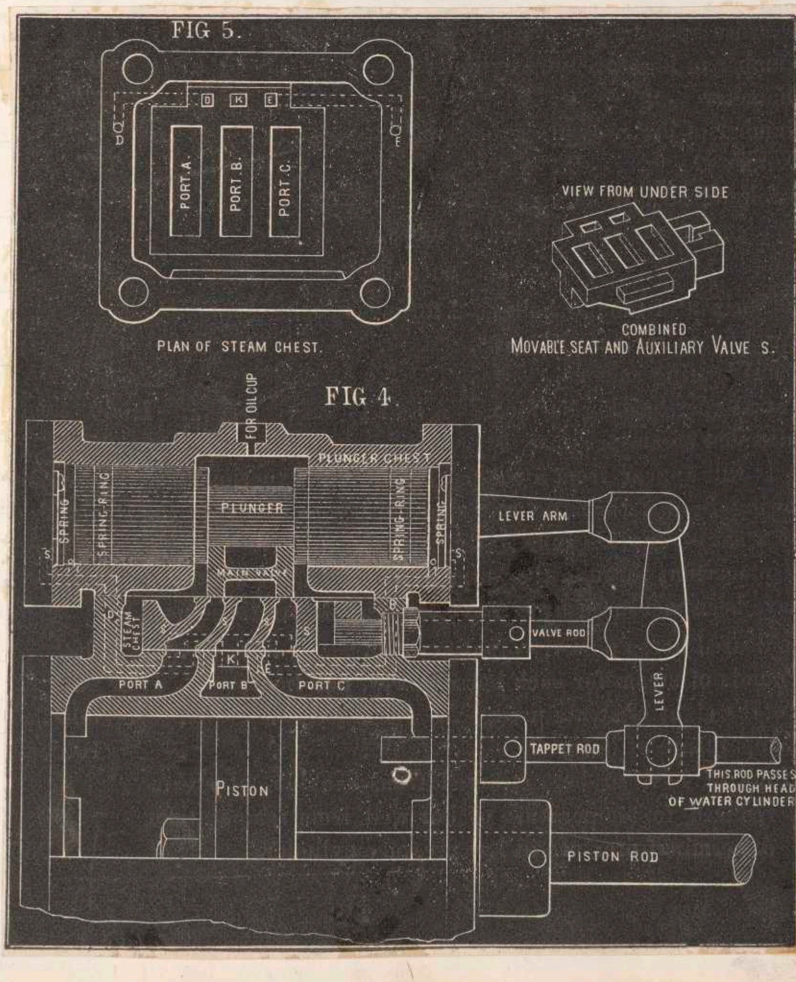
This pump is built for all kinds of work and is direct double acting.

Its steam valve is peculiar to itself, and entirely different from any other form of pump steam valve so far as I have been able to learn; for changing the stroke, they make use of a tappet arm, and tappets; where the distance between the steam and water cylinders is considerable; but when this distance is required to be small, as in the case on ship board the tappet rod passes through stuffing boxes and into the steam cylinder at each end, and is acted upon directly by the piston head. or sometimes it passes through the heads of both steam and water cylinders, being moved in one direction on being struck by the steam piston, and in the opposite direction when struck by the water piston.

The following description and cut I have taken from a report on the trial of a Blake circulating pump, reprinted from the Journal of the Franklin Institute for Dec. 1874.

"The tappet rod is connected through a vibrating lever and stem to a casting which combines both the auxiliary valve and a moveable seat for the main steam valve," which "is an ordinary "D" ~~slide~~ valve, sliding upon the moveable seat, and held between two shoulders of a supplementary piston or plunger."

The ends of this plunger are fitted in their cylinders, and packed with steel rings to take up wear, The cylinders are cast in one piece with the valve chest, "the outer ends of these cylinders being connected with openings under the auxiliary valve by little ports cast in the chest. These small ports or passages lead from the auxiliary valve seat towards each end of the supplimentary cylinder, and are divided so as to enter at two different points, one, "s," through the head, and the other, "o," some distance from it,



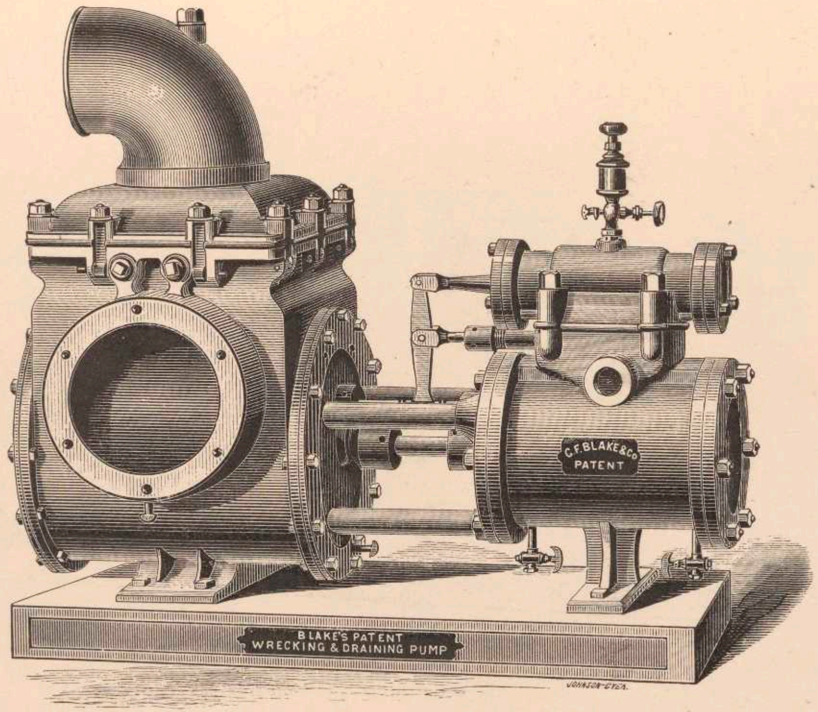
the one in the cylinder head" being covered by a piece of brass acting as a valve which allows steam to enter the cylinder but opposes its exit."

"In order to understand the action of the valve", suppose "the piston moving to the right. The movable seat having been previously moved to the left, the former partly closing the port in the valve seat, the plunger and main valve will have been moved to the right, thus admitting steam to the left of the piston, and releasing it from the right. The piston moving toward the right will, when near the end of its stroke, strike the tappet rod, moving it, and with it the auxiliary valve first into position shown in fig. 4. The ports to either end of the supplementary cylinder are closed, but the main steam port to the left and the exhaust port to the right end of the main cylinder are yet open, the main valve being still at the extreme right. The main piston being still exposed to the steam pressure continues on towards the right, and moves the auxiliary valve with it until the steam communication is opened by the small ports to the right end of the supplementary cylinder, and at the same time the steam in the other end is released.

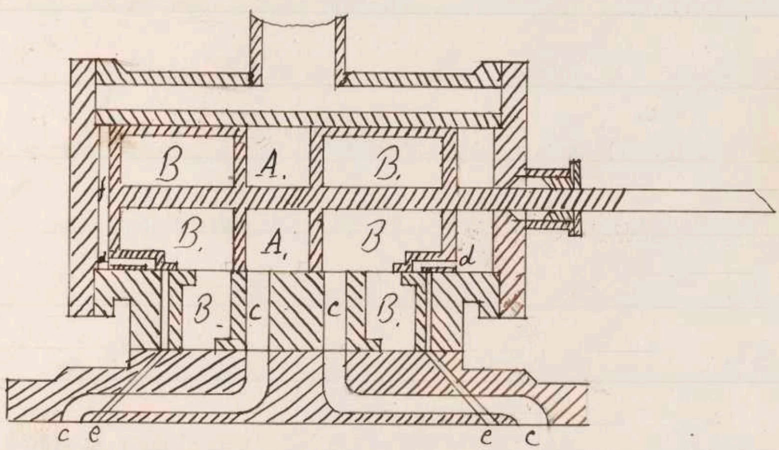
"The full pressure of steam then acts on the plunger," moving "the main valve to the left and admiting steam to the right hand end of the steam cylinder.

"At this instant the main piston is" near "the end of its stroke, but may continue to move towards the end until the steam has had time to overcome the inertia of the plunger. When this has been overcome it moves rapidly to the left until the left end of the plunger has closed the "port, 0, the port" in the head being closed by the brass valve, the steam remaining in the cylinder cannot escape", forming a cushion of steam and gradually bringing the plunger to rest. "During this interval the main piston commences its return stroke."

"In this pump if the main piston continues towards the head it must draw with it the movable seat, until the right hand port passes the outer edge of the main valve, opening the port to steam, and the left hand port passes the inner edge opening the left end of cylinder to exhaust. Under the above circumstances, the main piston will make a return stroke even though the "plunger" and main valve should not have time to move at all".


C.F. BLAKE & Co
PATENT
BLAKE'S PATENT
WRECKING & DRAINING PUMP

The "Earle Steam Pump" has but one valve, doing away with an auxilsiary valve, this valve is a cylindrical slide valve, being in fact a hollow plunger having a steam port in the middle at A.



B, B, are the exhaust cavities, c, c, the steam passages to the cylinder, d, d, small passages in the valve that form a communication between the open space between the end of the plunger and its cylinder head, and the small passage, e, e, which is open to steam.

To understand the

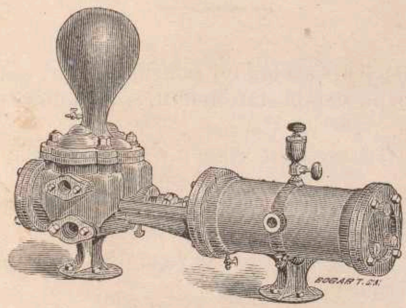
operation suppose the steam piston to be at the left hand end of the cylinder and travelling towards the right; when near the end of its stroke the tappet arm hits the tappet on the valve rod and brings the passage, d, into communication with the passage, e, admitting steam to the space, f, and reversing the valve so as to admit steam to the right hand and exhaust at the left hand end of steam cylinder; this operation being repeated at the end of each stroke gives the required motion to the valve.

The water valves are flat pieces of metal turning on a hinge at one side and known as "flap valves"; they open upwards and do not have any springs to bring them back to their seats, but depend entirely upon the pressure of the water.

The sizes of steam chest, and steam cylinder, in this pump seem to be very much out of proportion to the water cylinder.

The Cope and Maxwell direct

Fig. 1. DIRECT ACTING STEAM PISTON PUMP.



acting steam pump, is shown in the small cut on this page.

Its peculiar feature, the absence of any steam chest, rods, cams, tappets and other mechanical contrivances for operating the valve, generally found in connection with steam pumps, is the first thing to be noticed.

It dispenses entirely with all complications of levers, cranks, cams fly-wheels, tappets and valve gearing, which are indispensable to other pumps. All the working parts are inside the body of the machine, and under cover, being protected so that it can be placed in exposed dirty and dusty places, where it would be impossible to place some of the other descriptions, on account of exposure to the wear and tear due to grit, &c. getting onto the surfaces and bearings.

The whole machine is perfectly independent of bed plate, and may be placed in any convenient position, requiring no accurate adjustment of level. Some of them are even placed on end, working equally as well as when horizontal.

They work with great smoothness of motion, and without striking at any point, have great efficiency at high speed and capacity for maintaining low speed when necessary.

The steam chest and slide valve, are inside the steam piston; the steam chest is a cylindrical chamber bored true, and the valve a piston working in it.

The movement of the valve is produced by the direct action of the steam on it; the steam being admitted through grooves in the steam piston, and at each end of the cylinder.

As the steam valve is worked entirely from the inside of the steam cylinder; there are no valve rods required to be packed; and the distance between the steam and water cylinder can be made as short as desired; the water valves are of the ordinary form of poppet valves.

The Plungers used in their plunger pumps are made hollow so as to be light.

With the exception of the pump valves, there are but two moving parts in the whole machine; the steam and water pistons with their connecting rod forming one, and the steam valve forming the other.

Eickemeyer Pump.

The engine of this Pump is of that class wherein the piston performs the function of the valve for the admission and exhaust of steam. "This is accomplished by means of a peculiar construction of the ports in the cylinder, in combination with a piston having a double motion, which is produced by a crank so constructed that it causes the piston to make one-third of a revolution around its longitudinal axis and back to its original position during every stroke of the engine."

Fig 2. is a transverse vertical section through the cylinder.

Fig. 3. a longitudinal vertical section through the axis of the cylinder showing the piston, and cylinder heads.

Fig. 4. shows a top longitudinal view of the piston. and a sectional view of

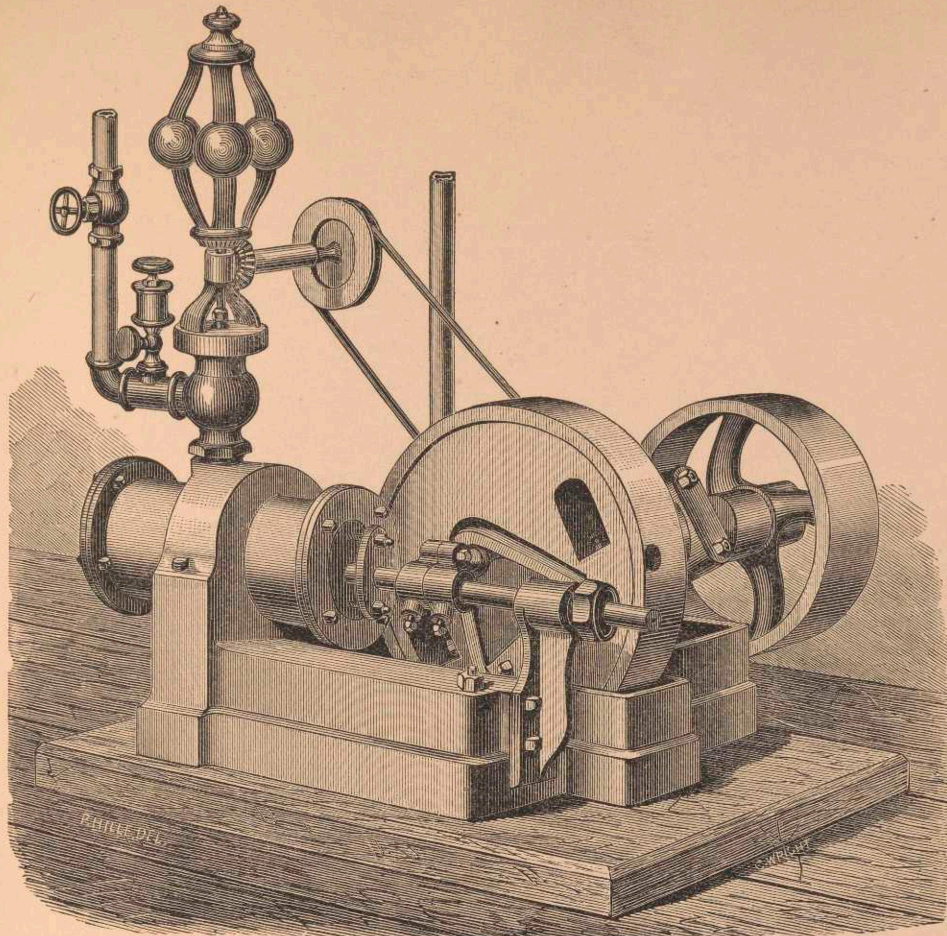


Fig. 2

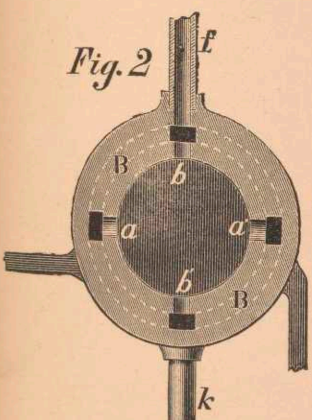


Fig. 3

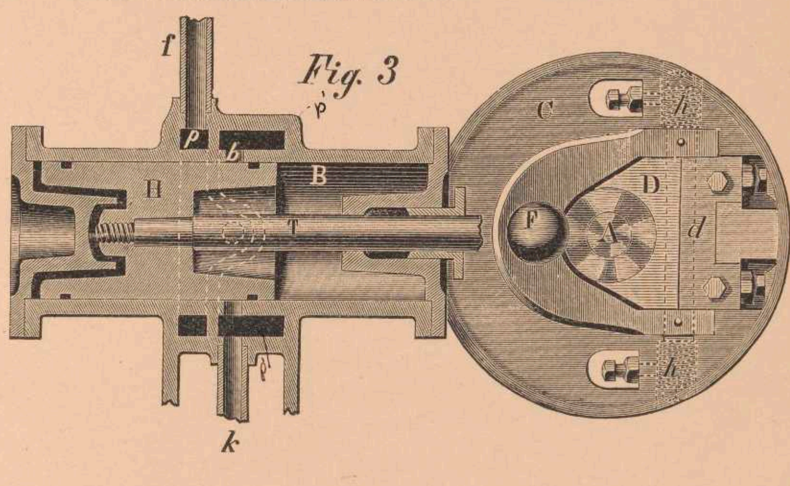
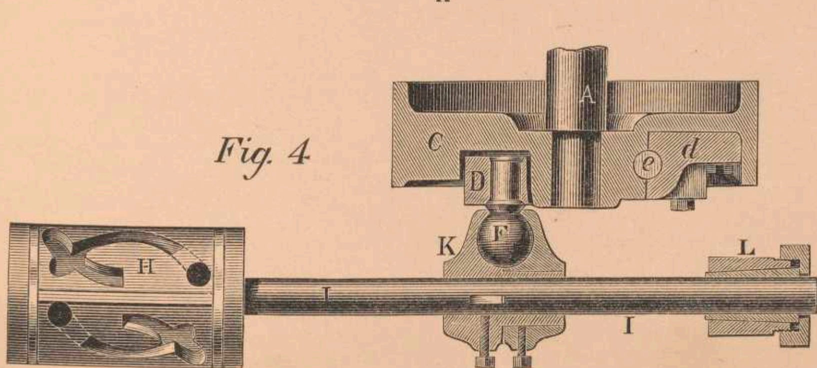


Fig. 4



the crank, crank shaft, and cross-head.

The cylinder, B, has cast around it, near its middle, two separate annular channels p and p'; into the channel p the steam-pipe f, enters on the top, while two ports, a and a', communicate directly with the inside of the cylinder. The channel, p', is in communication with the cylinder through the two ports, b and b', and the exhaust pipe k.

In Fig. 4. the curved grooves in the piston, H, which serve as the steam valve, are shown; the two holes, one in each of the grooves, allowing the steam to enter one or the other end of the cylinder, while the grooves pass over the ports in the cylinder.

The peculiar shape of the grooves determines the length of the stroke at which both the feed and exhaust enter and leave the cylinder.

Each groove is composed of two semi-circular channels, the longer one serving as the exhaust passage, opening the exhaust at the end of the stroke, and closing it after the piston has made nine-tenths of its stroke; while the short passage serves as the feed, shutting off the steam at half-stroke.

Lengthening this passage will lengthen the time of admission of steam, while shortening will reduce the time, thus enabling the steam to be cut off at any point of the stroke.

To produce the double motion of the piston, a hinged crank is used. The forked piece, D. which serves as the connecting rod, is hinged on the disc. C, by means of the pin, c, and to the piece D, a ball shaped crank-pin, F, is fastened. The pin c has an adjustable bearing d, and is held endwise by two steel stips, h, h, shown in dotted lines in fig. 3.

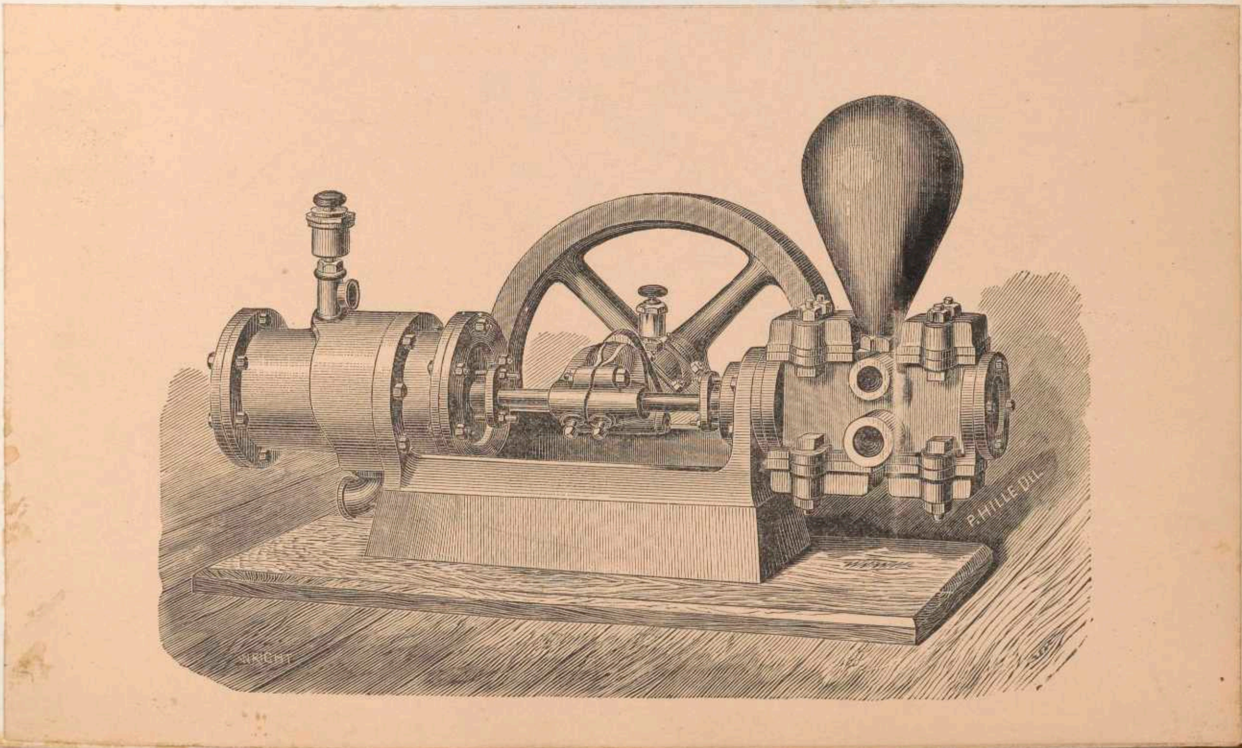
The piston rod, I, has an adjustable bearing, K, and this bearing, or cross-head, furnishes the connection between the piston and crank-shaft, A.

In fig. 4. the piston and crank are shown at the end of the stroke. Now, let us suppose we turn the shaft around its centre, and we will cause the piston to turn in the same direction. When the crank-shaft has made one fourth of a revolution, the piston will have made about one-sixth; the hinged piece, D. will have followed the circular path of the cross-head by a slight turning motion on its bearing, C. Continuing the motion of the crank another quarter of a revolution, we will have the hinged piece D, in its original position with respect to the disc C while the piston is also turned back, but is now at the other end of its stroke. To insure a perfectly central bearing for the piston rod, the box, I, is made in a conical form and can be tightened by a nut on its end, taking up the wear on all sides.

The hinged crank has its bearings so near the cylinder head that the frame of the engine can be made extremely short.

The two inlet-ports are of exactly the same dimensions, and are opposite eachother, thus balancing the pressure; the exhaust ports operate in the same manner.

The water piston is constructed on the same principle as that of the steam piston just described, the pistons being connected by a connecting-rod, and the connecting rod being connected to a fly-wheel as shown below.



The greatest work of the Steam Pump, however, is its application to the supplying of towns and cities with the greatest of all blessings, with the exception, perhaps, of pure air, namely pure water. Formerly, and in some cities at the present time, the inhabitants depended entirely upon wells or cisterns for their water. As the towns increased in size, and the buildings were crowded together the entire soil became impregnated to a greater or less extent with the filth from the sewers, which necessarily tainted the well water, and of course was extremely injurious. The cistern water being generally in the cellar and entirely away from sun light and in contact only with damp, not to say unhealthy air, was scarcely any better; hence the necissity of getting water from some pond or river, free from all these causes of impurity.

But as ponds ~~and rivers~~ and rivers are not always so obliging as to locate themselves near, and at a considerable height above cities, (perhaps they are in league with pump manufacturers, - one thing sure, they form an important part of the water ring), Pumping Engines of large capacity are required. The first form to be used was the Cornish, but owing to the large and expensive cost of the foundation, as well as of the engine itself, this style of engine has gradually been replaced by simpler, and cheaper ~~and more effective~~ forms. I have time to give but a short discription of two of these, namely the Leavitt at Lynn, and the "Duplex" Worthington.

"The leading characteristic

of this latter Engine is that it is a direct acting, non-rotative Engine there being two steam cylinders, each with its proper steam and exhaust valves, its proper piston and piston-rod, and pump-plunger attached to the piston rod; the piston rod of each Engine being made, in the course of its stroke, to operate the steam and exhaust valves of the other Engine through suitable connections, without the intervention or control of any crank-shaft, or other device for producing rotatory motion".

"The first requirement of a pumping engine is, that the rate of movement of the water through the forcing main should be constantly uniform, so that no alteration of pressure should be shown at any time while the pump is working.

"The Cornish Engine fails in this respect, being single acting and intermittent, absolutely requiring a stand pipe, into which to throw the water, to avoid the distructive effect which follows the attempt to put the water column in motion through a long main after every stroke.

"The crank engines also fail in this requirement, since the speed of a piston driven by a crank must always vary according to its distance from the centre."

"The propulsion of the water should be produced by the use of the smallest amount of moving material practicable, for transmitting the force of the steam to the water; the Cornish depends entirely upon the descent of a heavy weight to move the water. Another requirement is, that there should be time allowed at the end of each stroke, before the return of the piston, to allow the valves to seat themselves quickly, and also to allow the incoming supply of water to fill the space behind the plunger completely; otherwise the piston will jump through a part of the return stroke."

"Lastly, the Engines should be, in the greatest practicable degree, compact and self-containing, requiring only small and cheap foundations."

It is claimed that all these requirements are fulfilled in the Worthington, making it one of the cheapest and best forms of Pumping Engines now in use; and its advantages are fully appreciated if we can judge from the large number now in use. The duty of the Worthington is very low, ranging from 30 to 60 million but its cost is about half that of the Leavitt Engine.

The Pumping Engine built for the Brookline water works is one of Worthingtons' Compound Duplex Engines, consisting of one high-pressure, and one low-pressure cylinder, placed side by side, the piston rod of each being connected to its own seperate plunger, forming two complete steam pumps.

The pump cylinders are placed in advance of the steam cylinders, so as to allow for the guides of the cross head, and are held in this position with the water cylinders by four wrought iron rods.

There is one air pump, double-acting, which is driven by a rocker shaft off the main piston rod, and is situated in a convenient position beneath the guides.

The steam cylinders and heads are steam jacketed and thoroughly lagged.

The steam valves are ordinary B slide valves carefully balanced. The double acting water plungers are hollow cylinders with tight heads, their weight being nearly floated. The water cylinders are divided in the middle of their lengths by a metal plate, having an opening in the middle of it for the plunger to work in, This opening is surrounded by an annular flange which is the only part of the cylinder that the plunger touches. The water entering the suction valves passes in a nearly direct line into and through the force valves above, there being a set of suction and discharge valves on each side of the metal diaphragm.

The water valves are the ordinary poppet valves so generally used, they are made of rubber and backed with iron, working vertcally on fixed spindles.

The engines are horizontal and each drives its plunger at a speed said to be uniform throughout its stroke, during which it opens, by a rocker shaft and appropriate connections, the steam valve of the other, and is obliged to pause at the end of its own stroke, until its own steam valve is opened by the motion of the other piston.

The combined, and reciprocal action of the two double acting plungers, thus produces a uniform piston speed, and discharges the water in a steady, quiet stream.

Lynn Pumping Engine.

This engine is of the compound form, having a working beam, crank, and fly-wheel; it was designed by Mr. E. D. Leavitt Jr. of Cambridgeport. There are a number of novel features about it, the most noticeable, being the manner in which the steam cylinders are arranged. They are placed under the beam centre and incline outwardly, so that their pistons are connected to the opposite ends of the beam, and move in contrary directions.

The top of the high pressure cylinder exhausts into the top of the low pressure cylinder; and the bottom of the high pressure cylinder into the bottom of the low pressure.

by this arrangement the passages between the two cylinders are very short and direct.

A single valve controls the passage between the two cylinders at the bottom, while two valves are used in the connection at the top, one close to each cylinder so that the capacity of this passage is not added to the clearance of the high-pressure cylinder when being filled with steam, nor is it exhausted when the low-pressure cylinder is exhausted.

All the steam valves are gridiron slide valves, the valves of the high-pressure having a cam cut off, controlled by a governor the other valves are positive in their working. The cams have large radii and the opening or closing of any valve is extremely quick.

The air pump is double

acting and driven by a connection with the beam; the water from the hot well being discharged into the pump well.

The pump is of the bucket and plunger type, having a secondary pipe and valves to reduce the friction caused by the passage of water through a single bucket valve in the piston.

The water valves are of the form known as double beat valves, there being seven suction, and three discharge valves, one in the bucket and two in the secondary pipe.

This pump has given the remarkably high duty of 129460306 lbs. of water raised one foot high per 100 lbs. of fuel consumed.

The valves make a great deal of noise in seating, but with this

exception the pump gives entire
satisfaction.