June 27, 1939. J. J. WALL 2,164,263

JET AIR PUMP

Filed March 25, 1938 2 Sheets-Sheet 1

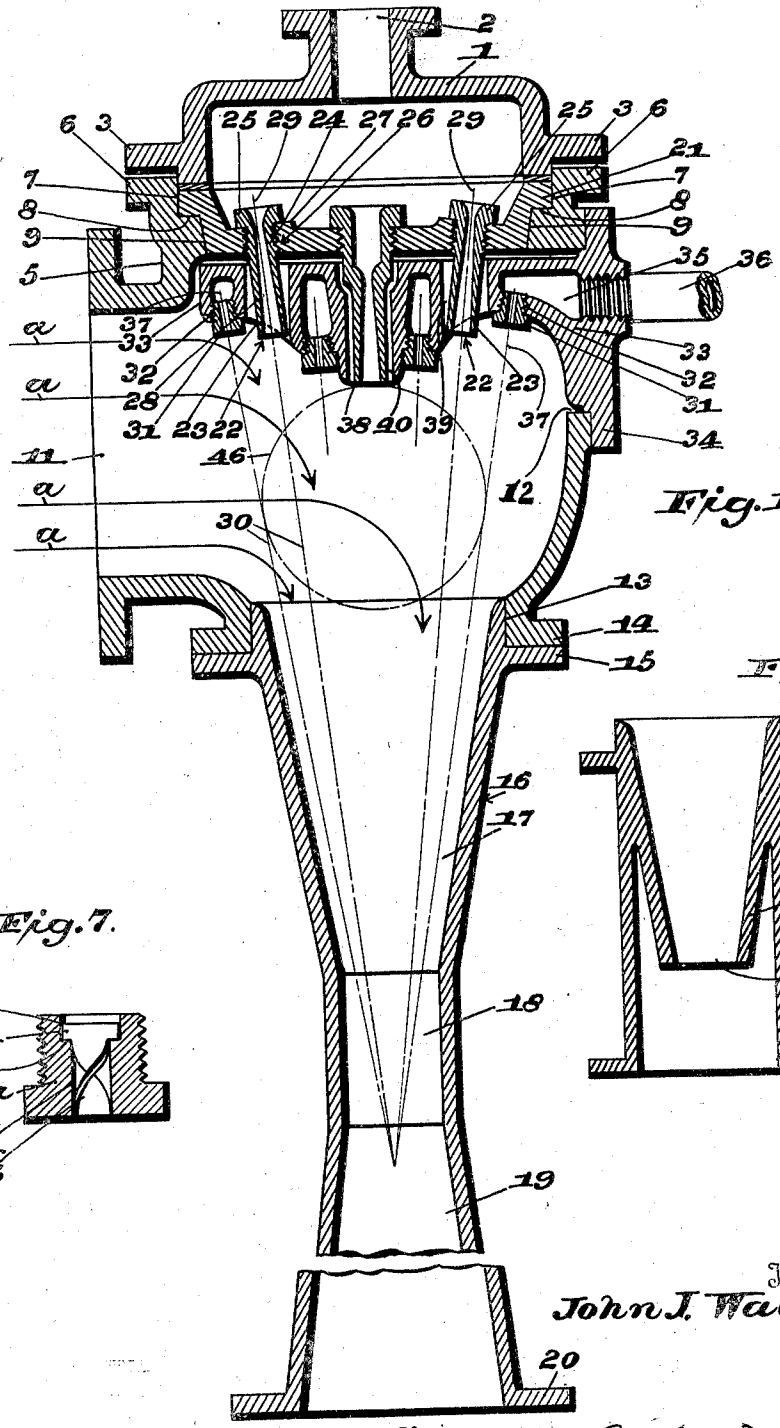


Fig. 1.

Fig. 8.

Fig. 7.

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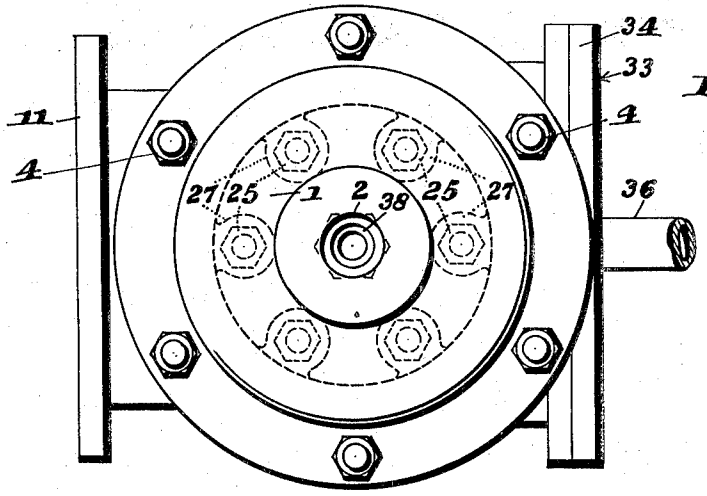


Fig. 2.

Fig. 3.

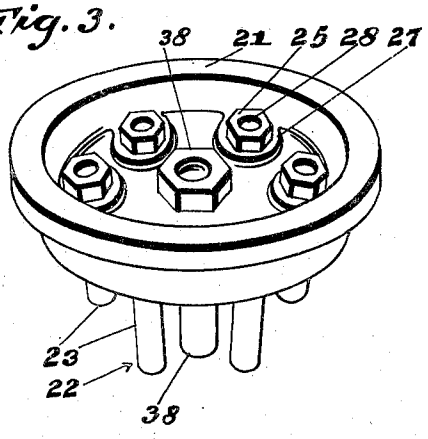


Fig. 4.

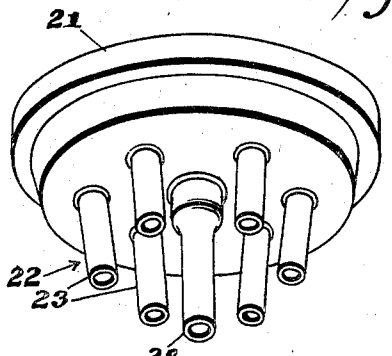


Fig. 5.

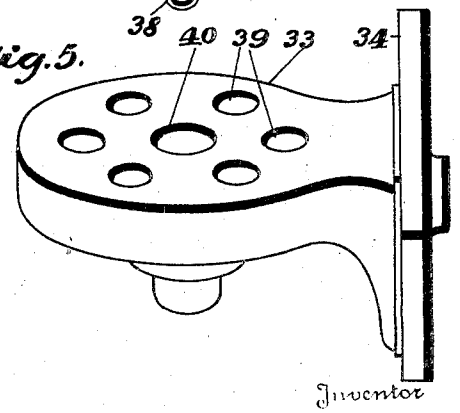
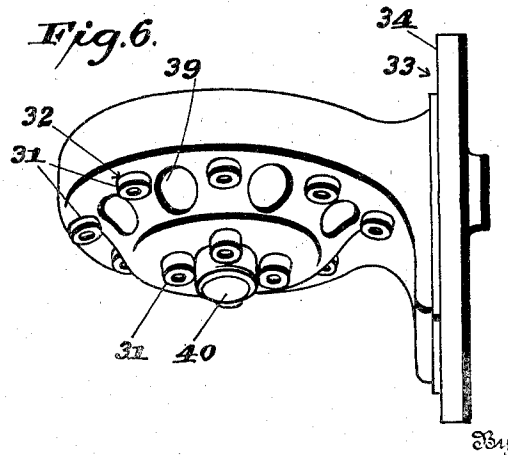


Fig. 6.



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JET AIR PUMP

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Application March 25, 1938, Serial No. 198,131

4 Claims. (Cl. 230—95)

This invention relates to improvements in pumping apparatus, generally of the type known as jet pumps. This type, as its name indicates, distinguishes from rotary, piston and other kinds of pumps by the employment of nozzles which produce fluid jets in such a manner as to draw in low pressure fluid and expel it under a degree of compression.

One of the outstanding advantages of a pump of the type herein disclosed, is the absence of moving parts which, ordinarily are subject to more or less rapid wear and breaking down, said absence also having the result that the pump may be operated continuously for long periods without any perceptible wear and with little or no noise. The effectiveness with which its simple construction can be made to work is a recommendation for its use in substitution for the known kinds of mechanical pumps in a wide variety of uses. With this preamble in mind, the objects of the invention are as follow:

First, to provide a pump of the character described for compressing air by means of steam jets in combination with water jets or sprays, arranged in such manner and in such numbers as to entrain the desired quantity of air and compress the same without an excessive rise in temperature, thus accomplishing very nearly isothermal compression.

Second, to effect complete or nearly complete condensation of the motive fluid before it enters the throat of the Venturi tube, thus reducing the volume of the fluid which must go through said tube.

Third, to thoroughly mix and cool the fluids to reduce their volume, thereby making it possible to use a smaller Venturi tube than has heretofore been the case.

Fourth, to so interrelate the nozzles through which the respective hot motive and condensing fluids are introduced, as to minimize the transfer of heat before said fluids emerge from said nozzles.

Fifth, to effect a thorough mixing of the motive, cooling (or condensing) and entrained fluids as quickly as possible after the motive and cooling fluids have left their nozzles, for the purpose of transferring the maximum amount of the heat and kinetic energy from the motive fluid to the cooling and entrained fluids.

Sixth, to arrange the outlets of the nozzles in such a way that the discharge side of the nozzles assemblage roughly takes the form of a cone to conform so far as is practicable, to the direction and shape of the air stream flowing through the pump and compressor.

Other objects and advantages will appear in the following specification, reference being had to the accompanying drawings, in which:

Figure 1 is a central vertical section of the preferred form of the pump.

Figure 2 is a plan view.

Figure 3 is a perspective view of the steam nozzle holder.

Figure 4 is an inverted perspective view of the steam nozzle holder.

Figure 5 is a perspective view of the water nozzle manifold.

Figure 6 is an inverted perspective view of said manifold.

Figure 7 is a sectional view of a modified form of water nozzle.

Figure 8 is a sectional view of a modified Venturi tube.

In carrying out the invention provision is made of a chest 1 which has an inlet 2 for the admission of steam or equivalent motive fluid. The chest 1 is flanged at 3 for the reception of bolts 4 (Fig. 2) which secure the steam chest to the main body 5 by virtue of being screwed into the corresponding flanges 6 of the latter. The main body 5 has a cylindrical recess 7 which ends at a supporting step 8. This step meets a tapering opening 9 which, as shown in Fig. 1, communicates with a chamber 10 which is combined suction and mixing chamber.

A large opening 11 admits air or other fluid to be entrained, to the chamber 10. It is here that the air is made to commingle with the motive and cooling fluids in the manner presently explained. There is a rectangular opening 12 in the main body 5 at a location opposite to the opening 11. A discharge opening 13 is situated in a plane at right angles to the plane of the opening 11. The perimeter of the discharge opening 13 is flanged at 14 so that the flange 15 of a Venturi tube 16 may be secured in place by any suitable means.

Said tube comprises a downwardly converging passage 17 which communicates with the throat 18 of the Venturi tube. From there said tube has a downwardly flaring passage 19 which is flanged at 20 for attachment to a pipe line or the like.

Reference is made to Fig. 8 at this point. Here the downwardly tapering tube 16a ends at 18a where the throat 18 would begin. The mouth at 18a opens into the cylindrical pipe 19a which is flanged 20a for attachment to a pipe line as above.

From this it will be understood that the venturi may comprise a converging tube of different types.

The recess 7 and tapering opening 9 contain a holder 21 which is cross sectionally shaped to fit the contour 7, 8, 9. This holder and its carried parts is capable of being removed from its assemblage in the pump by first taking off the steam chest 1. A plurality of steam nozzles 22 is carried by the holder 21 in a circular series (Figures 2 and 3). Each of these nozzles has a tubular portion 23, a threaded shoulder 24 and a non-circular head 25. In each case the threaded shoulder is screwed into a bore 26 which goes through the bottom of the holder 21 and through a conveniently provided boss 27 which adds to the length of the thread passage and improves the holding quality of the threads when the nozzle is driven home by applying a wrench to the head 25. The passageway 28 within each nozzle 22 is of the Venturi form shown.

It is to be observed that the axes 29 of the various nozzles 22 are set at a pitch. These axes, if extended as indicated by the extension lines 30, converge to a common center in the vicinity of the Venturi throat 18. The configuration thus depicted is generally in the form of a cone. A similar principle obtains in the positioning of the circular series of water nozzles 31. These nozzles are screwed into threaded bores 32 in the nether side of a manifold 33 which is fitted into place within the chamber 10 through the previously mentioned opening 12. Said manifold is flanged at 34 and it is through these flanges that suitable securing means are driven into the main body 5.

The manifold 33 has a hollow interior 35 into which water under comparatively low pressure enters through a feed pipe 36. It is with the hollow interior that the nozzles 31 communicate. It will be seen in Fig. 1 that the axial lines 37 of the water nozzles converge in common with the axes of the steam nozzles, all of the axial lines falling within the previously mentioned cone configuration.

Said configuration is augmented by the stepped arrangement of the various nozzles. It will be seen in Fig. 1 that there is an outermost series of water nozzles, the orifices of which are in a plane slightly higher than the orifices of the steam nozzles in the next series reading in toward the center of the pump. Then there is a second series of water nozzles, and the crown of the whole series comprises the central nozzle 38, the orifice of which tops all of the others. The central nozzles 38 is also for the ejection of steam inasmuch as it communicates with the interior of the chest 1. Although its internal configuration is slightly different from the internal configuration of the other steam nozzles, yet its formation is that of a venturi as is also its function.

Again considering the manifold 33, it will be seen that there are fairly large openings 39, 40, for the steam nozzles. The openings 39 occur in a circular series while the opening 40 is only a single one. These various openings are sufficiently oversized to prevent any of the steam nozzles from touching the manifold 33. This arrangement minimizes the transfer of heat from the hot steam to the relatively cold water.

Instead of leaving the bores of the water nozzles 31 perfectly plain, as shown in Fig. 1, they may be modified according to the plan in Fig. 7. Here the nozzle 31*a* has a bore 41 which communicates with a counter-bore 42. The latter provides a shoulder 43 on which the end lugs 44 of a spiral insert 45 are rested. The spiral insert tends to impart a whirl to the water, and in doing so reduces it to a mist which facilitates the previously mentioned commingling function.

The operation is readily understood. Jets of steam moving at a high velocity, issue from the nozzles 22, 38, in the directions of the axial lines previously mentioned and indicated in Fig. 1. These jets move downward into the Venturi tube 16. At the same time jets of water issue at a lower velocity from the nozzles 31. These are also directed downward into the Venturi tube 16.

Inasmuch as the opening 11 communicates directly with the outside air or with some other space to be exhausted, such air will be drawn in because of the vacuum which the steam and water jets tend to produce in the chamber 10. The air stream generally designated by the arrows *a*, makes a right angle turn and flows into the passage 17 in common with the motive (steam) and cooling (water) fluids. A large amount of the incoming air is entrained by the steam and water jets and thus there enters the converging tube 17 a mixture of steam, water and air.

As this mixture moves downward, most of the steam comes into contact with the colder water and air and is condensed. At the same time most of the velocity and kinetic energy of the steam are imparted to the air and water. Because of the fact that the three fluids are thoroughly commingled it follows that the steam is condensed, reducing the volume of the mixture whereby the velocity of the air and water are greatly accelerated.

It is important to note that most or all of the steam is condensed in the region roughly encircled at 46, which lies just outside of the Venturi tube 16. In other words, most or all of the steam condensation occurs before it can enter or go through the Venturi tube. This function reduces the volume of the mixture which has to be forced through the tube, and makes possible a great reduction in the throat area of the venturi, makes possible a higher operating efficiency, and makes unnecessary the use of an after condenser.

As the mixture flows through the tube, reaching the flaring passage 19, its velocity decreases and pressure increases. Ordinarily when air is compressed, its temperature rises but according to this invention the particles of water which are mixed with the air absorb the heat of compression and prevent any rapid rise in temperature. Thus approximately isothermal compression is achieved and there emerges from the flaring tube 19 a mixture of cool, compressed air and finely divided particles of water. The excess moisture may then be removed from the air by a suitable separator (not shown). Two or more of these pumps or compressors may be connected up in series or stages to attain higher pressures or vacuum that is possible with the single stage illustrated.

This pump is not confined to the use of steam, water and air as the respective motive, cooling and entrained fluids, because the pump is adaptable to other applications wherein other types and combinations of fluids can be utilized. For example, in refrigeration and air conditioning, the compressor will operate with ammonia gas as the motive fluid, liquid ammonia as the cooling fluid and ammonia gas as the entrained fluid.

Instead of drawing atmospheric air in at the opening 11 the pump may be used for evacuating vapors of various kinds from vacuum stills, tire molds, deodorizers, etc. In many of these applications fluids other than steam, water and air will be employed.

The arrangement of nozzles, both steam and water, is mainly suggestive. The numbers of nozzles in the various series can and will be increased or diminished according to the size of pump to be developed. Still the actual number of nozzles of each kind for a particular installation is subject to being worked out according to a mathematical formula. If too many nozzles are used the ensuing large number of small jets will entrain too much air and the compressor will not be able to raise the pressure very high. On the other hand if too few large nozzles are used a small amount of air will be entrained, poor mixing will result, and a large amount of steam would go through the Venturi tube in an uncondensed state and still moving at a high velocity, for which reason the operating effiiciency would be low.

It is not always necessary to arrange the various nozzles in concentric circles as shown. The essential thing is to space the nozzles evenly. The principle of next importance is to alternate the motive and cooling fluid nozzles (Fig. 1) so that no two motive fluid, nor any two cooling fluid nozzles are adjacent. This arrangement produces the best interspersement of the motive and cooling fluid jets.

Although the illustrations and description are based on an erect position of the pump, it is not to be thought that the pump will work only in this position. It is true that it will work best in this position but it will do so almost equally as well mounted horizontally or in any desired intermediate position. By way of a further permissible variation it is not imperative that the sets of nozzles 22, 31, shall always be set so that their axes converge to a common center in the vicinity of the Venturi throat. They can be set approximately parallel and still have a fairly good operation, although the converging nozzle-axis arrangement is the best and is preferred.

While referring to the disposition of the nozzles, it is desired to point out that the circular arrangement (Figs. 3 and 6) does not have to be adhered to in all cases. The nozzles could be mounted in rows to form a square, triangle or the like, and to suit this modification the Venturi tube can be cross-sectionally shaped to match.

I claim:

1. A pump comprising a Venturi tube having a suction opening and a throat, a hot motive fluid chest, a set of nozzles pendent from the chest communicating therewith and being directed past the opening toward the throat, a cooling fluid chamber having oversize openings through which said nozzles project providing ample spaces around the nozzles to prevent the transfer of heat, and other nozzles carried by said chamber, communicating with the interior and being directed to the throat, the various nozzles being interspersed to produce a commingling of the motive and cooling fluids prior to their entry into the tube.

2. A pump comprising a body having a suction opening, a Venturi tube extending from the body and communicating therewith, a member fitted upon the body defining a chest, a nozzle holder seated on the body beneath the chest, a plurality of nozzles pendent from said holder, a manifold carried by the body and having openings through which nozzles extend without touching the sides of the openings, and other nozles pendent from the manifold, the various nozles being interspersed with each other and set at such pitches that their combined axes define a cone.

3. A pump comprising a mixing chamber having a suction opening, a Venturi tube pendent from the mixing chamber, a hot motive fluid chest superimposed upon the mixing chamber and providing a cover therefor contiguous to the suction opening, a set of nozzles pendent from the chest communicating therewith and being directed toward the Venturi tube, a cooling fluid chamber supported by the mixing chamber independently of said chest, said chamber having openings through which said nozzles extend, and other nozzles carried by the cooling fluid chamber communicating with the interior thereof and being distributed between the nozzles of the chest.

4. A pump comprising a mixing chamber having confronting openings, one of which comprises a suction opening, a Venturi tube pendent from the mixing chamber, a manifold inserted in the other one of said openings, providing a closure for said other opening and having a plurality of transverse openings, nozzles attached to the manifold and communicating with the interior thereof, said nozzles being interspersed with said transverse openings, a hot motive fluid chest seated in the mixing chamber in spaced relationship to the manifold, and nozzles carried by said chest projecting through the transverse openings but in spaced relationship thereto.

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