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METHOD OF INCREASING THE VOLUMETRIC EFFICIENCY OF CYLINDER AND PISTON MACHINES.  
APPLICATION FILED JAN. 21, 1907.

899,706.

Patented Sept. 29, 1908.

2 SHEETS—SHEET 1.

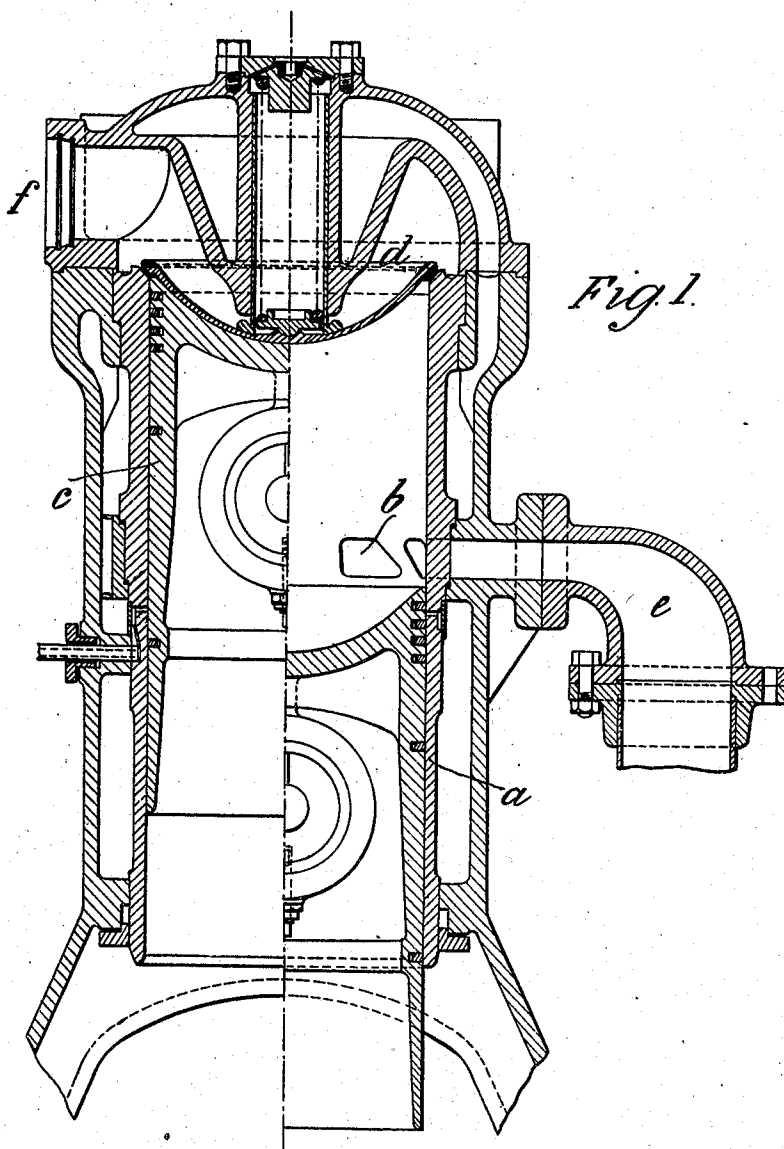


Fig. 1.

Witnesses.

Jesse H. Lutton.  
B. Rommers

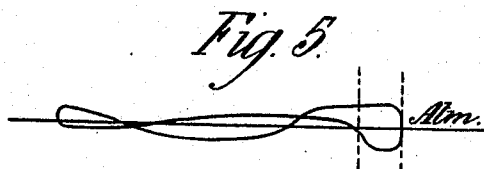
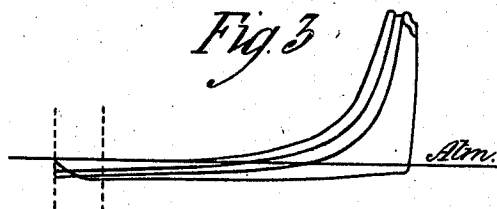
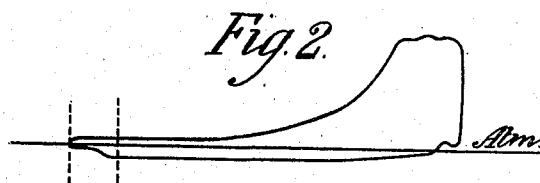
Inventor.

Adolf Vogt  
by Henry Orth  
Att'y.

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Witnesses.

*Jesse H. Sutton.*

*R. Mommers*

Inventor.

*Adolf Vogt.*  
*By Henry Orth*  
Atty.

# UNITED STATES PATENT OFFICE.

ADOLF VOGT, OF LONDON, ENGLAND.

## METHOD OF INCREASING THE VOLUMETRIC EFFICIENCY OF CYLINDER AND PISTON MACHINES.

No. 899,706.

Specification of Letters Patent.

Patented Sept. 29, 1908.

Application filed January 21, 1907. Serial No. 353,340.

*To all whom it may concern:*

Be it known that I, ADOLF VOGT, a citizen of Austria-Hungary, residing at 149 Tulse Hill, in the county of London, England, electrician, have invented a certain new and useful Method of Increasing the Volumetric Efficiency of Cylinder and Piston Machines, of which the following is a specification.

Machines wherein a piston working in a cylinder draws in a charge of elastic fluid, such as pumps, compressors, four-stroke-cycle internal combustion engines and the like, can at best draw in during the suction stroke a quantity of fluid such as air or gas which is equal to the capacity of that part of the cylinder which is passed through by the piston, or in other words, the volume of the stroke. In practice however when the fluid does not enter under pressure above that of the atmosphere, this quantity is never attained, and in cases where the piston moves at a high velocity the amount drawn in falls as low as 50 per cent. or even less, of this volume.

My invention has for its object to enable such cylinder and piston machines to draw in more air or gas than corresponds to the volume of the stroke, even when the piston travels at the highest speeds. For this purpose, in the case of an ordinary four-stroke-cycle internal combustion engine in which a suction stroke draws in a new charge, the suction pipe is made sufficiently narrow and long, and the inlet valve is operated in such manner as to cause a partial vacuum in the cylinder during the initial part of the suction stroke so that the air column will enter at a high velocity and will by reason of the kinetic energy of the moving column continue to enter the cylinder even after the internal pressure becomes equal to that of the atmosphere. Thus, if the suction valve is closed when or before the air column comes to a standstill the pressure of the charge before the compression stroke will exceed atmospheric pressure and may exceed it very considerably.

When the suction valve is closed the excess pressure at the closed end of the suction pipe will cause the column of air to surge backward towards the open end, thereby producing a diminishing pressure at the

closed end and an increasing pressure towards the open end. Consequently a pulsating column will be established in the suction pipe consisting of alternating waves of condensation and rarefaction in the manner of an organ pipe closed at one end, the wave length depending on the length of the pipe. It will be obvious therefore that by giving a proper value to the length of the pipe for any given engine, which value will depend primarily on the stroke speed of the piston, the suction valve can be arranged to open at a moment when the air column is surging inwardly towards the suction valve or port and consequently this initial velocity of the entering air column will assist the entering charge to follow up the movement of the piston and contribute to filling the cylinder with a charge of air which will be considerably in excess of the stroke volume of the cylinder. As in motor engines of this class the maximum useful effect is dependent upon the volume of the charge in the cylinder it will be evident that by the above described mode of operating, the useful effect of an engine can be greatly increased. Experiments have shown that by this means instead of a charge only equal to 85 p. c. of the stroke volume, a cylinder charge equal to about 130 p. c. of such volume can be obtained.

In applying the invention to pumps or compressors running at a high speed, the pump is, according to one arrangement, constructed with only a discharge valve, which is preferably made as large as or even larger than the diameter of the cylinder, while for the inlet of the fluid slots are formed in the cylinder walls which are opened and closed by the piston and are so arranged that during the first part of the piston's stroke they are closed and consequently a partial vacuum is produced in the cylinder. As soon as the piston uncovers the slots the air or other fluid under atmospheric pressure rushes into the cylinder at a speed which increases until an equilibrium of pressure has been established, whereupon the pressure of the cylinder charge will be raised above that of the atmosphere in the same manner as above described. The arrangement is such that the piston closes the slots again at the moment

when the maximum pressure has been attained. The column of air in the suction pipe will then rebound towards the outside, thereby momentarily causing a certain degree of vacuum in the part next the slots, and an oscillating motion will thus be set up in the air column. The diagrams Figures 4 and 5 shown on the drawing to be presently described, clearly indicate this action. With a correctly proportioned length of the air column in the suction pipe, it will swing towards the cylinder slots at the moment that these are uncovered by the piston. The end motion of this oscillation of the column will be very slow, as shown by the diagrams. When employing such pumps for gas turbines, as for example for the construction described in the specification to my pending U. S. application No. 317,591, where it is desired to compress to a very high degree, such as 25 atm. in one stage, it is preferable to inject water into the air drawn in, so that the charge will then leave the pump at a temperature corresponding to that of the saturated steam at the maximum pressure in the pump. If the pump is of upright construction and there is an excess of water supply this will accumulate on the piston, which water will be at once evaporated at the commencement of the piston's down stroke, in consequence of the decrease of pressure, so that during such stroke no complete vacuum will be produced, and a corresponding economy in the work will be effected. Towards the end of the stroke the steam will be more or less condensed on the cold cylinder walls, in a similar manner to the action of a pulsometer, and on the inrush of the next charge of air and water spray its condensation will be completed.

By the above described method of operating pumps or compressors can be worked very efficiently at high velocities and can be made to compress air in a single stage to from 20 to 30 atmospheres.

It will be seen that by means of the above described improved method of operating the advantages are gained, on the one hand of being able to supply a much larger quantity of compressed air, or other fluid even, when working at maximum speeds, than with the ordinary arrangements; and on the other hand a considerable decrease of weight and cost of the apparatus and an increase of mechanical efficiency is obtained.

For reducing the noise caused by the inrush of air there may be provided on the end of the suction pipe a sound deadener similar to the exhaust silencers of internal combustion motors.

On the drawings Fig. 1 shows by way of example a vertical section of a compressing pump constructed according to my invention, the cylinder *a* being provided with air

inlet slots at *b*, which are controlled by the piston *c d*; is the discharge valve, seated directly upon the end of the cylinder; *e* is the air suction pipe and *f* the discharge branch for the compressed air.

Fig. 2 shows an indicator diagram for a pump such as above described when running at 300 revolutions per minute, the scale of the indicator spring being 10 m. m. = 2.8 atm.

Fig. 3 shows a governing diagram for 265 revolutions per minute, the scale of spring being the same as at Fig. 2. The work of the pump is in this case regulated by means of a throttle valve in the suction pipe.

Fig. 4 shows a diagram of the oscillations of the air column, the length of the column being 4.4 m., with a speed of 120 revolutions per minute; the scale of the indicator spring is 20 m. m. = 1 atm.

Fig. 5 shows a diagram of the column oscillations when the length of the column is 9.9 m. the speed and scale of the spring being the same as at Fig. 4.

I claim:

1. A method of increasing the volumetric efficiency of cylinder and piston machines drawing in charges of elastic fluid, which consists in causing the suction to occur through a pipe of such length that the pressure at the inlet port at the moment of closing is greater than the normal pressure of the fluid at said port.

2. A method of increasing the volumetric efficiency of cylinder and piston machines drawing in charges of elastic fluid, consisting in causing the suction to occur through a pipe of such dimensions that the oscillations set up in the column of elastic fluid therein are so timed that when the suction port is closed, the pressure toward the suction port of the elastic fluid due to the effect of the inertia of the column is at or near its maximum, substantially as described.

3. A method of increasing the volumetric efficiency of cylinder and piston machines drawing in charges of elastic fluid, consisting in causing the suction to occur through a pipe of such dimensions that the oscillations set up in the column of elastic fluid therein are so timed that when the suction port is closed, the pressure toward the suction port of the elastic fluid due to the effect of the inertia of the column is at or near its maximum and introducing such an excess of cooling water into the machine that part of the water evaporates in the cylinder during the suction stroke and is subsequently condensed, substantially as described.

4. A method of increasing the volumetric efficiency of cylinder and piston machines drawing in charges of elastic fluid, which comprises causing the elastic fluid to move in a column toward the inlet port and giving

said column a substantially maximum pressure node at the moment of closing of the inlet port, thereby producing a pressure within the cylinder at the time of closure of the port  
5 greater than the normal pressure of the elastic fluid.

In testimony whereof I have signed my

name to this specification in the presence of two subscribing witnesses.

ADOLF VOGT.

Witnesses:

OLIVER IMRAY,

J. PHILLIPS CRAWLEY.