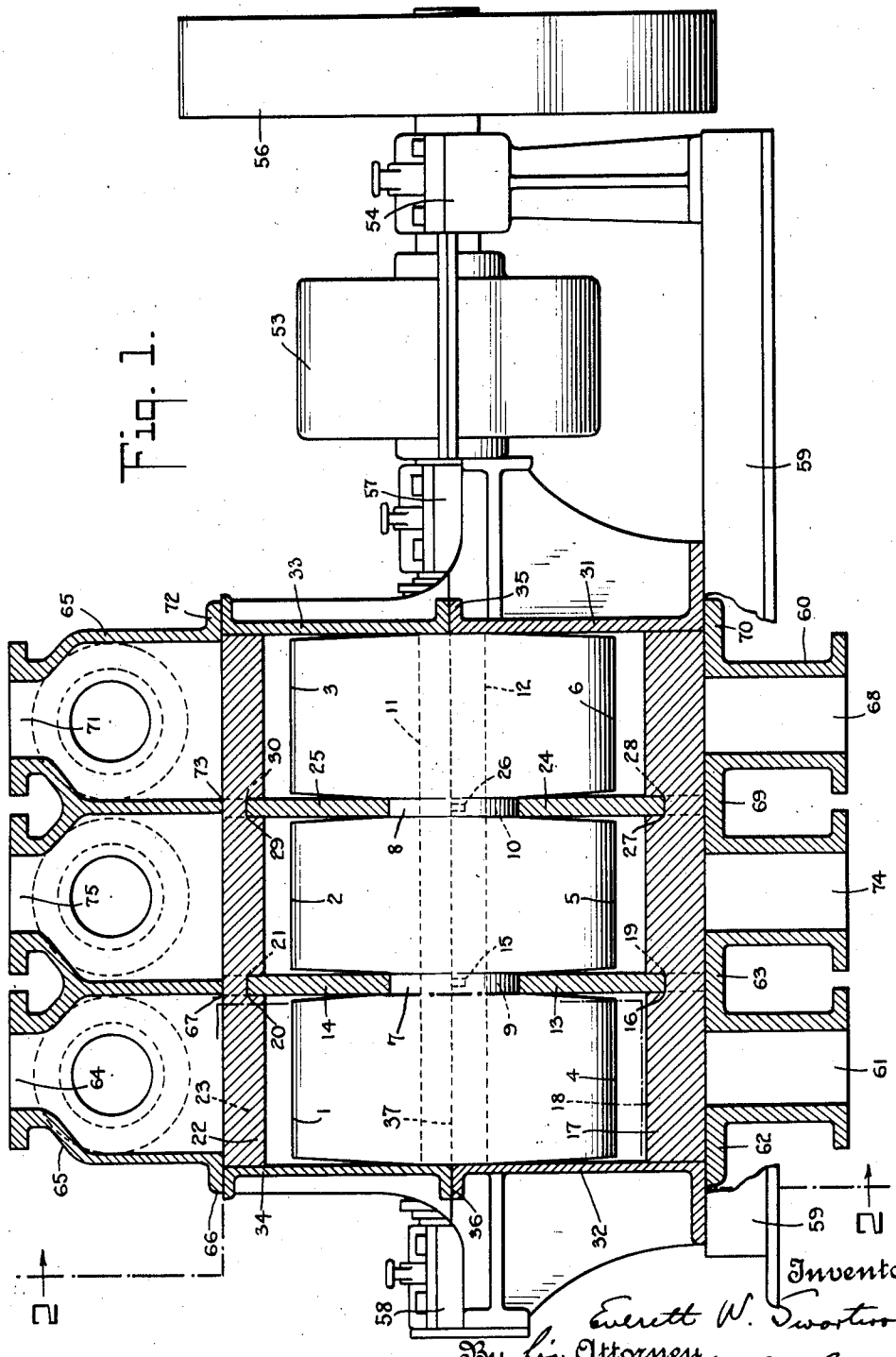
Aug. 11, 1931. E. W. SWARTWOUT 1,818,768

ROTARY BLOWER, PUMP, AND METER

Filed Sept. 28, 1927 4 Sheets-Sheet 1

Fig. 1.



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ROTARY BLOWER, PUMP, AND METER

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Fig. 2.

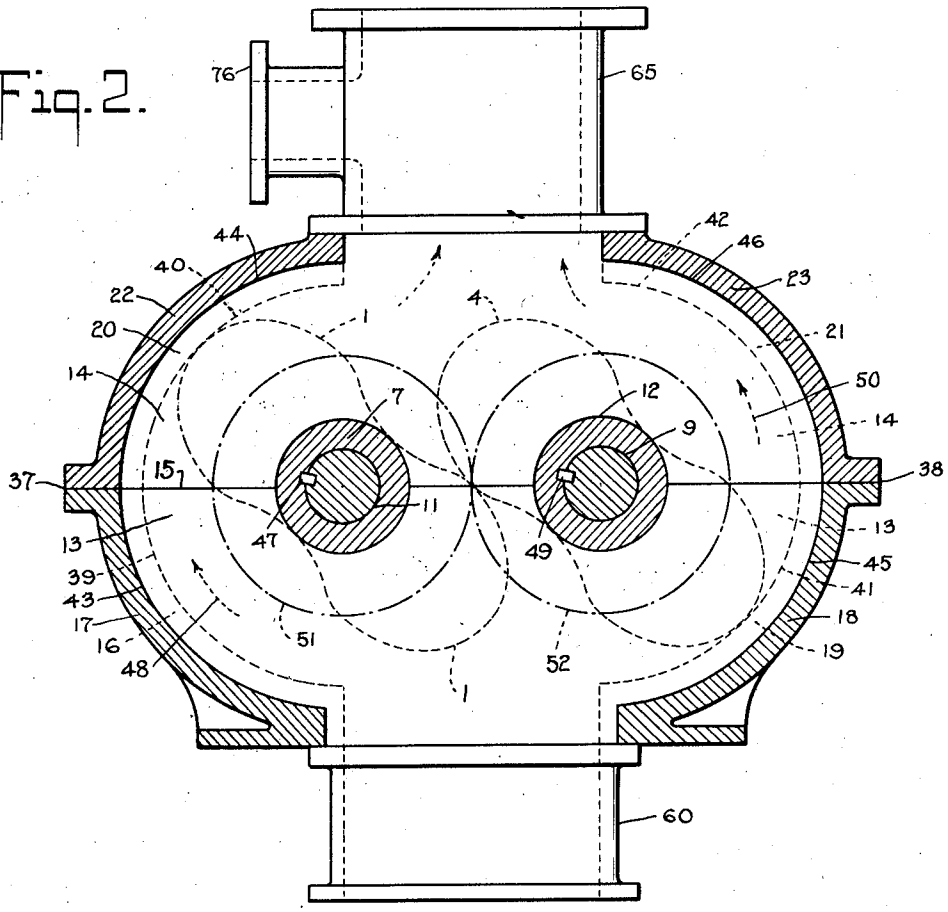
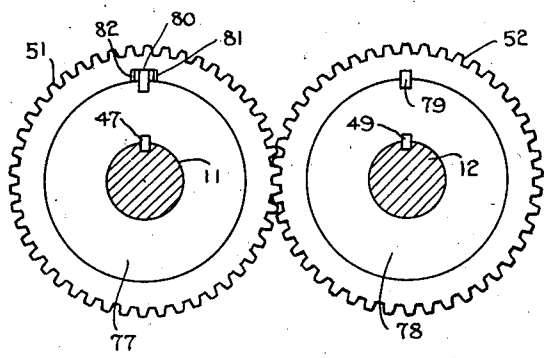


Fig. 3.



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ROTARY BLOWER, PUMP, AND METER

Filed Sept. 28, 1927 4 Sheets-Sheet 3

Fig. 10.

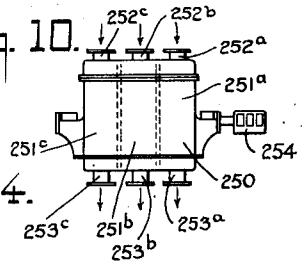


Fig. 4.

Fig. 6.

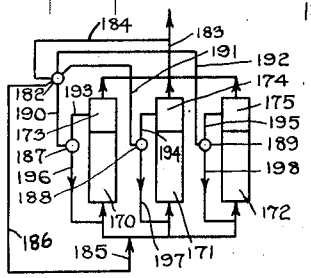


Fig. 7.

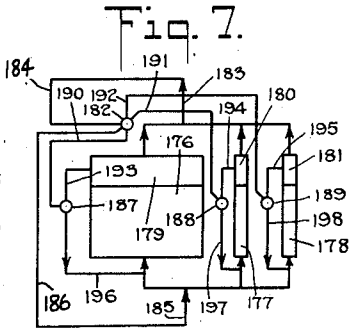


Fig. 8.

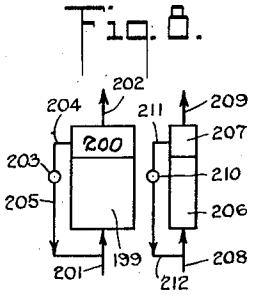
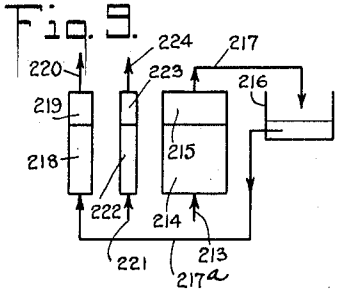


Fig. 9.



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ROTARY BLOWER, PUMP, AND METER

Filed Sept. 28, 1927 4 Sheets-Sheet 4

Fig. 5.

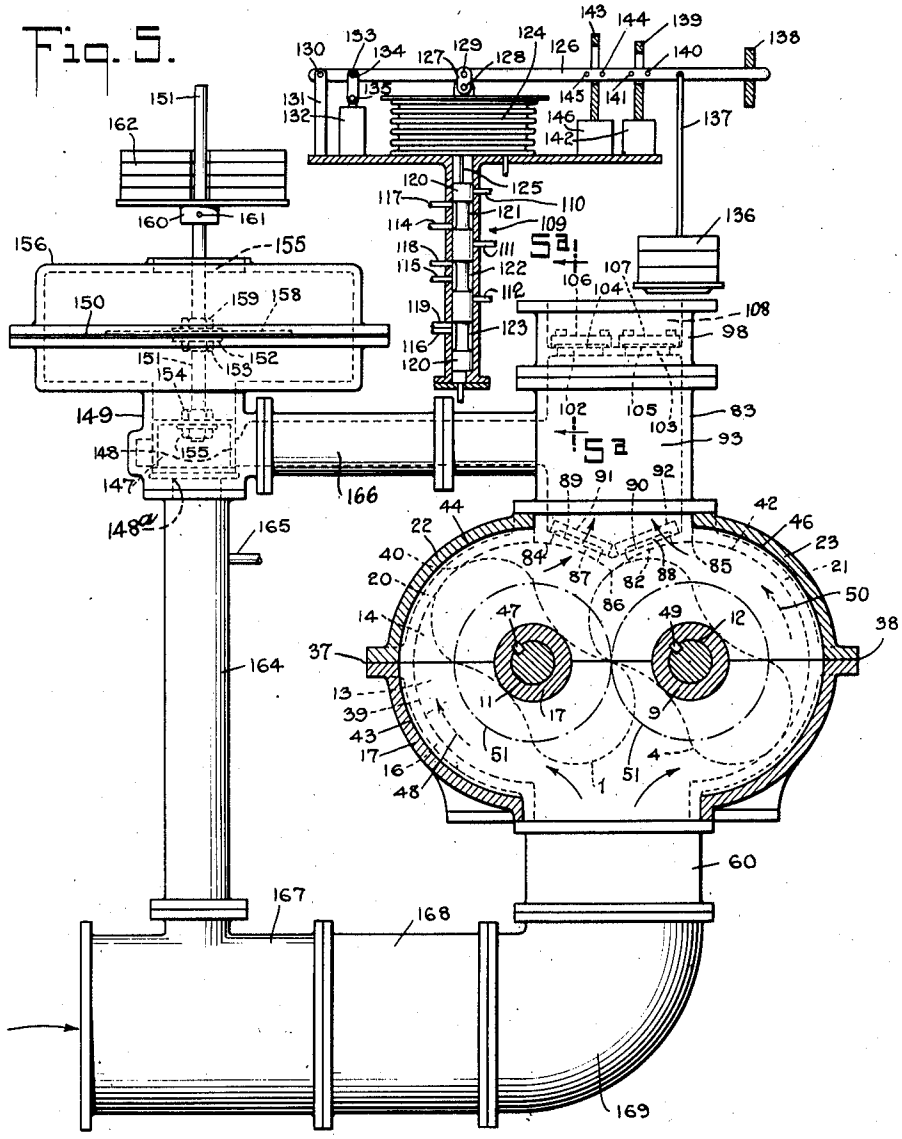
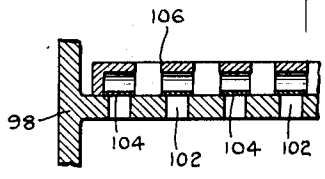


Fig. 5.a



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UNITED STATES PATENT OFFICE

EVERETT W. SWARTWOUT, OF WHITE PLAINS, NEW YORK

ROTARY BLOWER, PUMP, AND METER

Application filed September 28, 1927. Serial No. 222,455.

My invention relates to rotary blowers, pumps and meters.

More particularly, my invention relates to rotary machines, including blowers and pumps having more than one working compartment in each single cylinder provided with lobed impellers for the passage of the medium under compression or otherwise and further provided with means for progressively unloading the respective compartments when operating as a single stage unit on a single medium and adapted if desired to handle different media at the same time in adjoining compartments, with unloading means for each separate compartment, and also adapted to operate as a multi-stage single cylinder machine.

The invention embodies certain features set forth and claimed in my co-pending application Serial No. 219,225 filed September 13, 1927, entitled Rotary blowers and pumps.

According to my invention, when compressing or pumping solely one fluid or medium, the respective compartments, each having the same or different unit volumes respectively, may be controlled so that they will all deliver in parallel relation into the discharge pipe thus producing the full capacity of the unit to compress, or pump, and to deliver into the discharge pipe, or the respective compartments may be cut out or unloaded individually, and progressively, thus reducing the capacity and power consumption of the machine proportionately when operated at any particular speed, and, at the same time, heavy surging demands for electric power for the driving motor from the electric supply lines are avoided as compared with a motor driven single compartment unit in which unloading produces instantaneous electrical demand changes from full power to, say, nearly nothing and back to full power when delivery into the discharge pipe is resumed.

The accompanying drawings show one representative embodiment of my invention. Its principles may be applied in various ways without departing from the invention, as comprehended by the scope of the appended claims.

Fig. 1 is a side elevation of one form of my invention, partially in vertical central section terminating at the inlet and outlet pipe plates.

Fig. 2 is a transverse sectional elevation on line 2—2 of the arrangement shown in Fig. 1.

Fig. 3 is a detail elevation of a portion showing the method of attaching and setting the gears.

Fig. 4 is a side elevation, partially in central vertical section, showing one complete assembly of a unit embodying my invention, independently of my control or regulating equipment.

Fig. 5 is a transverse central elevation in partial vertical central section and shows one form of a complete assembly of my control and regulating equipment.

Fig. 5*a* is a detail section on line 5*a*—5*a* of Fig. 5.

Fig. 6 is a diagrammatic layout showing a three compartment machine with the same volume in each compartment, and under control of a master pilot valve controlling three diaphragm operated by-pass valves, one for each compartment, pursuant to my invention.

Fig. 7 is a diagrammatic layout showing a three compartment machine having one large volume compartment and two relatively smaller volume compartments with control, pursuant to my invention.

Fig. 8 is a diagrammatic layout of a two compartment machine for handling two different fluids, also pursuant to my invention.

Fig. 9 is a diagrammatic layout of a machine of a type and arrangement adapted to rotary filter presses, pursuant to my invention.

Fig. 10 is a side elevation, showing my invention applied to a multi-compartment meter.

Referring to Fig. 1, the three lobed sections of one of the impellers are designated 1, 2, 3, and the three lobed sections of the other impeller, directly behind the sections 1, 2, 3, are designated 4, 5, 6. The impellers may have their lobed sections in line with each other as shown or the respective sections or may be arranged in staggered relation in

paired relationship, as will be understood, thus producing an even torque on the respective shafts and an overlapping sequence of discharges when discharging into a common pipe. Each pair of opposite lobes will be made according to mathematical curves such as the involute, the cycloidal, or other curves which make their lobes interengage, mesh and mate in their various angular relationships with each other when rotated in opposite directions on parallel shafts, and without rubbing or contact between the respective pairs of lobes, or between the impellers and the surrounding casing, but with relatively small clearances. The cylindrical section 7 is provided between the adjoining lobes 1, 2. The cylindrical section 8 is provided between the adjoining lobes 2, 3. The cylindrical section 9 of the opposite impeller is provided between the adjacent lobes 4, 5, and the cylindrical section 10 or the opposite impeller is provided between the adjacent lobes 5, 6. The lobes 1, 2, 3 and the cylindrical sctions 7, 8 are preferably made of one continuous and integral casting when the adjacent lobes are in line. When desired, the adjacent lobes 1, 2, 3 may be made as separate elements, as may also the cylindrical sections 7 and 8. Also, the lobes 4, 5, 6 and the cylindrical sections 9, 10 may be made integral, or as separate parts as desired. The impeller lobed sections 1, 2, 3 and the cylindrical cojoining members 7, 8, forming one of the complete rotating elements, are concentrically mounted upon the shaft 11, preferably shrunk and keyed onto the shaft, first, and then machined and finished while in such position, while the impeller lobed sections 4, 5, 6 and the cylindrical co-joining members 9, 10 forming the other of the complete rotating elements are concentrically mounted upon the shaft 12, preferably shrunk and keyed onto the shaft first, and then machined and finished in such position.

The half section dividing plate 13, see Figs. 1 and 2, positioned in the lower half of the casing and its associated half section dividing plate 14 positioned in the upper half of the casing meet in a formed horizontal joint 15, and form a complete partition extending transversely across the interior of the casing, and are firmly held in place by projecting into the curved inner recesses 16, 19 of the quarter section of the cylinder in the back, both at the lower half of the casing, while the upper half section of the partition 14 projects into the curved inner recesses 20, 21 of the upper quarter sections 22 and 23 respectively of the cylinder.

Similarly, the lower half dividing section 24 meets the upper half dividing section 25 in the formed joint 26, the lower section 24 being firmly held in position in the recesses 27, 28 of the lower quarter sections 17, 18 of the cylinder and the upper half dividing section 25 being firmly held in position by the recesses 29, 30 of the upper quarter sections 22, 23 of the cylinder.

The casing is completed by the lower half end sections 31, 32 of the two head plates, attached to the ends of the cylinder quarter sections 17, 18 and by the upper half sections 33, 34 of the two head plates, attached to the ends of the quarter sections of the cylinder 22, 23.

Referring to Figs. 1 and 2, the head plate sections 31, 33, see Fig. 1, are bolted together along the parting line 35, and, similarly, the head plate sections 32, 34 are bolted together along the parting line 36. The cylinder quarter sections 17 and 22 are bolted together along the parting line 37, see Fig. 2, and the cylinder quarter sections 18, and 23 are bolted along the parting line 38.

The bore of the cylinder quarter section 17 is represented by the arc 39, see Fig. 2, which forms a semicircle when connected with the arc 40 representing the bore of the cylinder quarter section 22. Similarly, the bore of the quarter section 18 represented by the arc 42 forms a semicircle when joined together at the line 38. The recesses in the cylinder walls, in which the dividing plates 13, 14, 24 and 25 are held, are of depths as represented by the annular ring sections formed between the bore 39, 40 and the semicircular arc 43, 44 on one side of the machine, and by the annular ring sections formed between the bore 41, 42 and the semicircular arc 45, 46 on the other side of the machine.

The adjacent lobes 1, 2, 3 and the cylindrical sections 7, 8 of the one impeller member, mounted on the shaft 11 and also held by the key 47, rotates in clockwise direction as indicated by the arrow 48. The adjacent lobes 4, 5, 6 and the cylindrical sections 9, 10 of the second impeller member mounted on the shaft 12 and also held by the key 49, rotates in counter-clockwise direction as indicated by the arrow 50. One of the shafts 11, 12 may be the driving shaft and the other of the shafts may be the driven shaft. The shafts 11, 12 and their impeller members are connected together and one of them is driven from the other, and said shafts are caused to rotate in opposite directions by the meshing, synchronizing and timing gears represented by the circles 51, 52 respectively. The gears 51, 52 are disposed within the housing 53, preferably remote from the cylinder so that they can be fully protected from dust and dirt, and run in a bath of oil, to thereby more efficiently maintain the impeller members 1, 2, 3 and 4, 5, 6 respectively in proper timing relation to each other, and transmit half of the power. As there will be no rubbing between the impellers and the cylinder, and as a product free from oil is usually desired, with the small clearances provided, no lubrication within the cylinder is necessary.

The shorter shaft of the two shafts 11, 12 terminates in the double outer bearing 54 mounted upon the pedestal 55, whereas the longer shaft, the driving shaft, extends through the double outer bearing 54 and receives the drive pulley 56, or any other suitable driving means. The two shafts 11, 12 pass through the two bearings 57 supported by the head plate section 31 and, the two shafts 11, 12 terminate in the two bearings 58 supported by the head plate section 32. The head plate sections 31, 32 and the double outer bearing pedestal 55 are mounted upon the one piece bedplate 59.

The bottom pipe plate 60 has, in this embodiment of my invention, three separate openings, shown for the purpose of illustrating an arrangement suitable for handling three separate different mediums if desired without mixing. The bottom pipe plate 60 is provided with the opening 61, which with the flanges 62, 63 fitted against the head plate sections 32, the cylinder sections 17, 18 and the dividing partition plate 13, serves that compartment of the cylinder in which the lobes 1, 4 of the rotating members function. The medium discharged by the lobed sections 1, 4 passes through the opening 64 of the pipe plate 65. The top pipe plate 65 makes a tight fit with the region served solely by the impeller lobed sections 1, 4 by the flanges 66 and 67 fitted against the head section 34, the cylinder 22, 23 and the dividing partition plate 14. The opening 68 of the bottom pipe plate 60 makes a tight fit with the flanges 69, 70 with the cylinder sections 17, 18, the head plate section 31 and the partition plate 24, thus serving the lobes 3, 6 of the two impeller members. The discharge from the lobes 2, 5 passes through the opening 71 of the top pipe plate 65 which makes a tight fit with the flanges 72, 73 and the head plate section 33, the cylinder sections 22, 23 and the partition plate 14. The lobes 2, 5 are served by the opening 74 in the pipe plate 60 and discharge through the opening 75 of the top pipe plate 65. Thus it will be noted that three separate and distinct regions are provided within a single cylinder for compressing and pumping the same or different mediums from the same or different suction pressures, and discharged against the same or different pressures, with common drive means. The flange 76 may be blanked off or connected with any by-passing arrangement desired. When used in compressing air or gases, the arrangement which I have shown and described in Figs. 1 and 2 utilizes the instantaneous compression cycle, which cycle has been so universally used in the prior art.

Fig. 3 shows an improved means for mounting the gears so that the initial timing of the impellers may be easily and accurately accomplished. When the setting and fitting of the keys 47, 49 has been the sole means available, slight errors at so small a radius have produced relatively large errors in the angular relationship and timing of the gears at their pitch lines and still larger errors in the timing of the impellers causing them to strike and wear resulting in mechanical troubles and loss in efficiency due to increased clearances and increased leakage or slip back through the machine. Ordinary wear on the gears requires occasional taking up to preserve the original efficiency of this type of machine. To improve the ease and accuracy of adjustment of the gears, I provide the cylindrical blank 77 held to the shaft 11 by the key 47, and the cylindrical blank 78 held to the shaft 12 with the key 49. The gear teeth are cut in the annular blank 52, and mounted upon the blank 78 and keyed together by the key 79. Gear teeth are also cut in the face of the annular blank 51 which is mounted upon the blank 77. For the purpose of extreme accuracy in timing the impellers in the proper angular relation with each other, I provide the gibbed key 80 between the blanks 51 and 77 which is at a relatively large radius from the center of the shaft 11 as compared with the radius at which the key 47 is positioned. In connection with the gibbed key 80, the shims 81, 82 may be provided and changed when required to maintain the proper timing relation of the impellers.

Referring to Figs. 4 and 5, like parts are designated by like numerals and the same description applies as in Figs. 1 and 2 with the following exceptions. The top pipe plate or discharge chamber 83 comprises means for continuing the cylinder walls from the lines 84, 85 respectively to the common line 86 past which common line 86 each of the impeller members sweep. Also, the chamber 83 is provided with the ports 87, 88, the unidirectional valves 89, 90 and the valve bonnets 91, 92 respectively for each of the three compartments 93, 94 and 95 respectively, thus providing gradual and preferably adiabatic compression in each of the three compression regions respectively when all of the medium compressed is delivered into the discharge pipe, or by-passed through a throttling by-pass valve. Thus I have provided means for compressing or pumping three separate mediums, without mixing them together, from different suction pressures, and delivering them against three different pressures, all three compressions being according to the substantially gradual or adiabatic cycle, all in a single cylinder of multiple compartments and with common driving means. Many variations may be obtained as by proportioning the respective compartment volumes to suit any desired results, and by many different arrangements of piping in parallel or in series relation or in combination as desired.

In such installations as require a variable

quantity of gas or the like, delivered against the same or different predetermined pressures, at fixed or at relatively unvarying speeds, my invention comprises fluid pressure motor means for partially or completely unloading the machine, and by unloading the respective compartments progressively until the complete machine is entirely unloaded, the partial and complete unloading all being accomplished automatically as will be hereinafter set forth. This embodiment comprises the multiple compartment check valve 98 having the partitions 100, and 101 forming tight compartments with the partitions 96, 97 and the partitions 25 and 14 respectively, and having ports 102, 103 in the respective sections unidirectional valves 104, 105 and the valve bonnets 106 and 107 respectively, which prevent the return of the compressed medium from the discharge pipe side of the check valve, as at 108, back into the compartments of the chamber 83.

This embodiment also comprises the multiple ported pilot valve body 109 having spacially located ports 110, 111, and 112 and the connections 113, 114, all connected with the discharge 108, and the spacially located ports 114, 115 and 116 connected with the suction side of the machine, and the spacially located ports 117, 118 and 119 connected respectively to the gas compartments of three diaphragm operated by-pass valves, one for each of the respective compression compartments, all of these spacially related ports are controlled by a pilot valve 120 having the spacially located cut-away ports 121, 122, and 123. The pilot valve 120 is connected to the expansible bellows member 124 or the equivalent, by the valve stem 125. The interior of the expansible bellows member 124 is connected through its port 124*a* and pipe 124*b* with the delivery pipe 108 to contain gas at the pressure of the gas in the delivery pipe 108 and is balanced at three positions of elevation by connection with the lever 126, the link 127, the pin 128 and the pin 129. The lever 126 is fulcrumed at the pin 130 supported by the stud 131 mounted upon the body 109. The dash pot 132 may be used to stabilize the movement of the lever 126 by connection with the link 133 and the pins 134 and 135. The lever 126 is directly loaded with the weights 136, the rod 137, and the adjustably positioned weight 138. The slotted link 139 operating between the pins 140, 141 engages the lever 126 when lifted, accordingly preventing its further lifting except upon also lifting the weights 142, otherwise supported on the stand of the pilot valve body 109. A further raising of the lever 126 will engage the slotted link 143 operating between the pins 144, 145 attached to the lever 126, after which the weights 146 are lifted from their supporting stand 109. The pilot valve 120 controls the operation of three by-pass valves, each one of which loads and unloads one of the three compression compartments. Only one by-pass valve is shown in Fig. 5; the other two by-pass valves are the same in size and arrangement as the one shown.

The by-pass valve 147 controlling the port 148 is disposed within the valve body 149 and is operated by the diaphragm 150 connected to the valve stem 151 by the plate 152 and the nut 153, and to the valve 147 by the nuts 154 and 155. The cover 156 has the opening 157 through which the valve stem 151 extends. The diaphragm is connected at its upper side with the valve stem 151 by the plate 158 and the nut 159. The valve stem 151 supports the stand 160, attached to it by the pin 161. The stand 160 supports the weights 162, which may be varied in number and weight to suit the requirements. The port 165 of the pipe 164 is piped to the port 117 of the pilot valve 120. The port body of the second diaphragm is a similarly operated valve body and has a port similar to the port 163, and is similarly piped to the port 118 of the pilot valve 120. The third diaphragm operated valve is similar to the valve 147 and is similarly piped to the port 119 of the pilot valve body 109. In the position of the pilot valve as shown, the weights on the lever 126 are sufficient to hold the expansible bellows member in its lowest position corresponding to a relatively low discharge pressure in the pipe 108, and, therefore, the pilot valve 120 is held in its lowest position as shown. With the pilot valve 120 in the position shown, the cut away port 121 now interconnects the ports 117 and 114, which connects the suction line 164 through the pipe 165 with the gas space between the diaphragm 150 and the body 149. The weights 162 now hold the valve 147 closed and there can be no by-passing when in such closed position. Similarly, the port 122 of the pilot valve 120 interconnects the suction pipe with the interior of the second diaphragm operated by-pass valve by the ports 115 and 118, thus keeping the second by-pass closed. And, likewise, a third by-pass valve is kept closed by maintaining the suction pressure under the diaphragm by interconnecting the ports 116 and 119 of the valve body with the port 123 of the pilot valve 120. With all three by-pass valves 147, and the other two not shown, completely closed, all three compression compartments of the machine are delivering their full capacity into the discharge pipe, and there is no unloading.

As the pressure in the discharge pipe rises above any predetermined setting, the pilot valve 120 is raised and restrained in its first raised position to close the port 114, thus cutting off communication of the first diaphragm operated valve 147 with the suction, the port 110 will be uncovered, and the discharge pressure is effective in the port 121 of the pilot

valve 120, also in the port 117 of the body 109 and thence to the interior of the diaphragm 150, thereby lifting the weights 162 to move the by-pass valve 147 to its fully open position, whereby the first compression compartment is fully unloaded. At this stage, the capacity of the machine, and the power consumption is but approximately two thirds of the full capacity and similarly in power consumption. The gas passing through the first compression compartment into the compartment 93, the pipe 166, through the exit port 148 of pipe 166, then through inlet port 148*a* of pipe 164, and thence through the pipe sections 164, 167, 168 and 169 continues to recirculate through the machine at suction pressure, while the remaining two compartments are still compressing and delivering into the discharge pipe. If the capacity of the two remaining compartments is still too great to supply the reduced needs, then the pressure in the discharge pipe will rise, the pilot valve 120 will be raised to its second restrained position, the port 115 will be cut off from communication with the suction, the ports 118 and 111 will be interconnected and the pressure under the second diaphragm will be the discharge pressure, the second by-pass valve will be fully opened, and the capacity and power consumption will be reduced another third, i. e., to one-third of the full capacity, the second compression compartment will be circulating gas at the suction pressure through the chambers 94 and 74 and the interconnecting piping and compression compartment. Should the discharge pressure still continue to rise, the pilot valve 120 will be raised to its maximum elevation, thus closing off the communication of the port 116 with the suction, thus interconnecting the ports 119 and 112 together, thus making the delivery pressure effective under the diaphragm of the third diaphragm operated valve, to cause the valve to fully open and the third compartment is thereby fully unloaded, thereby recirculating gas only at the suction pressure through the chambers 95 and 61, and through the interconnecting piping. At this stage the machine is completely unloaded and nothing is being delivered into the discharge pipe.

Conversely, as the gas is taken from the discharge pipe to cause a drop in the discharge pressure, the third by-pass valve will become closed, thus increasing the capacity of the machine to its one-third capacity, then as the pressure drops still more in the discharge pipe, the second by-pass valve will be closed, and the capacity of the machine will be increased another third, i. e., to two-thirds of its capacity, and finally upon the pressure in the discharge pipe being not yet maintained at the predetermined value, the first diaphragm operated valve 147 will again close, thus increasing the capacity of the machine to its full capacity and to full power consumption. At this stage all three of the compression compartments are now compressing and delivering into the discharge line, and no unloading is effective.

Also, it will be understood that many variations in the needs for delivered gas in the discharge pipe may occur, with many corresponding variations in the amount of gas compressed and delivered or exhausted by the three respective compression compartments of this machine. As will also be understood, machines of this type may be made with their compartments of relatively different volumes, and with a number of compartments to suit the particular requirements, and with regulating and control devices accordingly.

Referring to Figs. 6 and 7, the arrangement shown in Fig. 6 is a complete diagrammatic assembly of a machine having for illustration, three equal volume compression compartments, and unloading controls, whereas the arrangement shown in Fig. 7 is similar to Fig. 6, with the exception that one large volume and two small volume compression compartments are represented for the purpose of indicating how two machines, each of the same external dimensions, each having the same total capacity, and each requiring the same power at similar speed and pressure differential, may, at the same time be most suitable for two entirely different operating conditions. The arrangement of Fig. 7 would be best for handling a large base load, with two relatively small compartments to handle relatively small changes over the base load, as for example, in the exhausting of coke oven gas. The arrangement of Fig. 6 would be better adapted for a constant speed squirrel cage induction motor driven booster for pumping gas in any community having large variations in demand with heavy peaks at certain times of each day. The arrangement of Fig. 6 shows how one single machine would have nearly all the advantages of three duplicate smaller units, each having one-third of the total capacity, while, on the other hand, the three smaller units would be more expensive in first cost, foundations, piping in the pumping station, and in the cost of the required buildings. The arrangement of Fig. 6 is much more economical in power consumption than one single large machine of the prior art type with throttling by-passing for varying the capacity, which incidentally, can only be used successfully through a relatively small proportion of decrease in capacity.

The low pressure regions 170, 171, 172 and the high pressure regions 173, 174, 175 of the three compartments of the arrangement shown in Fig. 6, and the low pressure regions 176, 177, 178 and the high pressure regions 179, 180, 181 of the three compartments of the arrangement shown in Fig. 7 are both

controlled by similar unloading set-ups, both of which are designated with the same reference numerals. The master pilot valve regulator 182 is connected with the discharge pipe 183 by the pipe 184, and with the suction pipe 185 by the pipe 186. The master pilot valve regulator 182 is also connected with the by-pass valves 187, 188, 189 by the pipes 190, 191, 192 respectively. The by-pass valves 187, 188, 189 are connected by the pipes 193, 194, 195 with the high pressure regions 173, 174, 175, respectively, and with the low pressure regions 170, 171, 172 by the pipes 196, 197, 198, respectively. The master pilot valve regulator 182, and the by-pass valves are preferably of the type shown and described in reference to Fig. 5.

Referring to Fig. 8, the relatively large volume compartment suction region 199, and the relatively large volume compartment high pressure region 200 receives air or gas from the suction pipe 201 and discharges into the pipe 202. The single unloader 203 is connected by the pipe 204 with the high pressure region 200, and with the low pressure region 199 by the pipe 205. The relatively small volume compartment low pressure region 206, and the relatively small volume compartment high pressure region 207 receives air or gas from the suction pipe 208 and discharges into the pipe 209. The single unloader 210 is connected by the pipe 211 with the high pressure region 207, and with the low pressure region by the pipe 212. In this embodiment of my invention, not only the two quantities of the medium handled, but also the pressure ranges of the two, may be same or different, and when desired, the two discharge lines may be joined together to produce mixtures. This application of my invention is particularly adapted to the gasifying of oil and the furnishing of secondary air during combustion, and also in the atomizing of oil, and for furnishing secondary air for combustion in connection with oil burners, at the respective desired quantities and pressures.

Referring to Fig. 9, this arrangement, shown diagrammatically is especially applicable for use in connection with rotary filters. In this arrangement, the pipe 213 contains the mixture of filtrate and entrained air sucked into the region 214 of the one compartment at high vacuum, while the higher pressure region 215 is discharging into the separating tank 216 through the pipe 217. The entrained air is separated out in the tank 216 while the liquid filtrate without air is sucked through the pipe 217*a* to the low pressure region of the compartment and is pumped from the high pressure region 219 of this compartment into the discharge pipe 220 to another part of the process. The dry air port of the filter requiring relatively less vacuum than in the sucking of the filtrate, is connected by the pipe 221, the air from which is sucked into the low pressure compartment region 222 and is discharged from the corresponding higher pressure region 223 where it may be discharged into the atmosphere through the pipe 224, or connections may be made with this pipe 224 for furnishing air under pressure for blowing the cake when desired as will be understood. The low pressure regions 214, 218, 222, and the high pressure regions 215, 219 and 223 are all within the one cylinder, and therefore accomplishes in one machine, what has been previously done with different machines with greater first cost and with greater power consumption than required pursuant to my invention.

In Fig. 10, I have illustrated my invention of the various forms herein described, as applied to a meter 250 of the lobed impeller and other types applicable to my invention. As illustrated, the meter 250 is shown with three compartments 251*a*, 251*b*, 251*c*; the number of compartments of course may be varied, as desired. The inlet ports of the respective compartments are indicated at 252*a*, 252*b* and 252*c* respectively, and the outlets at 253*a*, 253*b*, 253*c*, respectively. The individual, multiple or other type of meter for the readings and register of the respective meter compartments as indicated at 254.

It will be observed that my invention as illustrated in the accompanying drawings provides for the discharge of the compressors respectively into their discharge lines under conditions of pressure in the respective discharge lines not exceeding a pre-determined value, under which condition the by-pass means between the discharge and inlet openings of any compresseor is closed; further, under the condition of the pressure in any discharge line exceeding its pre-determined value, the discharge from its compressor is by-passed back to its inlet. Preferably, as is illustrated and described above, the valve controlling my by-pass means assumes in this operation either a fully open position or a fully closed position, under which latter condition the discharge from its compressor is wholly prevented from going into its discharge line and is led back through the open by-pass valve to the inlet opening of its compressor.

From the above, it will be apparent that my invention is particularly applicable for boosters in gas pumping stations using electric motors as the driving units. Machines of this type are also extremely useful and efficient when used for producing constant pressure vacuums by exhausting variable volumes of air with condensed steam vapor in suspension in connection with varying numbers of steam pressing bucks as used in the garment industry, as well as in the manufacture of paper in connection with in-

dividual paper machines, or in central vacuum plants, for producing vacuum on suction rolls and flat boxes, and many other similar applications.

In coke ovens, especially those utilizing charging methods which require large momentary periodic changes in the rate at which the gas should be exhausted, the speed of steam engines and steam turbines cannot be varied quickly enough to vary the capacity of the exhausters enough correspondingly to prevent relatively large fluctuations in the pressure of the gas exhausted from the ovens. With the use of my invention, the effective capacity of the exhausters may be instantly varied by partial or complete unloading, or cutting in again, irrespective of changes in the speed of the operating unit, and consequently, the desired close regulation of the pressure of the gas taken from the coke ovens is obtained.

Blowers made according to my invention are especially well adapted to the efficient blowing of water gas sets and are protected should blow-backs from the water gas set occur, while at the same time a number of sets may be served by one blower efficiently even though the respective cycles require several different quantities of air at the several respective pressures followed by, say, no need for air, but ready to instantly repeat the cycles.

My invention is especially applicable to those processes in industry which require two or more different quantities, or two or more equal quantities of air at respectively two or more correspondingly different pressures, as in the gasifying and burning of oil, the atomizing of oil in oil burners and the supplying of secondary air at respectively different quantities and pressures.

My invention is economical in first cost and is efficient, when used in the compressing and mixing of two or more different gases at a constant delivery pressure as is now accomplished by using separate and distinct units of the prior type for each gas to be compressed and delivered to make the desired mixture.

The principles of my invention may be used in gas meters of the lobed impeller type for measuring and mixing together two or more gases in predetermined proportions.

A prime use of my invention is in connection with filter presses by using only one machine to accomplish the several separate operations previously requiring different units, as one compartment of my cylinder may serve the dry air port, another may remove the filtrate with its entrained air under vacuum, and discharge it into a tank separating the air, from the filtrate, and a third compartment can be used for pumping the filtrate without air to the next stage in the process.

Pumps for vacuum heating systems may be operated pursuant to my invention for removing the air and water under vacuum, or for discharging the mixture into a hot well thus getting rid of the air, the water then being pumped back into the boiler in one or more stages of pumping as required.

Another application of my invention is obtained by connecting the compartments of the cylinder, having the desired volume in each of the respective compartments, in series relation thus producing with intercooling if desired when compressing, or when pumping, a two, three or more stage unit suitable with a relatively high differential pressure above the suction pressure with a relatively low differential pressure in each of the respective stages.

Whereas, I have described my invention by reference to specific forms thereof, it will be understood that many changes and modifications may be made without departing from the spirit of the invention.

I claim.

1. The combination of a casing comprising a cylinder having different compartments, compression means disposed within said compartments respectively, common driving means for said compression means, and capacity varying means for said compartments respectively, said capacity varying means including a pilot valve, a diaphragm, a valve controlled by said diaphragm, by-pass passage means leading from the delivery side of said compartments respectively to the suction side of said compartments respectively, said valve controlling the opening and closing of said by-pass passage means, a housing for said pilot valve, said housing being provided with ports, and passage means co-acting with said pilot valve for moving said diaphragm and said valve to opened and closed positions respectively responsive to variations of the delivery pressure of said compartments respectively.

2. The combination of a casing comprising a cylinder having different compartments, compression means disposed within said compartments respectively, common driving means for said compression means, and capacity varying means for said compartments respectively, said capacity varying means including a pilot valve, a diaphragm, a valve controlled by said diaphragm, by-pass passage means leading from the delivery side of said compartments respectively to the suction side of said compartments respectively, said valve controlling the opening and closing of said by-pass passage means, a housing for said pilot valve, said housing being provided with ports, and passage means co-acting with said pilot valve for moving said diaphragm and said valve to opened and closed positions respectively responsive to variations of the de-

livery pressure of said compartments respectively.

3. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means for said compartments, inlet means for said compartments respectively, piping interconnecting certain of said compartments in parallel relationship to one another, passage means respectively connecting each said inlet means with its said discharge means, a valve for each of said passage means, means for operating said valves respectively to solely fully opened and fully closed positions, and means responsive to the pressure of said discharge means for controlling said valve operating means.

4. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, piping interconnecting certain of said compartments in parallel relationship to one another, passage means respectively connecting each said inlet means with its said discharge means, a valve for each of said passage means, individual means for operating valves respectively solely to fully opened and fully closed positions, and means responsive to the pressure of said discharge means respectively for controlling said individual valve operating means respectively.

5. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, piping interconnecting certain of said compartments in parallel relationship to one another, passage means respectively connecting each said inlet means with its said discharge means respectively, a valve for each of said passage means, means for operating said valve solely to fully opened and fully closed positions respectively and means responsive to the pressure of said discharge means and of said inlet means respectively for controlling said valve operating means.

6. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means for said compartments, inlet means for said compartments respectively, passage means respectively connecting each said inlet means with said discharge means, a valve for each of said passage means, and means responsive to the pressure of said discharge means for controlling said valves respectively, said pressure responsive means including a common pilot valve.

7. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, passage means respectively connecting said inlet means with said discharge means, a valve for each of said passage means, means for operating said valves solely to fully opened and fully closed positions and means responsive to the pressure of said discharge means respectively for controlling said valve operating means, said pressure responsive means including a common pilot valve.

8. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, passage means respectively connecting each said inlet means with said discharge means respectively, a valve for each of said passage means, means for operating said valves solely to fully opened and fully closed positions and means responsive to the pressure of said discharge means respectively for controlling said valve operating means, said pressure responsive means including a common pilot valve.

9. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments, piping interconnecting certain of said compartments in parallel relationship to one another, passage means respectively connecting each said discharge means with its said inlet means, a valve for each of said passage means, individual means for operating said valves to solely fully opened and fully closed positions and means responsive to the pressure of said discharge means and of said inlet means respectively for controlling said individual valves operating means respectively.

10. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments, passage means respectively connecting each said discharge means with said inlet means, a valve for each of said passage means, means for operating said valves solely to fully opened and fully closed positions and means responsive to the pressure of said discharge means and of said inlet means respectively for controlling said valve operating means, said pressure responsive means including a common pilot valve.

11. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, piping interconnecting certain of said compartments in parallel relationship to one another, passage means respectively connecting each said inlet means with its said discharge means, a valve for each of said passage means, means for operating said valves solely to fully opened and fully closed positions respectively, a uni-directional valve in said discharge means posteriorly of the location of communication therewith of its said passage means, and means responsive to the pressure of said discharge means respectively for controlling said passage means valve operating means respectively.

12. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, piping interconnecting certain of said compartments in parallel relationship to one another, passage means respectively connecting each said inlet means with its said discharge means respectively, a valve for each of said passage means, means for operating said valves respectively solely to fully opened and fully closed positions, a unidirectional valve in said discharge means posteriorly of the location of communication therewith of its said passage means, and means responsive to the pressure of said discharge means respectively for controlling said passage means valve operating means respectively.

13. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, passage means respectively connecting each said inlet means with said discharge means respectively, a valve for each of said passage means, a unidirectional valve in said discharge means posteriorly of the location of communication therewith of its said passage means, and means responsive to the pressure of said discharge means respectively for controlling said passage means valves respectively, said pressure responsive means including a common pilot valve.

14. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments, passage means respectively connecting said discharge means with said inlet means, a valve for each of said passage means, means for operating said valves respectively to fully opened and fully closed positions, a unidirectional valve in said discharge means posteriorly of the location of communication therewith of its said passage means, and means responsive to the pressure of said discharge means and of said inlet means respectively for controlling said passage means valve operating means respectively.

15. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments, passage means respectively connecting each said discharge means with said inlet means, a valve for each of said passage means, means for operating said valves respectively solely to fully opened and fully closed positions, a unidirectional valve in said discharge means posteriorly of the location of communication therewith of its said passage means, and means responsive to the pressure of said discharge means and of said inlet means respectively for controlling said passage means valve operating means respectively, said pressure responsive means including a common pilot valve.

16. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, piping interconnecting certain of said compartments in parallel relationship to one another, passage means respectively connecting each said inlet means with its said discharge means, a valve for each of said passage means, individual means for operating said valves respectively to fully opened and fully closed positions, a unidirectional valve in said discharge means posteriorly of the location of communication therewith of its said passage means, and pressure responsive means for controlling said individual valve operating means respectively.

17. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, means for actuating said impellers, discharge means respectively for said compartments, inlet means for said compartments respectively, passage means respectively connecting said inlet means with said discharge means respectively, a valve for each of said passage means, a unidirectional valve in said discharge means posteriorly of the location of communication therewith of its passage means, and pressure responsive means for controlling said valves respectively, said pressure responsive means including a common pilot valve.

18. The combination of a blower having a plurality of compartments, each compartment having an inlet opening and a discharge opening, impellers for said compartments respectively, common means for actuating said impellers, discharge lines for said compartments respectively, and means for controlling the discharge from said compressors respectively into said discharge line, said controlling means comprising by-pass means respectively for said compartments, each by-pass means connecting at its one end with the discharge opening of its compressor and its opposite end with the inlet opening of its compressor, valves respectively controlling said by-pass and valve means respectively controlled by the pressure in said discharge lines respectively for operating the valve means of its by-pass means alternately to fully opened and fully closed positions.

19. The combination of a blower having a plurality of compartments, each compartment having an inlet opening and a discharge opening, impellers for said compartments respectively, common means for actuating said impellers, discharge lines for said compartments respectively, and means for controlling the discharge from said compressors respectively into said discharge line, said controlling means comprising by-pass means respectively for said compartments, each by-pass means communicating at its one end with the discharge opening of its compressor and its opposite end with the inlet opening of its compressor, valves respectively controlling said by-pass means and power operated valve means respectively controlled by the pressure in said discharge lines respectively for operating the valve means of its by-pass means alternately to fully closed positions.

20. The combination of a blower having a plurality of compartments, each compartment having an inlet opening and a discharge opening, impellers for said compartments respectively, common means for actuating said impellers, discharge lines for said compartments respectively, and means for controlling the discharge from said compressors respectively into said discharge line, said controlling means comprising by-pass means respectively for said compartments, each by-pass means connecting at its one end with the discharge opening of its compressor and its opposite end with the inlet opening of its compressor, valves respectively controlling said by-pass means and valve means respectively controlled by the pressure in said discharge lines respectively for operating the valve means of its by-pass means alternately to fully opened and fully closed positions, each of said valve means comprising a pilot valve member, a casing enclosing said pilot valve member and provided with a port, and piping connecting said port with its discharge line.

21. The combination of a blower having a plurality of compartments, each compartment having an inlet opening and a discharge opening, impellers for said compartments respectively, common means for actuating said impellers, discharge lines for said compartments respectively, and means for controlling the discharge from said compressors respectively into said discharge line, said controlling means comprising by-pass means respectively for said compartments, each by-pass means connecting at its one end with the discharge opening of its compressor and its opposite end with the inlet opening of its compressor, valves respectively controlling said by-pass means and valve means respectively controlled by the pressure in said discharge lines respectively for operating the valve means of its by-pass means alternately to fully opened and fully closed positions, each of said valve means comprising a pilot valve member, a casing enclosing its pilot valve member and provided with a plurality of ports and piping respectively connecting its ports with its discharge line and the inlet opening of its compressor.

22. The combination of a blower having a plurality of compartments each compartment having an inlet opening and a discharge opening, impellers for said compartments respectively, common means for actuating said impellers, discharge lines for said compartments respectively, and means for controlling the discharge from said compressors respectively into said discharge line, said controlling means comprising by-pass means respectively for said compartments, each by-pass means connecting at its one end with the discharge opening of its compressor and its opposite end with the inlet opening of its compressor, valves respectively controlling said by-pass means and valve means respectively controlled by the pressure in said discharge lines respectively for operating the valve means of its by-pass means alternately to fully opened and fully closed positions, each of said valve means comprising a pilot valve member, a casing enclosing its pilot valve member and provided with a port and piping connecting its port with the inlet opening of its compressor.

23. The combination of a blower having a plurality of compartments, each compartment having an inlet opening and a discharge opening, impellers for said compartments respectively, common means for actuating said impellers, discharge lines for said compartments respectively, and means for controlling the discharge from said compressors respectively into said discharge line, said controlling means comprising by-pass means respectively for said compartments, each by-pass means connecting at its one end with the discharge

opening of its compressor and its opposite end with the inlet opening of its compressor, valves respectively controlling said by-pass means and valve means respectively controlled by the pressure in said discharge lines respectively for operating the valve means of its by-pass means alternately to fully opened and fully closed positions, each of said valve means comprising a pilot valve member, a casing enclosing its pilot valve member and provided with a port at which the pressure is maintained the same as that of the inlet opening of its compressor.

24. The combination of a blower having a plurality of compartments, impellers for said compartments respectively, common means for actuating said impellers, discharge piping and inlet piping for said compartments, piping interconnecting certain of said compartments in parallel relationship to one another, passage means for interconnecting each of said discharge means respectively with its inlet piping, unidirectional valve means for said discharge piping, valve means for said passage means, and means responsive to the pressure of said discharge piping for operating said valve means respectively solely to fully opened and fully closed positions.

In testimony whereof I have signed this specification this 20th day of September 1927.

EVERETT W. SWARTWOUT.