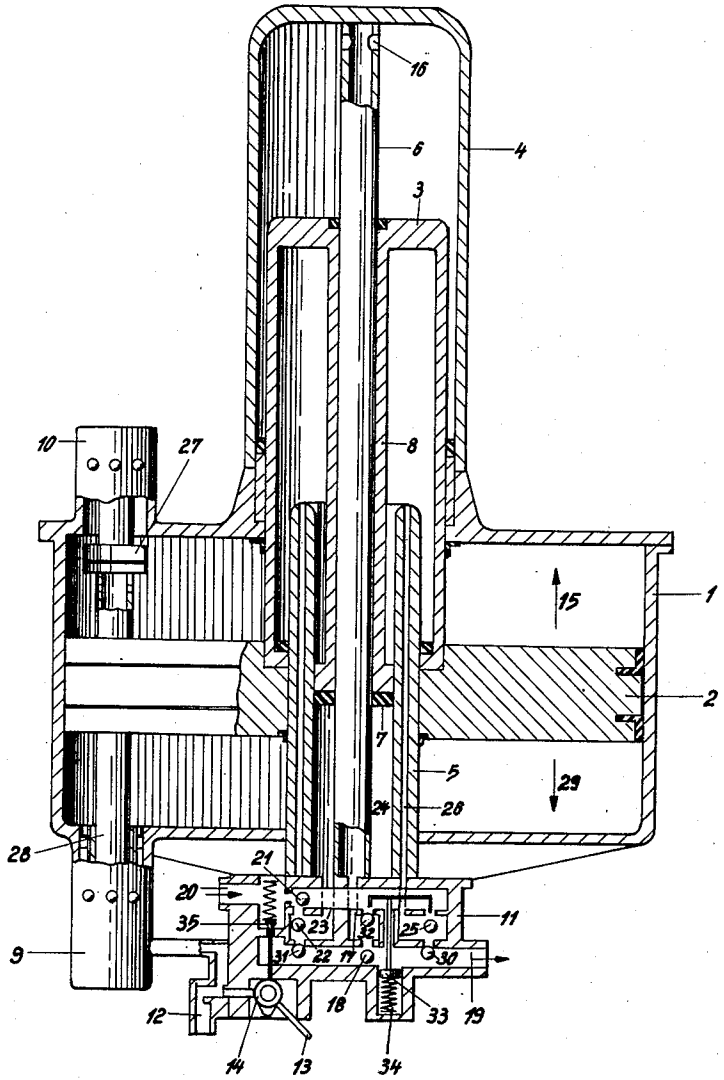
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MULTISTAGE PUMP

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MULTISTAGE PUMP

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It is generally known to use in lifting installations as operating medium especially compressed air beside other forms of energy since same can be generated and stored with comparative ease for stationary as well as portable installations. The compressed air may also simultaneously be used for different other purposes.

The pressures, however, at which the operation may be carried out usually can not be increased beyond a certain value in view of the stresses otherwise developing in all parts of the installation, such as conduits, valves, reservoir and outlet elements, and moreover in view of the extensive and difficult measures to be taken for sealing, particularly in movable elements, which measures must be taken to assure safety of operation.

In the pressures normally applicable for raising heavy loads the disadvantageous necessity arises of providing correspondingly high press dimensions and piston cross sections. This necessity becomes a reality if, as in portable installations, for structural reasons the storage volume of the compressed air is limited and telescopically related pressure pistons must be employed. While here the pistons successively operable need higher pressures corresponding to their decreasing cross-sections, the pressure available from the storage reservoir diminishes corresponding to the adiabatic or polytropic pressure drop occurring in the use of pressure. Thus two directly opposite requirements exist which cannot be complied with, and as a result, as practice has demonstrated, stored compressed air as a direct source of energy for driving such lifting installations, especially those with telescopic pistons, is an unsuited medium.

Lifting installations operated directly with compressed air, therefore, can operate only with single lifting piston, however here, particularly with portable installations, e. g. in tilting devices, structural limits as to piston diameter and piston stroke exist. The power excess conditioned by the pressure drop causes harmful inertia forces by high acceleration of the load to be lifted which in the long run lead to damaging the lifting installation and its base, e. g., the portable frame.

Auxiliary installations with compressed air in which hydraulic pressure means, e. g. oil, is interposed, can remove the above mentioned defects if they comply with the requirements of a telescopic piston. Oil pumps operated by compressed air can rationally operate only with a single hydraulic piston, have limited possibilities of use and are little suited if the stroke duration is intended to be short. In order to afford relief

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in this case, for lifting installations pressure changers were constructed which afford a proper outward stroke of the telescopic piston after due consideration of its pressure requirements.

Such a pressure changer operates e. g. with two hydraulic pressure generators which are driven by a double-acting compressed-air piston. Thereby two hydraulic pressure steps, one for the initial stage and the other for the final stage of the lifting operation, may be generated. This pressure changer shows already a superiority over other systems by a uniformity of the extension of the telescopic piston press, by the short duration of the stroke, but in its stroke power is also bound within certain limitations.

The present invention relates to a pneumatic-hydraulic multistage pressure generator or pump, especially for lifting installations with plural-step presses in which a double-acting pneumatic drive piston directly cooperates with several hydraulic pressure generators so that the effective cross-sections of the pressure generator pistons can be selectively connected singly or in any combination.

The drawing shows an execution example of the invention subject in lengthwise section.

In a housing 1 a pressure-propelled piston 2 displaceable in both directions is rigidly connected with a pressure-generating piston 3 constituting the piston rod. As a result, piston 3 is displaced corresponding to the displacement of piston 2 in a housing 4 which is connected to housing 1. In housing 1 is also arranged a stationary piston 5 and simultaneously constitutes an inner guide for the piston 2, sliding thereon in either direction. In housing 4 there is a stationary central guide tube 6 on which an additional piston 7 is displaceable within the interior of the stationary piston 5. Piston 7 is connected to piston 3 by rod 8. Therefore pistons 2, 3 and 7 move always in unison.

To housing 1 are connected control heads 9 and 10 for the pressure medium of piston 2 and a control head 11 for the pressure medium moved by pistons 3, 5 and 7 acting as pressure generators.

The drive piston 2 may be driven by fuel, steam, compressed air or other available energy. The present example relates to the employment of compressed air since this is the most frequent case.

As a medium in the pressure generator any liquid, preferably oil, may be used if, as in the present case, mostly lifting installations are concerned.

The admission of the compressed air which is either taken from a reservoir or, as needed, is supplied by an air pump, is effected through conduit 12 the admission valve 13 of which is mechanically controlled by handle 13 or automatically by a cam shaft 14. The compressed air admitted pushes piston 2 in direction 15, the air displaced by the moving piston on its rear side leaving through outlet openings in control head 10.

In the same direction as piston 2 moves piston 3 in housing 4, the oil displaced by corresponding pressure flowing through openings 16 into the central tube 6 and conduit 17 in control head 11 and through the automatic pressure valve 18 into pressure conduit 19 leading to the press of the lifting installation. Since of the pressure generating pistons 3, 5 and 7, piston 3 has the largest effective cross-section, the lowest pressure stage results thereby for the initial operation of a multistage press of the lifting installation for the largest piston thereof. The oil sucked in during this motion by piston 7 flows from a reservoir through conduit 29 to the automatic suction valves 21 and 22 and thereupon through conduit 23 into the annular space 24 between tube 6 and the inner surface of piston 5. The oil sucked in simultaneously by piston 3 flows through conduit 26 and suction valves 21 and 25 and through a conduit located within piston 5 which conduit may take the form of a bore, channel or as shown in the illustration, may preferably be constructed as a concentrically arranged hollow space 26 with circular ring cross-section, into the interior of piston 3. At the end of its first stroke in direction 15 piston 2 automatically closes by the pickup and outlet valve 27 the air outlet openings in control head 10 and while simultaneously opening the supply conduit also in control head 10, guides the compressed air through tube 28 to the other side of piston 2 which accordingly carries out the second stroke in direction 29. During this operation hollow piston 3 acts as a housing the oil content of which is pressed by piston 5 into pressure conduit 19 corresponding to its circular ring cross-section while pressure is created above hollow space 26 by opening the automatic pressure valve 30. The oil quantity displaced by piston 7 flows through conduit 23 and the pressure valve 31 also automatically opening simultaneously into the pressure conduit, during this stroke the effective cross-sections 5 and 7, which are smaller than the effective cross-section of piston 3, are added up and as a result cause by the increased oil pressure the second operating stage of the lifting press. The oil sucked in during this second stroke of piston 2 by piston 3 flows from supply conduit 29 through the again automatic suction valves 21 and 32 and through conduit 17 and pipe 6 through openings 16 into housing 4. The opening of suction valve 32 can be effected by the aid of small piston 33 which is displaced by the increased pressure of conduit 19 in opposition to the action of a spring 34 and transmits this motion by a rod structure to valve 32. During this second stroke of piston 2 the two suction valves 21 and 22 open during the first stroke, and also pressure valve 18 are automatically closed.

The third stroke of piston 2 which after the automatic change of the compressed air stream in control heads 9 and 10 proceeds again in direction 15, increases the pressure generated during the second stroke in conduit 19 since piston 3 during this operation presses the oil under pressure in the housing 4 through openings 16 and tube 6 into conduit 17 and the automatically opening pressure valve 18 into conduit 19. The effective cross-section of piston 3 is then decreased by the effective cross-sections of pistons 5 and 7, is thus smaller than during the second stroke of piston 2 so that in this manner owing to the increased oil pressure the third piston stage of the lifting installation is operated. During this stroke suction valves 22, 25 and 32 are automatically opened, the latter two by small piston 33 which is still more displaced in opposition to the effect of spring 34 by the increased pressure and thereby holds the two valves open by the rod structure connected thereto so that a part of the pressure oil can flow into space 24 and the interior of piston 3. Suction valve 21 during this stroke of piston 2 is closed like valves 30 and 31.

During the fourth stroke of piston 2 in direction 29, piston 7, the cross-section of which is alone effective, presses the oil through conduit 23 and the automatically opening pressure valve 31 into conduit 19 while otherwise a pressure equalization takes place through suction valves 25 and 32 subsequently opening and oil flows from conduit 29 through automatically opening suction valve 21 to the extent that it is not displaced by piston 3 during this stroke through hollow space 26 and the tube 6 into housing 4. Suction valve 22 and pressure valve 18 are closed at that time. During this stroke the highest oil pressure in conduit 19 is reached and thereby the fourth stage of the lifting press is started for operation.

The interruption as well as the continuation of the operations is effected mechanically or automatically by handle 13 or control shaft 14 respectively, which closes or opens the admission valve of compressed air supply pipe 12. Simultaneously with the closing at the end of the fourth stroke of piston 2 valve 35 may be opened through mechanical connection which valve connects the oil pressure and suction conduit 19 and 29 to one another so that a pressure equalization takes place and the oil is automatically forced back to the reservoir by the potential energy of the lifting installation returning to its initial position. Valve 35 simultaneously constitutes an automatic safeguard against exceeding the maximum pressure permissible for the installation.

In an arrangement of additional suction and pressure valves by further combinations of the three telescoping pressure generators the number of attainable pressure stages can be increased as desired. For example, by addition of a further valve arrangement corresponding to the elements controlled by small piston 33, results the possibility of using as further steps of the effective cross-section piston 3 alone, the difference between pistons 3 and 5, and also piston 5 alone.

The movable pistons, piston rods and their guide elements in the described arrangement are in telescopic concentric relation which has the advantage of an extraordinarily simple and compact construction. This is only possible by the fact that each element performs several functions.

Piston 3 constitutes simultaneously the piston rod of the compressed air piston 2 and the housing for piston 5 and thus has a triple function, while piston 5 also serves as housing for piston 7 and as inner guide of piston 2, thus also serves a triple purpose.

In the particular arrangement of the elements

of the pressure generator and of the performances of several tanks the described automatically acting valve arrangement in the control head 11, it is made possible to render the effective cross-sections effective alone or to couple them in added or subtracted relation during successive strokes of the drive piston in a manner corresponding to the respective requirements and to thereby obtain the required necessary number of pressure steps.

As a matter of course the plant of the described kind may be employed not only for lifting installations. Fundamentally it may also be employed as high pressure lubricating press, lubricant measuring pump, conveying pressure generator, as pressure generator in metal presses, stamping, hydraulic hammers and the like, that is its employment within the meaning of the invention is possible everywhere where the generation of pressure of different valves in a steplike manner corresponding to purpose is concerned.

What we claim as new and want to secure by Letters Patent is the following:

1. A multistage pump comprising a penumatic cylinder, a double-acting piston movable within the cylinder, a conduit connected to a source of pneumatic pressure, means connected to the cylinder and conduit and alternately directing the pneumatic pressure medium to opposite sides of the piston, a hydraulic cylinder connected to the pneumatic cylinder, a plurality of the plungers including a double-acting plunger rigid with the pneumatic piston and slidable in the hydraulic cylinder, the plurality of plungers also including plungers in slidable relation to the piston, a hydraulic reservoir, a hydraulic suction inlet conduit connected at one end to the reservoir and at the other end to the hydraulic cylinder, a hydraulic outlet conduit connected to the hydraulic cylinder, and automatic valve means increasing the pressures of the plungers in the hydraulic outlet conduit successively during successive strokes of the piston.

2. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston and one of the remaining plungers is stationary and of a cross-section smaller than that of the first plunger and guides the piston.

3. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston and comprising a central hollow rod guiding the first plunger and constituting a conduit for the hydraulic pressure medium.

4. The pump according to claim 1 and wherein the first plunger is hollow and connected to a third plunger having a smaller cross-section than a second stationary plunger guiding the piston.

5. The pump according to claim 1 and wherein the first plunger is hollow and guided by a second stationary plunger and connected to a third plunger guided within the second plunger.

6. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston and comprising a central hollow rod guiding the first plunger and having one end adjacent the hydraulic cylinder top and having openings adjacent thereto and being at the other end connected to a valve housing having valves automatically establishing communication with the interior of the stationary plunger.

7. The pump according to claim 1 and wherein the first plunger is the piston rod of the piston guided by a second smaller and stationary hollow plunger having a hollow wall, a valve housing, the hollow of the plunger wall constituting the connection between the interior of the first plunger and the valve housing and the interior of the second stationary plunger.

8. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston, the piston being guided by a second, stationary, hollow plunger of smaller cross-section than that of the first plunger and having a hollow wall, a valve housing, the hollow of the wall constituting the connection between the interior of the first plunger and the valve housing.

9. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston and comprising a central hollow rod guiding the first plunger and having one end adjacent the hydraulic cylinder top and having openings adjacent thereto, a valve housing connected to the other end of the hollow and to the hydraulic inlet conduit, suction valves in the hydraulic outlet conduit, and a spring-loaded plunger and rod opening the suction valves.

10. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston and comprising a hollow rod guiding the first plunger and having one end adjacent the hydraulic cylinder top and having holes adjacent thereto, a valve housing connected to the other end of the hollow rod and connected to the hydraulic inlet conduit, a spring-loaded valve in the hydraulic inlet conduit and constituting safety-valve and a valve connecting to the hydraulic inlet conduit.

11. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston and comprising a central hollow rod guiding the first plunger and having one end adjacent the hydraulic cylinder top and having openings adjacent thereto, and also comprising a valve housing connected to the other end of the hollow rod, and control means in the valve housing for the pneumatic pressure medium driving the piston.

12. The pump according to claim 1 and wherein the first plunger constitutes the piston rod of the piston and comprising a central hollow rod guiding the first plunger, and having one end near the hydraulic cylinder top and having openings adjacent thereto, and comprising a valve housing connected to the other end of the hollow rod, a hydraulic safety valve in the valve housing, a control valve for the pneumatic pressure medium connected to the hydraulic safety valve and opening upon closing the safety valve and closing upon opening the safety valve.

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