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Yoda et al.

[11] **3,759,560**

[45] **Sept. 18, 1973**

[54] **CONVEYING APPARATUS HAVING VACUUM TYPE HOLDING MEANS**

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[73] Assignee: **Hitachi, Ltd.**, Tokyo, Japan

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[30] **Foreign Application Priority Data**

Aug. 12, 1970 Japan 45/70071

[52] **U.S. Cl.** ..... **294/64 R**

[51] **Int. Cl.** **B66c 1/02**

[58] **Field of Search** ..... 294/64 R, 65

[56] **References Cited**

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Assistant Examiner—Johnny D. Cherry
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[57] **ABSTRACT**

A lifting apparatus including a cylinder having at its lower end a flexible holding pad adapted to be placed on the surface of a body to be conveyed, a piston airtightly received in the cylinder, and a piston rod secured to the piston and extending through the upper end of the cylinder, the projecting end portion of the piston rod being adapted to be used for the purpose of hanging the apparatus, characterized by a bottom plate arranged at a position displaced inwardly toward the cylinder from a plane including the peripheral edge of the holding pad, a valve provided in the piston for controlling the communication between said cylinder and the holding pad, and depressing means confronting to said bottom plate and adapted to control said valve, whereby said valve is automatically controlled each time when the apparatus is placed on the body to be conveyed so that the vacuum is alternately established in and released from the cylinder.

4 Claims, 12 Drawing Figures

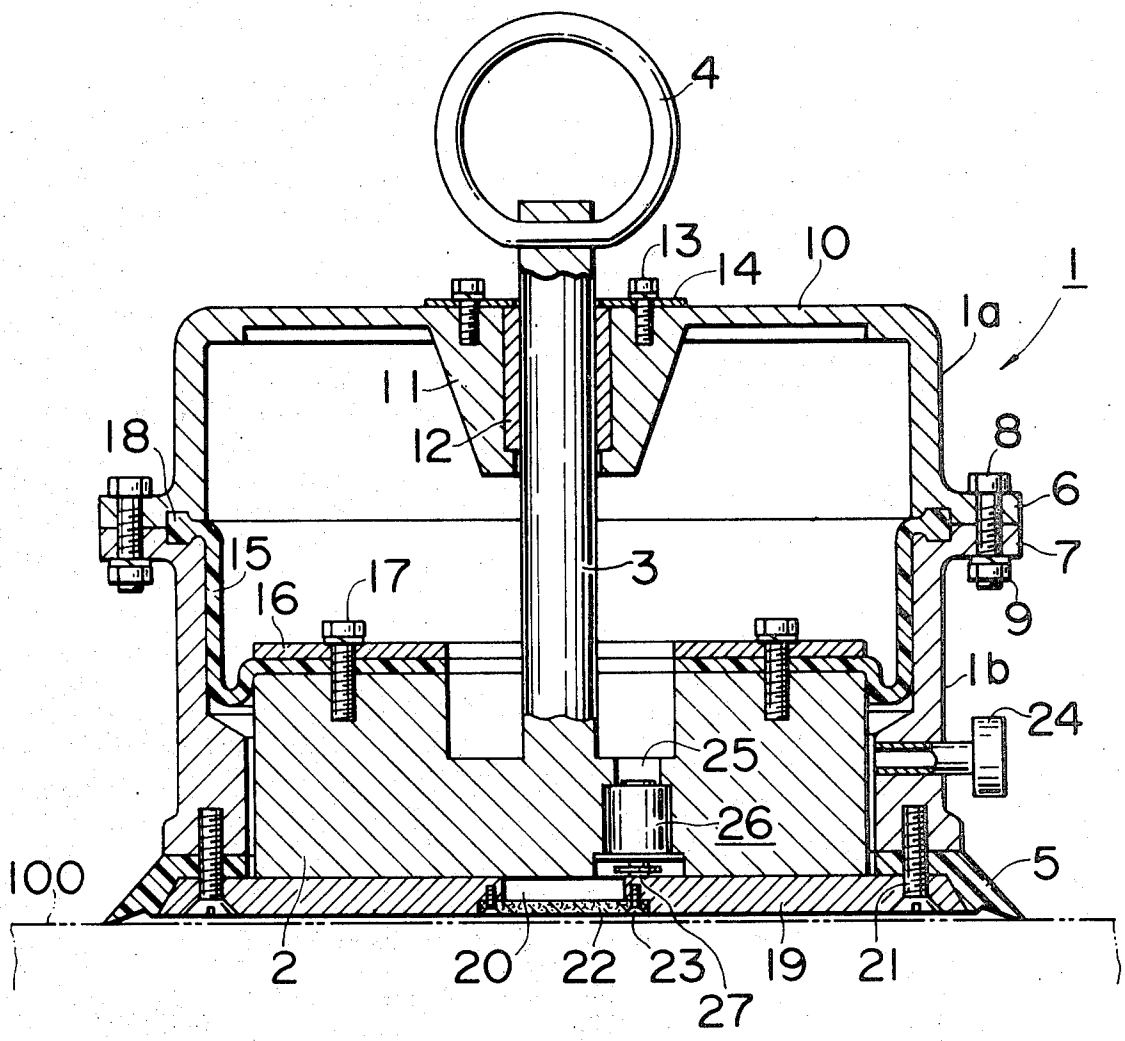
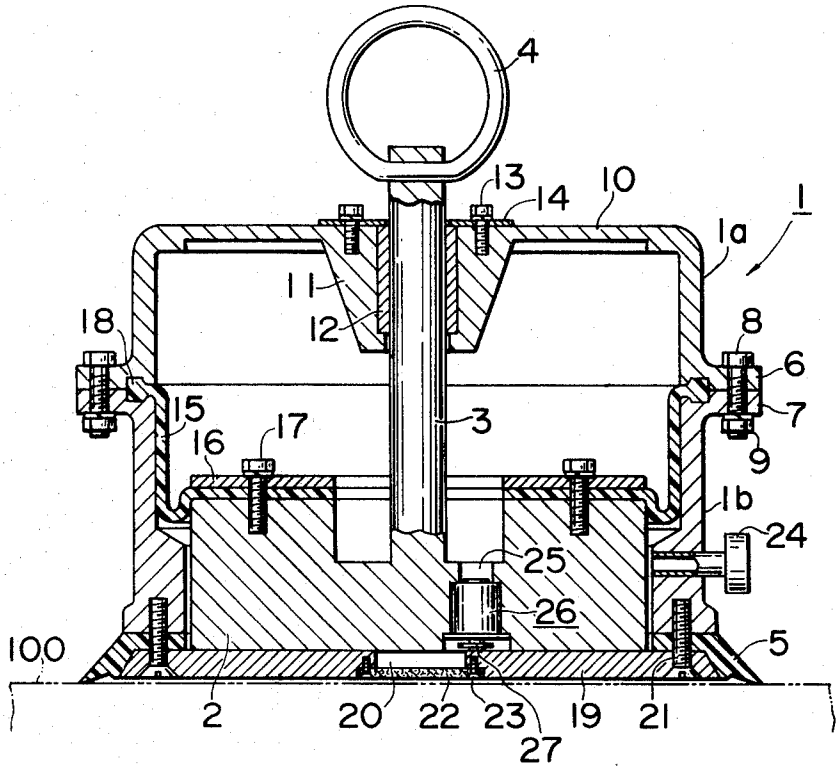


FIG. 1



III

FIG. 2

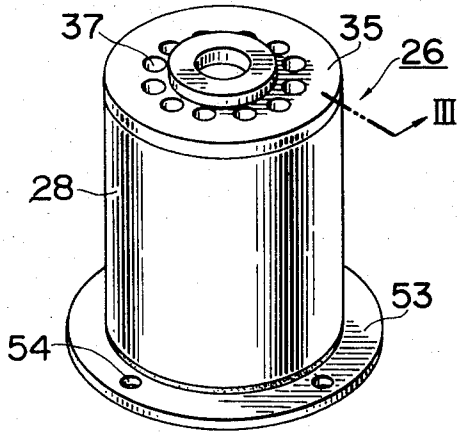


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FIG. 3

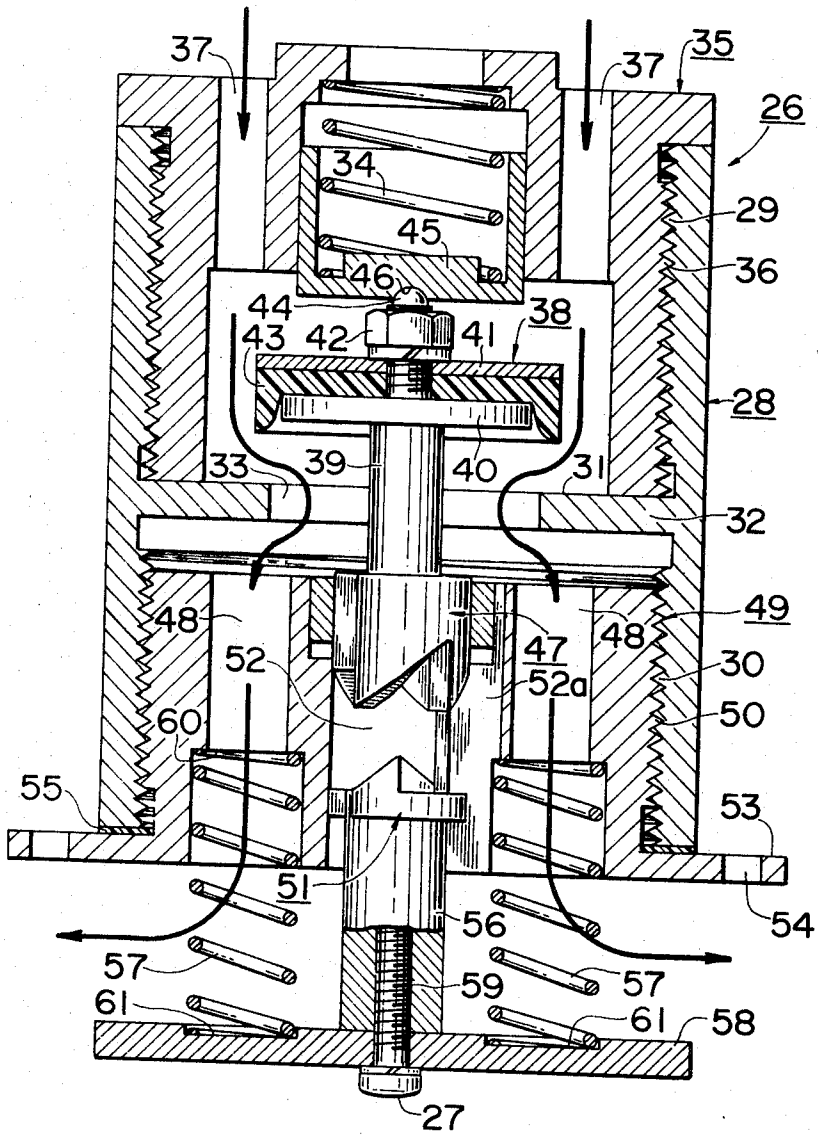

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FIG. 4

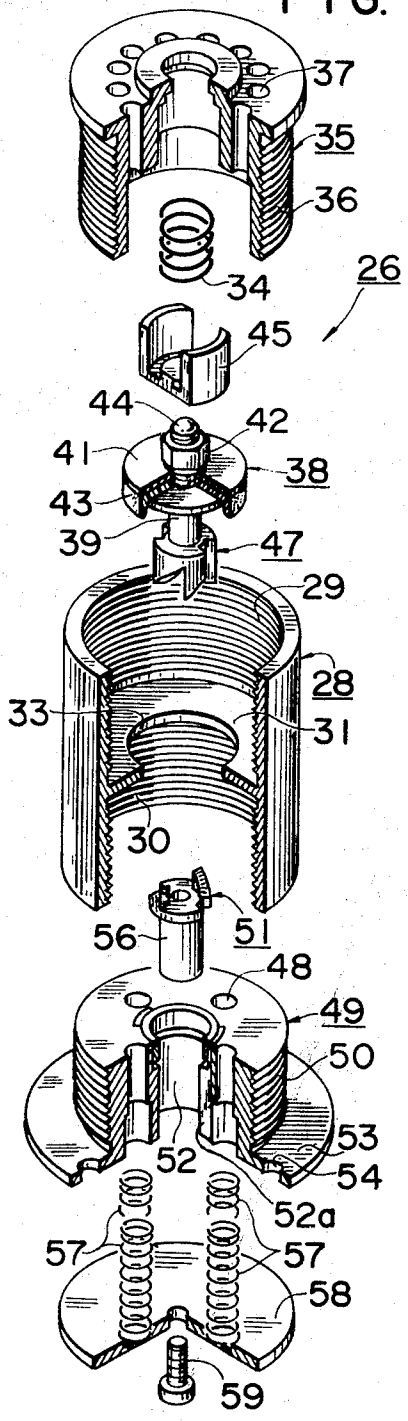

FIG. 5

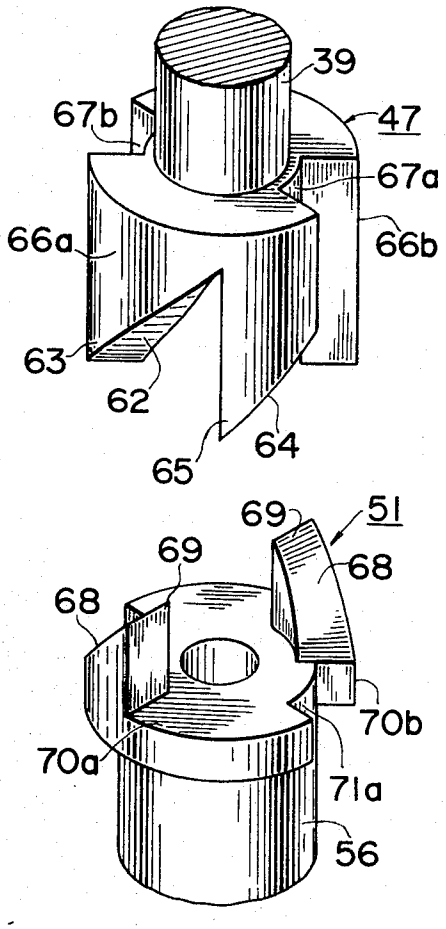

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FIG. 6

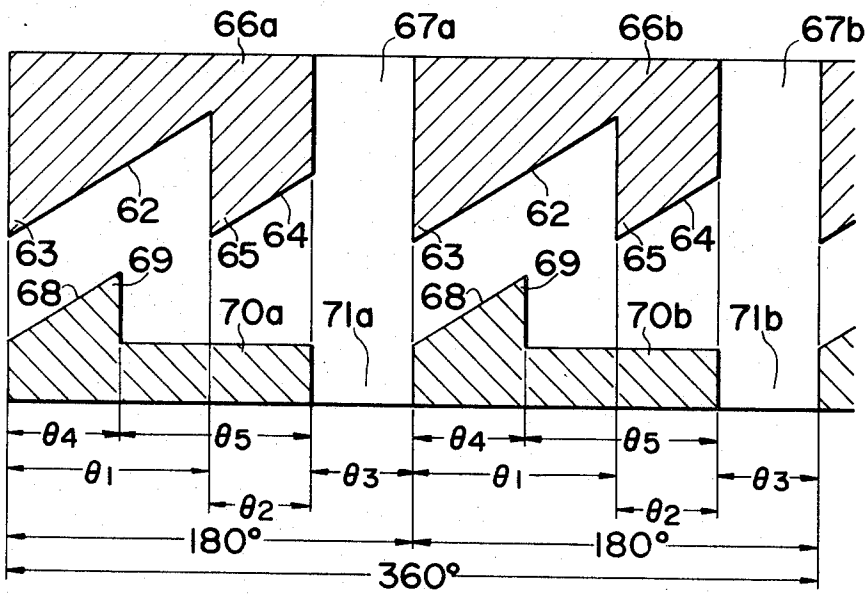


FIG. 7a

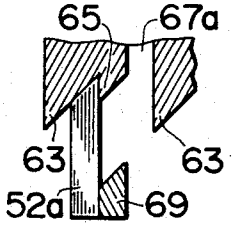


FIG. 7b

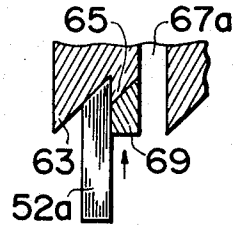


FIG. 7c

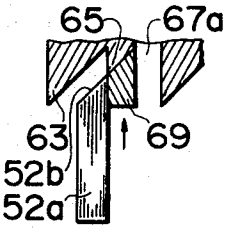


FIG. 7d

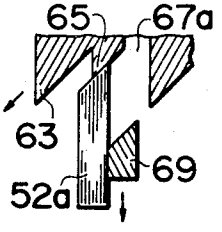


FIG. 7e

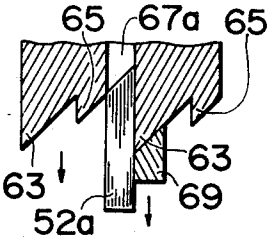
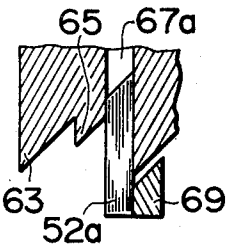


FIG. 7f



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CONVEYING APPARATUS HAVING VACUUM TYPE HOLDING MEANS

The present invention relates to an improvement in a lifting apparatus of a type in which the weight of body to be conveyed is utilized to produce a vacuum condition in a holding pad which is placed against the surface of the body to be conveyed, so that the body can be held by the vacuum pressure.

A vacuum holder type lifting apparatus has been known to be advantageous in that it can hold and lift a body to be conveyed irrespective as to whether the body is magnetic or non-magnetic in nature.

Such a known vacuum holder type lifting apparatus includes such a type in which a vacuum pump is provided for evacuating a holding pad which is placed against a body to be conveyed, as well as a pumpless type in which the weight of a body to be conveyed is utilized for producing a relative movement between a cylinder and a piston air-tightly engaged in the cylinder so as to produce a vacuum therein which vacuum is utilized to evacuate the holding pad.

Recently, the pumpless type which does not require any power source for driving the vacuum has widely been used as a portable type due to its convenience in use.

The former type in which a vacuum pump is used has an advantage in that the vacuum in the holding pad can readily be established or released through the use of a solenoid valve for gripping a body to be conveyed, carrying it to a desired position and releasing it. In contrast to this, in the latter type, that is, the pumpless type which does not require any power source, it is not recommendable to use a solenoid valve which requires a power source, because the use of a solenoid will reduce the advantages of this type as a portable lifting apparatus and also makes it impossible to use the apparatus at a site where the power is not available.

Therefore, it has been proposed to provide in the pumpless type lifting apparatus a manually operated valve which is adapted to be manually closed after the holding pad is placed on the surface of a body to be conveyed, so that the apparatus becomes ready for lifting the body.

Then the body is conveyed to a desired position, the apparatus is lowered until the body sits on the floor. Thereafter, the valve is manually opened and the apparatus is lifted. Since the vacuum in the holding pad is released in this position, the body can be released from the pad.

In this type of lifting apparatus which has a manually operated valve, an operator must always actuate the valve for holding and releasing a body to be conveyed, so that the apparatus cannot be used for handling a body placed on an elevated position.

An object of the present invention is to provide a vacuum holder type lifting apparatus which can hold and release a body to be conveyed irrespective of the elevation of the body without requiring any manual operation.

Another object of the present invention is to provide a vacuum holder type lifting apparatus which can be positively and automatically operated irrespective of the surface condition of a body to be conveyed.

In order to achieve these objects, the present invention provides a vacuum holder type lifting apparatus comprising a cylinder having at its lower end a flexible holding pad adapted to be placed against the surface of a body to be conveyed, a piston air-tightly received in the cylinder, a piston rod secured to the piston and extending through the upper portion of said cylinder, and an eye portion provided at the projecting end of the piston rod to be engaged by a crane and the like to lift the apparatus, characterized by a bottom plate having a vent hole and disposed at a position displaced inwardly toward the cylinder from a plane including the peripheral edge of said holding pad, a valve provided in said piston for controlling the communication between the cylinder and the holding pad, and a depressing portion confronting to said bottom plate for controlling said valve.

Further, said valve is opened or closed when the depressing portion is displaced through the engagement with the bottom plate and thereafter returned to its original position by being released from the bottom plate, and closed or opened when the depressing portion is subsequently displaced through the engagement with the bottom plate and thereafter returned to its original position by being released from the bottom plate.

The detail of the arrangement will become apparent from the descriptions of preferred embodiments of the present invention.

With the arrangement of the present invention in which the depressing portion for controlling the valve is placed in a confronting relation with respect to the bottom plate, the valve can be positively controlled irrespective of the surface condition of a body to be conveyed.

FIG. 1 is a longitudinal sectional view showing one embodiment of the vacuum holder type lifting apparatus in accordance with the present invention;

FIG. 2 is a perspective view showing an example of the valve used in the apparatus embodying the present invention;

FIG. 3 is a longitudinal sectional view taken along the line III — III in FIG. 2;

FIG. 4 is an exploded perspective view of the valve;

FIG. 5 is an enlarged perspective view showing a first and a second saw tooth control elements;

FIG. 6 is an expanded view of a cam in the saw tooth control element; and

FIGS. 7*a*–7*f* are diagrammatic views showing the sequence of the control of the valve.

FIG. 1 shows a typical example of a pumpless vacuum holder type lifting apparatus embodying the present invention and comprising a cylinder 1, a piston 2 received in the cylinder 1, a piston rod 3, a hoist fitting 4 secured to the upper end of the piston rod 3, and a holding pad 5 secured to the lower end of the cylinder 1.

The cylinder 1 includes an upper cylinder unit 1*a* and a lower cylinder unit 1*b* which are secured together at their opposed flanges 6 and 7 by means of bolts 8 and nuts 9.

The upper cylinder unit 1*a* includes an upper wall 10 having at its center a bearing part 11 for passing said piston rod 3 therethrough. A bearing 12 is secured to the bearing part 11 and guides the piston rod 3 for vertical movement. The bearing 12 is held in position by means of a holding plate 14 secured to the upper wall 10 by means of bolts 13.

The lower cylinder unit 1*b* receives said piston 2 which is secured to the piston rod 3. In order to separate the cylinder 1 air-tightly into two units, a dia-

phragm 15 is secured at its one edge to the upper surface of the piston 2 by means of a plate 16 and clamping bolts 17 and at the other end between the flanges 6 and 7 of the upper and lower cylinder units 1*a* and 1*b*, respectively. The diaphragm 15 may be a cylindrical one comprising a Tetron clothing coated by rubber material. Said other end of the diaphragm 15 is provided with a bead 18 so that the diaphragm 15 is securely held in the bead 18 for the purpose of air-tightly separating the cylinder units 1*a* and 1*b*.

The holding pad 5 is secured to the lower part of the cylinder 1. The pad 5 is made of a flexible but strong material such as natural or synthetic rubber and so formed that it can engage with the lower peripheral edge of the cylinder 1. A bottom plate 19 is provided for securing the holding pad 5 to the cylinder 1.

The bottom plate 19 has an air port 20 formed at an appropriate portion and is adapted to engage with the lower surface of the piston 2 so as to limit the lower stroke end thereof. The holding pad 5 is secured between the bottom plate 19 and the lower edge of the cylinder 1 by means of screws 21.

It should of course be noted that the holding pad 5 can be secured to the cylinder 1 by any known means other than the bottom plate 19. For example, the holding pad 5 may be fitted to the inner or outer periphery of the lower part of the cylinder 1 and secured thereto by means of a band or a ring tightened by screws.

The air port 20 formed in the bottom plate 19 serves to pass the air taken into the cylinder when the piston 2 is moved upwardly in the cylinder under a no load condition. In order to prevent dust or foreign material taken into the cylinder 1, a filter 22 is secured to the bottom plate 19 by screws 23. A dial gauge type vacuum indicator 24 is secured to the side wall of the lower cylinder unit 1*b* for monitoring the pressure in the lower cylinder unit 1*b*. The piston 2 is provided with an opening 25 for making communication between the upper and lower cylinder units 1*a* and 1*b*. In the opening 25, a valve 26 is air-tightly mounted for the purpose which will be described later in detail.

The valve 26 is provided with a depressing portion 27 which is adapted to be placed against the bottom plate and senses a fact that the piston 2 abuts the bottom plate 19.

In the aforementioned description, the upper and lower cylinder units 1*a* and 1*b* of the cylinder have been separately prepared and connected together, however, they may be formed integrally. In the latter arrangement, the upper wall 10 of the cylinder 1 may be in the form of a lid and the diaphragm 15 may be held between the upper wall 10 and the cylinder 1.

The aforementioned valve 26 is shown by an elevational view in FIG. 2. The detail of the valve 26 will now be described taking reference to FIGS. 2 through 4.

The reference numeral 28 shows a cylindrical casing of the valve 26 which has on its inner surface spiral grooves 29 and 30 and at its central portion an inwardly projecting annular wall 32 which provides a valve seat 31.

The projecting wall 32 is provided at its central portion with an opening 33 for providing an air passage. A first cylindrical body 35 having a valve closing compression spring 34 is mounted on the upper part of the cylindrical casing 28 by a spiral groove 36 formed on the outer surface of the body 35 and the co-operating spiral groove 29 formed on the casing 28. The cylindrical body 35 is provided with a plurality of air ports 37 for communicating the exterior and the interior of the cylindrical casing 28 together.

The reference numeral 38 shows a valve body which comprises a plate 40 secured to the upper end of a valve rod 39 and a valve member 43 made of a flexible material secured to the plate 40 by a holding plate 41 and a nut 42. The valve rod 39 has a semi-spherical end 44 projecting from the nut 42 and the projecting end 44 is so arranged as to co-operate with a recess 46 formed on the lower surface of a spring seat 45 supporting the valve spring 34. The valve rod 39 is provided at its lower end with a first saw teeth element 47 for controlling the valve body 38. The cylindrical casing 28 receives at its lower part a second cylindrical body 49 having a plurality of air ports 48 and secured to the cylindrical casing 28 by a spiral groove 50 engaging with the spiral groove 30 in the casing. The second cylindrical body 49 is provided at its center portion with an axial hole 52 having ribs 52*a* and adapted to guide the second saw teeth element 51 co-operating with the first saw teeth element 47. Further, the second cylindrical body 49 is provided at its lower outer periphery with a flange 53 extending radially outwardly from the cylindrical casing 28. The flange 53 has a plurality of holes 54 for inserting screws to mount the valve 26 at the opening 25 of the piston 2 as shown in FIG. 1. A packing 55 is disposed between the lower edge of the cylindrical casing 28 and the body 49 so as to ensure an air-tight seal therebetween. The valve rod 56 having the second saw teeth control element 51 is further provided at its lower end with a spring seat 58 secured by means of a screw 59 for supporting compression springs 57 constantly biasing the valve rod 56 downwardly. The head of the screw 59 serves as the aforementioned depressing portion 27 of the valve 26. The upper end of each compression spring 57 seats on one of shoulder portions 60 formed in the air passages 48, and the lower end thereof engages with a recess 61 formed on the upper surface of the valve seat 58.

The details of the first and second saw teeth control elements 47 and 51 will now be described taking reference to FIGS. 5 and 6. The first control element 47 has a pair of cams 66*a* and 66*b* each comprising a first tooth 63 having a surface 62 of predetermined inclination angle and a second tooth 65 having a surface 64 of an inclination angle substantially the same as the angle of the surface 62. Slits 67*a* and 67*b* are formed between the cams 66*a* and 66*b* for co-operating with the ribs 52*a* on the hole 52 of the second cylindrical body 49.

The second control element 51 comprises a pair of cams 70*a* and 70*b* each having a tooth (69) having a surface 68 of an inclination angle corresponding to the angle of the surface 62 or 64. Slits 71*a* and 71*b* are formed between the cams 70*a* and 70*b* for co-operating with the ribs 52*a*.

In the embodiment illustrated in FIG. 6, the angular width θ_1 of the tooth 63 in the cam 66*a* or 66*b* may be for example 90°, the angular width θ_2 of the second tooth 65 may be for example 45° and the angular width θ_3 of the slit 67 may be 45°. With respect to the cam 70*a* or 70*b*, the angular width θ_4 of the tooth 69 may be for example 50° and the width of the slit 71 may be the same as the width θ_3. The angular width θ_5 shows a flat area between the tooth 69 and the slit 71.

The operation of the valve **26** will now be described in connection with the operation of the lifting apparatus shown in FIG. **1**. When the lifting apparatus is placed on a body **100** to be conveyed, the piston **2** is lowered due to its own weight as shown in the drawing. In this position, the depressing portion **27** of the valve **26** engages with the bottom plate **19**. Since the portion **27** is depressed upwardly, the valve rod **56** is moved in the opening **52** of the second cylindrical body **49** upwardly against the action of the compression spring **57**. Thus, the tooth **69** of the second saw tooth control element **51** engages with the tooth **65** of the first saw teeth control element **47** as shown in FIG. **7***b* so as to push the latter upwardly as shown in FIG. **7***c*.

As the first saw teeth control element **47** is thus moved upwardly, the valve body **38** is also slightly moved upwardly through the valve rod **39**. With this upward movement, the first saw teeth control element **47** moves slightly apart from the tooth **69**, and the tooth **65** on the element **47** engages with the slanted surface **52***b* of the rib **52***a*.

Thereafter, the hoist fitting **4** on the piston rod **3** is lifted for example by a crane, the piston **2** is moved upwardly in the cylinder **1**. As the piston **2** moves upwardly, the depressing portion **27** is released from the bottom plate **19** and caused to move downwardly by the compression spring **57**. Thus, the second saw teeth control element **51** is also moved downwardly when the depressing portion **27** is lowered. At this instance, the tooth **65** of the first saw teeth control element **47** slides along the surface **52***b* of the rib **52***a* as shown in FIG. **7***d* and thereafter downwardly along the ribs **52***a* at its slits **67***a* into the opening **52**. The position thus obtained is shown in FIG. **7***f*. Thus, the valve member **43** on the valve body **38** is placed in sealing contact with the valve seat **31** so as to close the opening **33**.

The compression spring **34** serves at this moment to lower the first saw teeth control element **47**. As the piston **2** moves further upwardly in the cylinder **1** after the valve is closed, the inside of the cylinder unit **1***b* is evacuated. Thus, the space between the holding pad **5** and the body **100** is also evacuated so that the body **100** is securely held by the holding pad **5**.

When the piston **2** is sufficiently moved upwardly, the weight of the body **100** is balanced with the holding vacuum force in the pad **5** and the relative movement between the cylinder **1** and the piston **2** is terminated. Therefore, a further lifting of the apparatus effectively lifts the body **100** held thereby. The vacuum pressure in the lower cylinder unit **1***b* is indicated by the vacuum indicator **24**.

The operation of the apparatus will further be described with respect to lowering of the body **100**.

When the lifted body **100** is placed on a floor, the piston **2** again abuts the bottom plate **19** so that the portion **27** is again moved upwardly. Then, the tooth **69** of the second saw teeth control element **51** serves to push the tooth **63** of the first saw teeth control element **47** upwardly so that the tooth **63** is placed at the level of the surface **52***b*. Thus, when the piston **2** is again lifted, the surface **62** of the tooth **63** engages with the surface **52***b* of the rib **52***a* as shown in FIG. **7***a*.

Therefore, in this position, the valve **26** is opened as shown in FIG. **3**. Therefore, when the apparatus is lifted, the air in the upper cylinder unit **1***a* is allowed to flow through the valve **26** into the lower cylinder unit **1***b* as shown by the arrow in the drawing. Thus, the inside of the holding pad **5** is not evacuated and the apparatus releases the body **100**.

In the above embodiment, the first saw teeth control element **47** is integrally formed with the valve rod **39** and the valve body **38** is pivotally mounted so that it can pivot with respect to the spring seat **45**, however, it should of course be noted that the first saw teeth control element **47** may be so mounted that it can pivot with respect to the valve rod **39**.

We claim:

1. A vacuum holder type lifting apparatus comprising a substantially longitudinally disposed cylinder provided at the lower end thereof with a flexible holding pad co-operating with the plane of a body to be conveyed, a piston air-tightly received in the cylinder and operated to move up-and-down, and a piston rod connected at the lower end thereof with said piston and provided at the upper end thereof with a hoist fitting, said upper end of said piston rod projecting from the upper portion of said cylinder so as to be guided, characterized in that the vacuum holder type lifting apparatus includes a bottom plate disposed slightly inwardly of the cylinder from a plane defined by the peripheral edge of the holding pad, said bottom plate being provided with a vent hole, and a change-over valve provided in the piston for selectively connecting upper and lower spaces formed in said cylinder and partitioned by said piston with each other, and that the change-over valve includes a valve seat, a valve body opposed to said valve seat and supported rotatably, means for biasing said valve body toward a valve closing direction, a first saw tooth control element secured to the lower end of said valve body and provided at the lower portion of said first element with at least a pair of circumferentially disposed teeth different in height from each other, and a second saw tooth control element provided at the upper portion thereof with teeth opposed to said first saw tooth control element and provided at the lower portion thereof with a depressing portion opposed to the bottom plate.

2. A vacuum holder type lifting apparatus according to claim **1**, characterized in that the first saw tooth control element of the change-over valve comprises slits guided selectively to ribs formed on a hole of a cylindrical body arranged beneath the valve seat opposed to said valve body, and the pair of teeth include first and second teeth formed adjacent to said slits and having inclined planes with substantially the same angle of inclination, and that the second saw tooth control element comprises slits guided to the ribs formed on said hole, and teeth formed adjacent to said slits and having inclined planes with the substantially same angle of inclination of that of the first and second teeth, said teeth being opposed to said first and second teeth.

3. A vacuum holder type lifting apparatus according to claim **1**, characterized in that the depressing portion provided at the lower portion of the second saw tooth control element is always depressed downwardly from the change-over valve body by a compression spring.

4. A vacuum holder type lifting apparatus according to claim **1**, characterized in that the change-over valve includes a cylindrical casing having the valve seat provided at the central portion thereof with an opening, said casing having the upper and lower inner peripheral faces thereof provided with internal threads, first cylindrical body provided at the outer periphery thereof with external threads engaging with the upper internal

threads of the cylindrical casing, said first cylindrical body being provided at the upper portion thereof with vent holes and a spring casing receiving therein a compression spring adapted to always depress the valve body, and a second cylindrical body provided at the outer periphery thereof with external threads engaging with the lower internal threads of the cylindrical casing, said second cylindrical body being provided at the central portion thereof with vent holes, an opening and ribs adapted to guide the first and second saw tooth control elements for up-and-down movement.

* * * * *