

the passage 193. The needle valve 110 is used by appropriately adjusting the gap with respect to the valve seat.

The duckbill valve 120 can adjust the valve lift with a vacuum force in the upper chamber 83 being applied to the outer surface of a bill 121 thereof. When the vacuum force is high, the valve lift of the duckbill valve 120 is increased due to a large pressure difference between the atmospheric pressure exerted upon the inner surface of the bill 121 and the high negative pressure exerted upon the outer surface of the bill 121, and when the vacuum force is low, the valve lift of the duckbill valve 120 is decreased due to a small pressure difference between the atmospheric pressure exerted upon the inner surface of the bill 121 and the low negative pressure exerted upon the outer surface of the bill 121.

According to the second example, when the valve lift of the duckbill valve 120, which is used as an opening time adjusting valve, is automatically controlled in accordance with the vacuum force in the chamber 83. In other words, for the vacuum transmitted from the vacuum discharge pipe 14, (a) the higher the vacuum is, the larger the valve lift of the duckbill valve 120 is increased, so that the vacuum valve 15 is closed in a short period of time, and (b) the lower the vacuum is, the smaller the valve lift of the duckbill valve 120 is decreased, so that the vacuum valve is opened for a long period of time. Due to the foregoing, an air/liquid ratio in the pipe line can

between the atmospheric pressure exerted upon the inner surface of the cone and the high negative pressure exerted upon the outer surface of the cone, and when the vacuum force is low, the valve lift of the orifice valve 130 is resiliently decreased due to a small pressure difference between the atmospheric pressure exerted upon the inner surface of the cone and the low negative pressure exerted upon the outer surface of the cone.

According to third example, when the valve lift of the orifice valve 130, which is used as an opening time adjusting valve, is automatically controlled in accordance with the vacuum force in the chamber 83, for (the vacuum transmitted from the vacuum discharge pipe 14) (a) the higher the vacuum is, the larger the valve lift of the orifice valve 130 is increased, so that the vacuum valve 15 is closed in a short period of time, and (b). the lower the vacuum is, the smaller the valve lift of the orifice valve 130 is decreased, so that the vacuum valve is opened over a long period of time. Due to the foregoing, an air/liquid ratio in the pipe line can be maintained in a predetermined range, and the vacuum type liquid collecting apparatus can be stably operated.

Fourth Embodiment

In the vacuum valve control device of the invention, preferably a resilient rolling diaphragm 31 is provided between the first and second housings 21, 22. The valve operating chamber in the housing is airtightly isolated by the rolling diaphragm. This

rolling diaphragm is made of resilient rubber, and bent between the outer circumferential surface of the plunger and the inner circumferential surface of the housing so that the rolling diaphragm can be brought into close contact with the outer circumferential surface of the plunger and the inner circumferential surface of the housing. In the case where the plunger is slid by the action of vacuum in the valve operating chamber in the housing, the rolling diaphragm is deformed so that the bent portion is moved in a sliding direction of the plunger. As described above, while a volume in the valve operating chamber is not changed, the plunger can be positively slid by the action of the rolling diaphragm when a vacuum is activated.

Usually, a portion close to the bent portion of the rolling diaphragm is not closely contacted with the inner circumferential surface of the housing, but the portion is contacted with the rolling diaphragm which is closely contacted with the outer circumferential surface of the plunger. When one portion of the rolling diaphragm is contacted with another portion with pressure as described above, there is a possibility that the contacting portion is rubbed and worn away in the case where the contacting portion is moved in accordance with the sliding movement of the plunger. When the rolling diaphragm is worn away, there is a possibility that airtightness of the rolling diaphragm is deteriorated. When airtightness of the rolling diaphragm is deteriorated,

CLAIMS

1. A vacuum valve control device for controlling operation of a vacuum valve by opening and closing a pipe-shaped connecting section connecting a vacuum discharge pipe in a vacuum condition with the suction pipe for sucking liquid-like materials from a tank, said vacuum valve control device comprising:

a liquid level detecting pipe whose inside pressure fluctuates in accordance with a liquid level in said tank;

a pressure adjusting chamber communicating with said liquid level detecting pipe;

a freely movable diaphragm that is not secured at its peripheral edge disposed between said liquid level detecting pipe and said pressure adjusting chamber;

a liquid level detecting diaphragm resiliently deformable in response to a pressure increase in said pressure adjusting chamber being transmitted thereto via a through-hole;

a detection valve controlled by deformation of said liquid level detecting diaphragm;

a changeover valve controlled by said detection valve to selectively supply a vacuum pressure and an atmospheric pressure to said valve,

wherein said damping diaphragm has at least one small through-hole so that said damping diaphragm does not resiliently deform when the pressure in said liquid level detecting pipe is gradually increased,

wherein said damping diaphragm resiliently deforms due to decompression of said pressure adjusting chamber to close said through-hole,

wherein said damping diaphragm quickly releases the pressure around the non-secured peripheral edge thereof to said liquid level detecting pipe when the pressure in said pressure adjusting chamber is rapidly increased to quickly close as said liquid level in said tank reaches a substantially empty condition.

2. A vacuum valve control device as claimed in claim 1, wherein a diameter of said through-hole is determined in such a manner that the area of said through-hole is less than $1/8$ of a cross-section of said through-hole.

3. A vacuum valve having a vacuum valve control device for opening and closing a communicating section between a suction pipe communicating with a tank and vacuum discharge pipe communicating with a vacuum source, said vacuum valve comprising:

a valve body for opening and closing said communicating section;

a valve operating chamber for accommodating a plunger connected with said valve body;

a closing force providing means for providing a closing force to said valve body via said valve operating chamber,

wherein said vacuum valve control device selectively provides an opening force to said valve body via said valve operating chamber, said vacuum valve control device comprising:

a liquid level detecting diaphragm which resiliently deforms in response to a liquid level in said tank;

a second plunger directly driven by said liquid level detecting diaphragm;

a detecting valve being driven by said second plunger;

a pressure control chamber maintaining a vacuum pressure from a vacuum passage applied thereto when said detecting valve is driven by said second plunger and maintaining an atmospheric pressure from an atmospheric passage applied thereto when said detecting valve is not driven by said second plunger;

a changeover valve which operates to connect a vacuum pressure from said vacuum passage to said valve operating chamber when said pressure control chamber maintains a vacuum pressure, thereby providing said opening force upon said valve body; and

an opening time adjusting valve for variably releasing a vacuum force introduced into said pressure control chamber, said opening time adjusting valve having an air hole for releasing said vacuum and being compressively deformed to change the section area of said air hole so that an opening time for said vacuum valve can be controlled according to the varying pressure of said pressure control chamber.

4. A vacuum valve control device as claimed in claim 3, wherein said opening time adjusting valve is formed of a cylindrical elastic body.

5. A vacuum valve having a vacuum valve control device for by opening and closing a communicating section between a suction pipe communicating with a tank and a vacuum discharge pipe communicating with a vacuum source, said vacuum valve comprising:

a valve body for opening and closing said communicating section;

a valve operating chamber for accommodating a plunger connected with said valve body;

a closing force providing means for providing a closing force to said valve body via said valve operating chamber,

wherein said vacuum valve control device for selectively provides an opening force to said valve body via said valve operating chamber, said vacuum valve control device comprising:

a liquid level detecting diaphragm which resiliently deforms in response to a liquid level in said tank;

a second plunger directly driven by said liquid level detecting diaphragm;

a detecting valve being driven by said second plunger;

a pressure control chamber maintaining a vacuum pressure from a vacuum passage applied thereto when said detecting valve is driven by said second plunger and maintaining an atmospheric pressure from an atmospheric passage applied thereto when said detecting valve is not driven by said second plunger;

a changeover valve which operates to connect a vacuum pressure from said vacuum passage to said valve operating chamber when said pressure control chamber maintains a vacuum pressure, thereby providing said opening force upon said valve body; and

an opening time adjusting valve for releasing a vacuum force introduced into said pressure control chamber, the opening time of said opening time adjusting valve being automatically controlled in accordance with a degree of vacuum in said vacuum discharge pipe.

6. A vacuum valve control device as claimed in claim 5, wherein said opening time adjusting valve comprises a needle valve having a diaphragm provided in a passage connecting the inside and outside of the pressure control chamber, wherein a valve lift of said needle valve being adjustable by applying vacuum pressure from said vacuum discharge pipe to said diaphragm, and wherein the valve lift of said needle valve being increased when the vacuum pressure is high, and the valve lift of said needle valve being decreased when the vacuum pressure is low.

7. A vacuum valve control device as claimed in claim 5, wherein said opening time adjusting valve comprises:

a duckbill valve provided in a passage connecting the inside and outside of said pressure control chamber, a valve lift of said duckbill valve being adjustable by applying vacuum pressure from a side of said pressure control chamber to an outer surface of said duckbill valve, the valve lift of said duckbill valve being increased when the vacuum pressure is high, and the valve lift of said duckbill valve being decreased when the vacuum pressure is low.

8. A vacuum valve control device as claimed in claim 5, wherein said opening time adjusting valve comprises:

an orifice valve provided in a passage connecting the inside and outside of said pressure control chamber, wherein a valve lift of said orifice valve being adjustable by applying vacuum pressure from a side of said pressure control chamber to an outer

surface of said orifice valve, the valve lift of said orifice valve being increased when the vacuum pressure is high, and the valve lift of said orifice valve being decreased when the vacuum pressure is low.

9. A vacuum valve control device for controlling operation of a vacuum valve by opening and closing a pipe-shaped connecting section which connects a vacuum discharge pipe in a vacuum condition with a suction pipe for sucking liquid-like materials from a tank, said vacuum valve control device comprising:

- a liquid level detecting pipe whose inside pressure fluctuates in accordance with a liquid level in said tank;

- a pressure adjusting chamber communicating with said liquid level detecting pipe;

- a free-standing damping diaphragm disposed between said liquid level detecting pipe and said pressure adjusting chamber, said damping diaphragm being situated without attachment upon a support portion such that a groove is formed around the periphery of said support portion to quickly release the pressure within the pressure adjusting chamber around the peripheral edge of the damping diaphragm and to quickly close the damping diaphragm in response to a decrease of the pressure inside said liquid level detecting pipe;

- a liquid level detecting diaphragm being resiliently deformed in response to a pressure increase in said pressure adjusting chamber;

- a detection valve controlled by deformation of said liquid level detecting diaphragm; and

- a changeover valve being controlled by said detection valve to selectively apply a vacuum pressure and an atmospheric pressure to said vacuum valve.

10. A vacuum valve control device as claimed in claim 9, wherein said free-standing damping diaphragm, said support portion, and said groove formed around the periphery of said support portion have an annular shape.

11. A vacuum valve control device as claimed in claim 9 wherein said free-standing damping diaphragm further comprises one or more through-holes,

wherein said through-holes prevent resilient deformation of said damping diaphragm when the pressure in said liquid level detecting pipe is gradually increased,

wherein said damping diaphragm resiliently deforms by decompression of said pressure adjusting chamber to close said through-hole,

wherein said damping diaphragm releases the pressure from its peripheral portion to the liquid level detecting pipe when the pressure in the pressure adjusting chamber increases substantially.

12. A vacuum valve comprising:

a housing having a valve operating chamber in which a vacuum is activated;

a plunger slidably provided in said housing; and

a self-lubricating rolling diaphragm provided between an outer circumferential surface of said plunger and an inner circumferential surface of said housing so that said valve operating chamber in said housing can be isolated in an airtight condition, said rolling diaphragm being resilient so that it can be deformed in accordance with the movement of said plunger,

wherein said rolling diaphragm contains a lubricant which is excreted onto an external surface of said rolling diaphragm from an interior of said rolling diaphragm.

13. A vacuum valve as claimed in claim 12, wherein said rolling diaphragm is made of rubber and wherein one of silicon oil, silicon grease and DOP is kneaded into the rubber as a lubricant during the process of forming, whereby the lubricant kneaded into the rubber is gradually excreted onto the external surface of the rolling diaphragm.

14. A vacuum valve comprising:

a housing having a valve operating chamber in which a vacuum is activated;

a plunger slidably provided in said housing;

a valve rod, one end of which is connected with said plunger, and the other end of which is positioned outside said housing so that said valve rod penetrates said housing, wherein the end of said valve rod positioned outside said housing is connected with a valve body; and

a self-lubricating resilient shaft seal coming into pressure contact with said valve rod so that a boundary between said housing and said valve rod can be airtightly sealed,

wherein said shaft seal contains a lubricant which is excreted onto an external surface of said shaft seal from an interior of said shaft seal.

15. A vacuum valve as claimed in claim 14, wherein said shaft seal is made of rubber and wherein one of silicon oil, silicon grease and DOP is kneaded into the rubber as a lubricant during the process of forming, whereby the lubricant kneaded into the rubber is gradually excreted onto the external surface of the shaft seal.

16. A vacuum valve for opening and closing a communicating section between a suction pipe communicated with a tank, and a vacuum discharge pipe communicated with a vacuum source, said vacuum valve comprising:

a valve body for opening and closing said communicating section;

a plunger connected with said valve body;

a valve operating chamber for accommodating said plunger;

a rolling diaphragm provided between said valve operating chamber and said plunger,

wherein a first end of said rolling diaphragm comes into pressure contact with an inner surface of said valve operating chamber, and a second end of said rolling diaphragm comes into pressure contact with an outer surface of said plunger wherein in a condition prior to assembly, said rolling diaphragm includes a large diameter section formed at said first end coming into pressure contact with the inner surface of said valve operating chamber, a small diameter section formed at said second end coming into

pressure contact with the outer surface of said plunger, and a tapered section formed between said large and small diameter sections;

means for providing a closing force to said valve body, said means being provided in said valve operating chamber; and

a controller for providing an opening force to said valve body by creating a vacuum in said valve chamber.

VACUUM VALVE CONTROL DEVICE AND VACUUM VALVE

ABSTRACT

A vacuum valve (15) includes: a pressure control chamber (83) for giving a vacuum force to a valve body (71) capable of connecting a valve operating chamber (25) with a vacuum passage; a detecting valve (68) capable of introducing a vacuum force into the pressure control chamber (83); a plunger (65) directly driven by a liquid detecting diaphragm (60), wherein the plunger (65) drives the detecting valve (68); and an opening time adjusting valve (74) which is opened so that the vacuum introduced into the pressure control chamber (83) can be released, wherein the opening time is automatically controlled by the vacuum in the vacuum discharge pipe (14). Furthermore, when the inside of a liquid level detecting pipe section (56) is quickly decompressed, pressure in a pressure adjusting chamber (102) is quickly released through a gap formed between a damping diaphragm (59) and supporting section (112). The pressure adjusting chamber (102) is communicated with an upper pressurizing chamber (81) through a communicating hole (103). Therefore, when the pressure adjusting chamber (102) is quickly decompressed, the upper pressurizing chamber (81) is also quickly decompressed. Due to the foregoing, resilient deformation of a liquid level detecting diaphragm (60) is quickly cancelled, and the pushing action conducted by a plunger (65) on a detecting valve (68) is released.

Fig. 3