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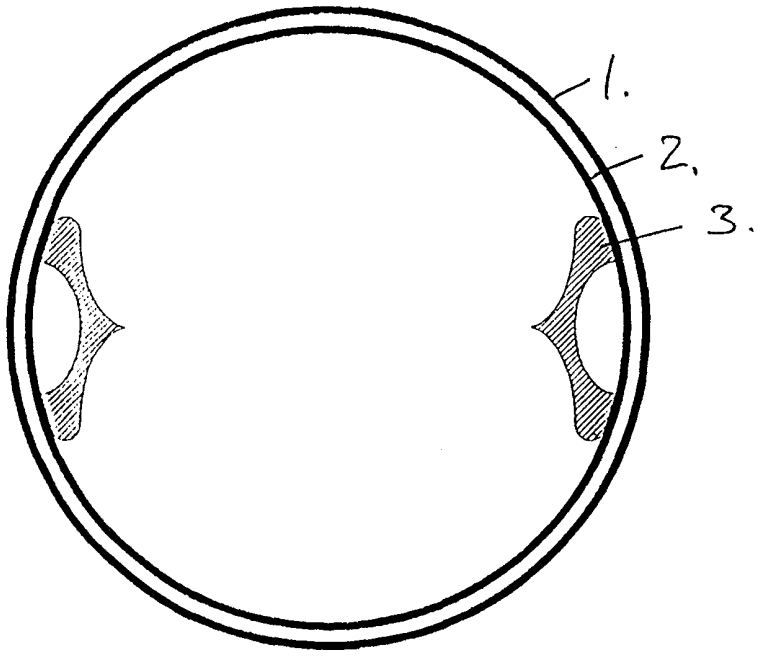
(57) Abstract

The invention consists of a valve with a flexible diaphragm for shutoff and regulation of air flow in ventilation ducting, liquid ducts, powder transport plants (conveyor) and for dosing of shoot bulk in industries. The valve consists of a cylindrical flexible diaphragm extended in a tube equipped with adequate connections for standard ducting (e.g. ventilation nipples) or process ducting. The diaphragm is fastened to the tube in such a way that compressed air can be blown into the space between the diaphragm and the tube causing the valve to close, fully or partly. The diaphragm of the valve is equipped with 2 special *guide vanes* that ensure the diaphragm to close in two tongues meeting in the centre. The guide vanes ar moulded in a shape so that they cover the part of the cross section of the valve that is not covered by the two tongues of the diaphragm. Thus the pinch valve can close fully and at the same time in partly open condition a slit is formed that is well suited for regulating an air flow or other process flow. The invention will be able to replace existing ventilation dampers and air regulating valves made of metal as it can be produced at a similar price, and at the same time has many advantages and flexibilities of the pinch valve.



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Pneumatic Pinch Valve for Shut-off and Regulation of an Airs Flow or Other Process Flow.

The Invention consists of a valve with a flexible diaphragm for shutoff and regulation of air flow in ventilation ducting, liquid ducts, powder transport plants , and for dosing of shoot bulk in industries. The valve consists of a cylindrical flexible diaphragm extended in a tube equipped with adequate connections for standard ducting (e.g. ventilation nipples) or process ducting. The diaphragm is fastened to the tube in such a way that compressed air can be blown into the space between the diaphragm and the tube causing the valve to close, fully or partly.
The diaphragm of the valve is equipped with two special *guide vanes* that ensure the diaphragm to close in two tongues meeting in the centre, when the space between the tube and the diaphragm is inflated with air or liquid. The guide vanes are moulded in a shape so that they cover the part of the cross section of the valve that is not covered by the two tongues of the diaphragm. Thus the pinch valve can close fully and at the same time in partly open condition a slit is formed that is well suited for regulating an air flow or other process flow.

At present is normally used a metal damper of various constructions for shutoff and regulation of process flow. In ventilation systems this is typically done by means of a swivel damper consisting of a turning blade in the middle of the air flow.
Alternatively is used a slide valve consisting of a metal plate with a hole in the same dimension as the duct installed in a slide device allowing the metal plate to be moved between open and closed position.
For somewhat more demanding tasks is used e.g. an iris valve consisting of a row of sliding metal plates that together can form an opening of variable dimension.
In larger ducts is often used shutter dampers consisting of a number of sliding metal flaps that cover the opening. The damper is opened and closed by turning the metal flaps.

Common for the present dampers and valves used in ventilation systems is that they are made of metal parts and consequently have difficulties in forming a flexible opening with variable dimension and at the same time have difficulties in closing airtight. A traditional metal damper is also characterized by the fact that its opening has sharp rims which will always cause noise problems and energy loss when installed in a duct with high air flow. Present dampers and valves have the disadvantage, too that they are difficult to install because they are heavy and require strong support, special safety and accurate position.

Present dampers that are able to close airtight and open 100% also require much maintenance. Experiences of many years also show that material (e.g. textile remains) will often gather round the closing blade often causing expensive break-downs when the material is loosened and remixed with the air flow.

In process industries at present are used pinch valves (or sleeve valves) for regulation of air flows with a high content of dust or powder, e.g. sugar. These valves distinguish themselves by high reliability and long life expectancy, but also by very high prices because of an expensive construction with e.g. a moulded valve box of machine type. The pinch valves are normally only offered in standard types up to 150 mm diameter and are almost only used for transportation of liquid or for air transportation of expensive materials. Such a sleeve valve is among others described in UK Patent GB 2080497A of 1990. This type of damper will be too clumsy and heavy for installation in a ventilation duct and is therefore not equipped with connecting devices for ventilation systems.

Pinch valves can also be produced with a pocket embedded in one side of the diaphragm as described in e.g. US patent 3397860 of 1968. Experiments prior to the invension have shown that such a valve with an embedded pocket in one side of the diaphragm works excellently at short sight, but will last less than 10.000 open/close movements before the diaphragm is fatigued and consequently perforated. The type with embedded pocket in the diaphragm has shown difficult to produce in standardized types and consequently with an equal life expectancy.

The American patent publication 3759483 describes a controlling valve consisting of a rubber tube pressed together by two metal jaws. Compared to this patent the invention represents a far more compact and reliable solution. The American patent will never be applicable for ventilation ducts because it is too heavy and clumsy and because it takes up too much room. The compressed rubber tube alone will take up 160% more room than its round diameter when it is pressed flat. In addition to this comes the width and hight of the jaws not counting the activation device.

The patent publication 3759483 differs from the invention by being mechanically operated instead of pneumaticly. In the invention the diaphragm also works in a totally new way as the invention exploits the ability of the diaphragm to form two tongues that together are just able to cover the cross-section 100% which is solely due to the size and shape of the *guide vanes* compared to the diameter of the valve. In the American patent the rubber tube is simply compressed vigoroursly without exploiting the ability of the diaphragm itself for folding and closing. This way of closing will also result in limited life expectancy for the American patent because the rubber tube will gradually break in the foldings.

Pinch valves consisting of a cylindrical diaphragm extended in a metal tube are inexpensive to produce but will inevitably form foldings in the diaphragm when this is pressed together by compressed air blown into the space between the diaphragm and the tube. Such a pinch valve will not be able to close tightly and as the area of opening is uncontrollable the valve is unsuitable for regulation purposes.

With the invention it is possible to obtain the advantages of the known types of pinch valves together with very low manufacturing costs and a safe and standadized manufacturing process. This is due to the fact that the invention makes use of a flexible diaphragm with two embedded *guide vanes* placed diagonally in the cylindric diaphragm. This special diaphragm construction with two *guide vanes* ensures a completely tight and equal closing device which is also indifferent to the medium and speed of flow through the valve. When the valve is closing the diaphragm is pressed into two mirror-inverted tongues meeting in the centre and filling the diagonal area of the valve as the pressure on the outside of the diaphragm increases.

The total width of the *guide vanes* must correspond to an exact part of the cross section diameter of the diaphragm, proportionally between 15% and 35%. This measure is crucial to obtain the correct folding of the diaphragm into two tongues which together cover the the diagonal area of the valve when the diaphragm is inflated. If the width is smaller two extra foldings are formed in in each tongue (causing hollow spaces and leaks), and with a larger width the two tongues cannot cover the full diagonal area.
The diagonal area of the *guide vanes* is also of great importance for the ability to close tightly. The vanes must end in a long sharp edge filling in the space between the vanes, and the sides of the vanes must be reasonably convex in order to obtain a perfect folding of the diaphragm along the vanes. In addition the surface of the vanes must be the exact size so that the two tongues of the inflated diaphragm have exactely the same surface as the diaphragm has in position of rest e.g. as cylindrical surface. If that is not the case extra foldings will also be formed in the diaphragm and consequently leaks will occur in the closed valve.

The invention makes it possible to produce a valve with variable opening for barring and regulation of flow in ducts at fairly low cost because it consists of straightforward components and is well suited for mass production. In this way the advantages of the expensive diaphragm with good function are combined with the low cost of normal ventilation dampers e.g. sliding dampers.

The market and the demands for dampers for e.g.ventilation systems is expected to rise notably in the next few years because of the wish for energy saving and the presence of modern adjusting electronics and measuring technics making it technically possible to design very accurate control systems. There has, however, been a lack of an equally accurate and inexpensive regulation valve or shut-off damper for transforming the signals to the process plant or to the ventilation plant.

The invention can be used both as a shutoff damper and as a regulation valve as it can close airtight and at the same time form a variable well defined opening merely dependened on the pressure of the pressing medium as e.g. compressed air.

The invention is chatacterized as follows:

1. The pinch valve is equipped with two *guide vanes* placed diagonally lengthwise on the inside of the diaphragm ensuring that the diaphragm is pressed into two mirror-inverted tongues when it is inflated with compressed air or other pressing medium of suitable pressure on the outside of the diaphragm.
2. *The guide vanes* are fastened directly on the rubber diaphragm as a part of this or they are fastened onto the metal tube with through-going screws or rivets or the like.
3. *The guide vanes* are moulded in a shape so that they cover the empty spaces forming on each side of the the two pressure loaded tongues.
4. *The guide vanes* are made of flexible or inflexible material of suitable hardness.
5. The diaphragm is fastened to the metal covering by means of an enlargement in each end of the diaphragm, and these two enlargements fit into the corresponding hollows in the metal tube covering.
6. The pipe formed covering (metal tube) is normally made of metal.
7. Alternatively the covering can be made of armoured rubber or other flexible material making it possible to vulcanize the diaphragm and covering together in a single unity.
8. Alternatively the diaphragm can be closed with a mechanical plunger device or turning device which in a position of rest is placed between the metal tube and the diaphragm. With a movement of turning or plunging this device can force the sides of the diaphragm towards each other and thus form a slit that can close airtight without the use of a pressing medium as e.g. compressed air.

The invention is illustrated in figure 1-4 and figure 5.

The 4 first illustrations show a sectional view of the middle of the valve, from fully open position (fig. 1) to partly open (fig. 2) with a low pressure, to almost closed (fig. 3) and fully closed (fig. 4). The inflexible tube is shown as item 1, and the diaphragm and the two *guide valves* are shown as partly item 2 and item 3.
In fig. 5 is shown how the diaphragm (item 2) and the *guide valve* (item 3) are positioned in the tube of the valve (item 1) in fully open position, corresponding to fig. 1.

The invention functions as follows:
The valve is built in a ventilation plant or a process plant by installing it in the duct system in suitable places. In position of rest the valve is fully open and allows totally free air flow. According to reqiurement the valve can close fully or partly and consequently either shutoff or regulate an air flow or other process flow. It is closed by means of a pressing medium e.g. compressed air, or by pressing together the diaphragm with a turning device or plunger device.

Below is listed the most important **applications:**
1. **Shutoff:** Pneumatic signal.
The valve is activated by opening and closing the supply of compressed air. The pressure of the compessed air must be regulated for typically 1,0 bar positive pressure. The reaction time can be reduced by installing an intensifier into the comressed air cycle.
2. **Shutoff function:** Electrical signal.
The valve is activated by an electrical signal (e.g. from a central regulating device) for opening and closing the supply of compressed air by means of an electrically driven compressed air feed valve.
3. **Control of volume flow:**
The valve is controlled from differential pressure transmitter via a control device and a compressed air feed valve.
The differential pressure is measured across a measuring diaphragm in the ventilation duct.
The differntial pressure transmitter + regulator exist as a ready unit that can be connected directly to a measuring diaphragm and which can feed a pinch valve directly with the correct pressure.
Alternatively the regulating device can lead a pneumatic feed valve to the pinch valve.
4. **Pressure control:** Pneumatic signal.
The valve is operated from a pressure transmitter via a pneumatic control device and a pneumatic feed valve.
Pressure transmitter + control device exist as a ready unit within the selected pressure range.
Alternatively the pinch valve is connected to a standard pressure transmitter and control device or to a central control system.
5. **Pressure control:** Electrical signal
The valve is controlled from a pressure transmitter via an electric control device and a pneumatic feed valve.
Pressure transmitter + control device exist as a ready unit within the selected pressure range.
Alternatively the pinch valve is connected to a standard pressure transmitter and control device or to a central control system.
6. **Pressure/volume control:**
The valve is controlled from a pressure transmitter (total pressure or differential pressure) via an electric control device and a electric motor. The motor can be modulation or on/off regulated.
The electric motor presses the diaphragm of the valve and consequently closes partly or fully the air flow in the duct.

7. **Adjustment/shutoff** : Manual.
The valve is activated or controlled manually via a particular mechanical closing device.
Suited as adjustment valve/damper or control cone in ventilation systems.
8. **Process plants:**
The valve can be used for shutting off or controlling other process flows as e.g. difficult liquids, heavy goods in silos, powder in dust conveyors, shoot bulks etc.

The invention can be described as follows:
The cylindrical diaphragm is produced with one or more layers of non-vulcanized rubber on a metal cylinder. The outer edges of the diaphragm are reinforced and equipped with a special enlargement for later attachment to the pipe coating.
The item is vulcanized for an adequate period of time in an autoclave for obtaining adequate hardness and wear resistant.
The completed cylindrical diaphragm is then fastended in each end of the pipe coating. This usually happens by placing the enlargement in the metal tube and then fastening the diaphragm with inserted nipples.

The patent claims are as follows (item 1-4):

1. The pneumatic valve for shutoff and regulation of an air flow or other process flow as illustrated in enclosed figure 1-5 with the above specified explanation item 1-3 and which consists of a flexible cylindrical diaphragm of adequate thickness fastened to the inside of a metal pipe and which is **characterized** of the diaphragm being equipped with two special *guide vanes* making it possible to make the valve close by means of two mirror-inverted tongues meeting in the centre allowing the valve to close fully or partly, as described in the above mentioned characteristics 1-4.

2. Pneumatic valve according to claim 1, **characterized** of metal pipe and diaphragm being connected with a rubber enlargement in a corresponding groove in a tube made of metal or alternatively armoured rubber, as described in the above mentioned characteristics 5-7.

3. Pneumatic valve according to claim 1 and 2, **characterized** of the diaphragm instead of by means of a pressing medium as e.g. compressed air is pressed together and in this way closes by means of a mechanical device placed between the the diaphragm and the tube and which can be screwed or pressed with a handle or a motor on the outside of the valve cover and thus squeeze the diaphragm together in a bigger or smaller slit and close the opening of the valve fully as described in characteristic no 8.

4. Pneumatic valve according to claim 1-3 **characterized** of the diaphragm being manufactured by vulcanizing or by the use of adequate adhesive.

Fig 1-4

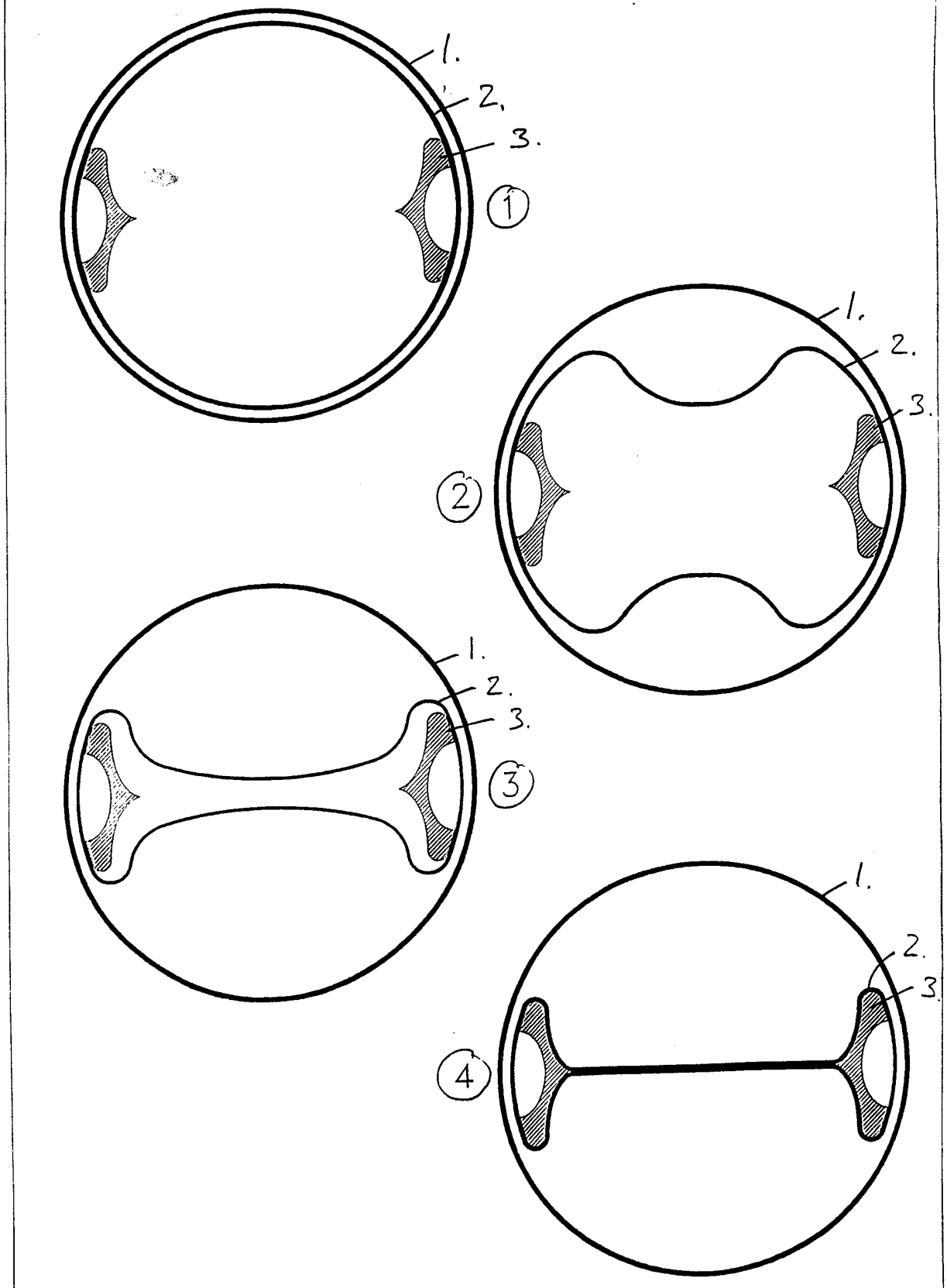

Fig 5