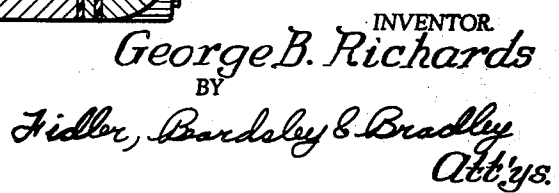


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Fig. 4A. Fig. 4B. Fig. 4C. Fig. 4D. Fig. 4E. Fig. 4F.

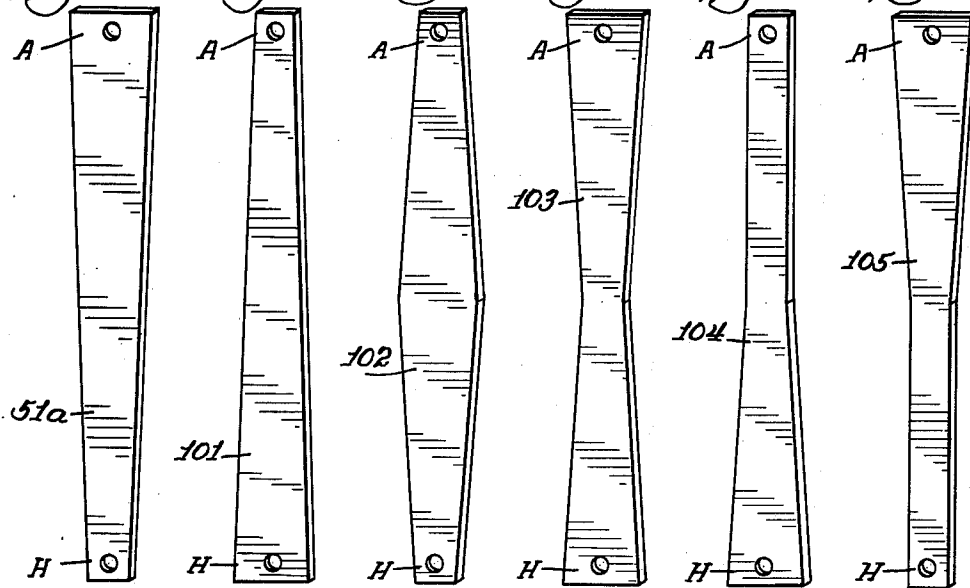
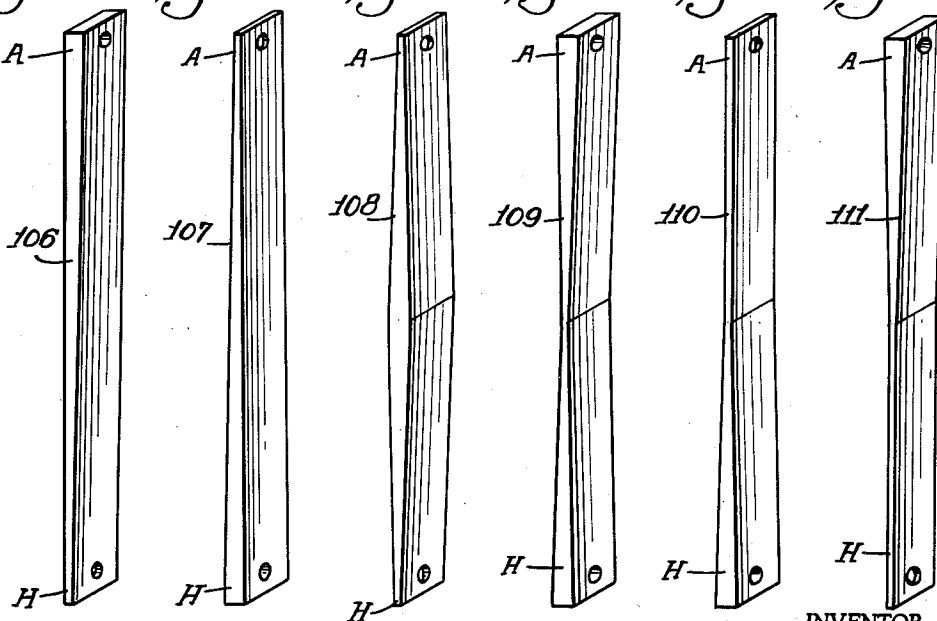


Fig. 5A. Fig. 5B. Fig. 5C. Fig. 5D. Fig. 5E. Fig. 5F.



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Fig. 6A. Fig. 6B. Fig. 6C. Fig. 6D. Fig. 6E. Fig. 6F.

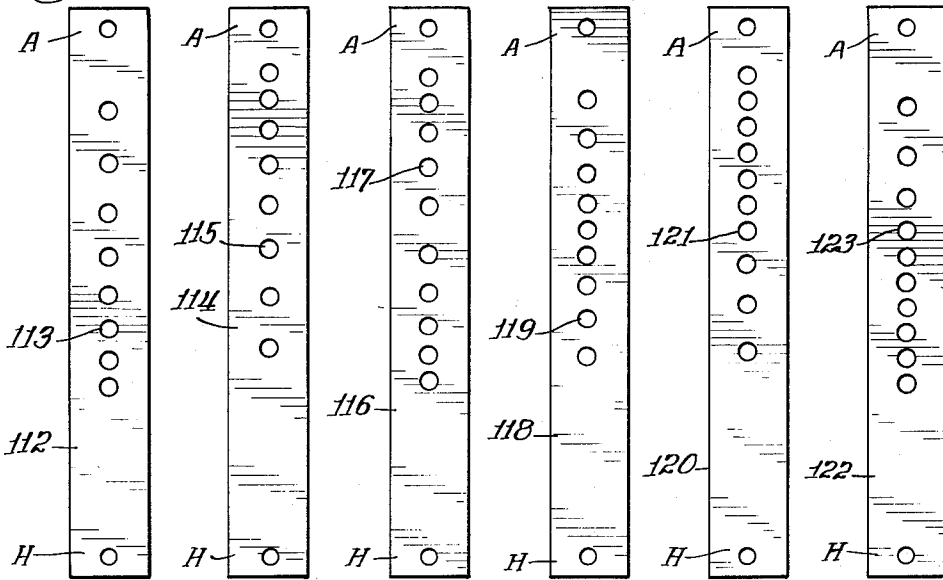
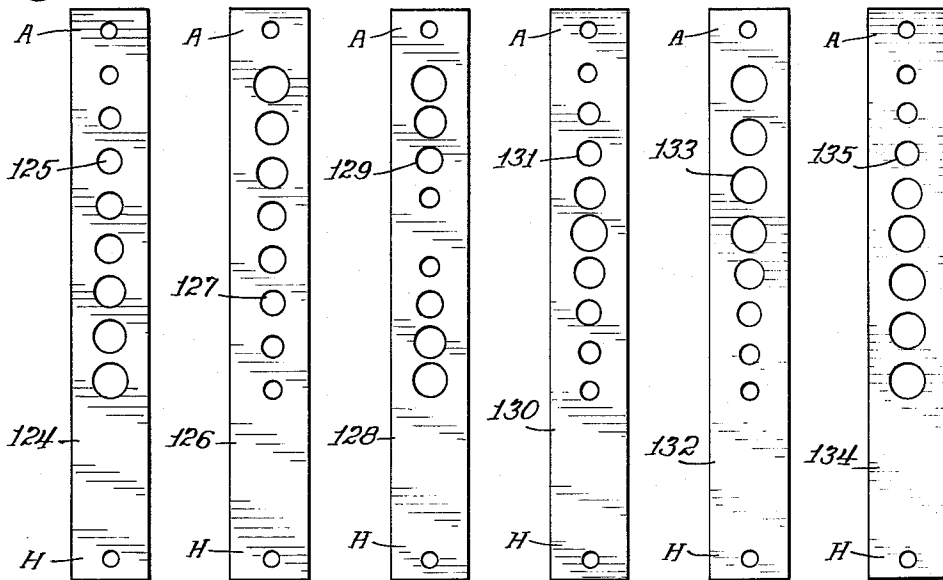


Fig. 7A. Fig. 7B. Fig. 7C. Fig. 7D. Fig. 7E. Fig. 7F.



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ACTUATOR MECHANISM

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19 Claims. (Cl. 137—202)

This invention relates to actuator mechanism and has to do more particularly with a new and improved actuating mechanism of the character wherein an actuator is connected to resilient bowed pressure elements which position the actuator from movement in either of two directions along a predetermined path.

One example of an actuator mechanism of the general character to which the present invention relates is shown, described and claimed in United States Patent No. 3,021,861, granted February 20, 1962, to Henry Robert Billeter and George B. Richards. The said Billeter and Richards patent in the illustrative embodiment discloses the actuator mechanism as employed in a liquid-level controlled device such as an air eliminator or liquid segregator or others wherein is provided a casing defining a chamber having an opening thereinto, a plurality of internal face portions disposed about an axis, an actuator movable in the chamber along the axis, a plurality of normally flat, resilient strip members or pressure elements having first portions secured to said casing adjacent the face portions, second portions secured to the actuator, and intermediate portions which are free and maintained in bowed shape, each strip member being bent back upon itself and of sufficient length to form two generally opposed portions, one lying against the corresponding face whereby each of the strip members exerts a force on the face with which it cooperates and the strip members position the actuator on the axis for movement therealong between a first position wherein the strip members lie against the corresponding faces to a predetermined extent, and a second position wherein the strip members lie against the faces to a lesser extent. In the illustrative embodiment, the strip members are moved between positions exposing orifices in the faces and positions closing such orifices and thus serve as valve elements.

In the invention disclosed in the aforesaid patent the strip members, or strips, are of uniform cross section throughout their effective lengths and have uniform resistance throughout their effective lengths to bending stresses. Thus as the actuator is moved from one position to another the strips maintain the same extent of bending and thus the same energy is recovered from the strips as is introduced so that there is substantially no resistance offered nor assistance rendered by the strips to the movement of the actuator. Thus the strips neither aid in nor resist the movement of the actuator along the axis of movement.

I have found that there are numerous situations wherein it is desired that the strips impart a force to the actuator in one direction or another along the axis of movement to aid in or resist the movement thereof along the axis of movement at least in a portion of the movement. For example, it is sometimes desirable to provide an aiding force or a resisting force, or an aiding and then a resisting force, or a resisting and then an aiding force, or an action wherein for a portion of the travel of the actuator there is an aiding or a resisting force but for the remainder of the travel there is neither an aiding nor a resisting force thereon. The present invention in its several embodiments provides a means for accomplishing the above described actions.

In accordance with the present invention, the strips are formed to have in each of various portions along the length of the intermediate portion, and more par-

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ticularly in the zone where the maximum bending of the strip takes place, different resistance to bending stress. Therefore, as the actuator is moved between its two positions, the strips will vary in their resistance to bending and thus will provide a force in the direction of the axis of movement of the actuator which will assist or resist the force applied to the actuator depending upon the construction of the strips. In accordance with the invention, the strips are so formed as to provide either an aiding force or a resisting force, or first an aiding force and then a resisting force, or first a resisting force and then an aiding force, or an action wherein for a portion of the travel of the actuator there is an aiding or a resisting force and for the remainder of the travel there is neither an aiding nor a resisting force. This result is provided by forming the strips in such manner that the transverse cross-section of each strip is different in various portions of the strip along its length. This may be accomplished by providing the strip with a different width at the different portions or a different thickness, or by providing openings through the strip which vary in size or proximity in various locations along the length of the intermediate portion of the strip. Thus, where the cross-sectional area is the greatest, there will be the greatest resistance to bending, and where it is the least there will be the least resistance to bending.

It will be understood that while the actuator is disclosed as taking the form of a float which is supported by a liquid and rises and falls with the rise and fall of the level of the liquid, the actuator may be adapted to be moved in either direction by forces generated by other means than the level of a liquid. Thus the actuator may include means other than a liquid supported float moving along the axis of movement, with the strips serving to position the actuator for movement along such axis. In such case, the actuator is supported and actuated by other means (not shown) and the strips serve to position the actuator and to apply an axial force on the actuator which tends to move it along the axis. Where the actuator is thus formed, it may be positioned for movement along an axis other than a vertical axis. Thus while the present invention finds wide application in connection with float actuators and is disclosed in connection therewith, it is not limited to such applications.

It will also be understood that while in the present application the strips or pressure elements or at least one of them is disclosed as serving as a valve member to close an orifice, the pressure elements may serve merely as guiding or positioning elements and having no valving function.

The present invention is especially well suited to use in a fluid separator for separating two immiscible fluids of different specific gravities, such as an air eliminator or a liquid segregator, and is disclosed in connection with an air eliminator but is not limited to such use.

An object of the present invention is to provide an actuating mechanism having an actuator and bowed strips for guiding the actuator wherein the strips are so formed as to exert a force on the actuator in a direction along the line of movement of the actuator.

Another object is to provide an actuating mechanism having an actuator and bowed strips for guiding the actuator for movement along a predetermined path, which strips in the various embodiments of the invention are adapted to exert on the actuator an aiding force, or a resisting force, or an aiding force followed by a resisting force, or a resisting force followed by an aiding force, or an action wherein for one portion of the travel of the actuator there is neither an aiding nor a resisting force and for another portion of the travel there is an aiding or a resisting force.

Still another object is to provide an actuator mech-

anism which is simple and inexpensive to build, strong and rugged in construction, effective in operation and which requires a minimum of servicing, repair and replacement of parts over a long period of service.

Another object is to provide a novel float guide means for liquid-level controlled devices.

Another object is to provide a novel float guide means for a float-type actuator including bowed strips so formed as to guide the float along a predetermined path and adapted in the various embodiments of the invention to exert on the actuator a lifting force, or a depressing force, or a lifting force followed by a depressing force, or a depressing force followed by a lifting force, or an action wherein for a portion of the travel of the actuator there is neither a lifting force nor a depressing force and for another portion of the travel there is a lifting force or a depressing force.

Other objects and advantages of the invention will appear from the following description taken in connection with the appended drawings, wherein:

FIG. 1 is an end elevational view of one form of air eliminator embodying the invention;

FIG. 2 is an enlarged vertical section taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged sectional view taken along line 3—3 of FIG. 2;

FIG. 4A is a perspective view of one of the strips shown in FIGS. 1 to 3;

FIGS. 4B to 4F are perspective views showing strips of various forms all of which vary in width in various portions along the length of the strip;

FIGS. 5A to 5F are perspective views showing strips which vary in thickness in various portions along the length of the strip, which strips correspond in their resistance to bending with the strips of FIGS. 4A to 4F, respectively;

FIGS. 6A to 6F are plan views of strips of uniform width and thickness and which are provided with openings therein along their length which strips correspond generally in their resistance to bending with the strips of FIGS. 4A to 4F, respectively; and

FIGS. 7A to 7F are plan views of strips of uniform width and thickness and which are provided with modified arrangement of openings therein, which strips correspond generally in their resistance to bending with the strips of FIGS. 4A to 4F, respectively.

Inasmuch as my invention is especially well adapted for use in air eliminators, I have illustrated it in a preferred embodiment in its application to an air eliminator. However, it will be understood as the description proceeds that the invention also is equally well adapted to other uses where an actuator and especially a liquid-level controlled actuator is employed.

Referring now particularly to FIGS. 1 to 3 of the drawings, there is shown an air eliminator which includes a head 20 formed by a hollow casing or housing 21, having a bottom flange 22 by which the head is secured to a flange 23 of a tank 24 which may be of any conventional construction. The head 20 is suitably secured to the tank 24, as for example, by machine screws 25.

The interior of the air eliminator tank 24 communicates with the interior of the head 20 through openings 30 (one of which is shown) formed in a plate 31, secured in the casing 21, as by a guide shaft 74 threaded into the top of the casing 21 and a nut 33 threaded on the lower end of the shaft 74.

The casing 21, which at its lower portion is of generally circular cross-section and at its upper portion is of generally rectangular cross-section, defines a float chamber 35, which communicates relatively freely through the openings 30 with the interior of the tank 24.

The upper portion of the casing 21 is preferably of generally rectangular cross-section and defines a valve chamber. Opposite portions of the valve chamber are provided with openings 39a and 39b in its ends which

are closed by end plates 40a and 40b respectively, suitably secured to the casing.

The end plates 40a and 40b are both provided with openings 42a and 42b adapted to receive a pipe such as the pipe 43a shown threaded into the end plate 40a in FIG. 2. In the embodiment of the invention illustrated in FIG. 2 the opening 42b in the other end plate 40b is closed as by a screw plug 49, although it is adapted to receive a pipe similar to the pipe 43a.

Interposed between the casing 21 and each of the end plates respectively are orifice plates 45a and 45b which are suitably secured in place and which are provided with vertically elongate orifices 46a and 46b respectively. The end plates 40a and 40b are recessed and provide with the respective orifice plates 45a and 45b, chambers 47a and 47b which communicate with the float chamber through the orifices 46a and 46b, except when the latter are closed by the valves hereinafter described.

Disposed against the inner face of the orifice plate 45a is a cover gasket 60a, formed with an orifice 61a corresponding in shape to the orifice 46a. A similar gasket 60b is provided for the orifice plate 45b. The gaskets 60a and 60b are clamped between the casing, and the orifice plates respectively, although they alternately may be adhesively secured to the respective orifice plates in order to insure that they are not displaced and that the orifices in the plates and gaskets remain in alignment. Ring gaskets 62a and 62b are provided between the orifice plates 45a and 45b and the cover plates 40a and 40b respectively. The gaskets are formed from a suitable material which is sufficiently resilient to provide an effective seal between the respective members and which is resistant to the liquid with which the air eliminator is adapted to be used. I have found that a synthetic rubber such as neoprene is excellently adapted for use in forming the gasket although other materials having the desired characters may be applied.

The chambers 47a and 47b are connected by two passages 48 formed in the upper portion of the casing 21. Thus, even though the right-hand chamber 47b is closed from the exterior by the screw plug 49, nevertheless, it communicates with the exterior through the two passages 48, the left-hand chamber 47a and the pipe 43a. The passages 48 thus equalize the fluid pressure in the chambers 47a and 47b. The orifice plates 45a and 45b as well as the gaskets 60a and 60b and 62a and 62b are provided with openings 148, 149 registering with the passages 48, whereby to permit free communication between the chambers 47a and 47b. When the valves (hereinafter described) are in open position, the interior of the casing 21 (that is, the float chamber 35) communicates with the pipe 43a not only through the left-hand orifice 46a, but also through the right-hand orifice 46b.

Where it is desired that the valves function independently to exhaust air from the interior of the head to separate points, the plug 49 is replaced by a pipe (not shown) threaded in the opening 42b and an orifice plate (not shown) which has no openings corresponding to openings 149 is substituted for the orifice plate 45b. Thus, there

is no communication between the chambers 47a and 47b. The orifices 46a and 46b (as well as the orifices 61a and 61b) are adapted to be closed by valve elements 51a and 51b which are similar in construction and accordingly only one of the valve elements and the associated portions of the air eliminator will be described in detail.

The valve element 51a sometimes called a "reed" takes the form of an elongated normally flat strip of flexible, resilient material, preferably metal, which is inert to the liquid with which the air eliminator is adapted to be used. While any spring material having suitable flexibility, resiliency and inertness may be used, I have found that a spring steel alloy sold under the name "Elgiloy" provides excellent results.

The valve element 51a is of sufficient width to extend across and completely close the orifice 46a when the valve,

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is in closed position and is of sufficient length to permit it to be mounted and actuated as hereinafter described.

The valve element or strip 51a is rigidly secured to the casing at a point below the orifice 46a and in such position that the adjacent portion of the strip lies against the face of the inside cover gasket 60a, as shown in FIG. 2, at all times. To this end, the lower end of the strip is secured, as by a machine screw 63, to a boss 64 projecting from the body in position to suitably support the lower end of the valve element in the desired position.

The boss 64 has an inclined face to which the unbent end of the strip 51a is attached. This insures that the portion of the strip which lies against the gasket 60a is firmly maintained thereagainst.

The other end of the strip 51a is attached to a tubular stop 70 which is formed with a straight, flat face 70a providing a flat surface against which the inner end of the strip is held and against which the adjacent portion of the strip lies to varying degrees as explained hereinafter. The face 70a extends parallel to the inner face of the gasket 60a for a purpose which will appear hereinafter. The stop 70 is connected to a guide stem 71 attached to and forming a portion of a float 72.

From the foregoing it will be seen that the stop 70 serves not only as means for halting the upward movement of the float 72, but it serves also to actuate the strips 51a, 51b by transmitting to the attached ends thereof movement corresponding to the movement of the float 72. Also the stop 70 provides reaction surfaces 70a and 70b in opposing relation to the surfaces of the gaskets 60a and 60b and against which the inner portions of the strips bear. Thus the stop may also be termed an abutment member. The stop 70 in the embodiment shown is secured to and movable with the float ball and may be considered to be part of the float. Since the assembly 100 of the float ball, guide stem and stop serves to actuate the strips, it may be termed an "actuator."

The stem 71 extends through and is sealingly secured in the "ball" portion 73 of the float and projects therefrom at each end. At its upper end the stem 71 is inserted into the stop 70 and is connected thereto by a machine screw 80a extending through these members. The screw 80a also serves to connect the ends of the valve elements 51a to the stop 70 as shown particularly in FIG. 2 of the drawings. A channel-shaped clip 82a is provided at the side of the stop 70 and is secured by the screw 80a for the purpose of retaining the ends of the valve element 51a against twisting out of position relatively to the stop 70. The stem 71 is hollow and receives the upstanding guide shaft 74 which is rigidly secured in and upstands from the plate 31. The stem 71 thus serves to guide the float 72 for movement in a vertical direction within the float chamber 35.

The strip 51a is so secured to and supported by the casing and the float that in all positions thereof throughout its range of movement from its lower, open position (as shown in full lines in FIG. 2) to its upper, closed position (as shown in broken lines in FIG. 2), it has a free, intermediate portion extending between the portion which bears against the face of the gasket 60a and the portion which bears against the opposing face 70a of the stop, which free portion is bent back upon itself and assumes a curved shape. As explained more fully hereinafter, the strip 51a exerts equal and opposed forces on the gasket 60a and the face 70a. However, as the actuator moves up and down the curvature of the free portion of the strip 51a changes and the force varies. Consequently, the energy stored in the strip varies.

The inner walls of the orifice plates 45a and 45b and hence the faces of the gaskets 60a and 60b are disposed symmetrically with respect to the central axis of the casing as are the reaction surfaces which are in opposition to the faces of the gaskets respectively. The actuator is positioned by the elements 51a and 51b for movement along such axis.

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The two valve elements 51a and 51b are connected to the casing 21 and to the stop 70 at diametrically opposite points whereby the two valves 51a and 51b are disposed in opposition. Accordingly, they exert on the stop 70 and accordingly on the float 72 equal and opposite forces so that the float normally is freely positioned by the strips 51a and 51b in the float chamber and does not bear against the guide shaft 74. The guide shaft 74, however, is provided so as to protect the float and strips from damage due to extraneous forces during movement of the air eliminator, as in shipment. Each of the elements 51a and 51b serves as a pressure element which yieldably resists lateral displacement of the actuator.

The second strip or element 51b is formed and supported in a similar manner to the element 51a as above described and cooperates with the inner face of the gasket 60b and the opposing face 70b of the stop 70 in a similar manner.

Since the assembly consisting of the strips 51a and 51b, the stop 70, and the float 72 is freely positioned, the forces exerted by the respective strips 51a and 51b against the faces of their respective orifice plates 45a and 45b (that is, against the gaskets 60a and 60b) are equal and the strips therefore are completely balanced against each other.

Moreover, the arrangement is such that each of the strips 51a and 51b is under stress throughout its entire range of movement which stress causes the strip to be urged against its orifice plate, throughout a portion of the strip, during its entire range of movement. As will be seen from the drawings when the float is in its lower position (as shown in full lines in FIG. 2) the strips 51a and 51b bear against the faces of their respective orifice plates 45a and 45b throughout only the lower portions of the strips and at an area on each of the orifice plates below the orifices 46a and 46b. However, as the float 72 rises to its upper position (as shown in broken lines in FIG. 2), as established by the abutment of the stop 70 against the upper wall of the float chamber 35, the strips 51a and 51b bear against greater areas of their respective orifice plates and close the orifices 46a and 46b and bear against the plates at portions above the orifices in order to provide complete closures for the two orifices 46a and 46b. Thus it will be seen that strips 51a and 51b are urged in to their positions closing and sealing the orifices 46a and 46b by the resilience of the strips 51a and 51b themselves.

In the operation of the air eliminator thus far described, the tank 24 is suitably connected to a liquid line (not shown) from which it is desired to remove air. Assuming that the air has been removed and liquid stands in the head 20 at a level sufficient to raise the float to its uppermost position (as illustrated in broken lines in FIG. 2) the strips 51a and 51b are in closed positions. Thus the strips lie against their respective orifice plates 45a and 45b and extend entirely over and sealingly close the respective orifices 46a and 46b so that no liquid can escape from the head.

It will be noted that the strips 51a and 51b lie flat against their respective orifice plates throughout a substantial zone thereof and particularly a zone on both sides of and above and below the orifices 46a and 46b so that the latter are fully closed. As noted above, the spring pressure of the strips 51a and 51b provided by reason of their bowed or arcuate form insures that the closing portions thereof are maintained against their respective orifice plates, regardless of whether or not the air or liquid within the float chamber 35 is under pressure.

When air (or other fluid) enters the float chamber 35 from the liquid line such air displaces the liquid in the float chamber 35 and causes the level to fall. When this occurs the float 72, which is buoyantly supported by the liquid, also falls and carries with it the stop 70 to which the strips 51a and 51b are attached. The downward movement of the stop 70 causes the ends of the strips 51a and 51b attached thereto to move downwardly in a direction parallel to the faces of the orifice plates with the result that

the portions of the strips **51a** and **51b** which previously lay against the orifice plates are stripped or "peeled" away from the orifice plates **45a** and **45b** progressively downwardly and as the downward movement of the float continues the orifices **46a** and **46b** are progressively uncovered in a direction from the upper portions thereof toward the lower portions.

There is a small force resulting from the pressure differential on the two sides of each strip which is applied over that portion of the face of each of the strips which overlies the corresponding orifice and which force tends to maintain each strip against its orifice plate to close the orifice. This force, however, is very small and is relatively ineffective in opposing the opening of the strip. It will be seen that each of the strips is progressively pulled away from its orifice plate and, owing to the resilience of the strip and the arcuate shape into which the strip is forced by the manner in which it is attached to the casing and to the stop, the strip is moved away from the orifice plate in progressively small increments so that only a small portion of the area of the strip which overlies the orifice plate is moved away from the plate at any instant. Thus, the orifice is progressively uncovered in increments and any fluid pressure-generated force opposing the movement of such small increments of the strip away from the orifice plate is extremely small.

As stated above, each strip is so supported and the arrangement of the associated elements is such that the free portion of the strip retains a curved shape in all positions of the float. Thus it will be seen that as the float moves downwardly and carries with it the corresponding end of the strip which is secured to the stop **70**, the adjacent portion of the strip is progressively flattened and the portion of the strip adjacent the end which is attached to the casing is progressively curved. In other words, the arc or bend in the strip is transferred from a portion nearer to the inner anchored end which is attached to the stop to a portion nearer to the outer anchored end which is attached to the casing.

It will be understood that the amount of energy stored in the strip by reason of its bent condition depends upon its degree of resistance to bending offered by the strip and primarily that zone of the intermediate portion where the maximum bending takes place. Thus, when the actuator is moved in a direction to move the zone of maximum bending toward a portion of the strip which exhibits an increased resistance to bending, energy is stored in the strip. In such case, the strip exerts a force on the actuator along the direction of movement of the actuator opposing movement of the actuator. This requires that a force be applied to the actuator to move it in such direction. On the other hand, where the actuator is moved in a direction to move the zone of maximum bending to a portion of the strip which exhibits a decreased resistance to bending, energy is given up by the strip. Thus, where the actuator is in such a position that the resistance to bending of the strip in the portions on opposite sides of the zone of maximum bending is different than at the zone of maximum bending, there will be a force created by the strip tending to urge the actuator to a position of less stored energy.

It will be seen that the strips **51a** and **51b** in the device shown in FIGS. 1 to 3 increase progressively in width in a direction from the end which is fixed to the housing (which end is indicated by H in FIG. 4A) toward the end which is fixed to the actuator (which end is indicated by A in FIG. 4A). Thus, in all positions of the actuator the strips exert a downwardly directed force on the actuator along the direction of the axis of the casing, which force progressively decreases as the actuator moves downwardly. Thus, it will be seen that the form of the strips is such that the strips provide a greater effective weight of the actuator when the latter is in a lower position than when it is in an upper position.

The rate of the variation in lifting effect provided by the strips **51a** and **51b** is determined by the taper of the

strips **51a**, **51b** and can be changed by suitably selecting the taper of such surface.

As soon as the orifices **46a** and **46b** have been uncovered by the above-described opening movement of the strips **51a** and **51b** the air or other fluid trapped in the float chamber **35** above the level of the liquid in the system and which normally is under some pressure is caused to flow out of the float chamber through the orifices **46a** and **46b** and the vent pipe **43a** by which it is conducted to a point of disposal.

Should the liquid level in the float chamber fall sufficiently, the downward movement of the actuator will be halted by it bottoming against the plate **31**.

When the air or other fluid has been discharged to such an extent that the liquid level rises sufficiently to support and lift the float **72**, the latter is elevated and causes the strips **51a** and **51b** to be moved in a reverse direction to that described above in connection with the opening of the valve. That is to say, that as the float **72** moves upwardly, the strips are caused to progressively move against their respective orifice plates to an increasing degree and to progressively close their respective orifices until the orifices are completely closed and the strips extend in contact with their respective orifice plates both above and below the orifices. When the strips are in closed position, no further air or other fluid can escape from the float chamber **35**. It will be understood that during the upward movement of the float **72** and the progressive movement of the outer portions of the strips into increasing engagement with their respective orifice plates, and the peeling off of the inner portions from the surfaces **70a** and **70b**, the zone of maximum curvature of the free portions is transferred toward the ends attached to the actuator. Thus, the amount of energy stored in the strips increases as the actuator moves upwardly and accordingly the lifting force increases.

The construction shown in FIGS. 1 to 3 and utilizing the strips **51a** and **51b** (the former of which is shown in FIG. 4A) provides a construction in which in all positions of the actuator there is a downward force exerted on the actuator by the strips. This has the effect of adding weight to the float and this expedient can be employed in lieu of ballasting the actuator, such as may be necessary, for example, where the actuator is used with a relatively heavy liquid. This construction is used where it is desired to open the valves more quickly, with less inertia because the apparent mass of the actuator in its upper position exceeds its true weight, which force is available in a mechanical advantage of 2 to 1 for closing the valve.

In FIGS. 4B to 4F, inclusive, there are shown different forms of strips which may be substituted for the strips **51a** and **51b**, respectively, in the device shown in FIGS. 1 to 3. It will be understood that where such strips are substituted the two strips will be identical to each other.

The strip **101** shown in FIG. 4B tapers from the end H which is secured to the housing uniformly toward the end A which is secured to the actuator. This strip thus provides an effect which is the reverse of the effect provided by strip **51a**. In other words, the resistance to bending increases as the actuator moves downwardly. Consequently, the construction provides a lesser effective weight for the actuator when the latter is in its lower position. Where this strip is used, there is an upward force on the actuator created by the strips. This construction is used, for example, where it is desired to reduce the effective mass of the actuator so that there is little or no inertial effect retarding closure and a greater effective mass available for opening the valves.

The strip **102** shown in FIG. 4C increases in width from the end H which is secured to the housing toward the central portion of the strip and then decreases in width from the central portion toward the end A which is secured to the actuator. Thus, when the actuator is in its lower position, there is less resistance to bending and less resistance to the upward movement of the actuator. However, this resistance increases until the actuator

reaches a mid-position and the zone of maximum bending is at the center of the strip. Upon further movement of the actuator, the zone of maximum bending occurs at a portion of the strip which is decreasing in width and thus the resistance to the movement of the actuator decreases. Thus, it will be seen when the actuator moves upwardly from its lowermost position toward its uppermost position, there is first a downward force on the actuator, which delays the upward movement of the actuator, whereafter there is an upward force on the actuator. This change takes place abruptly and thus there is a "toggle" or "over the center" action. The arrangement preferably is such that the over-centering action takes place just as the strip tends to close the adjacent orifice and thus the orifice is closed rapidly. Thus, there is no delay in closing the orifice once the actuator has moved into a position to do so. This construction is used where it is desired to have the valves either opened or closed at a minimum time interval as, for example, where it is desired to avoid any "wire drawing" effect. The quick closing of the valves permits the valves to remain in relatively open position until they are actuated to close the orifices. At the same time, the construction provides for the quick opening of the valves when the liquid level falls.

The strip 103 of FIG. 4D is tapered from the end H attached to the housing toward the central portion and then increases in width from the central portion to the end A which is attached to the actuator. Thus, if the actuator is in either a position above its central position, or below its central position, there will be a force created by the strips tending to move the actuator toward its central position. In this construction, the actuator will be moved rapidly from either of its end positions toward its central position.

In some instances, it may be desirable that the strips exert no upward or downward force on the actuators in one portion of its travel and exert a force axially in one direction or the other when the actuator is in another portion of its travel. Strips suitable for such operation are shown in FIGS. 4E and 4F.

Referring to FIG. 4E, the strip 104 tapers from the end H attached to the housing toward the center and is of uniform width from the center to the end A attached to the actuator. Where strips of this form are used in the air eliminator, there is an upward force on the actuator when the latter is in its lower position and after it passes its central position there is no force exerted on the actuator by the strips. This construction is used where it is desired that there be a rapid initial closing action followed by a normal further closing action. This construction is employed, for example, where fluid in the air eliminator is under high pressure and it is desired that the full weight of the actuator be available to open the valves. On the other hand, when the actuator is in its lower position, it will respond quickly to the rise in the liquid level of the chamber.

In the case of the strip 105 shown in FIG. 4F, the action is the reverse of that of the strip 104 shown in FIG. 4E. In this case, the strip is of uniform width from the end H to the center and then increases in width from the center to the end A attached to the actuator. Thus, the strips 105 neither add to nor subtract from the weight of the float of the actuator when the latter is in its lower position, but serve to provide a greater effective weight when the actuator moves to its upper position. Thus the actuator will respond normally when in its lower position, but will open the valves rapidly when the liquid level falls at a time when the actuator is in its upper position.

The strips 106 to 111 shown in FIGS. 5A to 5F correspond in their action to the strips 51a and 101 to 105, respectively. However, the strips 106 to 111, inclusive, instead of varying in width are varied in thickness to provide the desired sections at the several portions along

the lengths of the strips. Each of the strips 106 to 111 is of equal width throughout its length. The strip 106 increases in thickness from the end H to the end A. The strip 107 decreases in thickness from the end H to the end A; the strip 108 increases in thickness from the end H to the center and then decreases in thickness from the center to the end H; the strip 109 decreases in thickness from the end H to the center and increases in thickness from the center to the end A; the strip 110 decreases in thickness from the end H to the center and is of uniform thickness from the center to the end A; the strip 111 is of uniform thickness from the end H to the center and then increases in thickness from the center to the end A.

I have found that the variation in transverse cross-section of the strips, in order to provide the desired variation in resistance of bending, is only necessary in that zone of the strip which is subjected to a maximum bending effect. In the example shown, this zone is at approximately the central one-third of the length of the strip. Therefore, ordinarily it is necessary only to provide the variation in section in the center one-third of the strip. In FIGS. 4A to 5F, inclusive, I have shown the variation not only in the center one-third, but in the entire strip. However, as will be understood, it is not necessary to provide the variation in those portions of the strip which are not subjected to the maximum extent of bending. Accordingly, in FIGS. 6A to 6F the modification of the transverse cross-sections of the strips, in order to provide the variation in resistance to bending, is effected only in the central zone of the strips.

I have also found that the variation in section of the strips may be effected by providing a longitudinally extending series of spaced openings in the strips throughout the central zone. It will be understood that the variation in section thus provided, while generally equivalent to that provided by a strip which varies continuously in section, is not identical for the reason that the variation in section is provided only in the portions of the strip where each opening occurs. In other words, the variation in bending resistance does not take place in infinitely small increments, but in discrete increments corresponding to the locations of the openings.

The strip 112 shown in FIG. 6A is provided with a longitudinal series of spaced openings 113 which are closer together at the end of the series nearest the end H and are more widely spaced at the end of the series nearest the end A. Thus the strip has a greater resistance to bending at the portion of the central zone nearest the end A. This strip, therefore, has a resistance to bending which varies in a manner generally similar to that of the strip 51a of FIG. 4A and its action is generally similar.

The strip 114 shown in FIG. 6B is provided with a longitudinally extending series of spaced openings 115 in which series the openings are more widely spaced at the end nearest the end H of the strip and more closely spaced nearest the end of the end A. Thus the strip has a greater resistance to bending in a portion of the zone nearest zone H. This strip, therefore, has a resistance to bending generally similar to that of the strip 101 shown in FIG. 4B.

The strip 116 of FIG. 6C is provided with a longitudinally extending series of spaced openings 117 in which series the portions nearest the end H are relatively close together and increase in mutual spacing toward the center of the zone whereafter the decrease in spacing is toward the end of the zone nearest the end A. This strip provides a resistance to bending generally similar to that of the strip 102 shown in FIG. 4C.

The strip 118 of FIG. 6D is provided with a longitudinally extending series of spaced openings 118 in which series the openings at the portion of the zone nearest the end H are relatively widely spaced and the openings decrease in spacing toward the center of the zone whereafter they increase in spacing to the portion of the zone

nearest the end A. This strip provides a resistance to bending generally similar to that of the strip 103 of the FIG. 4D.

The strip 120 of FIG. 6E is provided with longitudinally extending series of spaced openings 121 which decrease in mutual spacing from the portion of the zone nearest the end H toward the center of the zone and the openings from the center of the zone to the portion nearest the end A are uniformly spaced. This arrangement provides a resistance to bending generally similar to that of the strip 104 of FIG. 4E.

The strip 122 of FIG. 6F is formed with a longitudinally extending series of spaced openings 123 in which series the openings at the portion nearest the end H are uniformly spaced and the openings at the portion of the series in the center to the portion nearest the end A increases progressively in spacing. The strip 122 therefore provides a resistance to bending generally similar to that of the strip 105 of FIG. 4F.

It will be understood that each of the strips shown in FIGS. 6A to 6F is of uniform width and thickness throughout its length.

Instead of providing a series of openings, all of which are the same size and are variably spaced, I may provide a series of openings in which the openings are uniformly spaced but vary in size in the various portions of the series. Such an arrangement is shown in FIGS. 7A to 7F, inclusive.

Each of the strips of FIG. 7A to FIG. 7F is of uniform width and uniform thickness throughout its length and the openings preferably are equally spaced.

The strip 124 of FIG. 7A is provided with a longitudinally extending series of spaced openings 125 which decrease progressively in diameter from the portion of the series nearest the end H of the strip toward the portion of the series nearest the end A. This strip, therefore, has a resistance to bending which is generally similar to that of the strip 51a of FIG. 4A.

The strip 126 of FIG. 7B is provided with a longitudinally extending series of spaced openings 127, which openings increase in diameter from the portion nearest the end H of the strip toward the portion nearest the end A. Thus, this strip has a resistance to bending generally similar to that of the strip 4B.

The strip 128 of FIG. 7C is provided with a longitudinally extending series of spaced openings 129 which decrease in diameter from the portion nearest the end H of the strip to the center of the series and then increase in diameter to the other end of the series—that is, the end nearest the end A of the strip. This strip, therefore, has a resistance to bending generally similar to that of the strip 102 of FIG. 4C.

The strip 130 shown in FIG. 7D is provided with a longitudinally extending series of spaced openings 131, which openings increase in diameter from the end of the series nearest the end H of the strip to the center of the series and then decrease in diameter to the other end of the series. This strip has a resistance to bending generally similar to that of the strip 103 of FIG. 4D.

The strip 132 shown in FIG. 7E is provided with a longitudinally extending series of spaced openings 133 which increase in diameter from the end of the series nearest the end H of the strip to the center of the series and are of the same diameter from the center of the series to the end nearest the end A of the strip. Thus, this strip has a resistance to bending which is generally similar to that of the strip 104 of FIG. 4E.

The strip 134 of FIG. 7F is provided with a longitudinally extending series of spaced openings 135 which are of uniform diameter from the end of the series nearest the end H of the strip to the center of the series, and then the decrease in diameter from the center of the series to the end of the series nearest the end A of the strip. This strip, therefore, has a resistance to bending generally similar to that of the strip 105 of FIG. 4F.

I claim:

1. A fluid separator comprising casing means defining a chamber and providing a set of faces opposed relatively to an axis, an actuator movable along said axis and a plurality of normally flat resilient strip members, said strip members each having a first portion secured to said means adjacent said faces, respectively, and a second portion secured to said actuator, said first and second portions of each strip member being spaced apart by a third and intermediate portion which is free and maintained in bowed shape, each strip member having at each of various portions along the length of the intermediate portion a different resistance to bending stress, each of said strip members being bent back upon itself and being of sufficient length so it forms two generally opposed portions, one lying against the corresponding face whereby each of the strip members exerts a force on the face with which it cooperates and said strip members position the actuator on the axis for movement therealong between a first position wherein said strip members lie against the corresponding faces to a predetermined extent and a second position wherein said strip members lie against said faces to a lesser extent, at least one of said faces having an orifice opening into said chamber and positioned to be closed by the corresponding strip member when said actuator is in said first position and to be exposed when said actuator is in said second position.

2. A fluid separator according to claim 1 wherein each strip member is formed to vary in its resistance to bending stress progressively throughout the length of its intermediate portion.

3. A fluid separator according to claim 1 wherein each strip member is formed to decrease in its resistance to bending stress progressively along the length of its intermediate portion in a direction from said first portion toward said second portion.

4. A fluid separator according to claim 1 wherein each strip member is formed to increase in its resistance to bending stress progressively along the length of its intermediate portion in a direction from said first portion toward said second portion.

5. A fluid separator according to claim 1 wherein each strip member is formed to increase in its resistance to bending stress progressively along the length of the intermediate portion from adjacent said first portion to a point intermediate said first and second portions and to decrease in its resistance to bending stress progressively from said point toward said second portion.

6. A fluid separator according to claim 1 wherein each strip member is formed to decrease in its resistance to bending stress progressively along the length of the intermediate portion from adjacent said first portion to a point intermediate said first and second portions and to have a substantially uniform resistance to bending stress throughout its extent from said point to adjacent said second portion.

7. A fluid separator according to claim 1 wherein each strip member is formed to decrease in its resistance to bending stress progressively along the length of the intermediate portion from adjacent said second portion to a point intermediate said first and second portions and to have a substantially uniform resistance to bending stress throughout its extent from said point to adjacent said first portion.

8. A fluid separator according to claim 1 wherein each of said strip members varies in transverse cross-sectional area at each of various portions along the length of the intermediate portion.

9. A fluid separator according to claim 1 wherein each of said strip members varies in width in various portions along the length of said intermediate portion.

10. A fluid separator according to claim 1 wherein each of said strip members varies in thickness in various portions along the length of the intermediate portion.

11. A fluid separator according to claim 1 wherein each of said strip members is provided with a longitudinal

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series of spaced openings therethrough in the intermediate portion providing a variation in the transverse cross-sectional area of the strip members in various portions of the strip member along the length of the intermediate portion.

12. A fluid separator according to claim 1 wherein each of said strip members is provided with a longitudinal series of openings therethrough in the intermediate portion thereof which openings vary in size in various portions of said intermediate portion.

13. A fluid separator according to claim 1 wherein each of said strip members is provided with a longitudinal series of openings therethrough in the intermediate portion thereof which openings vary in their mutual spacing in various portions of the intermediate portion.

14. An actuator mechanism comprising means providing a set of faces opposed relatively to an axis, an actuator movable along said axis and a plurality of normally flat resilient strip members, said strip members having first portions secured to said means adjacent said faces, respectively, and second portions secured to said actuator, said first and second portions of each strip member being spaced apart by a third and intermediate portion which is free and maintained in bowed shape, each strip member having at each of various portions along the length of the intermediate portion a different resistance to bending stress, each of said strip members being bent back upon itself and being of sufficient length so it forms two generally opposed portions, one lying against the corresponding face whereby each of the strip members exerts a force on the face with which it cooperates and said strip members position the actuator on the axis for movement therealong between a first position wherein said strip members lie against the corresponding faces to a predetermined extent and a second position wherein said strip members lie against said faces to a lesser extent.

15. An actuator mechanism according to claim 14 wherein each of said strip members varies in transverse cross-sectional area at each of various portions along the length of the strip.

16. An actuator mechanism according to claim 14 wherein each of said strip members varies in width in various portions along the length of said intermediate portion.

17. An actuator mechanism according to claim 14

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wherein each of said strip members varies in thickness in various portions along the length of said intermediate portion.

18. An actuator mechanism according to claim 14 wherein each of said strip members is provided with a longitudinal series of spaced openings therethrough in the intermediate portion providing a variation in the transverse cross-sectional area in various portions of the strip member along the intermediate portion.

19. An actuator mechanism comprising means providing a set of first faces opposed relatively to an axis, an actuator movable along said axis and having a set of second faces opposed respectively to said first faces and about said axis and a plurality of normally flat resilient strip members, said strip members having first portions secured to said means adjacent first faces respectively and second portions secured to said actuator adjacent said second faces, respectively, said first and second portions of each strip member being spaced apart by a third and intermediate portion which is free and maintained in bowed shape, each strip member having at each of various portions along the length of the intermediate portion a different resistance to bending stress, said strip members being bent back upon themselves and being of sufficient length so that they form two generally opposed portions, one lying against each of the corresponding faces whereby each of the strip members exerts equal forces on the opposed faces with which they cooperate respectively and position the actuator on the axis for movement therealong between a first position wherein said strip members lie against the corresponding first faces to a predetermined extent and a second position wherein said strip members lie against said first faces to a lesser extent.

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