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(54) Automatic one-way fluid valves

(57) One automatic one-way fluid valve comprises a cylindrical valve tube (510) in which a cup-shaped diaphragm (540) is carried on radial supporting fins (524). The diaphragm (540) comprises a cylindrical side wall (542) extending from a closed end wall (544), and has externally near the free end of the side wall (542) a sealing surface which engages with, and presses by virtue of the inherent resilience of the diaphragm (540), against an annular sealing ridge (522) formed internally within the valve tube (510). An end cap (512) and dust barrier (538) carried on the free end of the valve tube (510) protect the mating valve sealing surfaces against contamination.

In another such valve, (Fig. 3) a radial inlet throat (50) is defined by annular seatings (48,46) spaced axially apart and formed on a valve tube (14) and on an end closure cap (12). A thin, tubular, elastomeric valve diaphragm (52) presses resiliently at its respective borders against the seatings so as to close the throat and prevent fluid flow between the valve tube and inlet passages which communicate with the throat. A fall in fluid pressure in the valve tube below that in said throat withdraws parts of the diaphragm from at leat one of the seatings to admit fluid to the valve tube. External fins (20) and internal fingers (36,38) limit the deformation of the diaphragm.

In Figs. 5 and 6 (not shown), the diaphragm (138,238) is frusto-conical and closes a frusto-conical throat (142,240), one border of the diaphragm being held firmly against one seating (140,232), and the other border pressing resiliently against the other seating (126,222). Modified forms of those several valves are described.

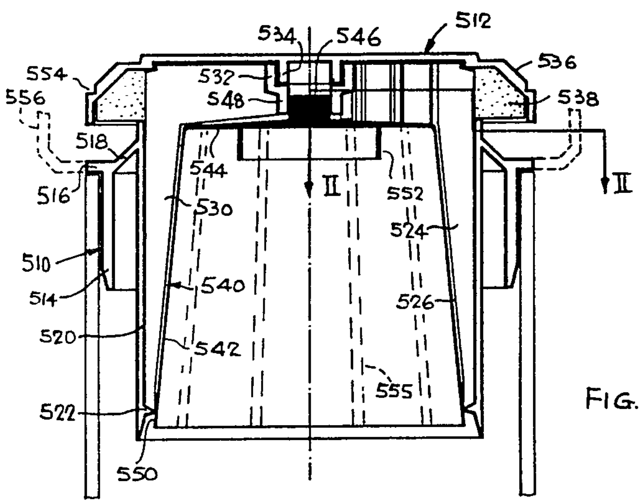

FIG. 1

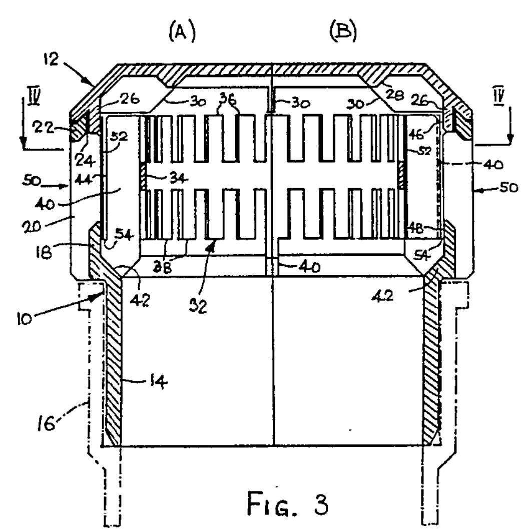

FIG. 3

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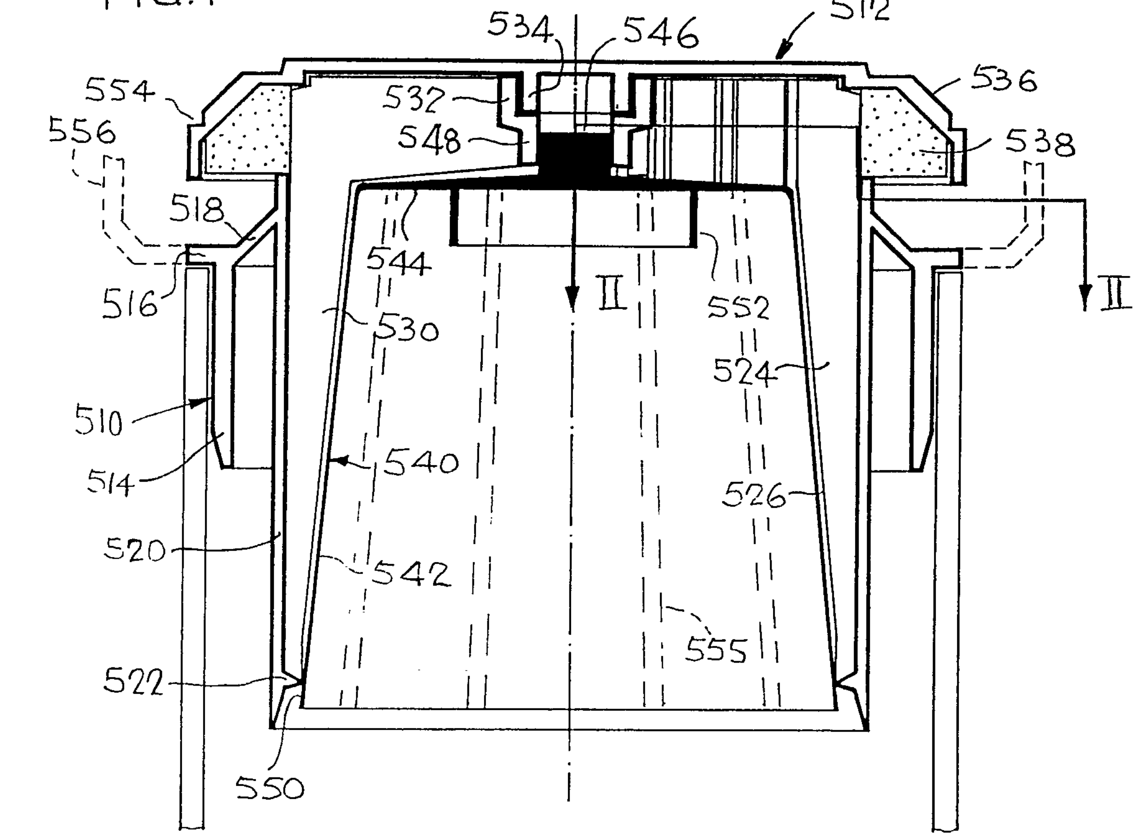
FIG. 1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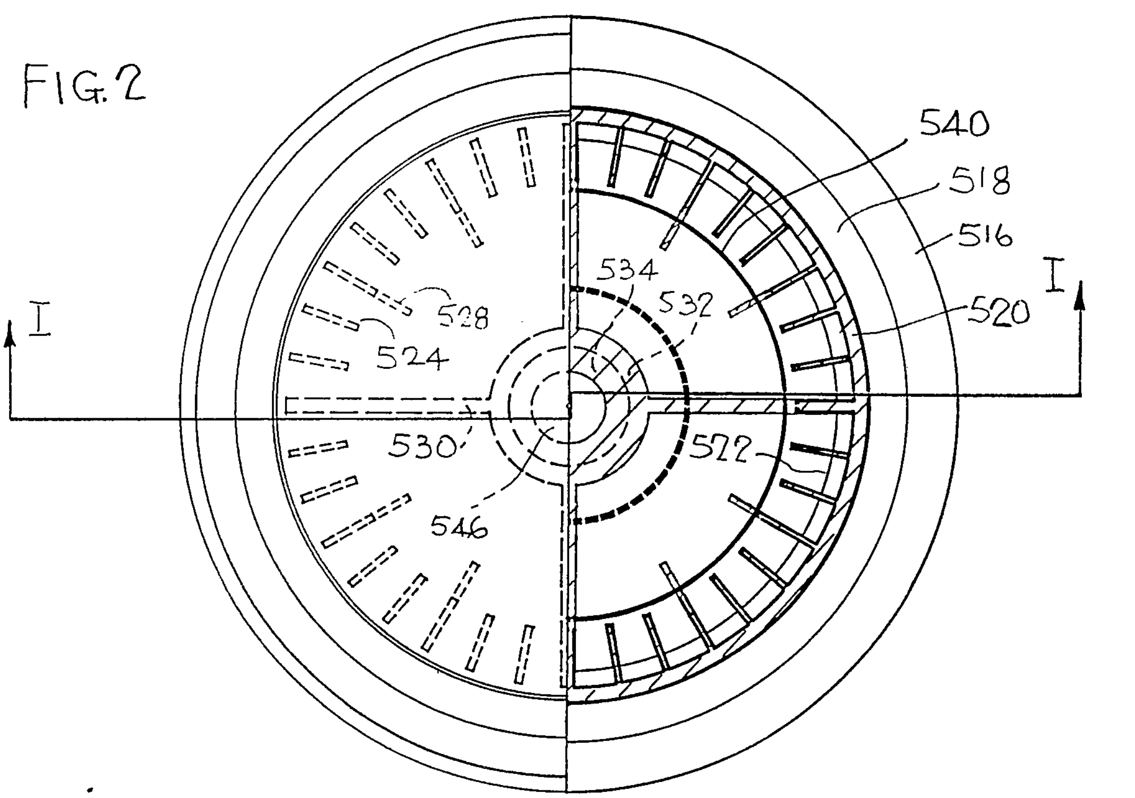
522
550

FIG. 2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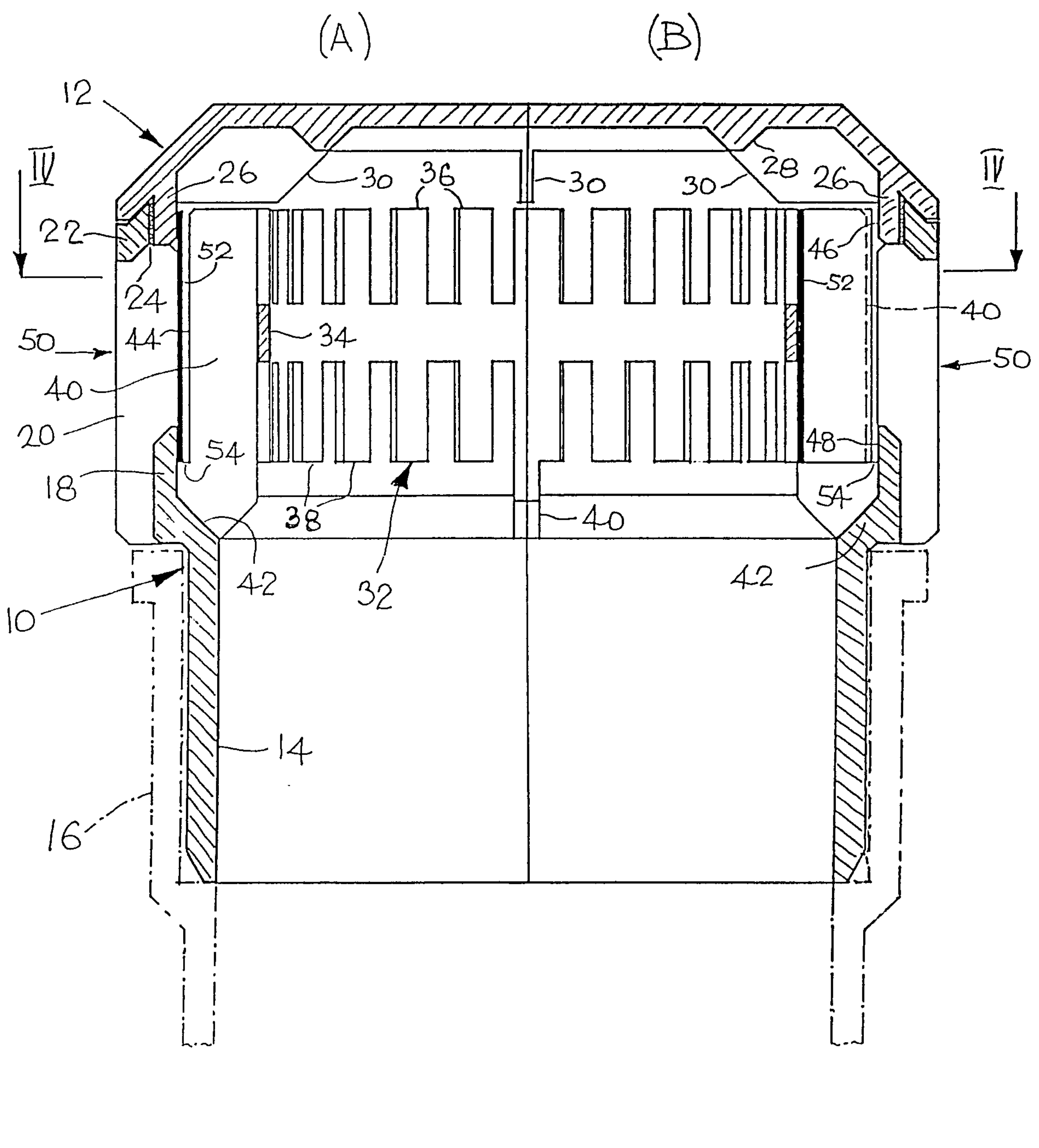
546

FIG. 3


(A)
(B)
12
IV
IV
26
30
36
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30
28
26
22
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52
46
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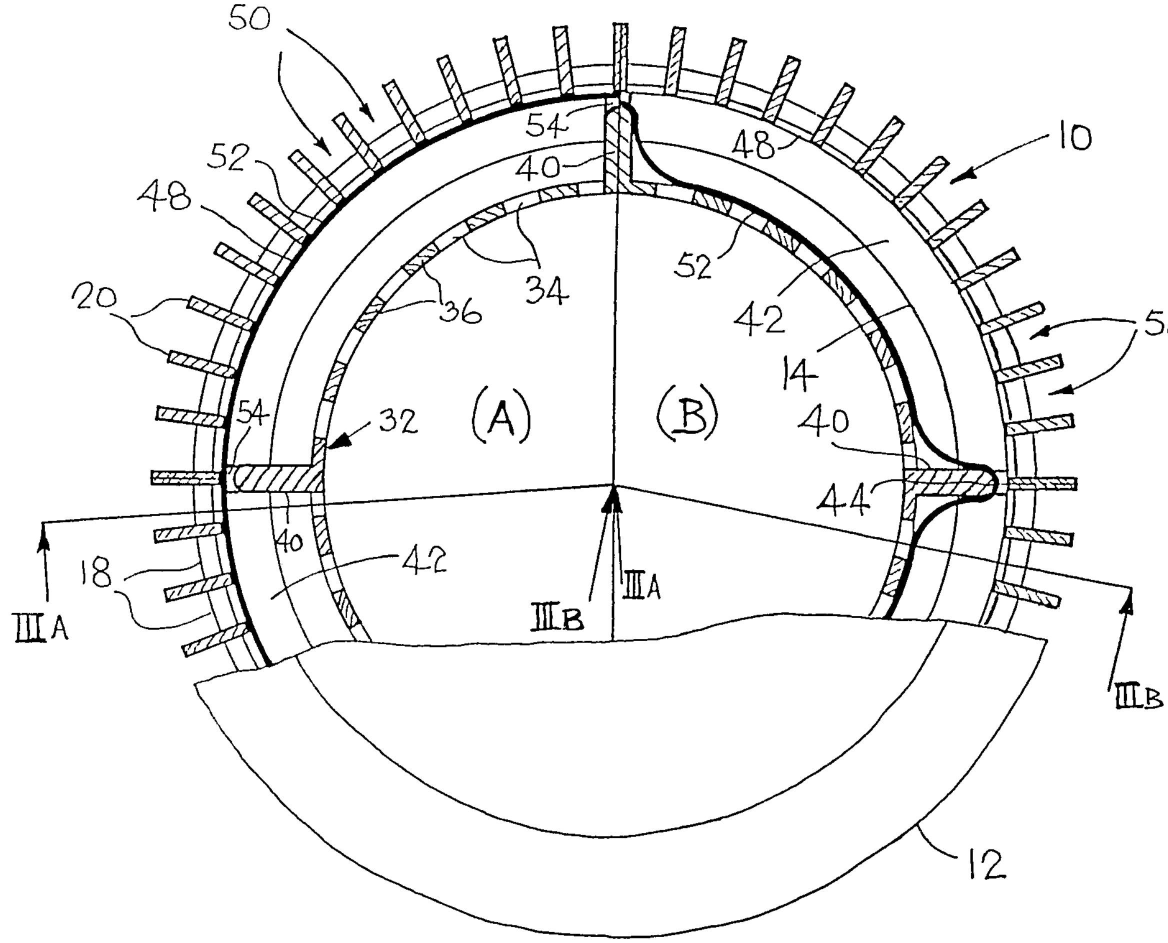
FIG. 4


50
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18
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32
(A)
(B)
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44
42
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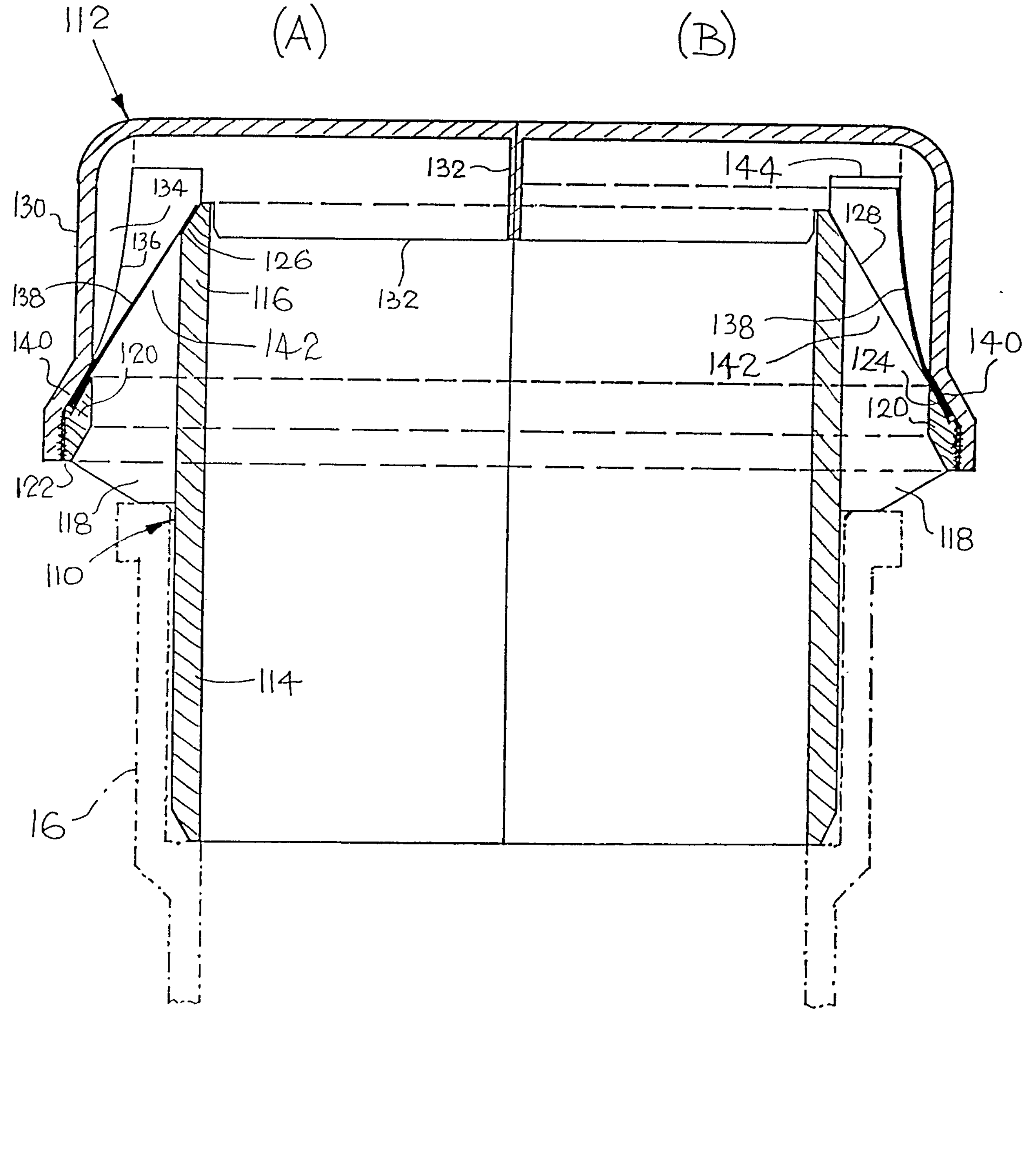
IIIA
IIIB
IIIB
IIIA
12

FIG. 5


112
(A)
(B)
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110
114
16

FIG. 6

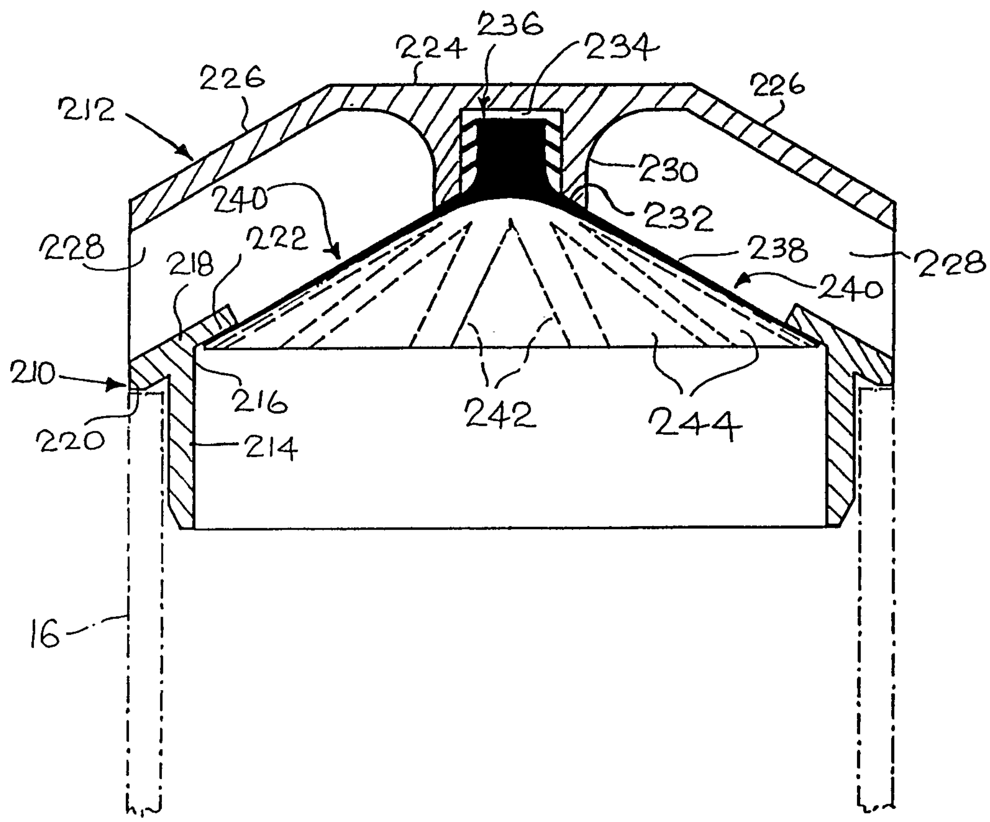
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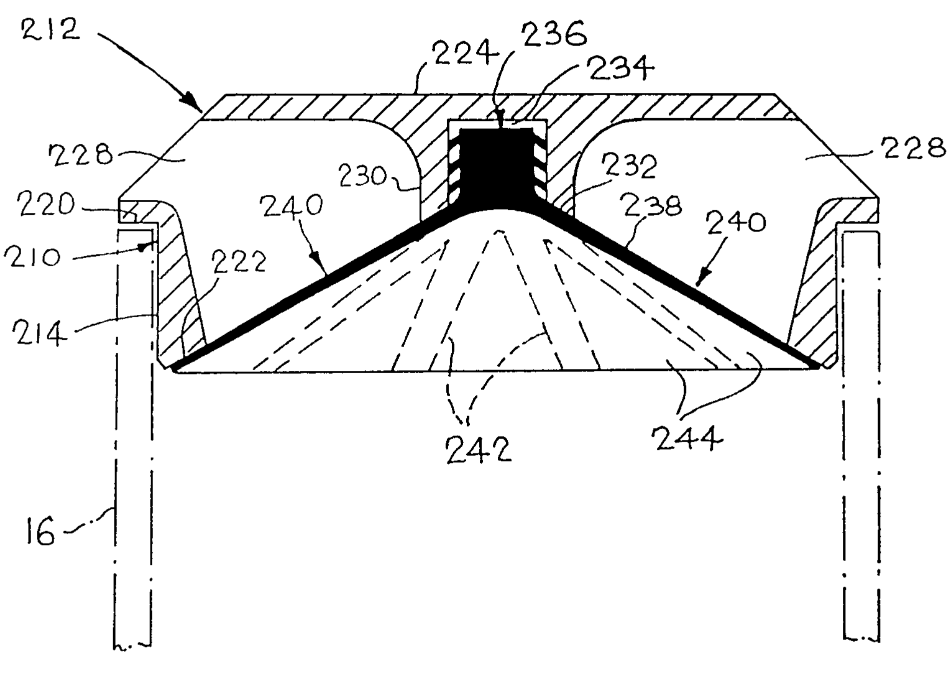
FIG. 7


212
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(A) (B)

FIG. 8

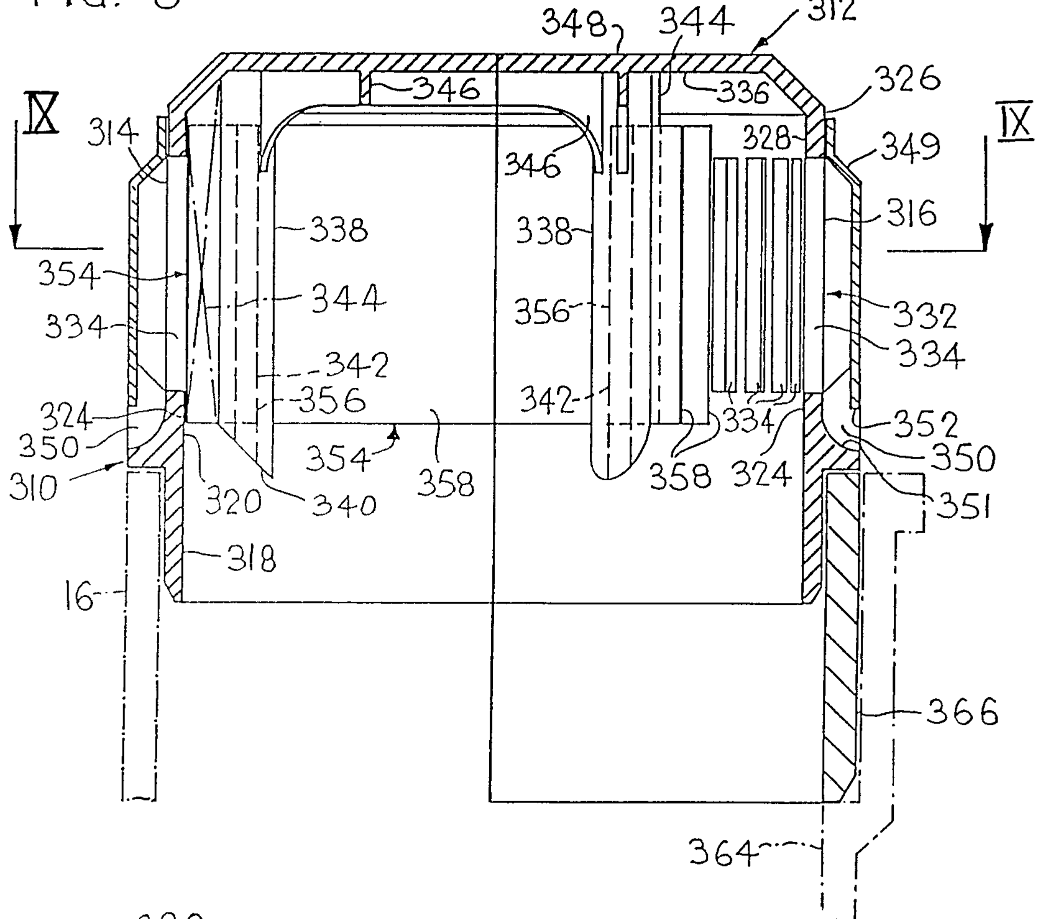
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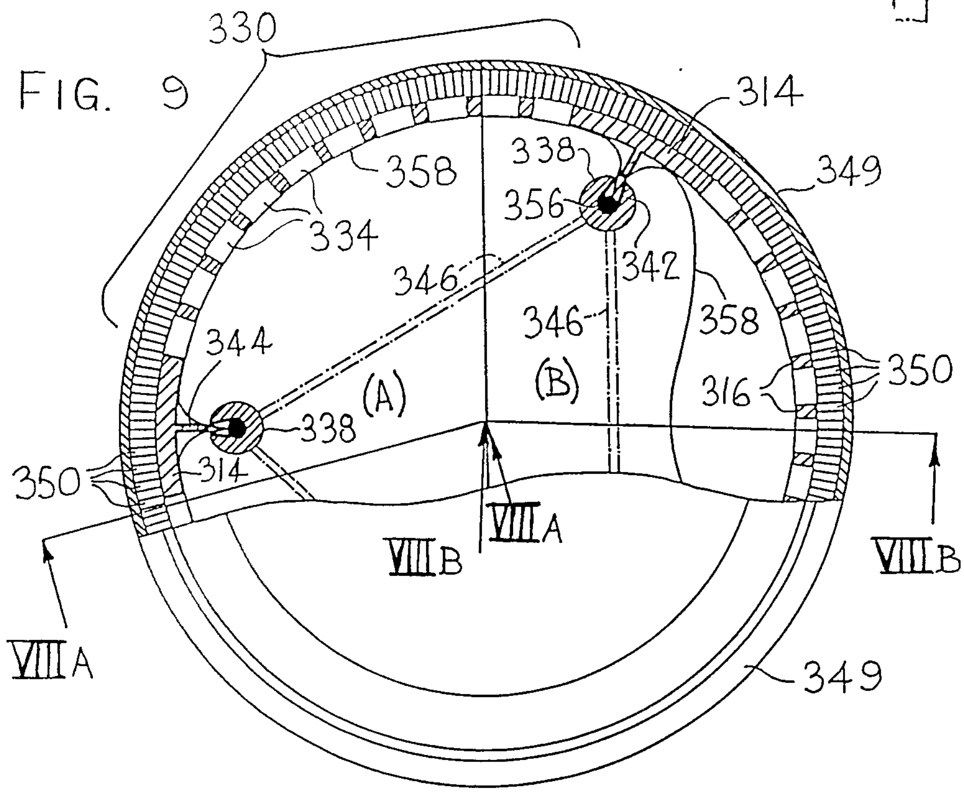
FIG. 9


330
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356
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334
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(A)
(B)
350
316
338
350
314
VIIIA
VIIIB
VIIIB
VIIIA
349

FIG. 10

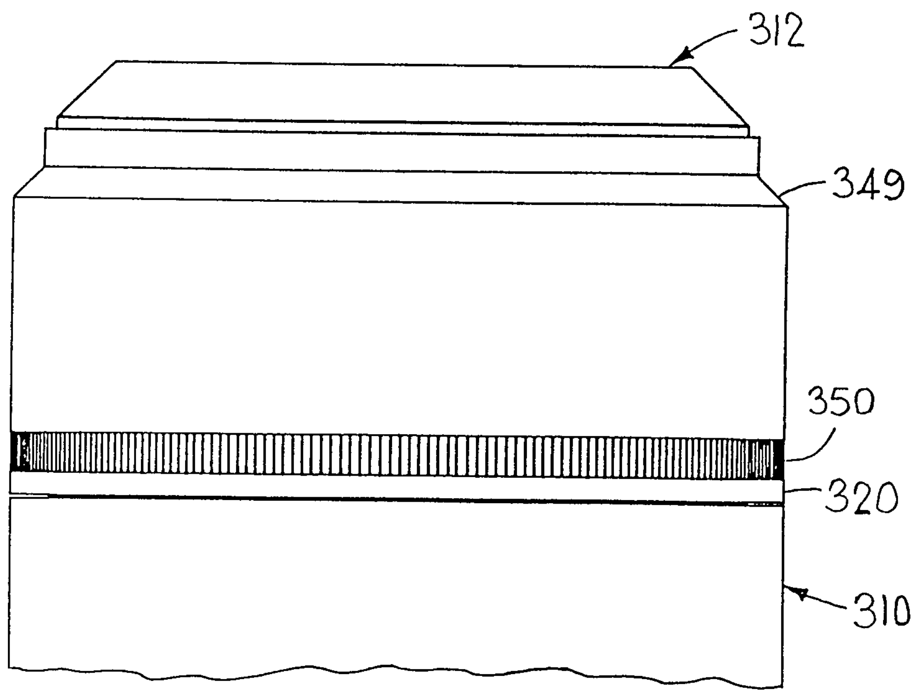

FIG. 11

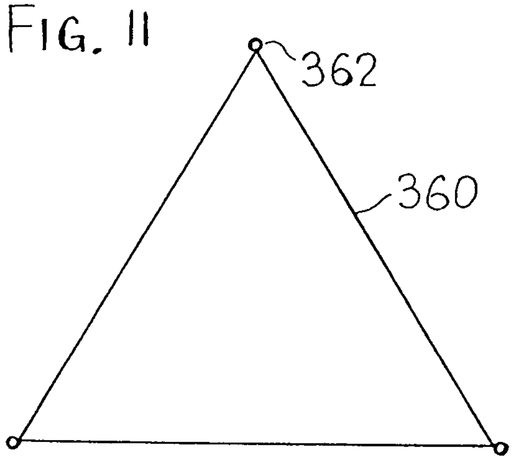

FIG. 12

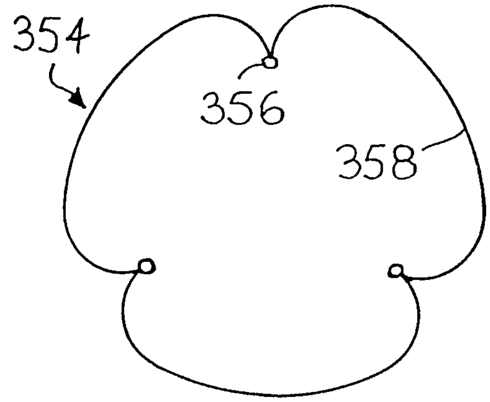

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FIG. 13

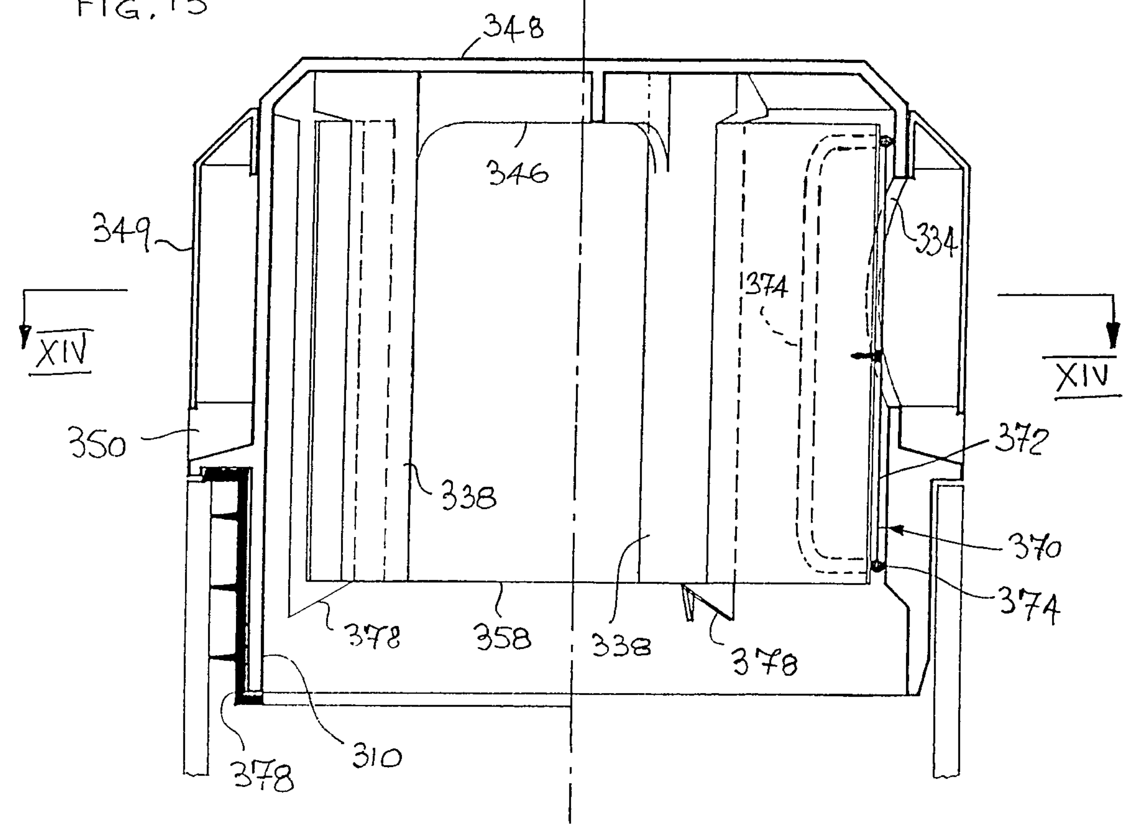


FIG. 14

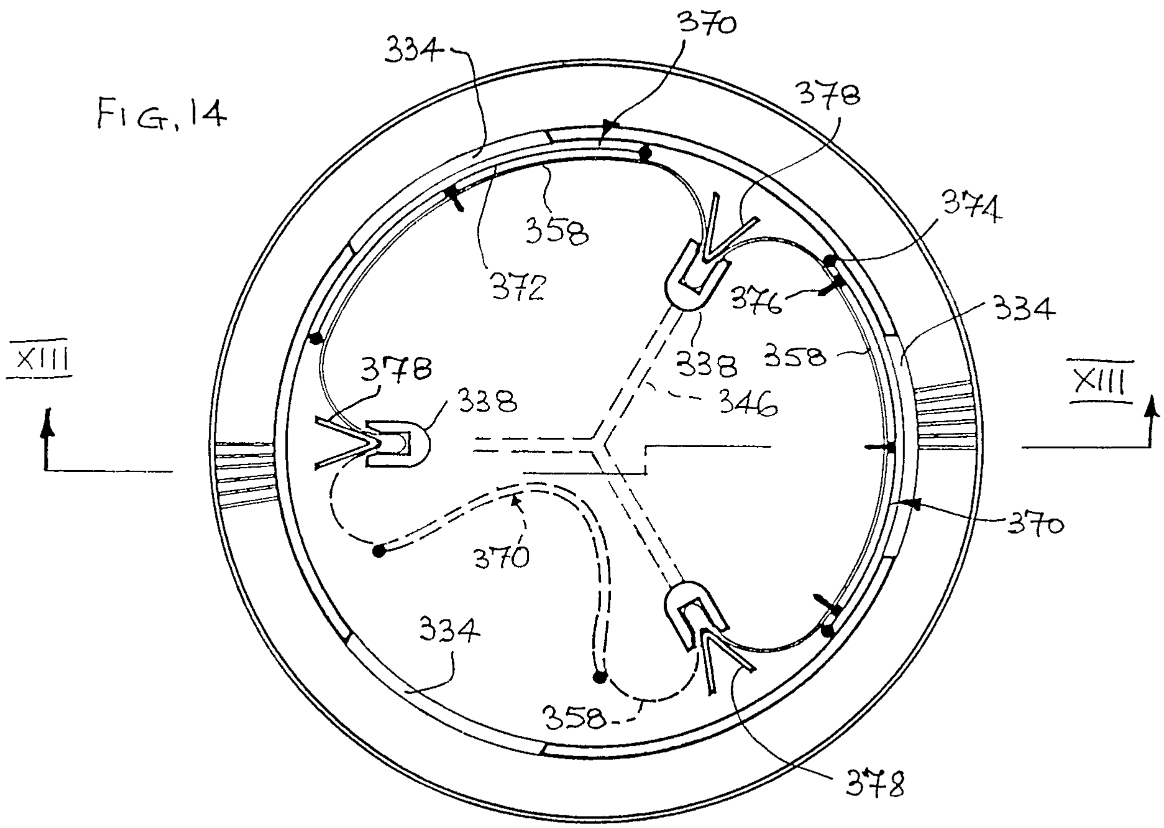
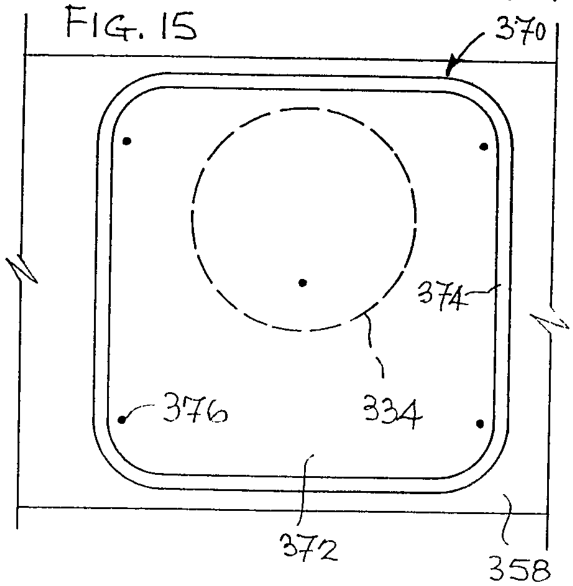


FIG. 15



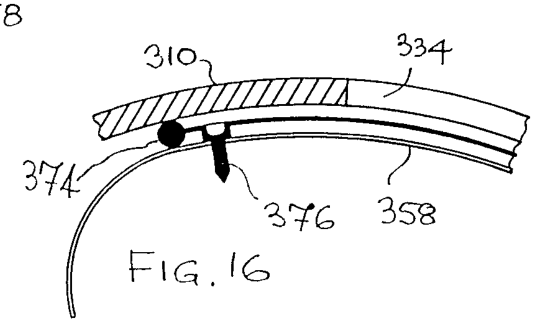
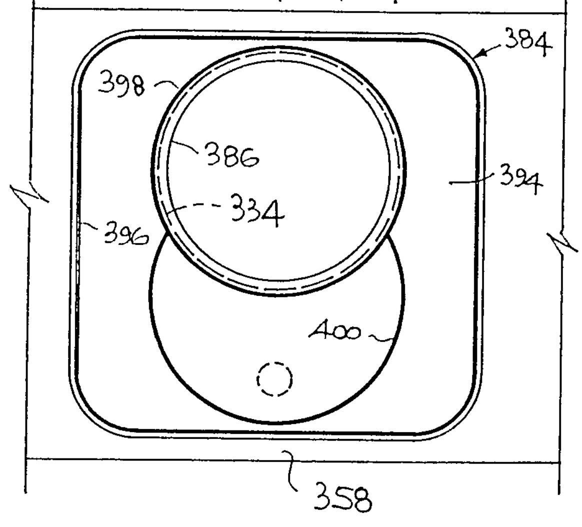


FIG. 16

FIG. 17



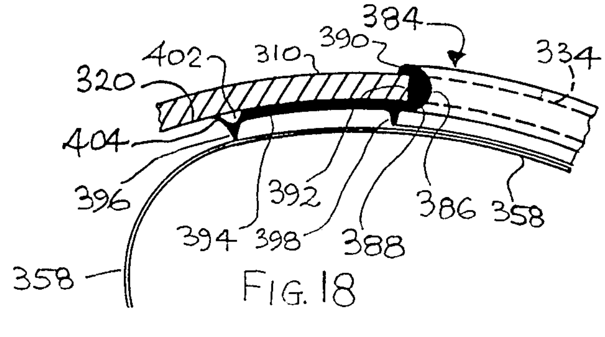


FIG. 18

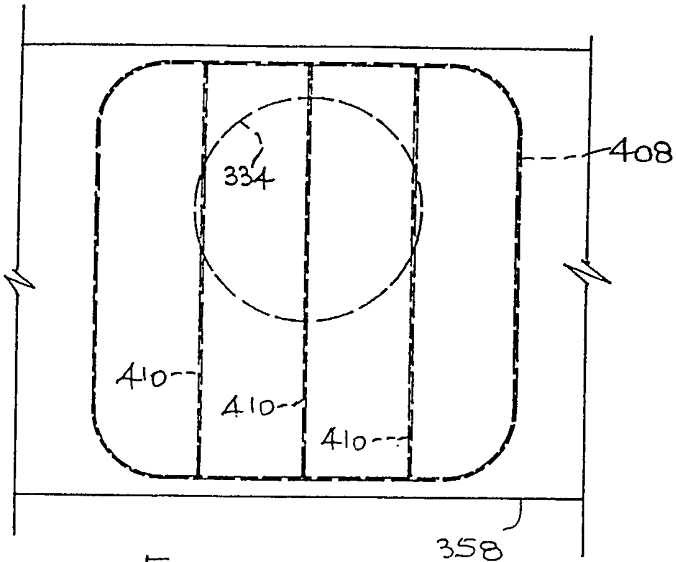


FIG.19.

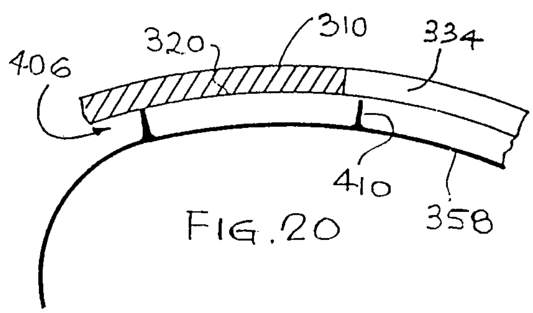


FIG.20

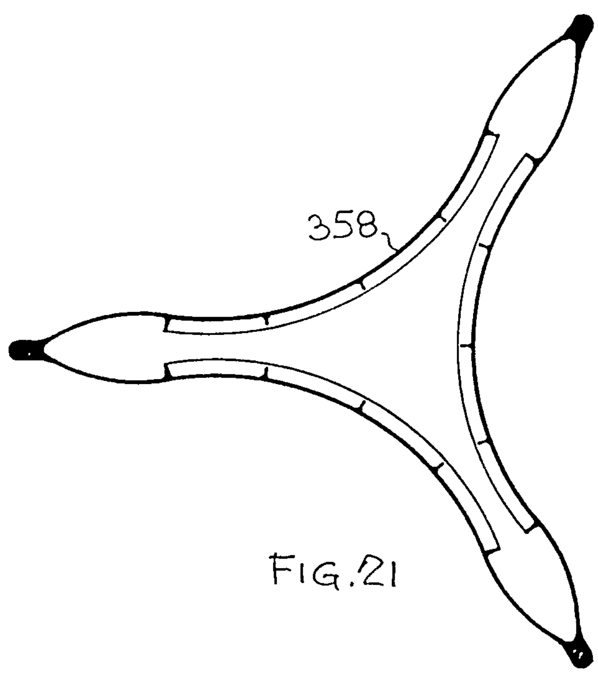


FIG.21

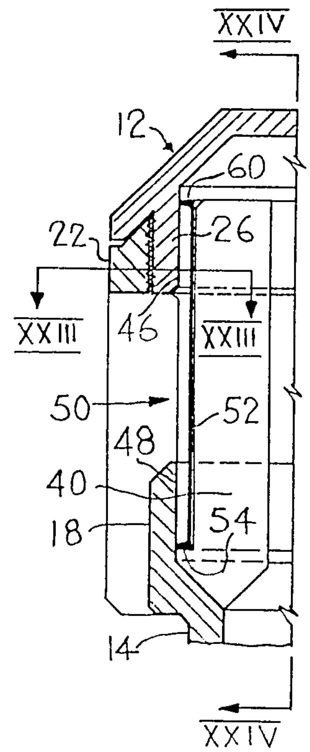


FIG.22

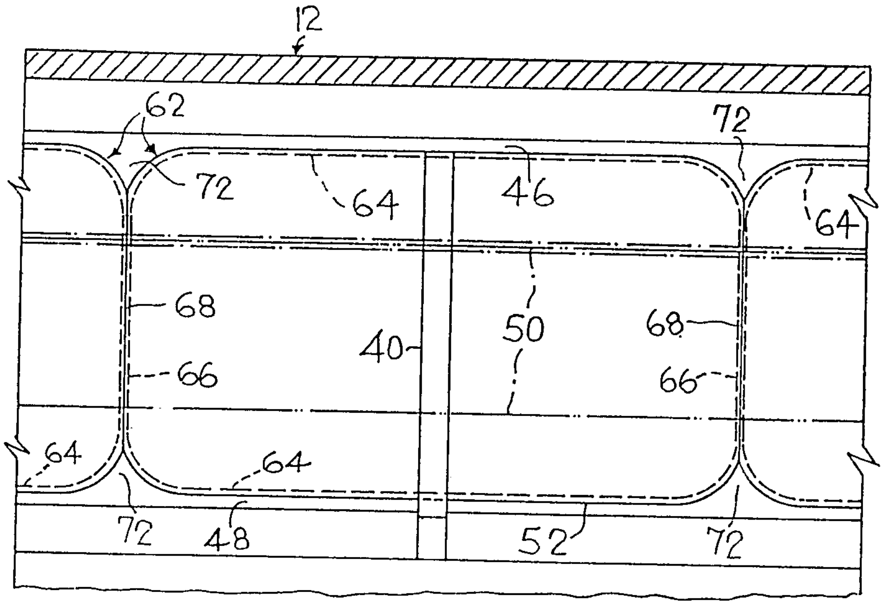


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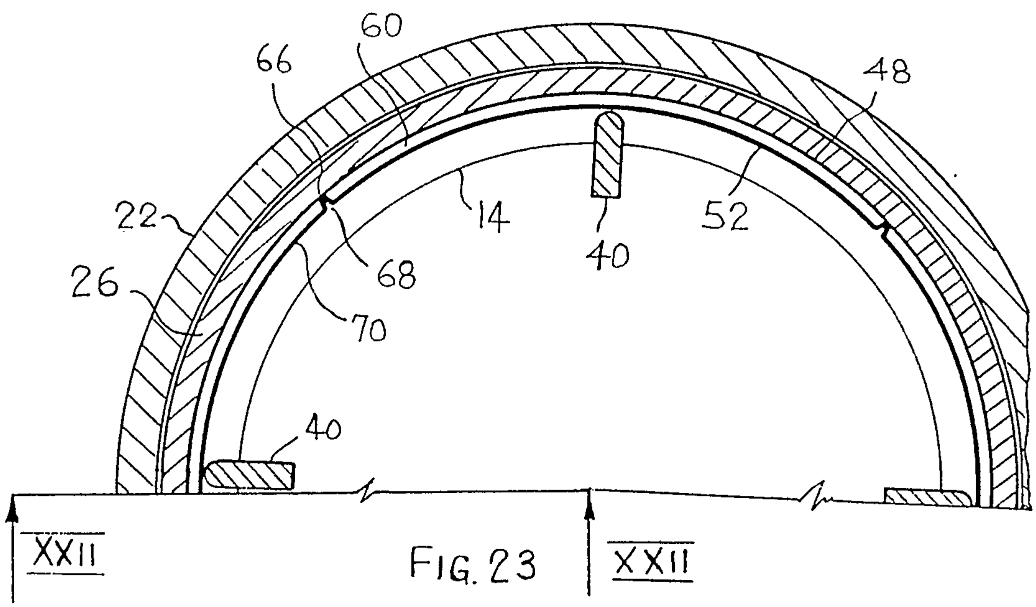
FIG. 24



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66
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14
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52
22
68
26
70
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XXII
XXII

FIG. 23

SPECIFICATION

Automatic one=way fluid valves

Technical Field

This invention relates to automatic one-way fluid valves.

Such valves are used, for example, as pressure relief valves at fluid pressure relief positions on fluid flow systems in which a fluid pressure present therein may fluctuate, rapidly or slowly, between positive and negative values relative to a pressure prevailing elsewhere (e.g. a pressure existing externally of the system, such as the atmospheric pressure). Such pressure relief valves operate automatically (a) to allow the flow of fluid in the appropriate direction so as to prevent or relieve the build up of an undesirable positive or negative pressure, and (b) to prevent the flow of fluid in the reverse direction.

Such pressure relief valves are widely used in connection with drainage and waste-liquid pipework systems associated with buildings, where such valves (commonly known as "air admittance valves") are intended to prevent the escape from the pipework system of "foul air", generated within the system, when a positive pressure builds up therein, whilst allowing the admission of air into the system when a negative pressure is induced therein, for example, as by the movement of liquids in full pipes.

Though automatic one-way fluid valves according to the present invention have particular merit in their application as air admittance valves, they are not limited to that particular field of application.

Background Art

Various different forms of air admittance valve are commercially available, being designed to open sensitively when the pressure within the pipework system is lowered. However, such valves are difficult to design and make in such a way that they are sensitive in opening, yet seal tightly at zero pressure differential. On that account, the prior art valves comprise numerous parts and are relatively expensive to produce.

The present invention seeks to provide an automatic one-way fluid valve which (a) is quite sensitive to small changes in the pressure difference developed across the diaphragm, yet seals tightly at zero pressure difference, and hence is particularly suited for use as an air admittance valve (b) is simpler in general construction and less bulky in relation to prior art valves, and hence likely to cost less to produce, (c) is less likely to be affected by condensation that collects on its operative parts under condensation-producing conditions, (d) can have 'full-flow' characteristics (i.e. having a fluid flow throat area no less than the flow area of the pipework to which the valve is connected), and (e) is not dependent for its operation on a particular way of mounting.

In some known prior art admittance valves, a cylindrical valve tube is arranged for connection at one end thereof to a pipework system, and has secured at its other end an end closure cap which incorporates, or forms with said valve tube, air inlet passages. A movable valve diaphragm is disposed concentrically within the valve tube, or within said end cap, for bodily movement axially of the valve tube towards and away from a transverse (i.e. axially facing) planar air inlet throat which communicates with said air inlet passages in or formed by said end cap. The valve diaphragm is biased towards said air inlet throat so as to close it, and is automatically opened by a pressure drop that is developed across the valve diaphragm when the pressure in the valve tube falls below the prevailing atmospheric pressure.

In one case, the valve diaphragm comprises a valve disc disposed concentrically within the valve tube, and is biased against a circular, re-entrant inlet throat by a helical compression spring that is carried on a spider support mounted in said throat.

In two other cases, the valve diaphragm comprises an annular diaphragm that is arranged to close, under its own weight, an annular inlet throat that is concentric with and surrounds the valve tube. In one such valve, the annular valve diaphragm is carried concentrically on a stalk which is mounted coaxially in the end cap, whilst in the other such valve, the annular valve diaphragm has a ring of spaced radial guide vanes which cooperate peripherally with an internal cylindrical surface of the end cap.

Disclosure of the invention

According to a first aspect of the present invention, an automatic, one-way fluid valve comprises:

(a) a valve tube arranged for connection at one end thereof with a fluid flow system;

(b) a first annular sealing surface formed internally within said valve tube;

(c) location means secured on said valve tube; and

(d) a cup-shaped diaphragm having a resilient side wall extending from a closed end wall, said diaphragm being carried at said end wall on said location means and having externally near its rim a second, annular sealing surface which is biased into contact with said first sealing surface by the resilience of the side wall, and said side wall having a length-to-average-diameter ratio sufficient to cause parting of said sealing surfaces when the pressure difference existing across said side wall exceeds a predetermined working value.

Such a valve may incorporate in said diaphragm any of the following preferred features:

(i) at least a part of the closed end wall is also resilient;

(ii) said closed end wall part has a thickness that decreases progressively as the radius increases; and

(iii) the parts constituting said side wall and said closed end wall are integral.

Preferably, (a) said first sealing surface is constituted by a surface raised from the internal surface of said valve tube on an annular ridge that projects inwardly from said valve tube internal surface; (b) said location means comprises a spider member supported from said valve tube, which spider member is preferably disposed on the upstream side of said diaphragm; and (c) an external diaphragmsupport means is carried on said valve tube and arranged to provide support for said diaphragm against undesirable distortion under pressure developed downstream of said diaphragm.

According to a further aspect of the present invention: an automatic, one-way fluid valve in which: (a) a valve tube is arranged for connection at one end thereof with a pipework system; (b) an end closure cap is secured to the opposite end of said valve tube and incorporates or forms together with said valve tube fluid flow passages for conveying fluids to/from said valve tube; (c) said end cap and valve tube have formed therein respective concentric circular valve seatings which together define an annular valve throat which communicates on one side with said fluid flow passages and on the opposite side with the interior of said valve tube; and (d) an annular valve diaphragm is arranged for movement relative to said valve throat and provided with means arranged to bias said diaphragm into contact with said seatings whereby to close off said throat and so prevent the passage of fluid between said throat and flow passages and said valve tube except when the fluid pressure in said valve tube differs by a predetermined amount from that prevailing on the side of said throat remote from said valve tube—is characterised in that:

said valve seatings are spaced apart axially of said valve tube, and said valve diaphragm comprises a thin-walled diaphragm of a resilient material, shaped and adapted by virtue of its own inherent resilience to normally exert bias pressure on at least one, preferably both, of the said valve seatings in the absence of a fluid pressure difference on opposite sides of said diaphragm.

Such a valve according to this second aspect may also incorporate any of the following preferred features:

(i) where said fluid flow passages comprise fluid inlet passages for admitting fluid to said valve tube, said diaphragm has throat-sealing surfaces which are disposed adjacent the respective seatings on the downstream side thereof; and said diaphragm is shaped and adapted to admit fluid via said inlet passages to said valve tube only when the pressure upstream of said diaphragm exceeds that on the opposite side of said diaphragm by an amount sufficient to overcome the inherent resilience of the diaphragm;

(ii) said valve seatings may comprise similar cylindrical surfaces which define between them a radially-facing throat of cylindrical configuration, in which case said valve diaphragm comprises a cylindrical tubular diaphragm of an elastically-deformable, elastomeric material, which diaphragm (a) is positioned radially inwards of said seatings, (b) is supported freely so as to permit radially inwards movement of parts of that diaphragm away from said seatings, and (c) exerts a small radially-outward bias pressure on the respective seatings;

(iii) alternatively, said valve seatings may comprise complementary frusto-conical surfaces of different diametral sizes, which surfaces define between them a radially and longitudinally facing throat of frusto-conical configuration, in which case said tubular valve diaphragm is convergent and of a frusto-conical configuration which is matched to that of said frusto-conical seatings;

(iv) one of the throat-sealing surfaces of said convergent tubular diaphragm is held permanently against its associated frusto-conical seating, whilst the other throat-sealing surface of said valve diaphragm presses resilently against its associated frusto-conical seating; and

(v) where the valve throat is of frusto-conical configuration, said valve diaphragm is in the form of an inverted, shallow, conical cup, or of a deep, bell-shaped, conical cup.

In another form of valve according to this second aspect of the present invention: (a) said concentric valve seatings are constituted by parts of a common, internal cylindrical surface of a wall which extends between adjacent parts of said end cap and valve tube; (b) a plurality of circumferentially-spaced, radially-facing throat apertures is formed in said wall; (c) said valve diaphragm comprises a resilient, thin-walled diaphragm having a plurality of similar, circumferentially-spaced throat aperture-sealing portions which lie in contact with respective parts of said cylindrical surface and seal off the respective throat apertures from the interior of said valve tube; (d) each said throat-sealing portion has respective integral end parts which are resiliently flexed inwardly from said cylindrical surface so as to form with adjacent end parts of adjacent throat-sealing portions respective inwardly directed cusps; and (e) said cusps are secured in predetermined positions relative to one another and to said end cap, valve tube and throat apertures.

Such a diaphragm may comprise a resilient elastomeric material, or alternatively, a resilient strip-metal material. Said cusps preferably terminate in enlarged axially-aligned members which are received in slotted diaphragm-support posts secured to either one of said end cap and valve tube.

If desired, there may be provided between each of said throat-sealing portions of said valve diaphragm and the juxtaposed part of said cylindrical wall surface a respective, intermediate, resilient throat-sealing means secured to either one of said diaphragm portion and said cylindrical wall surface.

Other features of the present invention will appear from a reading of the description that follows hereafter, and of the claims that are appended at the end of that description.

Various automatic one-way gas valves (and various modifications thereof), all according to the present invention and designed specifically for use as air admittance valves, will now be described by way of example and with reference to the accompanying diagrammatic drawings.

Brief Description of the Drawings

Figure 1 shows a vertical sectional view of a valve according to the said first aspect of the present invention, as seen on the section I-I indicated in the Figure 2, the valve being shown in the 'valve-closed' condition.

Figure 2 shows a part-sectional, plan view of the valve shown in Figure 1, in which view the right hand half is a view taken on the section II-II indicated in Figure 1.

The Figures 3 to 21 now to be referred to below all relate to valves constructed according to said second aspect of the present invention.

Figure 3 shows a vertical sectional view of a first such valve, in which view the left and right hand halves (A) and (B) show the valve in the closed and open conditions respectively, and by way of views taken respectively on the two sections IIIA-IIIA and IIIB-IIIB indicated in the Figure 4.

Figure 4 shows a part-sectional, plan view of the valve shown in Figure 3, in which view the left and right hand sectional halves (A) and (B) show the valve in the closed and open conditions respectively and as seen at the section IV-IV indicated in the Figure 3.

Figure 5 shows a vertical, sectional view of a second such valve, in which view the left and right hand halves (A) and (B) show the valve in its closed and open conditions respectively, the view being taken on a diametral plane.

Figure 6 shows a vertical, sectional view of a third such valve, with its valve diaphragm in the normal closed condition, the view being taken on a diametral plane.

Figure 7 shows a view, similar to that of Figure 6, of a modified form of that third valve.

Figure 8 shows a vertical sectional view of a fourth such valve, in which view the left and right hand halves (A) and (B) show the valve in the closed and open conditions respectively, and by way of views taken on the different sections VIIIA-VIIIA and VIIIB-VIIIB indicated in Figure 9.

Figure 9 shows a part-sectional, plan view of the valve shown in Figure 8, in which view the left and right hand sectional halves (A) and (B) show the valve in the closed and open conditions respectively and as seen at the section IX-IX indicated in Figure 8.

Figure 10 shows a side elevation of this fourth valve.

Figure 11 shows, to a reduced scale, a plan view showing the transverse configuration of an extrusion suitable for forming a diaphragm incorporated in this fourth valve.

Figure 12 shows, to the same reduced scale, a plan view showing the transverse configuration of that extrusion after it has been turned inside out ready for insertion in the valve.

Figure 13 shows a vertical sectional view of a fifth such valve, in which view the left and right hand halves (A) and (B) show the valve in the open and closed conditions respectively, and by way of views taken on the different sections XIIIA-XIIIA and XIIIB-XIIIB indicated in Figure 14;

Figure 14 shows a transverse sectional view of this fifth valve, as seen at the section XIV-XIV indicated in the Figure 13, in which view the valve is shown with its valve diaphragm partly in the 'valve-closed' condition (full lines) and partly in the 'valve-open' condition (dotted lines).

Figure 15 shows a developed scrap view looking radially outwards from inside the valve tube of the fifth valve, at a throat-sealing device which obscures a port aperture formed in said valve tube.

Figure 16 shows to an enlarged scale a portion of the Figure 14, which portion is indicated in Figure 14 by an arrow designated as 'XIV'.

Figures 17 and 18 show in views similar to those of the respective Figures 15 and 16 the modified parts of a first modified form of the fifth valve.

Figures 19 and 20 show in views similar to those of the respective Figures 15 and 16 the modified parts of a second modified form of the fifth valve.

Figure 21 shows an end view of tubular elastomeric extrusion which on being turned inside out forms a diaphragm for the modified valve of the Figures 19 and 20.

Figures 22 to 24 show in a series of scrap views a modification of the valve shown in the Figures 3 and 4, Figures 22 and 23 being views generally similar to those of the Figures 3(A) and 4(A), and Figure 24 being a developed view of a valve diaphragm incorporated in that modified valve as seen when looking outwards from inside the valve.

Best modes of carrying out the invention

Referring now to the Figures 1 and 2, the valve there shown comprises a valve tube unit 510 and, screwed into its upper end, an end cap 512. The valve tube unit 510 comprises an outer tubular part 514 having uppermost (a) an integral location flange 516 for engaging the upper end of a pipe 16 in which the valve tube unit is received, and (b) an integral, frusto-conical web 518 which supports internally an integral inner tubular part 520 which has formed internally near its lower end an integral, annular rib or ridge 522. The inner tubular part 520 also carries within it a series of internally-formed, circumferentially-spaced, vertical fins 524. Those fins have inwardly facing surfaces 526 which at their lower and upper ends are parallel with the inner tubular part 520, and which in between converge upwardly in the manner shown. Some of those fins (528) also extend inwardly, above the upper boundary of the inner tubular part 520, radially inwards a short way. Four of those fins (530), spaced equally around the inner tubular part, are thicker than the other fins, and extend radially inwards to support there an integrally-formed, internallyscrew-threaded, central, tubular socket 532, in which is received an externally-screw-threaded boss 534 which is formed integrally with the end cap 512.

Trapped between the upper parts of the inner tubular part 520 and the fins 524 and a frusto-conical part 536 of the end cap is an insect and dust barrier 538, in the form of an annulus of a low-density, open-cell foam plastics material.

Disposed within the inner tubular part 520, and encircled by the ring of vertical fins 524, is a valve diaphragm 540 of an inverted, cup-shaped configuration. That diaphragm has a relatively thin and long, flexible side-wall portion 542 which depends from a transverse disc-shaped end-wall portion 544, from which an integrally-formed, central support boss 546 extends upwardly and is received in an internally-screwthreaded socket 548 formed in the lower part of the end cap supporting socket 532. That boss 546 is preferably solid, though if desired it may be pierced by a central bore.

The lower external rim part 550 of the diaphragm side-wall 542 engages, with a light outward pressure and in a gastight, sealing manner, the crest of the ridge 522 formed internally within the lower end of the inner tubular part 520, and so provides, in the absence of a pressure difference across the diaphragm, a gas-tight seal for preventing the escape of 'foul air' from the pipe 16 via the valve tube unit.

In the event that the diaphragm support boss 546 is pierced, the screw-threaded engagement of the diaphragm support boss 546 in the socket 548 provides a second gas-tight seal for preventing the escape of 'foul air' from the pipe 16, and to prevent the escape of 'foul air' through the engaged screwthreads of the end cap 512 and the socket 532, those threads are likewise rendered gas-tight.

The diaphragm is optionally provided internally with a short cylindrical wall 552, so as to facilitate the distortionfree stacking of the diaphragms after manufacture and before assembly into valves. Likewise, the end cap 512 is provided with an annular step 554 so as to enable the caps to be stacked stably whilst awaiting assembly into valves.

The vertical fins 524, 528 provide external support for the diaphragm when it is subjected to a positive pressure (i.e. one above the local atmospheric pressure) arising in the pipe 16, which pressure is above that required to effect reinforcement of the initial resilient seal of the diaphragm side wall with the ridge 522. That external support thus prevents undesirable distortion of the diaphragm, and hence the escape of gases from the pipe 16, under those conditions.

The side-wall portion 542 of the diaphragm may be provided, if desired, with locally thickened rib areas 555 so as to provide extra strength without impairing unduly the operational flexibility of the lower rim part 550 of the diaphragm side-wall.

The advantageous operating characteristics of this valve arise principally from the relatively long, resilient sidewall of the diaphragm. That side-wall has a length-toaverage-diameter ratio which is sufficient to initiate the opening of the valve throat when the pressure difference across the diaphragm exceeds a predetermined small working value, for example, a pressure difference in the range: −0.5mm to −1.5mm of water. By way of contrast, the diaphragm has also to be capable of maintaining a pressure in the valve tube unit 510 and pipe 16 of +40mm of water, whilst providing a positive sealing-off of the valve throat at zero pressure difference. A preferred range for said length-to-average diameter ratio is 1:1 to 4:1.

This valve has the advantages that (a) the cooperating sealing surfaces of the annular ridge 522 and the diaphragm skirt 542 have small areas of contact, (b) those contact areas are disposed at the warmest part of the valve, and are well protected from condensation that runs off other areas of the valve, and (c) relatively small changes in the pressure difference across the diaphragm bring about unusually high sealing and unsealing forces, so that surface tension effects due to the presence of liquid at those contact areas have negligible effect on the operation of the valve.

Where valves similar to those described above are to be used to admit pressure-relieving fluids into the valve tube, and hence into the pipework system 16, from another part of the pipework system, or from another pipework system, a further tubular member is formed around the upper part of the valve, is connected to the upper part of the valve tube, and is connectable at its free upper end with that other part of a pipework system. Such a modification is shown, by way of example, in dotted form in the Figure 1 at reference 556.

Referring now to the Figures 3 and 4, the valve there shown comprises generally a valve tube unit 10, and an end cap 12 screwed into the upper end of the valve tube unit.

The valve tube unit 10 comprises lowermost a cylindrical tube 14 arranged for fitting in a gas-tight manner into a socket 16 (indicated in chain-dotted form) provided on a drainage or other pipework system (not shown). An upper end part 18 of the tube 14 carries externally a ring of circumferentially-spaced, upwardly-extending, radial fins 20 which are formed integrally with the tube 14 and which carry at their upper ends, and are united by, a continuous ring 22. That ring is formed integrally with the fins 20 and is provided internally with a screw-thread 24.

The end cap 12 is frusto-conical in shape, and is provided with an integral, dependent, cylindrical wall 26, which is provided externally with a screw-thread. The end cap is secured in position on the valve tube unit by engagement of those two screw-threads. An annular gas-deflecting rib 28 is formed integrally with the end cap, and from that rib four equi-spaced ribs 30 radiate outwards to the cylindrical wall 26.

Disposed within the upper part of the valve tube unit 10 is an annular cage 32, which (in this particular embodiment) is formed integrally with the valve tube 14. That cage comprises a central ring portion 34 from which upper and lower finger portions 36, 38 extend in opposite directions at regular circumferential intervals. Four equi-spaced vertical pillars 40 formed integrally with that digitated ring 34 extend radially outwards therefrom and meet, and are supported by, a frusto-conical portion of the enlarged upper end of the tube 14. The four pillars 40 are offset circumferentially relative to the finger portions 36, 38 from which they radiate.

The outer, vertical edge surfaces 44 of those pillars 40 are set radially inwards from the coaxial, inner, cylindrical surfaces 46, 48 which are formed on the end cap 12 and the enlarged upper portion 18 of the valve tube 14 respectively. Those concentric cylindrical surfaces 46, 48 constitute a pair of similar, axially-spaced, annular valve seatings which define between them a radially-facing, air-inlet throat 50 through which atmospheric air may be drawn inwardly between the fins 20 into the end cap 12 and valve tube 14.

A thin-walled, cylindrical valve diaphragm 52 of an elastomerically-deformable material (e.g. natural or synthetic rubber, or other suitable elastomeric material) is received within the valve tube unit, in a cylindrical void defined externally by said fins 20 and internally by said annular cage 32, and at one end by the end cap ribs 30 and at the other end by supporting shoulders 54 formed at the lower ends of the radial pillars 40. The upper and lower annular border portions of the diaphragm abut the respective valve seatings 46, 48, and whilst the lower cylindrical edge of the diaphragm rests on the shoulders 54, the upper cylindrical edge of the diaphragm has clearance from the end cap ribs 30. Hence, the diaphragm is free to change its shape in response to pressures exerted on its internal and external cylindrical surfaces respectively, between the limiting shapes shown in the respective sectional halves of the Figures 3 and 4.

The diaphragm is arranged so that when placed in position in that void, it exerts a small radially-outward pressure on the two annular valve seatings 46, 48, sufficient to firmly close the throat 50 and so prevent the flow of gas from the valve tube 14 when the pressure within that tube is substantially equal to the atmospheric pressure prevailing externally of the fins 20. Any increase in pressure within the valve tube increases the radial pressure exerted by the diaphragm on the two seatings 46, 48, and so ensures that the valve diaphragm firmly retains its pressure-tight seal on the two seatings, thereby containing the valve tube gases.

On the other hand, in the event that the pressure in the valve tube 14 falls substantially below the external atmospheric pressure, the diaphragm (or part thereof) is caused to withdraw from its continuous intimate contact with the seatings 46, 48 under the differential pressure then existing across the diaphragm, and so permit air from the throat 50 to enter the air passages above and below the diaphragm and pass thence to the valve tube 14 to relieve the negative pressure in the pipework system. The magnitude of any such pressure differential, and of its rate of rise, will determine the extent to which the tubular diaphragm will be deformed from its truly circular configuration of the Figure 4(A). In the ultimate case, the diaphragm will elastically deform to the shape shown in the Figure 4(B), where the diaphragm is shown fully withdrawn from the seatings and external fins 20, and resting for the greater part of its circumference against the internal cage 32. By appropriate design, the circumferential length of the deformed diaphragm of Figure 4(B) can be made equal to that of the undeformed diaphragm of Figure 4(A), so that no stretching of the diaphragm occurs or is relied upon.

The radially-projecting pillars 40 provide an effective means for ensuring uniform distribution of the deformation of the tubular diaphragm, and also for ensuring that even when in the ultimate position of Figure 4(B), the tubular diaphragm will automatically and fully resile to its position of Figure 4(A), thus reclosing the throat 50, without the existence of a positive pressure in the valve tube 14.

The digitated construction of the internal cage 32 ensures that the pressure prevailing in the valve tube 14 is communicated quickly and uniformly to all parts of the internal surface of the tubular diaphragm, so that a sudden removal or reversal of a negative pressure in the valve tube 14 causes a prompt and rapid closure of the air inlet throat 50 and a rapid containment of gases coming from the pipework system.

Valves designed in accordance with this embodiment can be of the 'full-flow' variety, since the flow area of the valve tube 14 may be readily matched by the flow areas of the passages over the upper and lower boundaries of the deformed diaphragm, and by the flow area of the throat 50 as defined by the seatings 46, 48 and the intervals between the vertical fins 20.

The valve just described comprises only three components 10, 12 and 52, and its assembly consists essentially of inserting the tubular diaphragm into the valve tube unit 10, and then screwing the end cap into position on that unit.

In one modified form of the valve of Figures 3 and 4, the internal support cage 32 comprises instead a continuous annular wall in which external, axial flutes are formed. Alternatively, said continuous wall may be corrugated circumferentially so as to form corrugations which run in the axial direction of the valve tube. If desired, the cage assembly 32 may be separate from the rest of the valve tube unit 10.

Figures 22 to 24 show a second modified form of the valve shown in the Figures 3 and 4. In that modified valve, the height of the throat openings 50 has been reduced by increasing the depths of the seatings 46 and 48, and the diaphragm 52 has been provided on its outwardly-facing surface with a raised bead or ridge 60 in the form shown. That bead comprises a series of similar bead sections 62 lying side by side, each section having a generally rectangular configuration, but with rounded corners. The horizontal bead parts 64 of adjacent bead sections merge into common vertical bead parts 66 which are rendered hollow and cusp-like by V-shaped depressions 68 formed behind them in the inwardly-facing surface 70 of the diaphragm. The horizontal and rounded corner parts of the beads define the boundary of the diaphragm, so that the upper and lower boundaries of the diaphragm are, in effect, notched at the places designated 72 between adjacent bead sections. This modification provides a diaphragm which is more sensitive in operation and which provides good sealing of the valve throat when there is no pressure differential across the diaphragm.

Though the valve of the Figures 3 and 4 has been described above as having a valve tube 14 that fits plug-fashion in a pipe socket 16, that valve tube may be constructed alternatively as a socket for fitting on a plug connection forming part of a pipework system.

Referring now to the Figure 5, the valve there shown likewise consists of a valve tube unit 110 and an end cap 112 screwed to the upper end of the valve tube unit. That unit comprises lowermost a cylindrical valve tube 114 arranged for fitting in a gas-tight manner in a socket 16 of a pipework system. The upper end part 116 of the tube 114 carries externally a ring of circumferentially-spaced radial fins 118 which are formed integrally with the tube 114 and which carry at their outer extremities, and are united by, a continuous ring 120. That ring is formed integrally with the fins 118, and is provided externally with a screw thread 122.

The ring 120 and the upper end 116 of the valve tube 114 have complementary annular seating surfaces 124, 126 respectively, which surfaces comprise axially and radially separated, concentric, annular elements of a common frusto-conical surface, which surface also defines the upper boundaries 128 of the radial fins 118.

The end cap 112 has a dependent cylindrical wall 130 whose lower portion is enlarged and provided with an internal screw-thread arranged for engagement with the male screwthread of the valve tube unit. The end cap is also provided witn integral, downwardly-projecting, radial ribs 132 arranged in a cruciform manner, which ribs engage in and with the upper end 116 of the valve tube 114, so as to limit the extent to which the end cap can be screwed on to the valve tube unit 110. Furthermore, the end cap is provided with a ring of circumferentially-spaced ribs 134 which have inwardly facing surfaces 136 shaped for a purpose that will be explained later.

A thin-walled valve diaphragm 138 of an elastically-deformable material (such as for example, a natural or synthetic rubber) and having its lower surface conforming to the shape of the aforesaid frusto-conical surface, has its lowermost peripheral border seated on the seating 124 and trapped against it by a correspondingly shaped annular valve seating 140 formed on the end cap 112 above the screwthread. The uppermost peripheral border of the diaphragm 138 sits on and resiliently presses against the seating 126 at the upper end 116 of the valve tube 114. The radial cross sectional thickness of the valve diaphragm decreases progressively from the lower border to the free upper border.

This resilient pressure of the diaphragm on the valve tube seating 126 ensures that no flow of gas to and from the valve tube 114 can occur when the pressure in the valve tube is substantially equal to that in the radially-facing throat 142 which is defined by the axially and radially spaced, concentric annular seatings 140 on the end cap and 126 on the valve tube.

In the event that the pressure in the valve tube rises above that in the throat, the pressure of the diaphragm on the valve tube seating 126 increases, and so contains the increased pressure in the valve tube 114. On the other hand, in the event that the pressure in the valve tube falls below that in the throat, the diaphragm is subjected to net upward forces which lift the upper border of the diaphragm clear of the seating 126 and so open the throat to the inward flow of air to the valve tube over the seating 126. The greater the depression in the pressure in the valve tube 114, the greater is the elastic displacement of the upper parts of the diaphragm, and the greater the throat opening and inflow of air from outside. In the ultimate case, the diaphragm is elastically deformed to the extent that it lies back against the ribs 136 formed in the end cap. Those ribs then prevent any further and damaging distortion of the diaphragm, and thus ensure that the diaphragm is capable of resuming its normal unstressed condition in which it closes off the air inlet throat 142 when the pressure in the valve tube rises again to atmospheric value. Parts 144 in the ribs 132 of the end cap have been relieved so as to permit the desired full expansion of the diaphragm.

In the left hand part of Figure 5, the diaphragm is shown in the valve closed position, whilst in the right hand part of that Figure, the diaphragm is shown extended to its maximum throat opening position.

As in the case of the earlier valve described above, this valve may be designed as a full-flow valve.

Referring now to the Figure 6, the valve there shown comprises a valve tube unit 210, and an associated end cap 212 which is formed integrally with the valve tube unit. That unit comprises a cylindrical valve tube 214 arranged for fitting in a socket 16 of a pipework system. The upper end 216 of the tube carries an integrally formed frustoconically shaped annular wall 218 which projects outwardly of the tube 214 to provide a stop 220 for limiting the insertion of the tube into the socket 16, and inwardly of the tube to provide a downwardly-facing frusto-conical valve seating 222.

The end cap comprises a central disc part 224 and an outer, integrally formed, frusto-conical, annular part 226 which lies parallel with the wall 218 of the valve tube unit 210. The end cap is supported on circumferentially-spaced, radial fins 228 which are integrally formed with both the end cap and the valve tube unit. Centrally formed on the underside of the end cap is a dependent annular wall 230 whose lower boundary defines an annular valve seating 232 of frusto-conical shape. That wall forms a central recess 234 in which is secured a valve diaphragm support member 236 which carries at its lower end an integral, concentric valve diaphragm 238 which is of shallow conical shape. That diaphragm is made of an elastically deformable material such as a natural or synthetic rubber, and has a radial cross sectional thickness which decreases progressively towards the outer periphery of the diaphragm.

The two valve seatings 222 and 232 are complementary and are shaped as two axially and radially spaced, concentric, annular elements of a common frusto-conical surface. The diaphragm is arranged so that its upper surface exerts a resilient upward pressure on the two seatings 222 and 232 and so closes off an annular air inlet throat 240 which is defined by those seatings. The diaphragm is also provided on its underside with integrally-formed radial ribs 242 for strengthening purposes.

The diaphragm ensures that no flow of gas through the throat 240 occurs when the pressure in the valve tube 214 is substantially equal to that in the throat. A rise in the pressure in the valve tube 214 increases the pressures exerted by the diaphragm on the respective seatings 222 and 232, and so ensures the containment of the gases in the valve tube. Conversely, a fall in the pressure in the valve tube causes the diaphragm to be drawn away from the two seatings 222 and 232 so that air may be drawn into the valve tube 214 through the throat 240. The greater the depression in the valve tube, the greater is the downward deformation of the diaphragm.

The provision of the ribs on the underside of the diaphragm enables folding of the peripheral parts of the diaphragm to occur at the weaker diaphragm parts between the ribs, so that deformation of the diaphragm occurs regularly around the periphery thereof. Moreover, the ribs provide the stronger parts of the diaphragm for driving the diaphragm back to its normal, relatively unstressed condition without delay when the pressure in the valve tube rises to atmospheric pressure. The radial fins 228 are shaped to provide back support for the diaphragm when the valve tube pressure exceeds that in the throat.

The support member 236 of the diaphragm comprises a cylindrical plug which carries externally a series of axially spaced annular fins for gripping in a non-return manner the cylindrical wall of the recess 234.

The valve diaphragm 238 may be replaced, if desired, by a frusto-conical diaphragm of which the smaller diameter peripheral parts are held firmly against the end cap seating 232 by a clamping ring which is itself secured to the end cap by means of a screw engaged centrally in the end cap. The larger diameter peripheral parts of the diaphragm cooperate with the valve tube seating 222 in the manner already referred to above in relation to the Figure 6.

The valve shown in the Figure 6 may, if desired, be modified to render it more compact, by (a) lowering and flattening the crown 224 of the end cap 212, and (b) correspondingly lowering the valve tube seating 222 so as to cause it to lie at the bottom edge of a locally-thickened lower end portion of the valve tube 214. Such a modified valve is shown in the Figure 7, which shows a vertical diametral section through the valve.

Both of the valves described with reference to the Figures 5 and 6 respectively can, as in the case of the valve of the Figures 3 and 4, have their respective valve tubes arranged alternatively as a socket for fitting in a gas-tight manner on a plug connector forming part of a pipework system.

Whilst satisfactory performance characteristics have been obtained with prototype air admittance valves according to the Figures 3 and 4, even better results have been obtained with a modified form of that embodiment, which modified form will now be described with reference to the Figures 8 to 12.

Referring now to the Figures 8 to 12, the valve there shown comprises, generally, at its lower end a valve tube unit 310, and at its upper end an end closure cap 312 which is disposed above and carried on the valve tube unit by a series of circumferentially spaced wide and narrow pillars 314 and 316, which pillars are integrally formed with both the valve tube unit and the end cap.

The valve tube unit 310 comprises lowermost a cylindrical tube 318 arranged for fitting, plugwise, in a gas-tight manner in a pipe 16 (indicated in chain-dotted form in the left hand half (A) of the Figure 8) provided on a drainage or other pipework system (not shown). An upper cylindrical wall 320 of the valve tube 318 carries upwardly the said wide and narrow pillars 314, 316. The upper internal cylindrical surface 324 of that cylindrical wall 320 constitutes one annular valve seating of the valve.

The end cap 312 is frusto-conical in shape, and has lowermost an integral, dependent, cylindrical wall 326 which is integrally formed with, and is supported by, the upper ends of the wide and narrow pillars 314, 316. The inner cylindrical surface 328 of that dependent wall 326 constitutes the second annular seating of the valve. The wide pillars 314 are equi-spaced at intervals of 120 around the valve tube 318, and define between them three separate circumferential sections 330 of a valve throat 332 which is bounded above and below and defined by the two valve seatings 324 and 328. Between each pair of adjacent wide pillars 314 is a series of nine narrow pillars 316 spaced apart to provide in each said throat section 330 a series of ten equi-spaced, similar, radially facing throat apertures 334, which define the actual gas flow passages of the throat section.

The internal cylindrical valve seating surfaces 324 and 328 (of the valve tube and end cap respectively) constitute axially-spaced, separate annular portions of a common cylindrical surface. Likewise, the internal surfaces of the wide and narrow pillars 314, 316 all constitute other parts of that common cylindrical surface.

The end cap 312 carries, dependent from its lower surface 336, three equi-spaced axially-extending support posts 338, each of which has an oblique lower face 340 and each of which has formed therein a U-shaped flute 342 which faces radially outwards towards the radially adjacent wide pillar 314. In each such flute the sides thereof converge slightly to form a narrowing neck. Each wide pillar 314 carries internally an integral, central, radially-inwardly directed fin 344 which is aligned with and extends to the neck of the adjacent flute 342 in the adjacent support post.

Each such axial fin 344 extends uppermost above the level of the upper cylindrical seating 328 to the underside of the end cap, and lowermost below the level of the lower cylindrical seating 324 of the valve tube. The oblique lower faces 340 of the support posts 338 are disposed below the lower ends of the fins 344. Strengthening ribs 346 in triangular configuration are formed integrally with the end cap roof 348 and support posts 338.

The valve is provided externally with a removable dust cover 349 which fits uppermost around the dependent wall 326 of the end cap 312 and which carries internally at its lower margin a ring of integrally formed, circumferentially spaced radial fins 350 which engage lowermost on an external curved surface 351 of the valve tube wall 320. Those fins are spaced closely together so as to prevent insects from crawling into and obstructing the valve throat apertures 334.

A resilient valve diaphragm 354 of an elastically deformable, elastomeric material is carried within the space enclosed by the end cap 312, the ring of spaced pillars 314, 316, and the lower valve seating 324. That diaphragm is of an integral construction and comprises three parallel, axial plugs 356, located in the bottoms of the respective flutes 342 in the three support posts, from each of which plugs there extend, radially outwards and then circumferentially in opposite directions, the respective ends of two resilient, thin-walled diaphragm elements 358. Each such element lies in contact with the inner sealing surfaces of the respective valve seatings and of the axial lands constituted by the vertical margins of the associated wide pillars, and extends to and joins an adjacent plug 356 in the manner indicated in the left hand half (A) of the Figure 9, thus sealing off the throat apertures 334 of the associated throat section.

The diaphragm is sized and proportioned so that when placed in its operative position, by passing it through the lower end of the valve tube 318 and then pushing the three axial plugs 356 into the fluted support posts 338, the three diaphragm elements 358 take up their positions as indicated in the left hand halves (A) of the Figures 8 and 9. In those positions, the three diaphragm elements close off the respective throat sections, and so prevent the outward flow of gases through the throat of the valve.

The end portions of the respective diaphragm elements are guided by the slightly converging walls of the flutes 342 in the support posts 338 and the sides of the associated radial fins 344, so that those end portions are directed initially radially outwards against the fins 344 before turning in a circumferential direction, and so that those end portions are resiliently stressed and thereby maintain the central parts of the respective elements in contact with the said cylindrical sealing surfaces of the valve tube and cap.

An increase in the gas pressure present in the valve tube serves merely to increase the outward pressures exerted by the respective diaphragm elements on those valve sealing surfaces, thus preventing any escape of gas from the valve tube despite the increased pressure in the valve tube. If, however, the pressure in the valve tube falls below that prevailing in the throat apertures 334, then the central portions of the diaphragm elements are sucked inwards away from the sealing surfaces, and air enters the valve tube through the throat apertures 334. In the event of a large and sudden drop in pressure in the valve tube, the diaphragm elements will be sucked inwards rapidly to a highly deflected position such as that shown in the right hand halves (B) of the Figures 8 and 9, so as to permit a rapid inflow of air to the valve tube.

The valve diaphragm 354 is conveniently made by extruding a suitably elastic or resilient, elastomeric material in the form of a thin-walled, plane-sided tube having a transverse configuration (as shown in the Figure 11) in the form of an equilateral triangle 360, and axial cylindrical ribs 362 formed integrally at the respective external corners of the tube. Those ribs become the said plugs 356 after a suitable, short length of the extrusion has been turned inside out to produce a diaphragm having the transverse configuration in the form shown in the Figure 12. Such a diaphragm can be readily inserted in position in the valve tube by first radially compressing the thin diaphram elements 358, then by sliding the compressed diaphragm into the valve tube, and finally by inserting and pushing the plugs 356 into the flutes 342 in the support posts 338. The diaphragm is held in position by frictional engagement of those plugs in the flutes 342.

If desired, the diaphragm may alternatively comprise simply the three thin strips which constitute the respective diaphragm elements 358, those strips (whether joined or separate) being anchored in any suitable manner in the support post flutes 342. Alternatively, those diaphragm element strips may be secured in any suitable manner on opposite side faces of the associated radial fins 344 (suitably extended inwards if necesary) at appropriate positions thereon, whereby to locate and anchor the ends of those strips at positions generally similar to those used in the Figure 9.

If desired, other similar valves according to the present invention may be provided with more or fewer than three throat sections and associated diaphragm elements.

In an alternative form of the valve just described above, the end cap together with the upper valve seating is made separately from the valve tube unit, and is removably carried on the valve tube unit. For example, the end cap and dust cover may be united and provided lowermost with an integral, internally screw-threaded ring for engaging an externally screw-threaded part of the valve tube wall 320. In that case, the support posts 338 may be mounted, as an alternative, by their lower ends in the upper part of the valve tube unit, and the diaphragm be inserted from above after first removing the end cap and dust cover.

The valve just described above may be converted for alternative mounting into a socket 364 on a pipework system (not shown), by the addition thereto of a spigot collar 366. Such a socket and collar are indicated in the right hand half (B) of Figure 8.

The valve just described above has the particular merit that it may be made very sensitive in operation, whilst at the same time it comprises merely two operative parts, and requires but two operations to assemble it.

To still further improve the performance of the valve just described above with reference to the Figures 8 to 12, that valve may be provided with intermediate throat-sealing means interposed between the juxtaposed sealing surfaces of the respective diaphragm elements 358 and their respective associated throat-defining surfaces which are constituted by respective parts of the annular valve seatings 324, 328 and the associated axial lands of the respective wide pillars 314.

Such sealing means may be secured on, or be integrally formed with, either or both of (a) those diaphragm elements 358 and (b) those throat-defining surfaces; and be made of elastomeric materials generally similar to those used for the diaphragm elements 358.

One valve utilising such an intermediate throat-sealing means will now be described with reference to the Figures 13 to 16. Two modified forms of that valve will then be described with reference to the group of Figures 17 and 18 and 19 to 21 respectively.

The valve shown in the Figures 13 to 16 is generally similar to that described with reference to the Figures 8 to 12, so that the references used in those earlier Figures are used again in the Figures 13 to 16 for parts which are common or equivalent in both such valves. The valve of those later Figures differs from that earlier valve in the following significant ways:

(a) the radially-facing throat apertures comprise for each diaphragm element 358, but a single circular port 334, instead of a group of elongate apertures 334;

(b) each diaphragm element 358 is provided adjacent its outwardly facing surface with a resilient, elastomeric sealing device 370, which device comprises a thin, squareshaped sealing membrane 372 having integrally formed therewith (i) a peripheral sealing bead 374 of circular transverse cross section and (ii) five similar, pointed, fixing studs 376 which project inwardly of the membrane 372 and engage securely in corresponding apertures formed in the adjacent diaphragm element 358;

(c) the axial fins 344 for guiding and retaining the diaphragm elements 358 are omitted and replaced by V-shaped channel members 378 which depend from the end cap roof 348, serve to secure and guide the respective end parts of the associated diaphragm elements 358, and can be flexed away from the associated diaphragm support posts 338 so as to facilitate the insertion of the diaphragm 354;

(d) the diaphragm support posts 338 are strengthened by ribs 346 which radiate to them from the centre of the end cap;

(e) the lower part 318 of the valve tube 310 is provided with a push-fit, elastomeric, sealing sleeve 378 which is equipped with a transverse sealing flange 380 and a series of transverse sealing fins 382. Such sealing sleeve is shown in only the left-hand half of the Figure 13. In the right-hand half of that Figure, the valve tube is shown as being solvent-welded directly into the cut end of the pipe 16 in which it is received; and

(f) the axial fins 350 constituting an insect barrier are formed integrally with the valve tube 310 itself instead of with the dust cover 349, and extend upwardly so as to just overlap the lower end of the dust cover.

The interposition of the intermediate throat-sealing means (a) renders the valve less dependent on the finish of the juxtaposed surfaces of the diaphragm elements 358 and the valve tube 310; (b) provides enhanced throat sealing and opening forces, since the area enclosed by the sealing membrane 372 and its peripheral bead 374 can be made larger than the size of the associated port 334 formed in the valve tube wall; and (c) renders the valve less prone to the deleterious effects of internal condensation.

Figures 17 and 18 show a first modification of the valve just described with reference to the Figures 13 to 16. In that modification, there is provided for each circular port 334 formed in the valve tube wall 320 a resilient, elastomeric, throat-sealing device 384 in the form of an annular grommet 386 which lines and, by means of opposed, integrally-formed, inner and outer annular flanges 388, 390, grips the edge 392 of the valve tube wall that defines the port 334. The inner flange 388 has formed integrally therewith a square-shaped sealing membrane 394 which carries around its periphery a first, radially-inwardly projecting sealing rib or ridge 396, and around the periphery of the port 334 a second, radially-inwardly projecting sealing rib or ridge 398. A third, radially-inwardly projecting rib or ridge 400, similar to the said second rib 398, is optionally provided and extends in a circular manner between similar positions on opposite sides of that port-hole rib 398, thus providing additional support for the associated diaphragm element 358, which is normally biased into contact with rib 396 and so presses against its crest parts to provide the desired seal, while standing slightly clear of ribs 398 and 400, which are provided for supporting the diaphragm element 358 when it is under internal positive pressure.

The peripheral sealing rib 396 is rendered hollow, and thus more supple, by a depression 402 formed at the back of that rib. That depression produces at the peripheral extremities of that sealing membrane a highly flexible sealing lip 404 which contacts and makes a good gas-tight seal with the adjacent surface of the valve tube wall 320.

In the valves of the Figures 13 to 18, the valve diaphragm 354 may comprise instead a suitably flexible, resilient, thin-walled cylinder of a stainless strip metal, such as spring steel, or an analagous plastics strip material.

Figures 19 to 21 illustrate the relevant parts of a second modification of the valve described above with reference to the Figures 13 to 16. In that modification, each of the diaphragm elements 358 has formed integrally therewith, on its radially-outwardly facing surface, a throat sealing device 406 in the form of a continuous, peripheral sealing rib or ridge 408 of a generally square configuration which makes contact with and envelopes the area of the valve tube wall 320 in which the associated circular port 334 is formed. Extending vertically between, and formed continuously with, the upper and lower parts of that rib

408 are three horizontally-spaced ribs or ridges 410 which provide additional strength and support for the diaphragm element 358 so as to minimise its distortion in the region of the port-hole 334. In this modification, the diaphragm 358 is moulded in the inside-out configuration shown in the Figure 21, and is then intro-verted to its operating condition before insertion into the valve tube 310.

The various components of the several valves described above may be made from any suitable mouldable plastics materials, such as for example: for the valve tube units and end caps

ABS (acrilonitrile butadiene styrene), or UPVC (unplasticized polyvinyl chloride); and for the diaphragms

any suitable resilient and/or elastomeric material.

Though the valves described above are intended to control the flow of gases, valves using similar principles of construction and operation may be used, in appropriate circumstances, for the control of liquids.

Wherever appropriate, any feature described above, in relation to one of the valves, may be used in any other one of the valves described.

It will be appreciated that each of the valves described above comprises only a small number of constituent parts, which parts are simply fitted together to assemble the desired valve.

Valves according to the present invention may also be arranged for use in other applications where, instead, the escape of fluids from a pipework system is to be permitted, whilst the intake of fluids to that system is to be prevented. In such a case, for example, the valve of Figures 3 and 4 would be modified to exhibit outwardly (instead of inwardly) facing valve seatings on the upper end 18 of the valve tube 14 and on a downward extension of said end cap wall 26; and the cylindrical valve diaphragm 52 would then circumscribe those seatings and the radiallyfacing throat defined therebetween, and resiliently press inwardly on those axially spaced seatings. That diaphragm would be freely confined in an annular void defined between the external fins 20 and the internal cage 32 (suitably enlarged to lie in axial alignment with the seatings), and be free to expand radially outwards when the pressure in the valve tube exceeds that outside the cylindrical valve diaphragm.

In each of the valves described above, although a zero pressure differential across the diaphragm produces a positive sealing-off of the valve throat, by virtue of the inherent resilience of the diaphragm, only a small pressure differential in the range −0.5mm to −1.5mm is sufficient to initiate opening of the valve throat.

The air admittance valves described above generally have, and other embodiments of the present invention may readily have, the following advantages over the prior art valves:(a) they are generally less bulky than their prior art counterparts; (b) they are less dependent for their operation on the particular physical attitude in which they are disposed, so that they do not have to be mounted in any particular disposition (e.g. vertically, as with valves having a gravity-biased valve diaphragm); (c) they can be constructed as 'full-flow' valves, and without substantially increasing the bulk of the valves on that account; and (d) they are more sensitive to opening pressure differentials developed across the diaphragm, and moreover, they seal positively and tightly at zero pressure differential.

The term 'tubular' as used in this specification in relation to the valve diaphragms shall be construed, in the light of the total disclosure thereof, as including diaphragms (of both cylindrical and frusto-conical configurations) which have an axial length which is relatively small in comparison with the diametral size of such diaphragms. This contrasts with the definitions given on page 1559 of the 'Collins Dictionary of the English Language', published London, 1979, of the terms 'tube' and 'tubular'. There, 'tube' is recited as having a meaning: "1. a long hollow and typically cylindrical object used for the passage of fluids or as a container."; and 'tubular' has meanings: "1. ... having the form of a tube or tubes. 2. of of relating to a tube or tubing.".

CLAIMS

1. An automatic one-way fluid valve comprising:

(a) a valve tube arranged for connection at one end thereof with a fluid flow system;

(b) a first annular sealing surface formed internally within said valve tube;

(c) location means secured on said valve tube;

(d) a cup-shaped diaphragm having a resilient side wall extending from a closed end wall, said diaphragm being carried at said end wall on said location means and having externally near its rim a second, annular sealing surface which is biased into contact with said first sealing surface by the resilience of the side wall, and said side wall having a length-to-average-diameter ratio sufficient to cause parting of said sealing surfaces when the pressure difference existing across said side wall exceeds a predetermined working value.

2. A valve according to claim 1, wherein in said diaphragm, at least a part forming the closed end wall thereof is also resilient.

3. A valve according to claim 2, wherein in said diaphragm, said closed end wall part has a thickness that decreases progressively as the radius increases.

4. A valve according to any preceding claim, wherein in said diaphragm, the parts constituting said side wall and said closed end

wall are integral.

5. A valve according to any preceding claim, wherein said first sealing surface is constituted by a surface raised from the internal surface of said valve tube on an annular ridge that projects inwardly from said valve tube internal surface.

6. A valve according to any preceding claim, wherein said location means comprises a spider member supported from said valve tube.

7. A valve according to claim 6, wherein said spider member is disposed on the upstream side of said diaphragm.

8. A valve according to claim 7, wherein there is provided an external diaphragm-support means carried on said valve tube and arranged to provide support for said diaphragm against undesirable distortion under pressure developed downstream of said diaphragm.

9. An automatic, one-way fluid valve comprising:

(a) a valve tube arranged for connection at one end thereof with a pipework system;

(b) an end closure cap secured to the opposite end of said valve tube and incorporating or forming together with said valve tube fluid flow passages for conveying fluids to/from said valve tube;

(c) said end cap and valve tube have formed therein respective concentric circular valve seatings which together define an annular valve throat which communicates on one side with said fluid flow passages and on the opposite side with the interior of said valve tube; and

(d) an annular valve diaphragm arranged for movement relative to said valve throat and provided with means arranged to bias said diaphragm into contact with said seatings whereby to close off said throat and so prevent the passage of fluid between said throat and flow passages and said valve tube except when the fluid pressure in said valve tube differs by a predetermined amount from that prevailing on the side of said throat remote from said valve tube; characterised in that: said valve seatings are spaced apart axially of said valve tube, and said valve diaphragm comprises a thin-walled diaphragm of a resilient material, shaped and adapted by virtue of its own inherent resilience to normally exert bias pressure on at least one of the said valve seatings in the absence of a fluid pressure difference on opposite sides of said diaphragm.

10. A valve according to claim 9, wherein:.

(a) said fluid flow passages comprise fluid inlet passages for admitting fluid to said valve tube;

(b) said diaphragm has throat-sealing surfaces which are disposed adjacent the respective seatings on the downstream side thereof; and

(c) said diaphragm is shaped and adapted to admit fluid via said inlet passages to said valve tube only when the pressure upstream of said diaphragm exceeds that on the opposite side of said diaphragm by an amount sufficient to overcome the inherent resilience of the diaphragm.

11. A valve according to claim 10, wherein said valve seatings comprise similar cylindrical surfaces which define between them a radially-facing throat of cylindrical configuration, and said valve diaphragm comprises a cylindrical tubular diaphragm of an elastically-deformable, elastomeric material, which diaphragm (a) is positioned radially inwards of said seatings, (b) is supported freely so as to permit radially inwards movement of parts of that diaphragm away from said seatings, and (c) exerts a small radially-outward bias pressure on the respective seatings.

12. A valve according to claim 11, wherein an apertured external, diaphragm-support means is provided externally of said cylindrical diaphragm between said seatings, so as to support said diaphragm against outwards distortion when an abnormally high pressure is developed in said valve tube.

13. A valve according to claim 12, wherein said external diaphragm support means is formed on or secured to said valve tube.

14. A valve according to any one of the claims 11 to 13, wherein an internal diaphragm-support means is provided internally of said cylindrical valve diaphragm between said valve seatings and spaced radially inwards thereof, so as to support said diaphragm against excessive inwards movement in response to a rapid fall in the pressure in the valve tube and thus permit said diaphragm to recover under its own inherent resilience its normal cylindrical configuration in which it closes off said valve throat.

15. A valve according to claim 14, wherein said internal diaphragm support means is formed on or secured to said valve tube.

16. A valve according to claim 14 or 15, wherein said internal diaphragm support means is annular, and is provided with apertures or depressions for communicating any change of pressure in said valve tube to the internal surface of said tubular diaphragm when abutting said annular internal support means without any substantial delay.

17. A valve according to claim 10, wherein said valve seatings comprise complementary frusto-conical surfaces of different diametral sizes, which surfaces define between them a radially and longitudinally facing throat of frusto-conical configuration, and said tubular valve diaphragm is convergent and of a frusto-conical configuration which is matched to that of said frusto-conical seatings.

18. A valve according to claim 17, wherein the larger diameter throat-sealing surface of said convergent tubular diaphragm is held per-

manently against the frusto-conical seating formed on said end cap, and the smaller diameter throat-sealing surface of said valve diaphragm presses resiliently against the frusto-conical seating formed on said valve tube.

19. A valve according to claim 17, wherein the smaller diameter throat-sealing surface of said convergent tubular diaphragm is held permanently against the frusto-conical seating formed on said end cap, and the larger diameter throat-sealing surface of said valve diaphragm presses resiliently against the frusto-conical seating formed on said valve tube.

20. A valve according to claim 19, wherein said valve diaphragm is in the form of an inverted shallow conical cup having a central support member secured at the apex of the conical cup, and said central support member is securely received and held in a central recess which is formed in said end cap inwardly of said frusto-conical seating of said cap.

21. A valve according to claim 19 or claim 20, wherein said convergent tubular diaphragm has formed thereon on the side thereof remote from said valve seatings a plurality of uniformly spaced radial ribs.

22. A valve according to claim 10, wherein:
(a) said concentric valve seatings are constituted by parts of a common, internal cylindrical surface of a wall which extends between adjacent parts of said end cap and valve tube;
(b) a plurality of circumferentially-spaced, radially-facing throat apertures is formed in said wall;
(c) said valve diaphragm comprises a resilient, thin-walled diaphragm having a plurality of similar, circumferentially-spaced throat aperture-sealing portions which lie in contact with respective parts of said cylindrical surface and seal off the respective throat apertures from the interior of said valve tube;
(d) each said throat-sealing portion has respective integral end parts which are resiliently flexed inwardly from said cylindrical surface so as to form with adjacent end parts of adjacent throat-sealing portions respective inwardly directed cusps; and
(e) said cusps are secured in predetermined positions relative to one another and to said end cap, valve tube and throat apertures.

23. A valve according to claim 22, wherein in said diaphragm, adjacent end parts of adjacent throat-sealing portions are permanently secured to each other.

24. A valve according to claim 23, wherein the diaphragm is of an integral construction.

25. A valve according to any one of the claims 22 to 24, wherein said diaphragm comprises a resilient elastomeric material.

26. A valve according to any one of the claims 22 to 24, wherein said diaphragm comprises a resilient strip-metal material.

27. A valve according to any one of the claims 22 to 24, wherein said cusps terminate in enlarged axially-aligned members which are received in slotted diaphragm-support posts secured to either one of said end cap and valve tube.

28. A valve according to claim 27, wherein additional support means are disposed adjacent the respective slotted diaphragm-support posts and are adapted to direct said end parts of said throat-sealing portions at predetermined angles into the respective slotted diaphragm-support posts whereby to pre-stress the respective throat-sealing portions into a firm, throat-sealing contact with the associated parts of said cylindrical wall surface.

29. A valve according to any one of the claims 22 to 28, wherein there is provided between each of said throat-sealing portions of said valve diaphragm and the juxtaposed part of said cylindrical wall surface a respective, intermediate, resilient throat-sealing means secured to either one of said diaphragm portion and said cylindrical wall surface.

30. A valve according to claim 10, wherein:
(a) said valve seatings comprise seating surfaces of different diametral sizes, which surfaces define between them a radially and longitudinally facing throat of a generally frusto-conical configuration;
(b) said valve diaphragm comprises a cup-shaped diaphragm having a side-wall portion extending from an end-wall portion on which is formed a central diaphragm-support boss;
(c) said support boss abuts against said smaller diameter valve seating; and
(d) a free, annular rim part of said side-wall portion abuts against said larger diameter seating.

31. A valve according to claim 30, wherein said larger diameter seating surface comprises the crest part of an annular ridge that is formed on the internal surface of said valve tube and abuts said free rim part of said diaphragm side-wall portion.

32. A valve according to claim 31, wherein an apertured, external support means is provided externally of said cupshaped diaphragm between said seatings and is adapted to support said diaphragm against excessive outwards deflection when an abnormally high pressure is developed in said valve tube.

33. A valve according to any preceding claim, substantially as hereinbefore described with reference to and as illustrated by any single figure or group of associated figures of the accompanying diagrammatic drawings.

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