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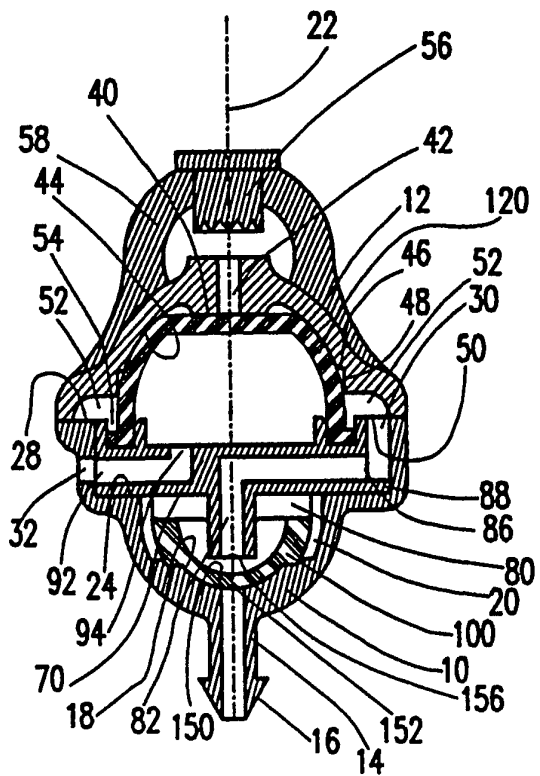
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(54) Title: IRRIGATION APPARATUS

(57) Abstract

An irrigation device including an inlet (16) receiving water under pressure, a water collection and releasing mechanism coupled to the inlet for collecting a quantity of water and subsequently releasing at least part of the quantity of water to the atmosphere, the compressible diaphragm (120) and flow control apparatus governing the supply of water from the inlet to the water collection and releasing mechanism.



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IRRIGATION APPARATUS

FIELD OF THE INVENTION

The present invention relates to irrigation apparatus generally and more particularly to pulsating type irrigation apparatus.

BACKGROUND OF THE INVENTION

Various types of pulsating type irrigation devices are known in the patent literature. The following U.S. and foreign Patents are believed to represent the current state of the art:

U.S. Patents 3,693,888; 3,788,544; 3,802,462;
3,882,892; 3,938,552; 3,976,250; 4,105,162; 4,161,291;
4,176,791; 4,428,397; 4,623,094; 4,718,608; 4,781,217;
4,796,660; 4,889,154; 4,949,747; 4,955,539; 5,132,208;
5,249,745; 5,279,462; 5,294,058; 5,295,506.

Soviet Union Patent Abstracts 854,326;
1,083,790; 1,219,011; 1,240,392; 1,400,551; 1,553,036.

South African Patent 82/5327.

French Patent Abstract 2,614,557.

SUMMARY OF THE INVENTION

The present invention seeks to provide improved irrigation apparatus.

There is thus provided in accordance with a preferred embodiment of the present invention an irrigation device including an inlet receiving water under pressure, a water collection and releasing mechanism coupled to the inlet for collecting a quantity of water and subsequently releasing at least part of the quantity of water to the atmosphere, the water collection and releasing mechanism comprising a compressible diaphragm and flow control apparatus governing the supply of water from the inlet to the water collection and releasing mechanism.

Preferably the flow control apparatus is operative for generally maintaining a given flow rate of water to the water collection and releasing mechanism notwithstanding variations in the pressure of the water at the inlet.

In accordance with a preferred embodiment of the present invention the flow control apparatus includes a flow control diaphragm which does not permit ingress of water to the water collection and releasing mechanism when the pressure of the water at the inlet is less than a predetermined pressure.

Preferably, the collection and releasing mechanism includes an opening and said flow control apparatus comprises a flow control diaphragm which is initially spaced from the opening and in response to a pressure buildup initially at least partially blocks the opening and only thereafter permits the flow of water from the inlet to the opening.

Further in accordance with a preferred embodiment of the present invention there is provided an irrigation device comprising an inlet receiving water

under pressure, a water collection and releasing mechanism coupled to the inlet for collecting a quantity of water and subsequently releasing at least part of the quantity of water to the atmosphere and flow control apparatus governing the supply of water from the inlet to the water collection and releasing mechanism and wherein the collection and releasing mechanism includes an opening and the flow control apparatus comprises a flow control diaphragm which is initially spaced from the opening and in response to a pressure buildup initially at least partially blocks the opening and only thereafter permits the flow of water from the inlet to the opening.

Additionally in accordance with a preferred embodiment of the present invention, the collection and releasing mechanism includes an outlet aperture and the flow control apparatus includes a flow control diaphragm which is initially spaced from the outlet aperture and is operative to intermittently be spaced from the outlet aperture so as to permit impurities to be flushed from the region of the outlet aperture.

Preferably, the collection and releasing mechanism includes a housing and the flow control apparatus includes a diaphragm which is disposed adjacent an inner surface of the housing and defines with the inner surface of the housing a water inlet passageway, the flow control diaphragm being operative to be further spaced from the inner surface upon blockage of the passageway so as to permit impurities to be flushed from the passageway.

Additionally in accordance with a preferred embodiment of the present invention there is provided an irrigation device including an inlet receiving water under pressure and a water collection and releasing mechanism coupled to the inlet for collecting a quantity of water and subsequently releasing at least part of the quantity of water to the atmosphere, the water collection and releasing mechanism including a water outlet and a

water collection and release diaphragm which when at rest seals the water outlet and which is periodically compressed by water received under pressure via the inlet and at least partially collapsed, thereby unsealing the water outlet, such that the potential energy of the compressed and collapsed diaphragm forces water out through the water outlet.

Preferably, the water collection and releasing mechanism includes a water outlet and a water collection and release diaphragm which when at rest seals the water outlet and which is periodically compressed by water received under pressure via the inlet and at least partially collapsed, thereby unsealing the water outlet, such that the potential energy of the compressed and collapsed diaphragm forces water out through the water outlet.

In accordance with a preferred embodiment of the present invention compression of the water collection and release diaphragm causes sudden at least partial collapse thereof.

Preferably, compression of the water collection and release diaphragm causes sudden unsealing of the water outlet.

In accordance with a preferred embodiment of the present invention, the at least partial collapse causes the water collection and release diaphragm to be separated from the water outlet by a distance sufficient to allow outflow of water through the water outlet substantially unimpeded by any particulate matter present adjacent the outlet.

Preferably, the at least partial collapse causes the water collection and release diaphragm to be separated from the water outlet by a distance greater than the smallest dimension of the water outlet.

There is also provided a drip irrigation device including a housing defining an inlet receiving water

under pressure and an outlet, flow control apparatus governing the supply of water from the inlet to the outlet, the flow control apparatus including a flow control diaphragm which is initially spaced from the outlet and in response to a pressure buildup initially at least partially blocks the outlet and thereafter permits the flow of water from the inlet to the outlet.

Preferably the flow control diaphragm is operative to be spaced from the housing upon blockage of a passageway therebetween so as to permit impurities to be flushed from the passageway.

Further in accordance with a preferred embodiment of the present invention there is provided a drip irrigation device including a housing defining an inlet receiving water under pressure and an outlet, flow control apparatus governing the supply of water from the inlet to the outlet, the flow control apparatus including a flow control diaphragm operative to be spaced from the housing upon blockage of a passageway therebetween so as to permit impurities to be flushed from the passageway.

In accordance with a preferred embodiment of the present invention there is also provided a drip irrigation device comprising a drip irrigation pipe, a plurality of drip irrigation assemblies fixed to the interior of the drip irrigation pipe at predetermined intervals, each of the drip irrigation assemblies comprising a housing having a water inlet communicating with the interior of the drip irrigation pipe and an outlet communicating with an outlet aperture formed in the drip irrigation pipe and a diaphragm disposed in the housing and having at least two operative orientations, including a non-pressurized operative orientation wherein the diaphragm is generally convex and a pressurized operative orientation wherein a radially outer portion of the diaphragm is generally convex and a radially inner portion of the diaphragm is generally concave.

Preferably, when the diaphragm is in the pressurized operative orientation it lies adjacent the outlet and is operative to provide pressure responsive flow control of water passing through the outlet.

In accordance with a preferred embodiment of the present invention, when the diaphragm is in the non-pressurized operative orientation it is operative to seal the water inlet until the water pressure within the irrigation pipe exceeds the water pressure downstream of the diaphragm by a predetermined amount.

Preferably the diaphragm operates in the non-pressurized operative orientation as a back-flow preventive valve.

In accordance with a preferred embodiment of the present invention, the housing comprises an outer member and an inner member seated within a recess formed in the outer member, the inner member and the outer member each being sealed to the interior of the pipe, thereby defining a seal between the inner member and the outer member.

There is also provided in accordance with a preferred embodiment of the present invention a method for producing drip irrigation apparatus which includes an irrigation pipe and a plurality of drip irrigation assemblies fixed to the interior of the drip irrigation pipe at predetermined intervals and wherein each of the drip irrigation assemblies comprises a housing including an outer member and an inner member seated within a recess formed in the outer member, the method comprising joining but not sealing together the inner member and the outer member and subsequently heat sealing both the inner member and the outer member to the interior of the drip irrigation pipe, thereby providing a seal between the inner member and the outer member.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description in which:

Figs. 1A, 1B, 1C, 1D, 1E and 1F together define an exploded view illustration of the irrigation apparatus of the present invention taken along one direction;

Figs. 2A, 2B, 2C, 2D, 2E and 2F together define an exploded view illustration of the irrigation apparatus of the present invention taken along a direction generally opposite to the direction along which Figs. 1A - 1F are taken;

Figs. 3A, 3B, 3C, 3D, 3E, 3F, 3G, 3H and 3I are sectional illustrations of one embodiment of the irrigation apparatus of the present invention at various stages of the operation thereof;

Figs. 4A and 4B are sectional illustrations of another embodiment of irrigation apparatus of the present invention at two stages of operation thereof;

Fig. 5 is a partially cut-away, simplified pictorial illustration of drip irrigation apparatus constructed and operative in accordance with a preferred embodiment of the present invention;

Figs. 6A and 6B are sectional illustrations taken along lines VI - VI of the drip irrigation apparatus of Fig. 5 in respective unpressurized and pressurized operative orientations; and

Figs. 7A and 7B are sectional illustrations taken along lines VII - VII, perpendicular to lines VI - VI, of the drip irrigation apparatus of Fig. 5 in respective unpressurized and pressurized operative orientations.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Figs. 1A - 3I and particularly to Figs. 1A - 1F and 2A - 2F, which are exploded view illustrations of the irrigation apparatus of the present invention taken along generally opposite directions. As seen in Figs. 1A - 1F and 2A - 2F, the irrigation apparatus of the present invention comprises a two part housing assembly including a water inlet portion 10 and a water outlet portion 12, which are preferably removably held together by a rotatable clamp arrangement (not shown).

The water inlet portion 10 comprises a generally longitudinal water inlet conduit portion 14 having a symmetric generally conical forward retaining configuration, indicated at reference numeral 16. Conduit 14 is preferably integrally formed with and communicates with the interior of a generally hemispherical bowl portion 18, the interior of which is formed with a peripheral array of grooves 20, which extend generally symmetrically about a longitudinal axis 22, along which conduit 14 is centered. Alternatively, only a single groove 20 may be provided.

At the mouth of bowl portion 18, the ends of the peripheral array of grooves 20 are surrounded by a generally circular shoulder 24, which lies generally in a plane perpendicular to longitudinal axis 22. An annular wall portion 26 surrounds shoulder 24 and extends to a further circular shoulder 28, which defines a mouth of the water inlet portion. Annular wall portion 26 is formed with a recess 30, which extends from shoulder 26 to shoulder 28 and defines a water conduit.

Facing recess 30 and disposed on an opposite side of annular wall portion 26 is a air relief aperture 32.

The water outlet portion 12 comprises a gener-

ally circular water outlet portion 40 having a central outlet aperture 42 which is preferably arranged to lie along longitudinal axis 22, when the irrigation apparatus is assembled. Outlet portion 40 is preferably integrally formed with and communicates with the interior of a generally hemispherical bowl portion 44. Portion 44 extends generally symmetrically about longitudinal axis 22 and terminates at a generally circular shoulder 46, which lies generally in a plane perpendicular to longitudinal axis 22.

An annular wall portion 48 surrounds shoulder 46 and extends beyond a further circular shoulder 50, which defines a mouth of the water outlet portion. When the irrigation apparatus is assembled, shoulder 50 of water outlet portion 12 lies against and in sealing engagement with shoulder 28 of water inlet portion 10. Shoulder 50 is formed with at least one and preferably a pair of recesses 52 which lie in opposite facing relationship. One of the recesses 52 lies in communication with recess 30, when the irrigation apparatus is assembled. Recesses 52 also cut through the protruding portion of the annular wall portion 48 which protrudes beyond shoulder 50, and which is indicated by reference numeral 54.

Considering the external configuration of the water outlet portion 12, it is seen that disposed in spaced facing relationship with aperture 42 is a flow deflector 56, which is retained by a retaining bridge 58, preferably integrally formed with the outlet portion 12. The flow deflector 56 is normally not integrally formed with the outlet portion 12, so as to enable various flow deflectors 56 to be selectably employed in a modular manner.

Disposed mainly inside water inlet portion 10 is an intermediate member 70. Intermediate member 70 is of generally disk-like configuration and includes an

annular generally circular cylindrical peripheral surface 72 and a planar surface 74. Arranged on planar surface 74 is a generally circular array 76 of mutually spaced protrusions 78 of generally uniform height, and preferably of generally triangular configuration. The spacings between protrusions 78 in array 76 preferably define radially directed water conduits 80 which permit water flow radially inward.

Disposed centrally of peripheral surface 72, and along longitudinal axis 22, when the irrigation apparatus is assembled, is a water inlet conduit 82 which extends outwardly of planar surface 74 beyond protrusions 78. Water inlet conduit 82 communicates via a transverse conduit 84 with a water outlet aperture 86 formed in peripheral wall surface 72. Disposed adjacent water outlet aperture 86 is a positioning protrusion 88 which is arranged to seat in recess 30, when the irrigation apparatus is assembled. In this manner aperture 86 is aligned with recess 30, whereby water entering water inlet conduit 82 passes through intermediate member 70 via recess 30 to recess 52.

Intermediate member 70 also defines a second transverse conduit 90, which is sealed from conduit 84 and which communicates via an aperture 92 between air relief aperture 32 in the water inlet portion 10 and the interior of the water outlet portion 12 via an air relief aperture 94.

Intermediate member 70 is formed with an underside surface 95 of intermediate member 70, opposite from planar surface 74 and generally parallel thereto.

Intermediate member 70 defines a pair of concentric annular retaining rings 96 and 98 which extend outwardly from surface 95 and also defines an annular planar surface 99 extending therebetween and lying generally parallel to surface 95.

A first flexible, resilient water impermeable

diaphragm 100 is disposed between intermediate member 70 and the water inlet portion 10 of the housing. Its rim, indicated by reference numeral 102, lies against array 76 of protrusions 78. Diaphragm 100 preferably has a peripheral shoulder surface 104. Alternatively, diaphragm 100 is formed without shoulder surface 104.

A second flexible, resilient water impermeable diaphragm 120 is disposed between intermediate member 70 and the water outlet portion 10 of the housing. Its rim, indicated by reference numeral 122, is retained in sealing engagement against surface 99 by rings 96 and 98 and by protruding portion 54.

Reference is now made to Figs. 3A, 3B, 3C, 3D, 3E, 3F, 3G, 3H and 3I, which are sectional illustrations of the irrigation apparatus of the present invention at various stages of the operation thereof.

Fig. 3A illustrates the irrigation apparatus of Figs. 1A - 2F at an initial stage of operation wherein the apparatus is not pressurized by water. It is seen that diaphragm 100 lies in sealing engagement with an ungrooved lower portion 150 of bowl portion 18 and seals an aperture 152 via which conduit 14 communicates with the interior of water inlet portion 10.

Upon supply of sufficiently pressurized water via conduit 14 to the irrigation apparatus, diaphragm 100 is initially partially displaced through the orientation shown in Fig. 3B at which aperture 152 is unsealed but the diaphragm 100 lies with shoulder surface 104 in sealing engagement with a peripheral shoulder surface 154 of water inlet portion 10. In the intermediate orientation shown in Fig. 3B, the diaphragm 100 lies against an opening 156 of conduit 82, not necessarily in sealing engagement therewith.

Alternatively, when diaphragm 100 is formed without shoulder surface 104, the water inlet portion 10 may be formed without peripheral shoulder surface 154.

Upon continuing pressurization, the diaphragm 100 reaches the orientation shown in Fig. 3C in which it is no longer in sealing engagement with peripheral shoulder surface 154 and thus partially defines a water flow passage from conduit 14, via grooves 20, radially directed water conduits 80 and opening 156 to conduit 82.

The flow of water into the interior of diaphragm 100, indicated by reference numeral 158, and the consequent filling of the interior causes the diaphragm to be displaced somewhat closer to shoulder surface 154, as seen, for example in Fig. 3D. Water from the interior 158 flows through conduits 82 and 84 and via recesses 30 and 52 into the interior 159 of the water outlet portion 12, exterior of diaphragm 120, and acts to depress diaphragm 120, as shown in Fig. 3E.

During initial supply of water to the irrigation apparatus, the operation of the diaphragm 100 between positions illustrated generally in Figs. 3C and 3D, provides pressure-responsive flushing of contaminants from the water flow path. This pressure responsive flushing results from an increase in the cross sectional area of the opening between the diaphragm and shoulder surface 154, responsive to a pressure buildup resulting from a blockage of the flow path.

Referring now to Figs. 3F and 3G, it is seen that if particles of contaminants are present between diaphragm 100 and shoulder surface 154, as shown schematically in Fig. 3F and indicated by reference numeral 160, and the particles cause at least partial blocking of the water path therepast, this blockage lowers the pressure at the interior 158 and cause displacement of the diaphragm 100 away from surface 154, as shown in Fig. 3G, providing a flushing function.

At all stages of operation up to and including that shown in Fig. 3G, diaphragm 120 lies in sealing engagement with central aperture 42 of circular water

outlet portion 40. Continued flow of water into the interior 159 causes partial collapse of diaphragm 120, as shown in Fig. 3H and thus opening of central aperture 42. Upon opening of central aperture 42, which occurs suddenly rather than gradually, the potential energy of the partially collapsed diaphragm 120 forces at least part of the water in interior 159 out of the irrigation apparatus via aperture 42, as the diaphragm 120 expands to an orientation shown in Fig. 3I.

As indicated by arrows 170 the water forced out of interior 159 preferably impacts upon flow deflector 56 and is redirected to the outside. As the water is removed from interior 159, the diaphragm 120 eventually returns to its initial state, shown, for example, in Fig. 3D.

Reference is now made to Figs. 4A and 4B which are sectional illustrations of another embodiment of irrigation apparatus of the present invention at two stages of operation thereof. The irrigation apparatus of Figs. 4A and 4B is a dripper which incorporates the principal constructional and operational features of the water inlet portion 10 and diaphragm 100 described above.

As seen in Figs. 4A and 4B, the irrigation apparatus of the present invention comprises a two part housing assembly including a water inlet portion 210 and a water outlet portion 212, which are preferably removably held together.

The water inlet portion 210 comprises a generally longitudinal water inlet conduit portion 214 having a symmetric generally conical forward retaining configuration, indicated at reference numeral 216. Conduit 214 is preferably integrally formed with and communicates with the interior of a generally hemispherical bowl portion 218, the interior of which is formed with a groove 220.

At the mouth of bowl portion 218, the end of the groove 220 communicates with a generally circular

shoulder 224, which lies generally in a plane perpendicular to a longitudinal axis 222. An exterior peripheral wall portion 226 surrounds shoulder 224 in spaced relationship therewith and with respect to bowl portion 218, thus defining a peripheral recess 228. Wall portion 226 is preferably formed with a peripheral protrusion 230 which is employed for coupling, as will be described hereinbelow.

The water outlet portion 212 comprises a generally circular water conduit portion 240 having a central outlet aperture 242 which is preferably arranged to lie along longitudinal axis 222, when the irrigation apparatus is assembled.

Water outlet portion 212 includes mutually spaced inner and outer generally circular cylindrical peripheral walls 270 and 272 and an inner planar surface 274. Walls 270 and 272 define therebetween a generally circular cylindrical peripheral recess 275 which is configured to receive exterior peripheral wall portion 226 for sealed clamping engagement therewith when the dripper is assembled, as shown in Figs. 4A and 4B. When the dripper is assembled, wall 270 resides within recess 228.

Arranged on planar surface 274 is a generally circular array of mutually spaced protrusions of generally uniform height, and preferably of generally triangular configuration. The spacings between the protrusions in the array preferably define radially directed water conduits 280 which permit water flow radially inward, much in the same way as described hereinabove in connection with the intermediate member 70.

A flexible, resilient water impermeable diaphragm 300 is disposed between water outlet portion 212 and water inlet portion 210 of the housing. Its rim, indicated by reference numeral 302, lies against the array of protrusions described above.

Fig. 4A illustrates the dripper at an initial stage of operation wherein the apparatus is not pressurized by water. It is seen that diaphragm 300 lies in sealing engagement with an ungrooved lower portion 350 of bowl portion 218 and seals an aperture 352 via which conduit 214 communicates with the interior of water inlet portion 210.

Upon supply of sufficiently pressurized water via conduit 214 to the irrigation apparatus, diaphragm 300 reaches the orientation shown in Fig. 4B in which it is no longer in sealing engagement with lower portion 350 and thus partially defines a water flow passage from conduit 214, via groove 220, radially directed water conduits 280 and aperture 242 to the atmosphere.

The flow of water into the volume between lower portion 350 and diaphragm 300, indicated by reference numeral 358, and the consequent filling of this volume causes the diaphragm 300 to be displaced close to the periphery of aperture 242, designated by reference numeral 360, as seen, for example in Fig. 4B.

Water from the volume 358 flows through the space defined between the exterior of diaphragm 300 and lower portion 350 into the interior volume of the diaphragm 300, indicated by reference numeral 362. Water from volume 362 passes into aperture 242 to the extent that it is not sealed by diaphragm 300. Preferably a small slit 364 is formed at the periphery 360 of aperture 242 to ensure a desired flow of water into the aperture.

It is appreciated that pressure responsive flow control of the quantity of water passing into aperture 242 is provided by pressure responsive positioning of diaphragm 300 against periphery 360.

An automatic self-cleaning feature is provided by diaphragm 300, much in the same way as described hereinabove in connection with diaphragm 100.

Reference is now made to Figs. 5 - 7B, which

illustrate drip irrigation apparatus constructed and operative in accordance with a preferred embodiment of the present invention. The drip irrigation apparatus of the present invention comprises a pipe 400, typically formed of polyethylene by extrusion, interiorly of which are heat welded at predetermined intervals, drip irrigation assemblies 402.

Each drip irrigation assembly 402 preferably comprises an outer portion 404, an inner portion 406 and a diaphragm 408, typically formed of rubber, which is disposed in sealing relationship therebetween.

The outer portion 404 defines a water inlet aperture 410, which communicates with the interior of pipe 400 and receives pressurized irrigation water therefrom. As seen particularly well in Figs. 6A, 6B, 7A and 7B, water inlet aperture 410 communicates with an interior generally concave volume 412, whose generally concave surface 414 is defined by outer portion 404.

Membrane 408 is seated within volume 412 and when it is in an unpressurized operative orientation, lies against generally concave surface 414 as seen in Figs. 6A and 7A. Inner portion 406 is seated within a recess 416 disposed within outer portion 404 above volume 412. Inner portion 406 includes a passageway 418 which provides communication between a passageway 420, lying adjacent to and communicating with volume 412 outside of diaphragm 408, and the remainder of volume 412 inside of diaphragm 408, as seen particularly in Figs. 7A and 7B. Disposed below passageway 420, and separated therefrom by a shoulder 421, there may be provided a peripheral, generally ring shaped recess 422, which fully or partially surrounds volume 412.

Inner portion 406 also defines an outlet aperture 424 which communicates between the interior of volume 412, interior of diaphragm 408, and an outlet volume 426. A water exit aperture 428, formed in pipe

400, communicates with outlet volume 426.

It will be appreciated by persons skilled in the art, that when the pressure in the interior of pipe 400 is insufficient to displace diaphragm 408 from its unpressurized orientation, as shown in Figs. 6A and 7A, substantially no water enters into that portion of volume 412 downstream of diaphragm 408.

When the pressure in pipe 400 reaches a sufficient level, the diaphragm 408 is displaced to a second operative orientation, illustrated generally in Figs. 6B and 7B. The position of the diaphragm 408 against a shoulder 421 lying at the junction between volume 412 and passageway 420 may define a pressure reducing, narrow opening through which water passes from the inlet aperture 410 to the outlet aperture 424.

In this orientation, the diaphragm 408 provides pressure responsive flow control. The pressure responsive flow control takes place at the peripheral edge of outlet aperture 424 as a function of the propinquity of the diaphragm 408 thereto, in response to the pressure applied to the diaphragm.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow, which are to be interpreted to include reasonable variations in the embodiments described with particularity.

C L A I M S

1. An irrigation device comprising:
 - an inlet receiving water under pressure;
 - a water collection and releasing mechanism coupled to the inlet for collecting a quantity of water and subsequently releasing at least part of the quantity of water to the atmosphere, said water collection and releasing mechanism comprising a compressible diaphragm;
 - and
 - flow control apparatus governing the supply of water from said inlet to said water collection and releasing mechanism.
2. Irrigation apparatus according to claim 1 and wherein said flow control apparatus is operative for generally maintaining a given flow rate of water to the water collection and releasing mechanism notwithstanding variations in the pressure of the water at said inlet.
3. Irrigation apparatus according to either of claims 1 and 2 and wherein said flow control apparatus comprises a flow control diaphragm which does not permit ingress of water to the water collection and releasing mechanism when the pressure of the water at the inlet is less than a predetermined pressure.
4. Irrigation apparatus according to any of claims 1 - 3 and wherein said collection and releasing mechanism includes an opening and said flow control apparatus comprises a flow control diaphragm which is initially spaced from said opening and in response to a pressure buildup initially at least partially blocks said opening and only thereafter permits the flow of water from said inlet to said opening.
5. An irrigation device comprising:

an inlet receiving water under pressure;

a water collection and releasing mechanism coupled to the inlet for collecting a quantity of water and subsequently releasing at least part of the quantity of water to the atmosphere; and

flow control apparatus governing the supply of water from said inlet to said water collection and releasing mechanism and wherein said collection and releasing mechanism includes an opening and said flow control apparatus comprises a flow control diaphragm which is initially spaced from said opening and in response to a pressure buildup initially at least partially blocks said opening and only thereafter permits the flow of water from said inlet to said opening.

6. Irrigation apparatus according to any of the preceding claims and wherein said collection and releasing mechanism includes an outlet aperture and a diaphragm which is initially spaced from said outlet aperture and is operative to intermittently be spaced from said outlet aperture so as to permit impurities to be flushed from the region of said outlet aperture.

7. Irrigation apparatus according to any of the preceding claims and wherein said collection and releasing mechanism includes a housing and said flow control apparatus comprises a diaphragm which is disposed adjacent an inner surface of said housing and defines with the inner surface of the housing a water inlet passageway, the flow control diaphragm being operative to be further spaced from said inner surface upon blockage of said passageway so as to permit impurities to be flushed from said passageway.

8. An irrigation device comprising:
an inlet receiving water under pressure; and

a water collection and releasing mechanism coupled to the inlet for collecting a quantity of water and subsequently releasing at least part of the quantity of water to the atmosphere, said water collection and releasing mechanism comprising a water outlet and a water collection and release diaphragm which when at rest seals the water outlet and which is periodically compressed by water received under pressure via said inlet and at least partially collapsed, thereby unsealing the water outlet, such that the potential energy of the compressed and collapsed diaphragm forces water out through said water outlet.

9. An irrigation device according to any of the preceding claims 1 - 7 and wherein said water collection and releasing mechanism comprises a water outlet and a water collection and release diaphragm which when at rest seals the water outlet and which is periodically compressed by water received under pressure via said inlet and at least partially collapsed, thereby unsealing the water outlet, such that the potential energy of the compressed and collapsed diaphragm forces water out through said water outlet.

10. An irrigation device according to claim 8 or claim 9 and wherein compression of said water collection and release diaphragm causes sudden at least partial collapse thereof.

11. An irrigation device according to any of claims 8 - 10 wherein compression of said water collection and release diaphragm causes sudden unsealing of said water outlet.

12. An irrigation device according to any of claims 8 - 11 and wherein said at least partial collapse causes

the water collection and release diaphragm to be separated from said water outlet by a distance sufficient to allow outflow of water through said water outlet substantially unimpeded by any particulate matter present adjacent the outlet.

13. An irrigation device according to any of claims 8 - 12 and wherein said at least partial collapse causes the water collection and release diaphragm to be separated from said water outlet by a distance greater than the smallest dimension of the water outlet.

14. A drip irrigation device comprising:
a housing defining an inlet receiving water under pressure and an outlet;
flow control apparatus governing the supply of water from said inlet to said outlet, said flow control apparatus comprising:
a flow control diaphragm which is initially spaced from said outlet and in response to a pressure buildup initially at least partially blocks said outlet and thereafter permits the flow of water from said inlet to said outlet.

15. A drip irrigation device according to claim 14 and wherein said flow control diaphragm is operative to be spaced from said housing upon blockage of a passageway therebetween so as to permit impurities to be flushed from said passageway.

16. A drip irrigation device comprising:
a housing defining an inlet receiving water under pressure and an outlet;
flow control apparatus governing the supply of water from said inlet to said outlet, said flow control apparatus comprising:

a flow control diaphragm operative to be spaced from said housing upon blockage of a passageway therebetween so as to permit impurities to be flushed from said passageway.

17. A drip irrigation device comprising:
a drip irrigation pipe;
a plurality of drip irrigation assemblies fixed to the interior of said drip irrigation pipe at predetermined intervals, each of said drip irrigation assemblies comprising:

a housing having a water inlet communicating with the interior of said drip irrigation pipe and an outlet communicating with an outlet aperture formed in said drip irrigation pipe; and

a diaphragm disposed in said housing and having at least two operative orientations, including a non-pressurized operative orientation wherein the diaphragm is generally convex and a pressurized operative orientation wherein a radially outer portion of the diaphragm is generally convex and a radially inner portion of the diaphragm is generally concave.

18. A drip irrigation device according to claim 17 and wherein when said diaphragm is in said pressurized operative orientation it lies adjacent said outlet and is operative to provide pressure responsive flow control of water passing through said outlet.

19. A drip irrigation device according to claim 17 or claim 18 and wherein when said diaphragm is in said non-pressurized operative orientation it is operative to seal said water inlet until the water pressure within said irrigation pipe exceeds the water pressure downstream of said diaphragm by a predetermined amount.

20. A drip irrigation device according to claim 19 and wherein said diaphragm operates in said non-pressurized operative orientation as a back-flow preventive valve.

21. A drip irrigation device according to any of claims 17 - 20 and wherein said housing comprises an outer member and an inner member seated within a recess formed in the outer member, said inner member and said outer member each being sealed to the interior of said pipe, thereby defining a seal between said inner member and said outer member.

22. A method for producing drip irrigation apparatus which includes an irrigation pipe and a plurality of drip irrigation assemblies fixed to the interior of said drip irrigation pipe at predetermined intervals and wherein each of said drip irrigation assemblies comprises a housing including an outer member and an inner member seated within a recess formed in the outer member, the method comprising:

joining but not sealing together the inner member and the outer member; and subsequently

heat sealing both the inner member and the outer member to the interior of said drip irrigation pipe, thereby providing a seal between the inner member and the outer member.

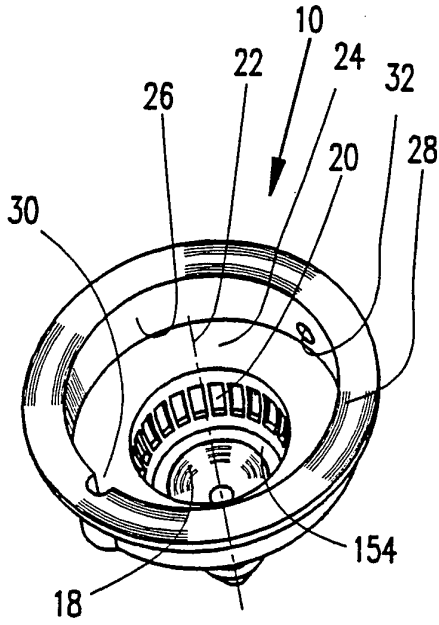


FIG. 1A

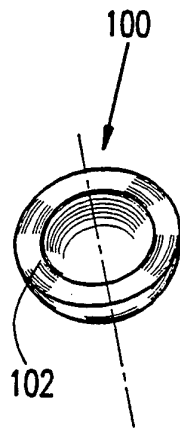


FIG. 1B

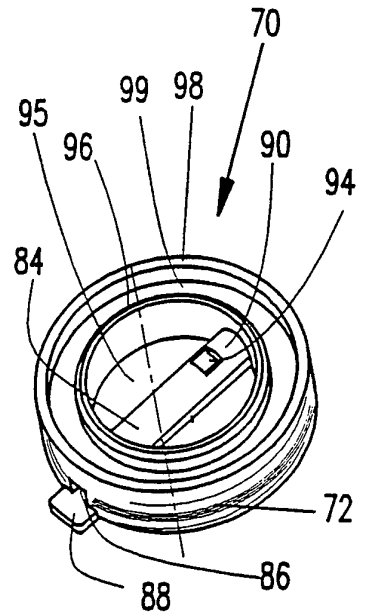


FIG. 1C

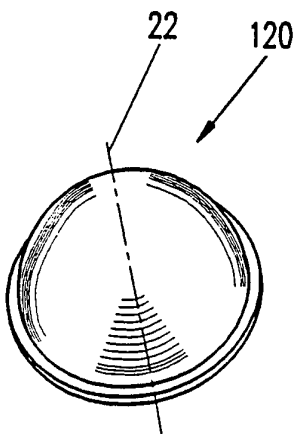


FIG. 1D

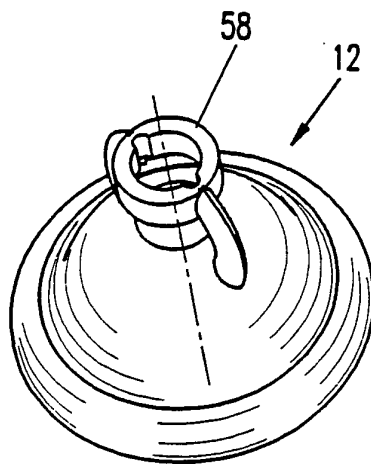


FIG. 1E

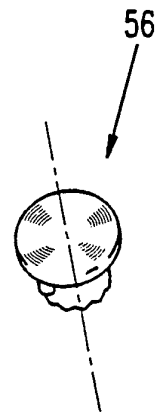


FIG. 1F

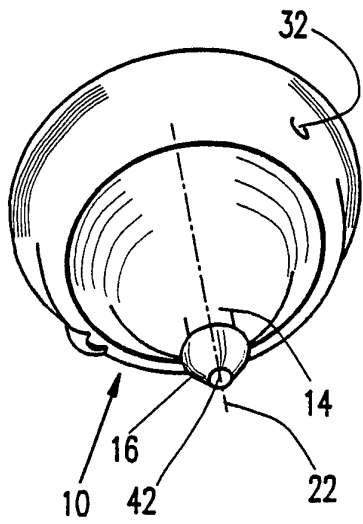


FIG. 2A

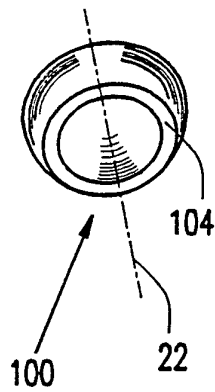


FIG. 2B

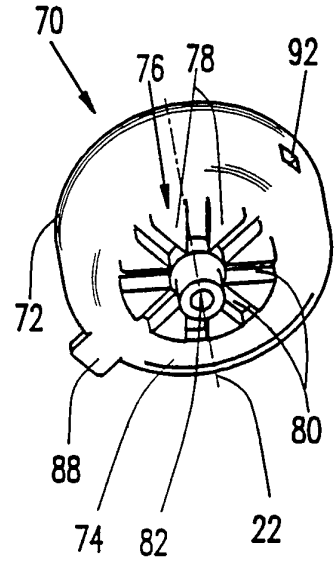


FIG. 2C

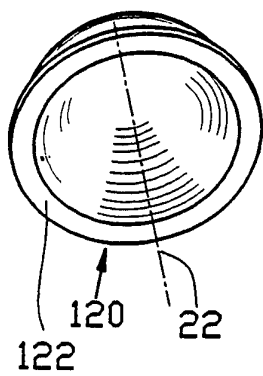


FIG. 2D

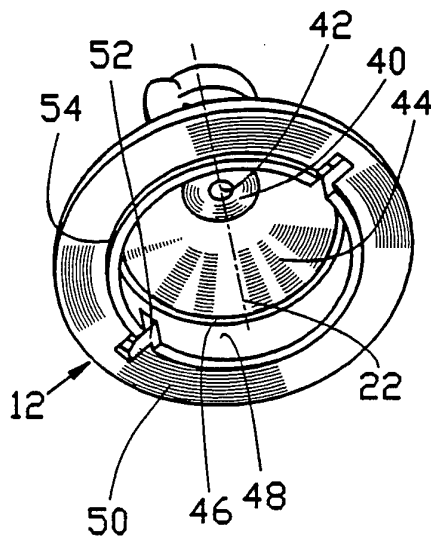
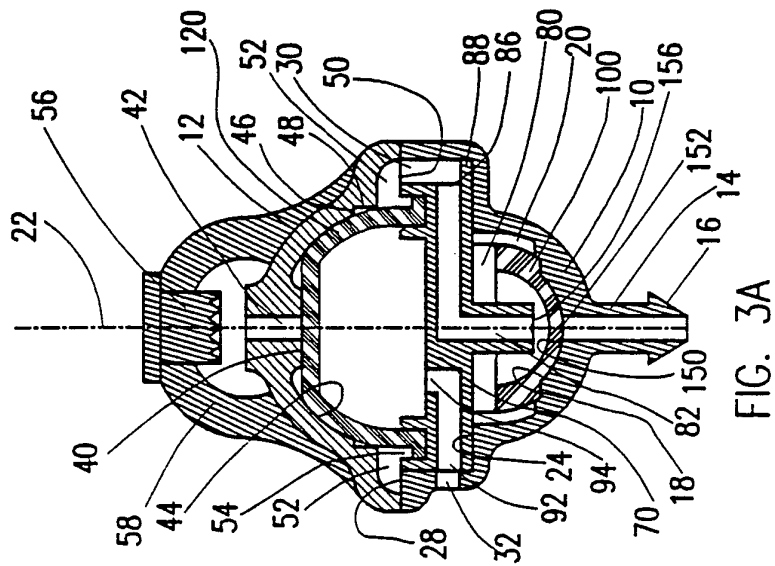
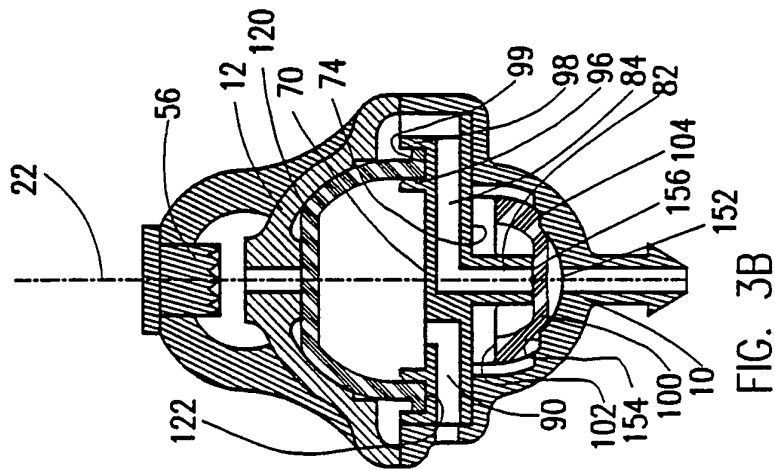
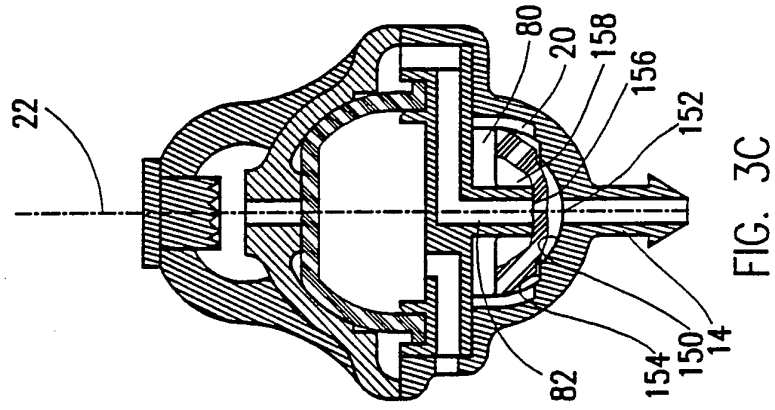


FIG. 2E



FIG. 2F



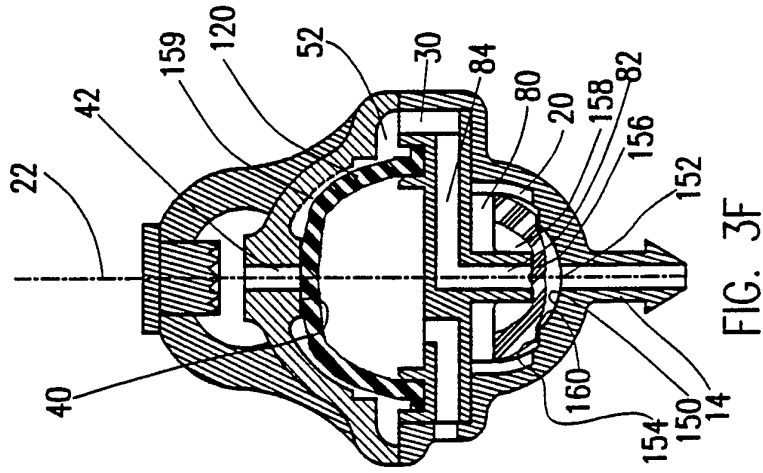


FIG. 3F

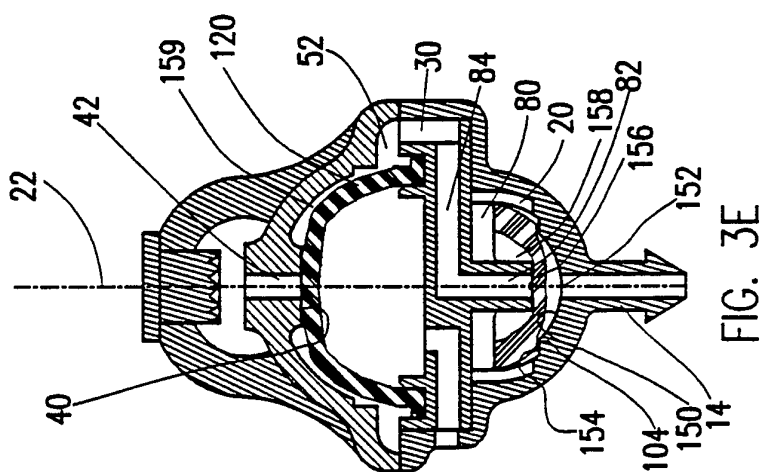


FIG. 3E

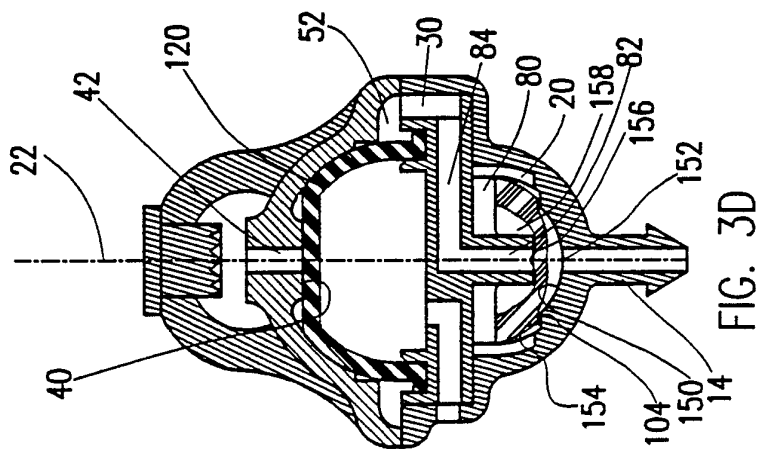
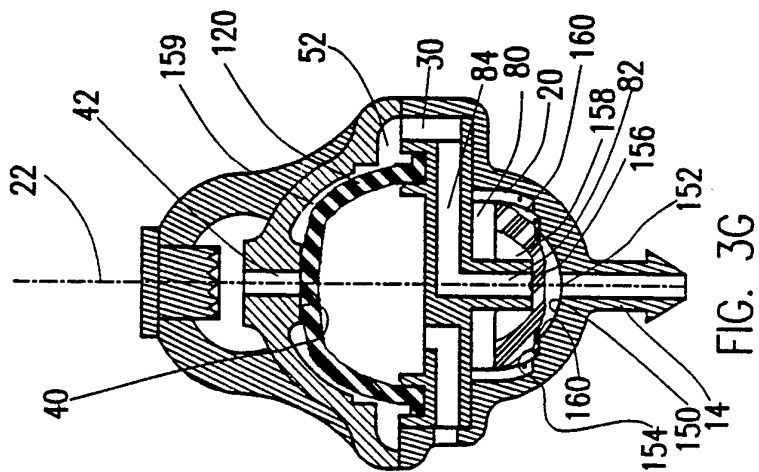
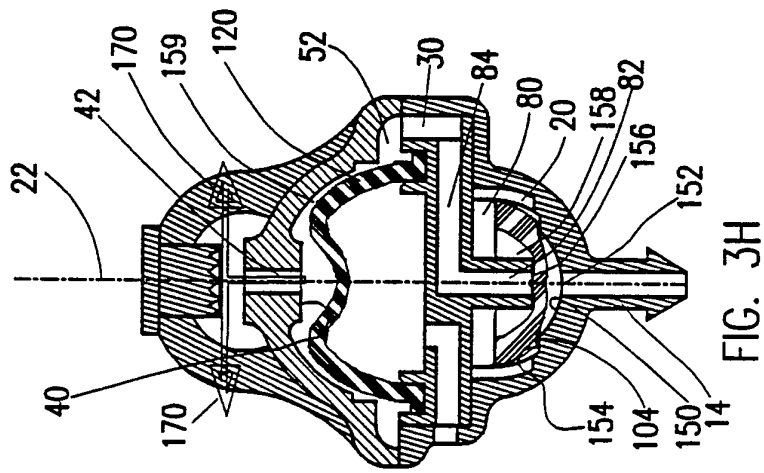
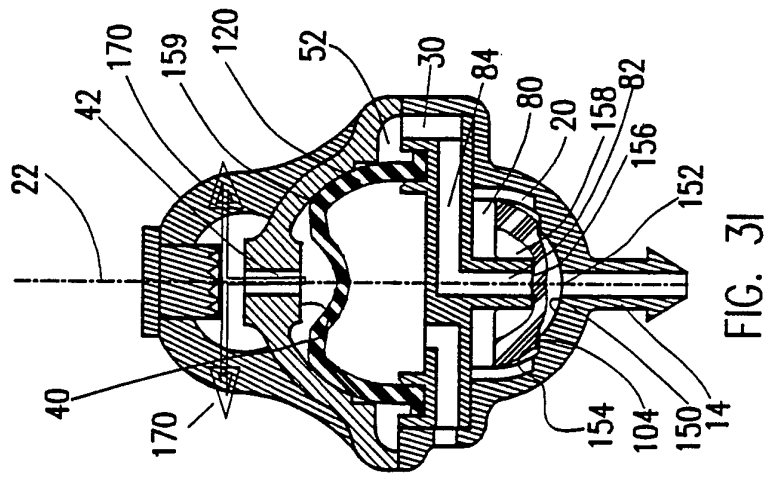


FIG. 3D



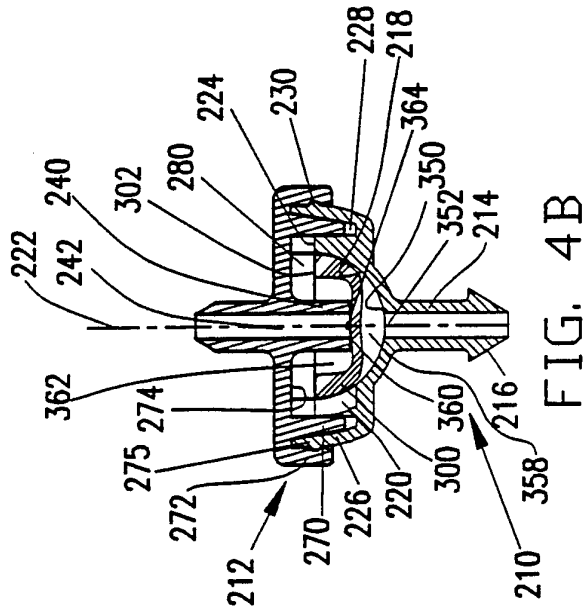


FIG. 4B

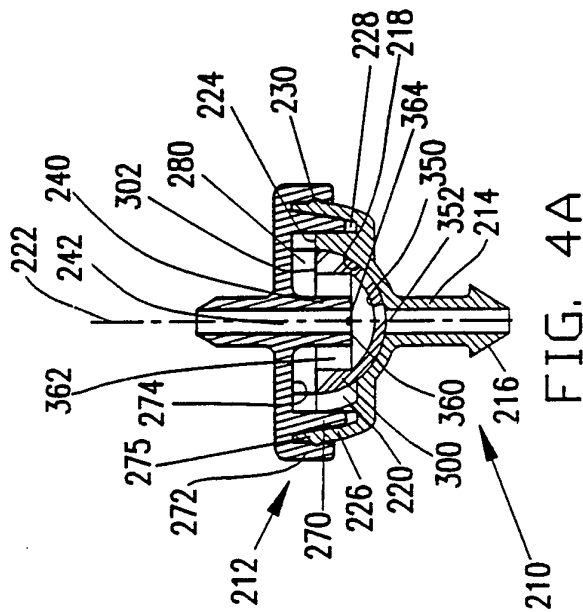


FIG. 4A

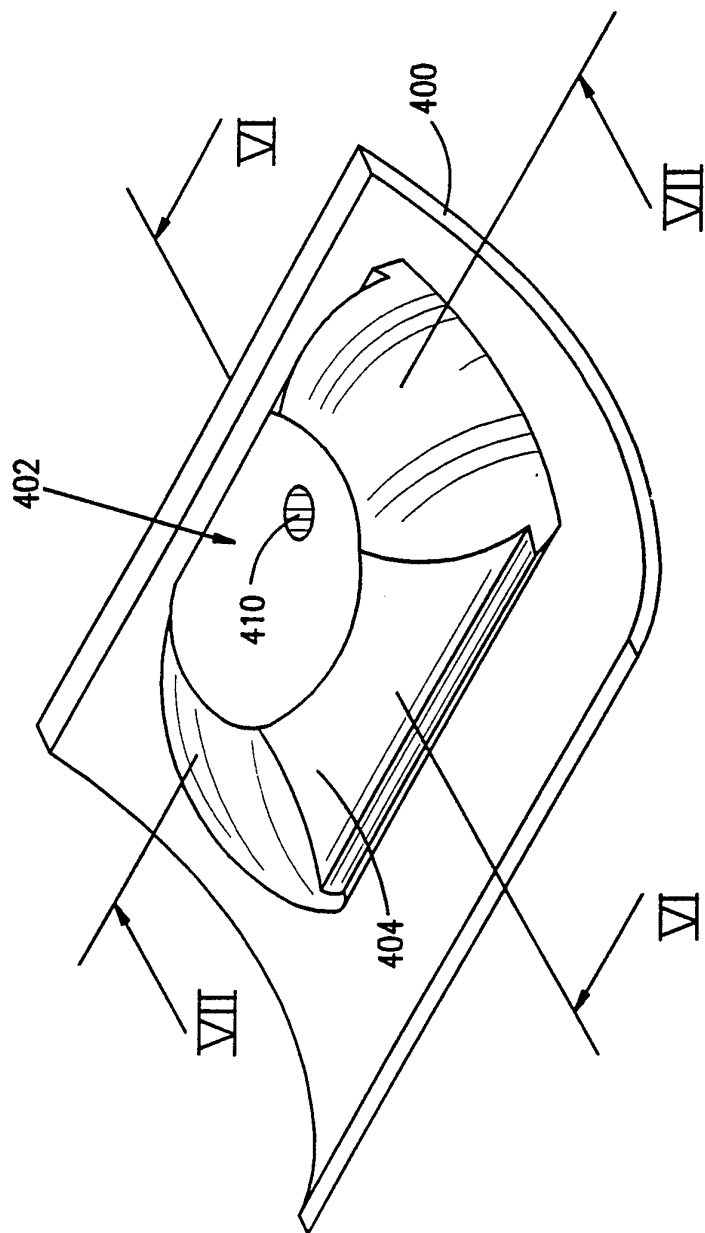


FIG. 5

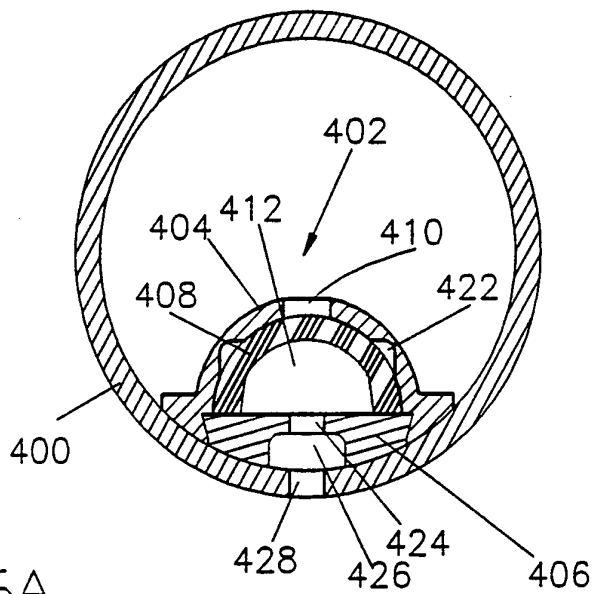


FIG. 6A

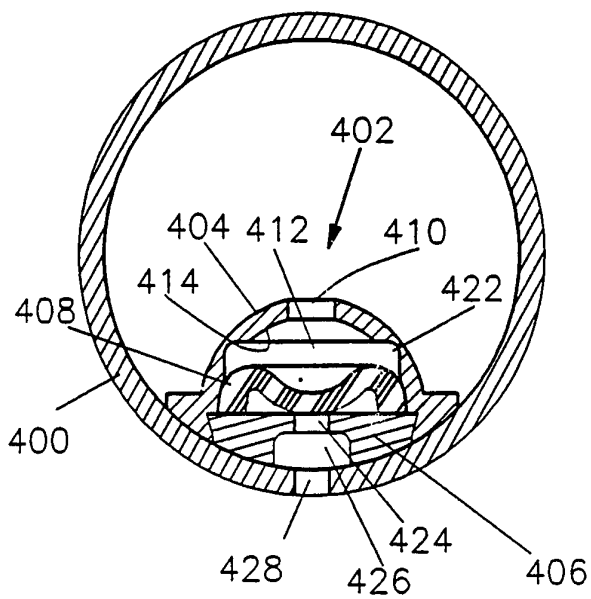


FIG. 6B

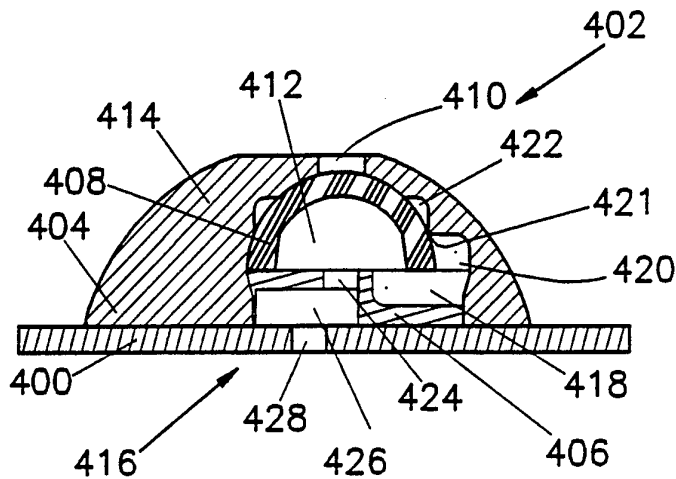


FIG. 7A

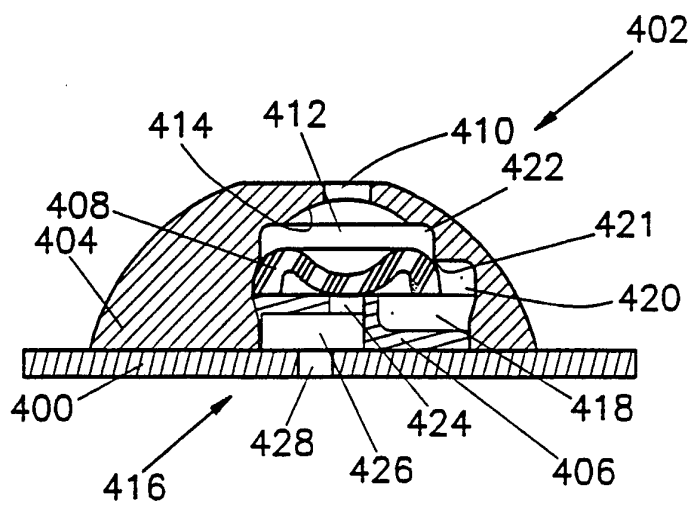


FIG. 7B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/05387

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B05B 15/00
US CL :239/542

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 239/542, 99, 570, 571

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Automated Patent System

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 3,976,250 (Bentzinger) 24 August 1976 See membrane (57) and housing (22)	1, 14-18
X	US, A, 4,405,084 (Georgieu et al) 20 September 1983 See membrane (13) and compression chamber (1).	8, 14, 16
X	US, A, 4,307,841 (Mehoudar et al) 29 December 1981 See column 1 lines 47-57.	20
A	US, A, 4,058,257 (Spencer) 15 November 1977 See column 4 lines 22-32.	NONE
A	US, A, 4,702,280 (Zakai et al) 27 October 1987 See membrane (10)	NONE

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

27 JUNE 1995

Date of mailing of the international search report

07AUG 1995

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