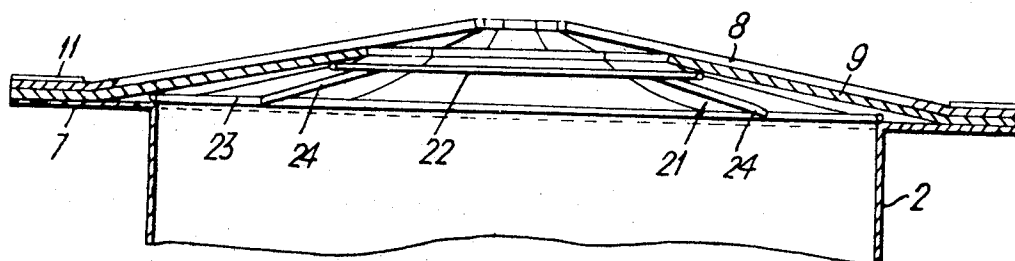


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 [21] Appl. No. **883,189**
 [22] Filed **Dec. 8, 1969**
 [45] Patented **Nov. 23, 1971**
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 [32] Priority **Dec. 7, 1968**
 [33] **Great Britain**
 [31] **58,248/68**

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[54] **VARIABLE-AREA NOZZLE**
8 Claims, 4 Drawing Figs.
 [52] U.S. Cl. **239/535,**
 98/78, 138/45, 239/602, 239/DIG. 19
 [51] Int. Cl. **B05b 1/02**
 [50] Field of Search 138/45;
 137/525.1, 525.3, 587; 98/78, 116; 220/44 C;
 222/490; 239/534, 535, 602, DIG. 19

ABSTRACT: A variable-area nozzle is located in a vent pipe, and has a central aperture of variable area dependent upon the fluid flow through the nozzle. The nozzle includes a flexible diaphragm transverse to the vent pipe and having an annular series of inwardly projecting leaves which are flexible to define a central aperture of variable area dependent upon said flow.



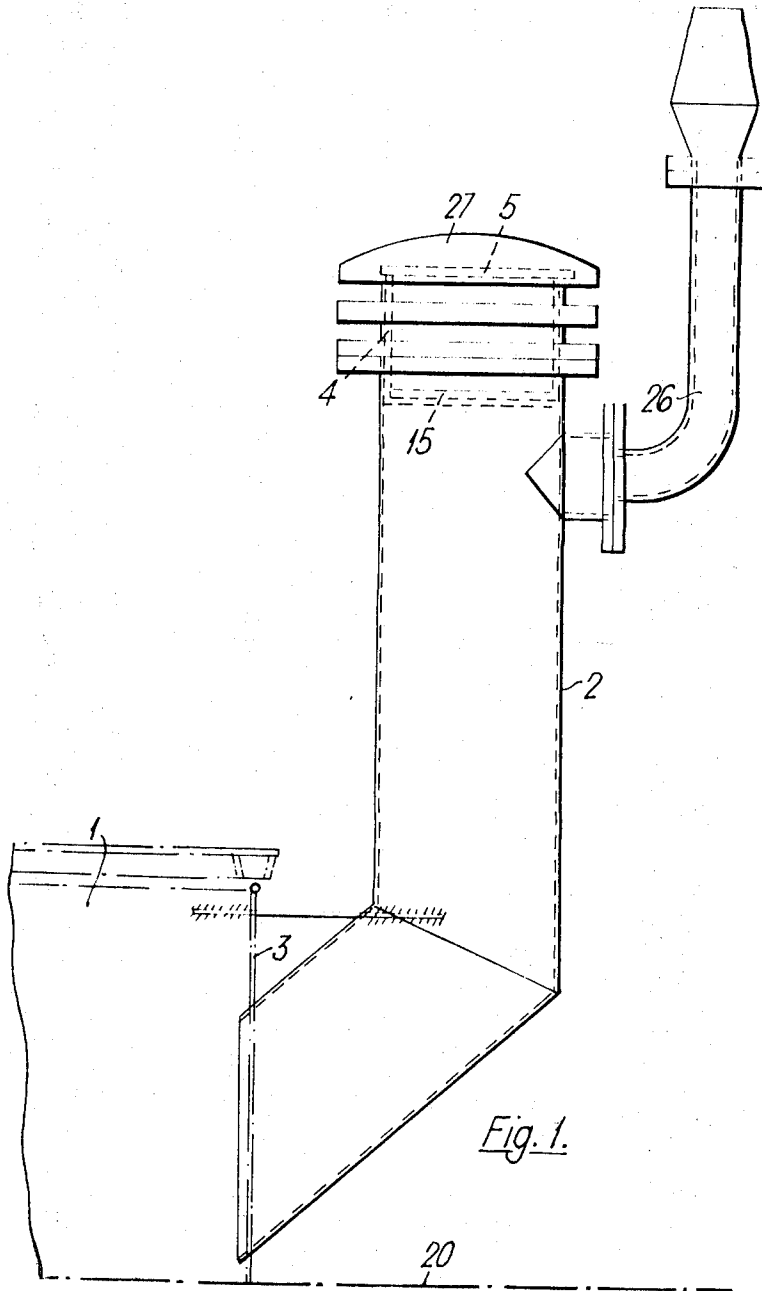
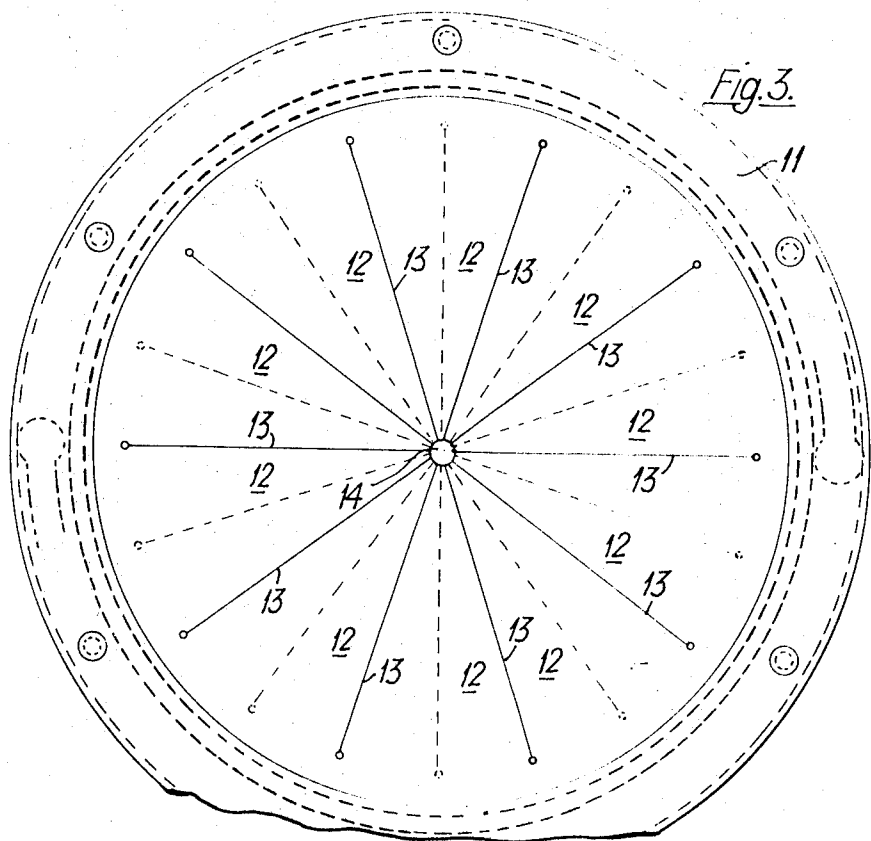
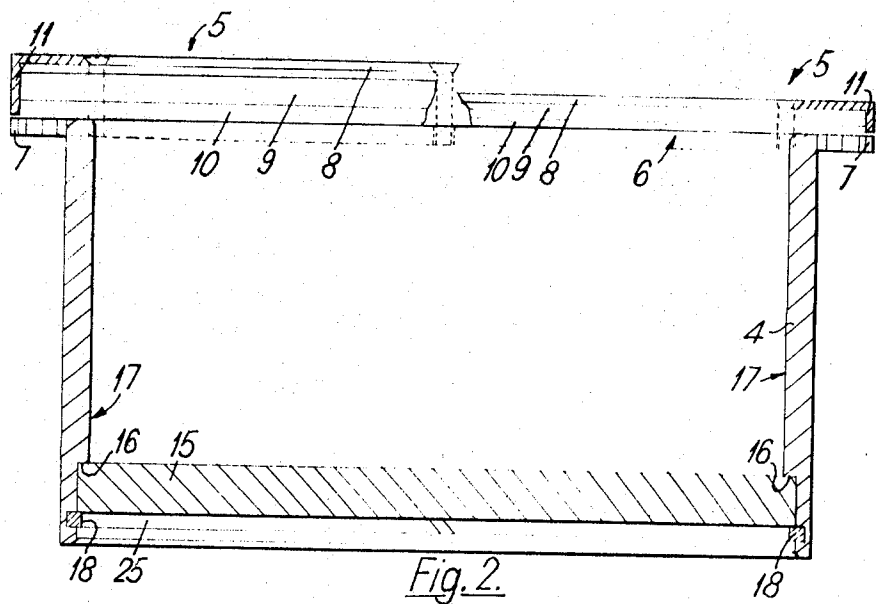


Fig. 1.

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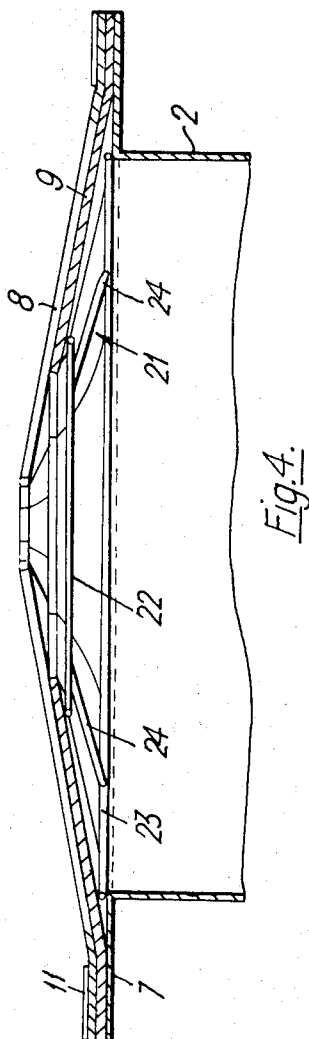
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VARIABLE-AREA NOZZLE

This invention relates to a variable-area nozzle, particularly to a variable-area nozzle for use with vent pipe arrangements.

It is the main object of the present invention to provide a variable-area nozzle arrangement enabling the safe discharge of inflammable gases at a satisfactory gas discharge velocity.

The object is satisfied by providing a variable-area nozzle comprising a plurality of flexible diaphragm devices arranged in side-by-side contiguous relationship and positionable in the line of fluid flow; each diaphragm including an annular series of leaves which are flexible to define a central aperture of variable area dependent upon the fluid flow through the nozzle; the pitching of the leaves of each diaphragm device being staggered relative to the pitching of the leaves of the next adjacent diaphragm device, and the flexibility of the leaves of each diaphragm device varying from that of the leaves of the next adjacent diaphragm device to damp any oscillations occurring in the diaphragm devices.

FIG. 1 shows a vertical vent pipe for a shipboard fluid storage tank and including a variable-area nozzle according to the present invention;

FIG. 2 shows a cross-sectional elevation of a cylindrical tube of the pipe of FIG. 1, and showing to the left of the centerline of the tube a variable-area nozzle according to one embodiment of the present invention and to the right a nozzle according to a second embodiment of the present invention;

FIG. 3 shows a plan view of the tube of FIG. 2; and

FIG. 4 shows a cross-sectional elevation of a variable-area nozzle according to a further embodiment of the present invention.

Referring to FIGS. 1 to 3, the oil cargo tanks 1 of an oil tanker each have a vertical vent pipe arrangement 2 extending from the side of the deck hatch 3 of the tank 1, for discharge of gases from the tanks 1 during charging of oil into the tank. Alternatively, a vent arrangement as described in the applicant's copending British Pat. application No. 32195/67 could be used.

The mouth of each vent pipe 2 serves as a socket for a tube 4 (see FIG. 2) and a variable area discharge nozzle 5 is incorporated at the mouth of each tube 4 to maintain a sufficient discharge velocity of the gases from the vent pipe 2. The mouth 6 of each tube 4 has an outwardly turned flange 7 and each nozzle 5 includes three side-by-side diaphragms 8, 9, 10 clamped to the flange 7 by means of a ring 11 bolted to the flange 7 and extending over the mouth 6 of the tube 4. The diaphragms 8, 9, and 10 are made from a flexible material which can resist any corrosive or other harmful effect of the discharged gas. Also, each of the diaphragms 8, 9, 10 are sufficiently stiff, whereby the diaphragms together can extend freely in the radial direction without drooping when no gas flow occurs in the vent pipe 2. In the embodiment of the present invention shown to the left of the centerline in FIG. 2, the diaphragms 8, 9 and 10 are made from neoprene and may have for example thicknesses of $\frac{1}{8}$ inch 7/16 inch and $\frac{1}{4}$ inch respectively. In the embodiment to the right of the centerline of FIG. 2, the diaphragms 8, 9, 10 are made from a urethane elastomer such as for example that sold under the name Polyvon, and have an equal thickness of for example, $\frac{1}{8}$ inch. However, it is arranged for this embodiment that the outer diaphragms 8, 10 have an equal shore hardness of say 95° but the central diaphragm 9 has a lower shore hardness of say 80°. Consequently the central diaphragm will have a natural resonance frequency different from that of the outer diaphragms, and consequently the arrangement provides for damping of oscillation of the nozzle, which oscillations may occur at certain rates of gas flow.

Each diaphragm 8, 9, 10 has a plurality, preferably 10 of radially inwardly projecting leaves 12; freely in the radial direction without drooping when no gas flow occurs in the vent pipe 2. In the embodiment of the present invention shown to the left of the centerline in FIG. 2, the diaphragms 8, 9, 10 are made from neoprene and may have for example thicknesses of $\frac{1}{8}$, 7/16 and $\frac{1}{4}$ inch respectively. In the embodiment to the right of the centerline of FIG. 2, the diaphragms 8,

9, 10 are made from a urethane elastomer such as for example that sold under the name Polyvon, and have an equal thickness of for example, $\frac{1}{8}$ inch. However, it is arranged for this embodiment that the outer diaphragms 8, 10 have an equal shore hardness of say 95° but the central diaphragm 9 has a lower shore hardness of say 80°. Consequently the central diaphragm will have a natural resonance frequency different from that of the outer diaphragms, and consequently the arrangement provides for damping of oscillation of the nozzle, which oscillations may occur at certain rates of gas flow.

Each diaphragm 8, 9, 10 has a plurality, preferably 10 of radially inwardly projecting leaves 12; and the diaphragm can be conveniently made by providing an appropriate number of equiangular diametral slits 13 on the material. The diaphragms are arranged such that the slits 13 of one diaphragm are positioned intermediate of the slits 13 of the next adjacent diaphragm. The slits 13 of the upper diaphragm 8 are thereby substantially covered and the lower diaphragms 9, 10 serve to ensure that the nozzle 5 is of a satisfactory form and also to mitigate against the occurrence of any vibrations in the upper diaphragm 8 during use. The diaphragms 8, 9, 10 are provided with a central aperture 4, and a closure lid 27 is provided for the mouth of the pipe 2 when oil charging has been completed.

The tube 4 additionally carries a flame screen 15 at its inner end. The flame screen 15 is held against a shoulder 16 on the inner wall 17 of the tube 4 by a circlip 25 located in an annular groove 18 of the wall 17, and the flame screen 15 is so located in the tube 4, that the leaves 12 can be bent downwardly in the tube 4 without fouling the flame screen 15. It is convenient, during unloading operations from the tanks 1, that the leaves 12 can be so bent downwards to permit free ingress of air to the tanks 1 via the vent pipes 2. The vent pipe 2 additionally carries a nozzle pipe 26 to cater for the expulsion or absorption of air by the tanks 1 due to expansion or contraction of the oil cargo on temperature variation within the tank, as will occur on passage of the ship from a tropical zone to a temperate zone or vice versa.

The variable-area discharge nozzle 5 operates as follows:

Each oil tank 1 is filled by the charging of oil therein through a suitable inlet (not shown) on the tank 1, the oil-charging rate at the initial stages of filling being at a maximum.

Simultaneous with the charging of the tank 1, the residual gases within the tank 1 are discharged by the inflowing oil through the vent pipe 2 to atmosphere at a volumetric rate equal to the volumetric rate of oil charging. The gas discharge, which will be at a maximum rate initially will cause the leaves 12 of the diaphragms 8, 9, 10 to fold upwards and the area of the throat of the nozzle 5 will be increased to a maximum size. The nozzle 5 will cause an increase in the gas discharge velocity.

When the filling of the tank 1 nears completion, the oil-charging rate will be required to be considerably reduced to minimize the risk of the inflammable oil overflowing from the tank 1 onto the deck 20; the gas discharge rate will consequently be reduced. With the reduction in the gas-discharging rate, the leaves 12 will fold downwards until a stage is reached when the leaves nearly return to their initial radial positions, and the throat of the nozzle 5 will consequently cause a marked increase in the gas discharge velocity relative to the velocity of the gas in the vent pipe 2, and the gases will be discharged to a sufficient height above the deck 20 to enable them to disperse clear of the deck 20 or superstructure (not shown).

Referring to the embodiment of the present invention shown in FIG. 4 the nozzle 5 in this case is comprised of only two contiguous diaphragms 8, 9 and a support 2 is provided for the diaphragms 8, 9 such that the leaves 12 of the diaphragms 8, 9 may be inclined upwardly even at low rates of gas flow. The support 2 is in the form of an open wire frame so that the gas flow through the nozzle is substantially unimpeded by the frame. The frame 2 includes a pair of concentric hoops

22, 23 a smaller diameter one 22 being arranged above the other larger diameter one 23 and supported therefrom by an annular series of struts 24. The larger diameter hoop 23 rests on the flange 7 of the tube 4 on the vent pipe 2 while the other small hoop 22 supports the leaves 12 diaphragms 8, 9 and serves to bias them in an upward direction. The wire of the frame 21 may be appropriately coated to minimize corrosion thereof by the discharging gas. It is arranged that, with now flow of gases in the vent pipe 2, the diaphragms 8, 9 occupy a closed position.

While the above described embodiments relate to a marine installation, it will be understood that the present invention is equally applicable to vent pipes or chimneys in land-based installations.

What I claim is:

1. A variable-area nozzle comprising a plurality of flexible diaphragm devices arranged in side-by-side contiguous relationship and positionable in the line of fluid flow; each diaphragm including an annular series of leaves which are flexible to define a central aperture of variable area dependent upon the fluid flow through the nozzle; the pitching of the leaves of each diaphragm device being staggered relative to the pitching of the leaves of the next adjacent diaphragm device, and the flexibility of the leaves of each diaphragm device varying from that of the leaves of the next adjacent diaphragm device to damp any oscillations occurring in the

diaphragm devices.

2. A nozzle as claimed in claim 1, characterized in that the leaves are flexible from a position in which the edges of adjacent leaves abut to a position in which the leaves are flexed apart to increase the aperture sizes, the extent of flexure being under the influence of the fluid flow through the nozzle.

3. A nozzle as claimed in claim 1, characterized in that three flexible diaphragm devices are provided, the leaves of the central diaphragm device being of a lower shore hardness than the leaves of the other diaphragm devices to provide for the variation in flexibility of the leaves.

4. A nozzle as claimed in claim 1, characterized in that the leaves of each diaphragm device are made of a urethan elastomer material.

5. A nozzle as claimed in claim 4, characterized in that the elastomer is a fluorocarbon.

6. A nozzle as claimed in claim 1, characterized in that the leaves of the diaphragm devices are made from neoprene.

7. A nozzle as claimed in claim 1, characterized in that a diaphragm support is provided below the diaphragm devices and arranged so as to incline the leaves to present a convergent surface to the fluid flow.

8. A nozzle as claimed in claim 1, characterized in that the tips of the leaves of at least one of the diaphragm devices defines an aperture.

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