June 30, 1964 S. KLINGMAN 3,139,108

PRESSURE OPERATED VALVE MEANS

Filed Sept. 24, 1962 2 Sheets-Sheet 1

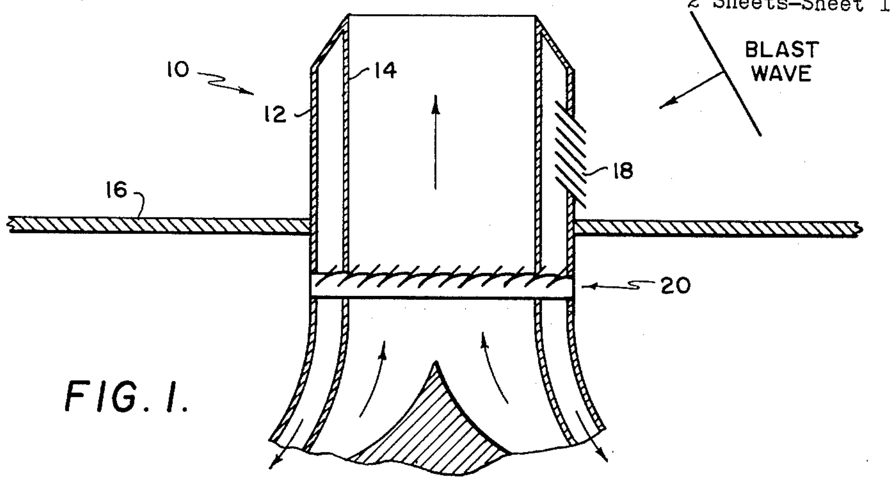

FIG. 1.

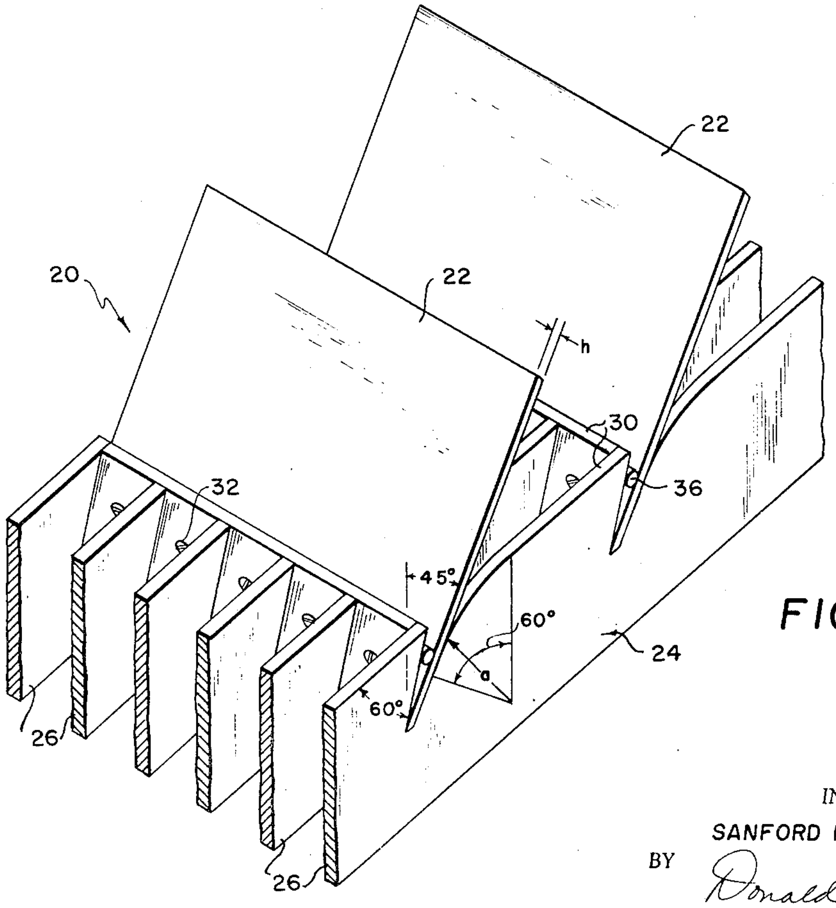

FIG. 2.

INVENTOR.
SANFORD KLINGMAN
BY Donald Kaul
AGENT.

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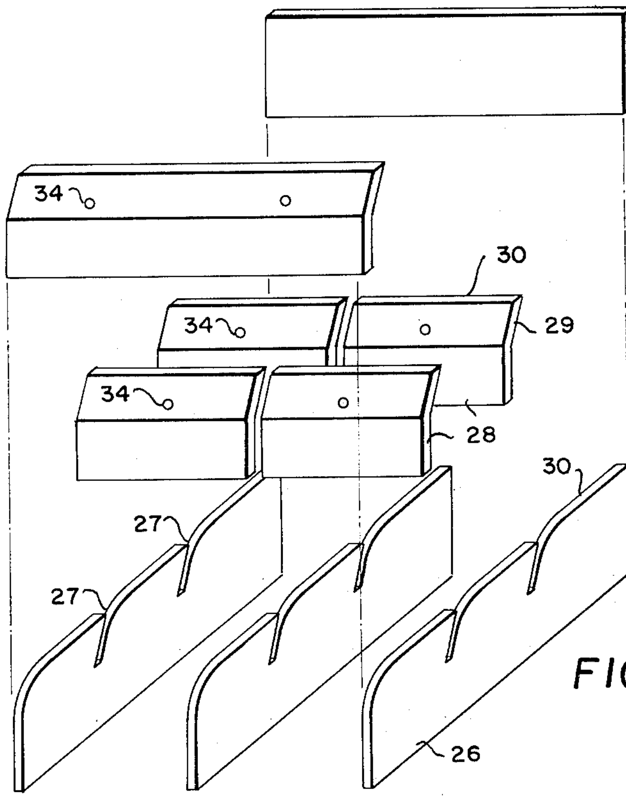

FIG. 3.

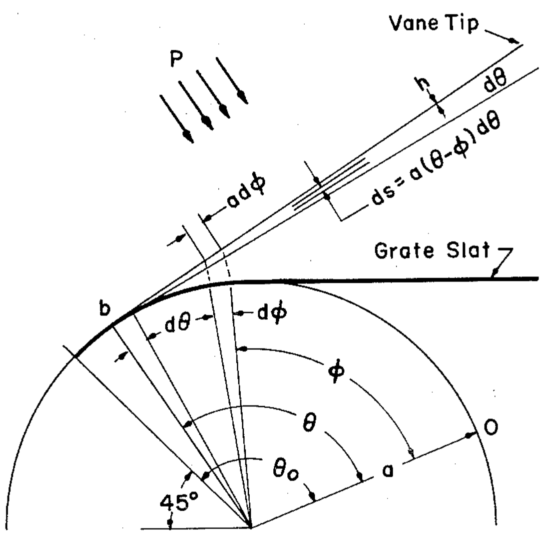

FIG. 4.

INVENTOR.
SANFORD KLINGMAN
BY Donald Kaul
AGENT.

United States Patent Office

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PRESSURE OPERATED VALVE MEANS

Sanford Klingman, Silver Spring, Md., assignor to the United States of America as represented by the Secretary of the Navy

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14 Claims. (Cl. 137—512.1)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to an external pressure operated valve means; and more particularly it relates to a shutter or flap type valve which is operable in response to pressure in the form of a blast or shock wave created by detonation of an explosive charge. Hence, such a valve can be termed an antiblast valve or a blast shutter.

When an explosive weapon, and particularly a nuclear weapon, is detonated above the ground in what is commonly termed an "air burst," the resulting blast wave may penetrate into the interior of a building or vehicle such as a ship and cause extensive damage to the structure therein, as well as causing injury to the personnel therein. On ships, blast penetration through ventilation openings can bulge or burst ducts and blow radioactive dust into compartments. Blast penetration of boiler systems can cause dishing and buckling of uptake structure, distortion of breeching, failure at end connections, blowing out of casings and damage to burners and firebrick. Such damage results in loss of propulition, as well as of all electric power supplied by steam generators and thereby constitutes a severe operational hazard since the ship which may otherwise retain its fighting ability, can neither complete its mission nor leave an area contaminated by radioactivity.

The problem of preventing blast penetration, especially in ship's boiler systems, is not a new one and many previous attempts have been made to build devices which will prevent such penetration. One form of these devices employs preformed cantilever springs to support louvers which are closed by the blast pressure. However, such springs must be made very thin and this presents manufacturing difficulties. Also, such springs are subject to rapid wear and deterioration due to their contact with corrosive agents in the flue-gas pathways. Other devices which have been developed contain a variety of shafts, bushings, bearings, lever arms, linkages, counterbalances, coil springs, hydraulic actuators, or other mechanical elements which are sensitive to corrosion or which are unnecessarily heavy or complex or otherwise objectionable.

Accordingly, it is an object of this invention to overcome the aforementioned shortcomings and to provide a valve means which prevents penetration of blast waves and which meets other requirements for marine or shipboard use.

Another object of the present invention is to provide a valve means which is suitable for use in corrosive and high temperature environments, which may be made to conform to openings of any size and shape, and which is adaptable to work through very wide range of pressures.

A further object of the present invention is to provide a protective valve means for a system, which closes very quickly in response to a pressure rise such as, for example, one caused by a blast wave, and which reopens quickly when the pressure wave subsides so as to restore the system to operative condition quickly. The valve means is especially useful in boiler air-supply systems.

Still another object of the present invention is to provide a valve means which is resistant to the high temperatures present in boiler stacks, which resists the clogging and corrosive action of soot and acids formed in the flue gases and which resists the corrosive action of saltwater spray.

Yet a further object of the present invention is to provide a valve means which is light in weight, which does not interfere with the normal service requirements of a ship, which can be easily and economically manufactured, which has a minimum amount of components, which requires a minimum of maintenance and which will be ready to operate reliably even after years of non-operation or "stand-by" in its associated environment.

Other objects, advantages and salient features of the present invention will become apparent from the following description, taken in connection with the accompanying drawings, which illustrate a preferred embodiment, in which:

FIG. 1 is a fragmentary diagrammatic transverse cross-sectional view of the valve means of the present invention located in a typical boiler system position;

FIG. 2 is a fragmentary perspective view of a valve means in accordance with the present invention;

FIG. 3 is a simplified exploded view of a portion of the grate which forms a part of the valve means of the present invention; and

FIG. 4 is a schematic diagram used for solving the equation of motion of the valve means of the present invention.

Briefly, the preferred embodiment of the present invention provides a valve strong enough to withstand the high pressures associated with a blast wave, a valve which will open or close quickly, and specifically in about 5 milliseconds (msec.), a valve resistant to high temperatures, and specifically up to 550° F., and a valve which will meet all the other requirements set forth above in the objects of this invention. To these specific ends, the valve means consists essentially of a stainless steel grate or framework formed of a plurality of intersecting longitudinal and transverse members which thus define a plurality of parallel rows of spaced openings or interstices. The grate is provided with a row of cut-out slot portions adjacent each row of interstices and a titanium vane mounted in each row of slot portions and extending angularly over the associated row of interstices at an angle of about 60 degrees. Vane stops then force the vanes to bend forward to an angle of about 45 degrees and remain in this position, thus forcing the vanes to bear partially against a curved portion of the grate adjacent each slot but without closing the slots. In this manner the vanes are pretensioned in normal open position and their tendency to rattle is reduced.

Upon arrival of a blast wave, the blast pressures force each vane to bend completely over the curved portion in the grate and then onto flat portions of the grate, adjacent the curved portions, thus closing the valve. After the blast pressure decays, potential energy stored in the elastically bent vanes forces them to spring back against the vane stops immediately, thus opening the valve and permitting normal air flow again.

Referring now to the drawings, FIG. 1 shows a preferred embodiment of the present invention on a marine vessel wherein the vessel's boiler system smokestack **10** having concentric outer and inner portions **12** and **14** respectively extends upward through the main deck **16**. An intake **18** in the outer portion **12** provides an air intake to the boilers between the concentric portions **12** and **14**. Exhaust fumes from the boilers escape through the interior of the inner stack portion **14**. A valve means **20** in accordance with the present invention is mounted within the stack **10** below the main deck **16** and extends completely across the intake and exhaust openings so that both will be closed when the pressures accompanying a blast wave operate the valve means **20**.

FIG. 2 shows the construction of the valve **20**. The movable valve member comprises a plurality of thin vanes, sheets, flaps or shutters **22** each having substantially parallel front and back planar surfaces and fabricated of a material which balances the requirements of fast closing and reopening times, corrosion and temperature resistance, high strength and elastic springback. Titanium has proved to be a satisfactory material since it satisfies the corrosion and temperature requirements and its light weight, less than two-thirds that of steel, contributes to fast operating times. The thickness and width of the vanes **22** and the bending radius cut in the grate must be balanced against the modulus of elasticity and yield strength of the vane material by a trial and error process. In a model which was built with a titanium vane such a trial and error process resulted in dimensions of (width) $\alpha=2\frac{1}{2}$ inches and (thickness) $h=\frac{1}{32}$ inch.

When a vane of thickness h and modulus of elasticity E is bent around a circular arc whose radius is α, the maximum bending stress σ is given by

$$\sigma=\frac{Eh}{2\alpha}$$

which for titanium is

$$\sigma=\frac{17\times10^6\times0.031}{2\times2.5}=106,000 \text{ p.s.i.}$$

It should be noted that this bending stress is less than 115,000 p.s.i., the yield strength of titanium. The low modulus of elasticity and high yield strength of titanium permit bending around the relatively small radius of 2.5 inches without permanent deformation so that 100% springback is obtained.

The yield strength of titanium decreases somewhat with increasing temperature but so does the modulus of elasticity so that the ratio E/σ, on which springback and permanent deformation depend, is not adversely affected by the hot stack gases.

The above formula for maximum bending stress shown that less stress results from a larger radius. However, fast closing times require a smaller radius. Also, the formula shows less stress and faster closing both result from a smaller thickness. However, vane thickness much below $\frac{1}{32}$ inch are insufficient to withstand blast pressures unless supported by a thicker grate which tends to cut down normal air flow. In addition, a high bending stress is desirable for good springback and fast reopening. In a model of the valve which was constructed with $\alpha=2.5$ inches and $h=0.031$ inch, the width of the vane **22** was $6\frac{1}{8}$ inches, and this was accounted for by the following design considerations:

	Inches
For attachment in the grate slots at 60°	0.50
For pretensioning from 60° to 45°	0.665
For bending about curve in grate	1.96
For closing flat part of grate	3.00
Total width	6.125

Obviously, the length of the vane **22** can be varied without affecting the closing time of the valve.

A grate **24**, as can be best seen from FIGS. 2 and 3, consists of slats **26** and crosspieces **28** which are assembled together by welding or other uitable fastening means and which form rows of spaces or interstices therebetween. Since titanium cannot be readily welded to steel as would be necessary in installation of the grate on a ship, other material should be used for fabrication of the grate. Type 316 stainless steel has proved satisfactory for use in boiler system smokestacks.

Each slat **26** is provided with at least one cut-out portion in the form of a slot **27**, the rear of which is sloped backward to form an angle of 60 degrees with the flat top surface of the slat and the front of which is a radial curve extending downward from the flat top surface for 60 degrees. Each crosspiece **28** is formed with its upper portion **29** sloping forwardly at an angle of 30 degrees with respect to the plane of its lower portion so that the upper portion **29** conforms angularly to the rear of the slot **27**. Each crosspiece upper portion has a flat top surface substantially coplanar with top surfaces of the slats **26**. The flat top surfaces of the slats **26** and crosspieces **28** are indicated as **30**.

The exact method of fabricating the grate **24** is not critical and it can be made as shown in FIG. 2, with solid crosspieces **28** extending between the outer slats **26**, or as shown in FIG. 3 with individual crosspieces **28** between each pair of slats **26**, or by interlocking the slats **26** and crosspieces **28** together in any other suitable manner.

Design of the grate **24** is governed by dimensions of the vanes **22**. On the basis of strength of the $\frac{1}{32}$ inch thick titanium vanes **22**, center spacing between the slats **24** should be approximately $1\frac{1}{2}$ inches. If a unit width of vane as it rests on the slats of the grate is considered to be a continuous beam equal spans with each span equally and uniformly loaded, maximum applied moment is approximated by the formula:

$M=0.1w\,(1.5)^2=0.23w$ inch-pounds where w is a static load per inch of length. Section modulus of the unit width strip is: $S=\frac{1}{6}h^2=\frac{1}{6}\,(\frac{1}{32})^2=0.000163$ cu. in. The maximum stress in the vane is then

$$\sigma=\frac{M}{S}=\frac{0.23w}{0.000163}=1400w \text{ p.s.i.}$$

In order for the stress σ to reach a yield stress of 115,000 p.s.i., the yield strength of titanium, w must reach about 80 lb./in. Since the strip is of unit width, the strip can statically withstand 80 p.s.i. without exceeding yield.

The flat top surfaces **30** of the slats **26** and crosspieces **28** act as seats for the vanes **22**. The area of these seats is determined by the thickness of the grate members **26** and **28**. The members **26** and **28** must be thick enough to withstand the stress which is caused by seating of the vanes **22**, but must not be too thick or else they will reduce normal service air flow. It was found experimentally in a valve which was made in accordance with the present invention that the thickness had to be $\frac{1}{16}$ inch or more to provide sufficient strength and corrosion resistance and had to be $\frac{1}{8}$ inch or less in order to minimize reduction of normal service air flow, so the proper range of thickness for the slats **26** and crosspieces **28** is between $\frac{1}{16}$ and $\frac{1}{8}$ inch. Depth of the slat and crosspiece members in the valve which was built was $3\frac{1}{2}$ inches.

The vanes **22** are attached to the grate **24** by suitable fastening means **32** which connect each vane to its associated crosspieces **28**. Apertures **34** are provided in each crosspiece, usually midway between each two slats **26**, for reception of the fastening means **32**. Bolts, rivets and other similar fasteners have proved satisfactory as fastening means **32**, however, for best results the fastening means **32** should be fabricated of the same material as the grate or the vanes.

A vane stop and stressing means **36** is interposed between the rear of each vane **22** and the grate **24** for the purpose of pretensioning the vanes **22**. The stop **36** can be a separate bar member or it can be formed as an integral, forwardly extending portion of the upper portion **29** of crosspieces **28**.

Referring now to FIG. 4 which shows a schematic diagram for the equation of motion of the vane **22**, it is assumed as an approximation in estimating the closing time of the valve, that a constant pressure difference equal to that between the incident and reflected pressure acts normal to and uniformly over the surface of the vane. It is also assumed that, during closure, the path of any point in the vane is an involute of the circle whose perimeter describes the curved portion of the cut-out portion **27** of the grate **24**.

The symbols in FIG. 4 represent the following:

α=the radius of the circle in inches,

b=the instantaneous point of contact between the vane and the grate,

O=the point where the vane tip would strike if the full length of the vane were wound on the circle,

θ=the angle between b and O in radians,

ϕ=a dummy variable of integration ranging over θ in radians,

P=the pressure acting on the vane in pounds per square inch,

h=the vane thickness in inches,

l=the length of the vane perpendicular to the plane of FIG. 4 in inches,

$\alpha\theta$=the width of the unclosed portion of the vane in inches, and

ρ=the mass density of the vane in lb.-sec.^{2}/in.^{4}.

At time $t=O$, $\theta_0=\theta_0$ and $=0$. At time $t=t_1$

$$(\theta_0-\theta)=\tfrac{1}{4}\pi$$

It is desired to find t_1.

One degree of freedom is assumed, and the La Grange equation is

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{\theta}}\right)-\frac{\partial T}{\partial \theta}=Q \qquad (1)$$

The terms on the left-hand side of Equation 1 are found as follows. The velocity of the elementary strip of vane having width $\alpha d\phi$ and mass $\rho h l\alpha(d\phi)$ is

$$ds/dt=\alpha(\theta-\phi)d\theta/dt$$

and its kinetic energy therefore is

$$dT=\tfrac{1}{2}(\rho hl\alpha d\phi)[\alpha(\theta-\phi)\dot{\theta}]^2 \qquad (2)$$

Summing for all such strips over the unclosed portion of the vane,

$$T=\tfrac{1}{2}\rho hl\alpha^3\dot{\theta}^2\int_{\phi=0}^{\theta}(\theta-\phi)^2d\phi=\tfrac{1}{6}\rho hl\alpha^3\dot{\theta}^2\theta^3 \qquad (3)$$

Then

$$\frac{\partial T}{\partial \theta}=\tfrac{1}{2}\rho hl\alpha^3\dot{\theta}^2\theta^2 \qquad (4)$$

and

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{\theta}}\right)=\tfrac{1}{3}\rho hl\alpha^3\ddot{\theta}\theta^3+\rho hl\alpha^3\dot{\theta}^2\theta^2 \qquad (5)$$

The term on the righ-hand side of Equation 1 consists of an applied moment and a resisting moment. The applied moment is found first. The increment of work done by P on the elementary strip having area $l\alpha d\phi$ is dW_1=—Force$\times ds$=—$(Pl\alpha d\phi)[\alpha(\theta-\phi)d\theta]$ so that the applied moment is

$$\delta Q=\delta\left(\frac{dW_1}{d\theta}\right)=-Pl\alpha^2(\theta-\phi)d\phi \qquad (6)$$

For all such strips over the unclosed portion of the vane.

$$Q_{\text{applied}}=\int_{\phi=0}^{\theta}\delta\left(\frac{dW_1}{d\theta}\right)=-Pl\alpha^2\int_{\phi=0}^{\theta}(\theta-\phi)d\phi=\tfrac{1}{2}Pl\alpha^2\theta^2 \qquad (7)$$

The sense of the applied moment is negative, since its action is such as to decrease θ.

The resisting moment is found next. The work done in closing an infinitesimal element of vane, that is, in bending the vane to the curvature of the circle so that the point of tangency moves a distance $\alpha d\theta$ is

$$bW_2=\tfrac{1}{2}(EI/\alpha^2)\alpha d\theta=(EI/2\alpha)d\theta$$

where EI represents the flexural rigidity of the vane. The preceding expression represents the potential energy stored in the bent element when the elastic limit of the material is not exceeded. The $dW_2/d\theta=EI/2\alpha$ represents the constant resisting moment. Its sense is opposite to that of the applied moment. Since, for the vane consider

$$I=lh^3/12$$

the resisting moment becomes

$$Q_{\text{resisting}}=\frac{dW_2}{d\theta}=\frac{Elh^3}{24\alpha} \qquad (8)$$

where E is Young's modulus for the vane material.

Substitution from (8) (7) (5) and (4) into (1) gives

$$\ddot{\theta}\theta^3+\frac{3}{2}\dot{\theta}^2\theta^2+\frac{3}{2}\frac{P\theta^2}{\rho h\alpha}-\frac{Eh^2}{8\rho\alpha^4}=0 \qquad (9)$$

as the equation of motion.

For the titanium vane

$p=5\times10^{-4}$ lb.-sec.^{2}/in.^{4}

$E=17\times10^6$ p.s.i.

$h=\tfrac{1}{32}$ in.

$\alpha=2\tfrac{1}{2}$ in.

The equation of motion then becomes, in a form convenient for numerical integration,

$$\ddot{\theta}=10^4\left(\frac{10.6}{\theta^3}-\frac{19.2+0.00003P\dot{\theta}^2}{\theta}\right) \qquad (10)$$

The limits of integration are taken as follows. When the vane is at its initial angle of 45 deg. with the plane of the grate, the distance from the vane tip to point b is 4.96 in. Then $\alpha\theta_0$=4.96 or θ_0=1.98 radians. Since the vane is considered closed when θ has decreased by ¼ radians, the limits of integration are from θ=1.98 down to θ=1.2. The equation of motion is inapplicable for θ less than 1.2 in the case of the present valve.

A test was run to see if the values from numerical integration of Equation 10, the equation of motion of the valve, corresponded accurately to the test results. It was found that the equation of motion satisfactorily approximated the actual test results.

Under static conditions when $\ddot{\theta}$ and $\dot{\theta}$=0, the equation of motion (9) beomes

$$\tfrac{1}{2}P(\alpha\theta)^2=\frac{Eh^3}{(24\alpha)}$$

The pressure P required to separate the vane **22** from its vane stop **36** while the valve is open may be estimated from Equation 11 since when the vane is open, the distance $\alpha\theta$ from point b in FIG. 4 to the tip of the vane is 4.96 inches. With values of E, h and α as previously listed, substitution into (11) gives P=0.7 p.s.i. for the pressure required to separate the vane **22** from its stop **36**. This pressure is approximately the velocity pressure associated with 160 m.p.h. winds. By comparison, hurricane winds are about 70 m.p.h. with an associated velocity pressure of about 0.1 p.s.i. Thus it can be seen that the present valve will not vibrate, flutter or chatter or close even in winds of hurricane velocity.

It can thus be seen that the present invention provides an extremely simple, but yet positively reliable antiblast valve. Although the invention has been described above as installed on a ship, it should be understood that it is equally useful in homes, buildings and the like where conditions aren't as severe as on board a ship. Also, although certain dimensions and materials have been herein described and illustrated in order to explain the nature of the invention and to define a workable model thereof, various changes may be made in such dimensions and materials by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. A quick closing valve means adapted to be mounted within an opening to normally permit flow therethrough but operable in response to an applied pressure to close very quickly and thereby terminate flow through said opening, said valve means comprising:

the combination of a grate-like framework and resilient flap type valve means;

said framework including a plurality of spaced parallel slat members and a plurality of spaced parallel crosspieces extending substantially perpendicularly to said slot members, said slot members and crosspieces thus defining a plurality of discrete interstices therebetween, said interstices being arranged in a row between each successive line of crosspieces;

said slat members each including a flat top surface adapted to serve as a valve seat and at least one cut-out portion extending downward from said top surface;

said cut-out portion including a rear surface extending angularly downward from said top surface at an acute angle and a forward curved surface defined by a circular arc which extends downward from said top surface for approximately the same acute angle as said rear portion;

said crosspieces including a lower portion substantially perpendicular to said slat member top surfaces and an upper portion at the same acute angle as, and thus conforming to, said cut-out rear surface;

said crosspiece upper portions including top surfaces coplanar with said slat member top surfaces;

said resilient flap type valve means including a relatively thin resilient vane having substantially parallel front and back planar surfaces and adapted to elastically move in response to an applied pressure on its back surface;

said resilient vane being mounted within said cut-out portions in said slat members with its back surface adjacent said cut-out rear portions and said crosspiece upper portions, and its front surface extending angularly over, but not normally closing, a row of said interstices;

said resilient vane having sufficient width so that when a pressure is applied to its surface, said vane will bend forwardly around said cut-out curved surfaces and seat tightly upon said slat member top surfaces with the end of said resilient vane seating tightly upon the top surfaces of the next adjacent row of crosspieces, thereby completely closing off the row of interstices beneath said vane front surface and preventing flow through them.

2. A valve means as defined in claim 1 wherein said framework is fabricated of stainless steel.

3. A valve means as defined in claim 1 wherein said resilient flap type valve means is fabricated of titanium.

4. A valve means as defined in claim 1 wherein a vane stop is interposed between said resilient vane back surface and said cut-out rear surfaces and crosspiece upper portions to thereby pretension said resilient vane by bending it forward toward its closed position.

5. A valve means as defined in claim 4 wherein said resilient vane forward bend is small enough in amplitude to render said resilient vane front surface out of contact with said cut-out curved surfaces.

6. As an article of manufacture, a flow controlling device for an opening comprising:

a plurality of spaced parallel slat members extending transversely across said opening;

a plurality of spaced parallel crosspieces positioned perpendicularly across said slat members in spaced linear relationship and extending transversely across said opening;

said slat members and crosspieces thereby defining a grate having linear rows of interstices formed between each successive line of crosspieces, said interstices permitting flow through said opening;

said slat members including lines of slots formed immediately forward of each line of crosspieces;

a plurality of resilient flat valve members each having one end fixed within a line of slots and its other end free to extend above the linear row of interstices immediately adjacent thereto;

said slots and said crosspieces sloping angularly away from each row of interstices at the same angle and

said valve members extending angularly over said rows of interstices; and

said valve members being operable in response to sufficient pressure to resiliently bend so their free ends move into contact with said grate thus closing off said interstices thereby terminating flow through said opening.

7. Pressure responsive valve means adapted to be mounted within an opening to normally permit flow therethrough but operable in response to an applied pressure to close thereby terminating flow through said opening, said valve means comprising:

a grate-like framework defining a plurality of discrete interstices therein;

said framework including a flat top surface surrounding each of said interstices and a cut-out portion extending downward from said top surface at each of said interstices;

resilient flap type valve means fixedly mounted at one end of each in said cut-out portions;

said cut-out portion including a rear surface extending downwardly from said top surface at an acute angle thereto and a forward curved surface extending in a smooth curve from said flat top surface to a point substantially tangential to said rear portion;

whereby as pressure is applied to said flap type valve the valve bends over said forward curved surface and at least a portion of said flap top surface.

8. Pressure responsive valve means as defined in claim 7 wherein:

said flap type valve means is a sheet of titanium; and

said forward curved surface is a circular arc.

9. Pressure responsive valve means for closing an opening upon application of pressure, comprising:

a framework surrounding said opening;

said framework including a flat top surface and a cut-out portion extending downwardly from said top surface at one edge of said opening;

a resilient flap fixedly mounted at one end in said cut-out portion;

said cut-out portion including a rear surface extending downwardly from said top surface at an acute angle thereto and a forward curved surface extending in a smooth curve from said flat top surface to a point substantially tangential to said rear portion;

whereby as pressure is applied to said flap the flap bends over said forward curved surface and at least a portion of said flat top surface.

10. Pressure responsive valve means as defined in claim 9 wherein:

said flap is a sheet of titanium; and

said forward curved surface is a circular arc.

11. A pressure responsive valve means comprising:

a frame work including intersecting cross members which thereby define interstices therebetween;

a slot in said framework extending at an acute angle with respect to the tops of said cross members;

at least one resilient valve member rigidly affixed to said framework within said slot and extending angularly over said interstices in spaced relationship to thereby permit flow through said interstices; and

a combination vane stop and pretensioning member is interposed in said slot between said framework and said resilient valve member;

said resilient valve member being operable in response to applied pressure to elastically bend into contact with said cross members and seat thereon, thereby closing off said interstices and thus terminating flow therethrough.

12. A valve means comprising:

a valve member mounting grate formed of a series of intersecting slats and crosspieces;

said slats including several rows of spaced parallel members each having cut-out slot portions at spaced intervals along the length thereof, the slots in each member being transaxially aligned with the slots in the parallel members to form lines of slots extending across said grate;

said crosspieces each being mounted between two slats adjacent one edge of the cut-out portions therein and thus defining lines of crosspieces extending across the grate;

each pair of crosspieces and its connected slats thus defining a rectangular flow passage therebetween and thus each two lines of crosspieces defining a row of flow passages across said grate; and

a resilient flat sheet-type valve member fixedly mounted on said crosspieces at one end within each line of slots and having the dimension between its side edges substantially equal to the distance between the outermost pair of slat members to thus extend completely along a row of flow passages, and having the dimension between its fixed and free end of sufficient dimension so that when said valve member is closed, its free end will seat upon the line of crosspieces ahead of the valve member mounting slot line and thus will effectively close the entire row of flow passages beneath the closed valve member;

said slots have a rear edge extending from the upper surface of said slats at an acute angle and a front edge in the form of a circular arc extending from the upper surface of said slats at substantially the same acute angle as the rear edge.

13. A valve means as defined in claim 12 wherein said crosspieces are adjacent the rear edge of said slots and have at least the upper portion thereof sloped at the same acute angle as the rear surface of said slots.

14. A valve means comprising:

a valve member mounting grate formed of a series of intersecting slats and crosspieces;

said slats including several rows of spaced parallel members each having cut-out slot portions at spaced

intervals along the length thereof, the slots in each member being transaxially aligned with the slots in the parallel members to form lines of slots extending across said grate;

said crosspieces each beign mounted between two slats adjacent one edge of the cut-out portions therein and thus defining lines of crosspieces extending across the grate;

each pair of crosspieces and its connected slats thus defining a rectangular flow passage therebetween and thus each two lines of crosspieces defining a row of flow passages across said grate;

a resilient flat sheet-type valve member fixedly mounted on said crosspieces at one end within each line of solts and having the dimension between its side edges substantially equal to the distance between the outermost pair of slat members to thus extend completely along a row of flow passages, and having the dimension between its fixed and free end of sufficient dimension so that when said valve member is closed, its free end will seat upon the line of crosspieces ahead of the valve member mounting slot line and thus will effectively close the entire row of flow passages beneath the closed valve member; and

a combination vane stop and pretenisoning member is interposed between each line of crosspieces and its associated valve member.

References Cited in the file of this patent

UNITED STATES PATENTS

680,245	Gutermuth	Aug. 13, 1901
1,029,726	Sprado	June 18, 1912
1,280,063	Miller	Sept. 24, 1918
3,059,565	Mears	Oct. 23, 1962

FOREIGN PATENTS

103,613	Sweden	Jan. 27, 1942