Jan. 2, 1962 C. D. PRICE 3,015,342

BLAST CLOSURE

Filed Sept. 24, 1959 3 Sheets-Sheet 1

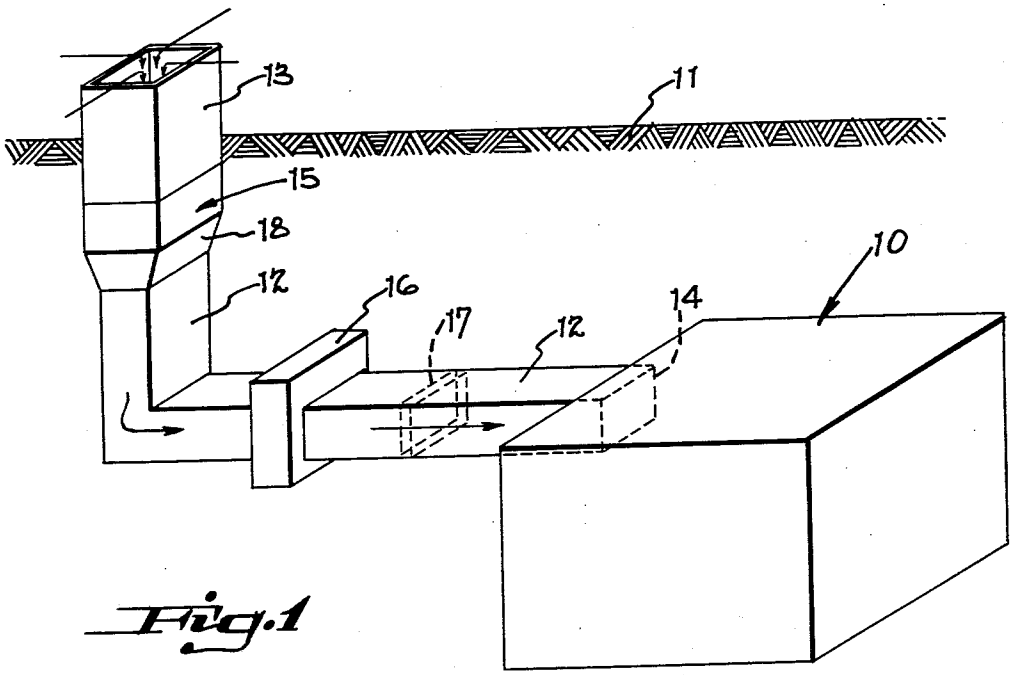


Fig. 1

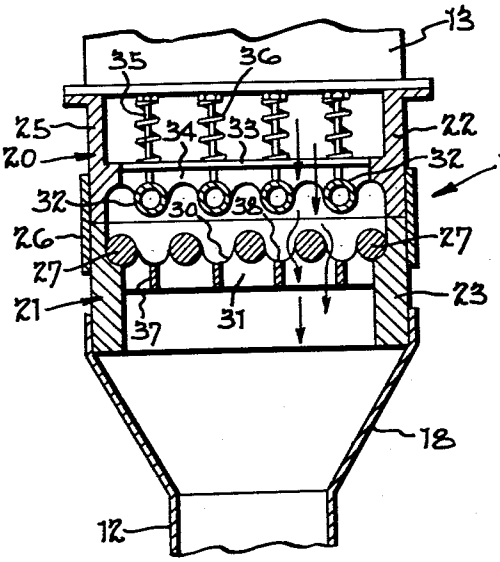


Fig. 3

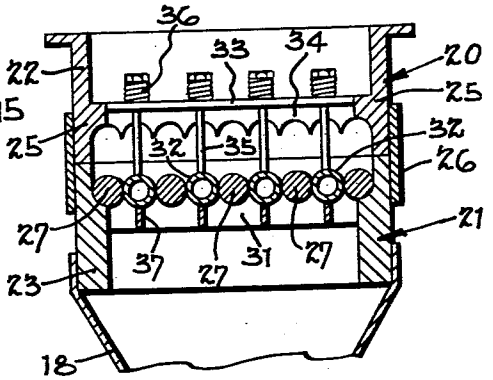


Fig. 4

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BLAST CLOSURE

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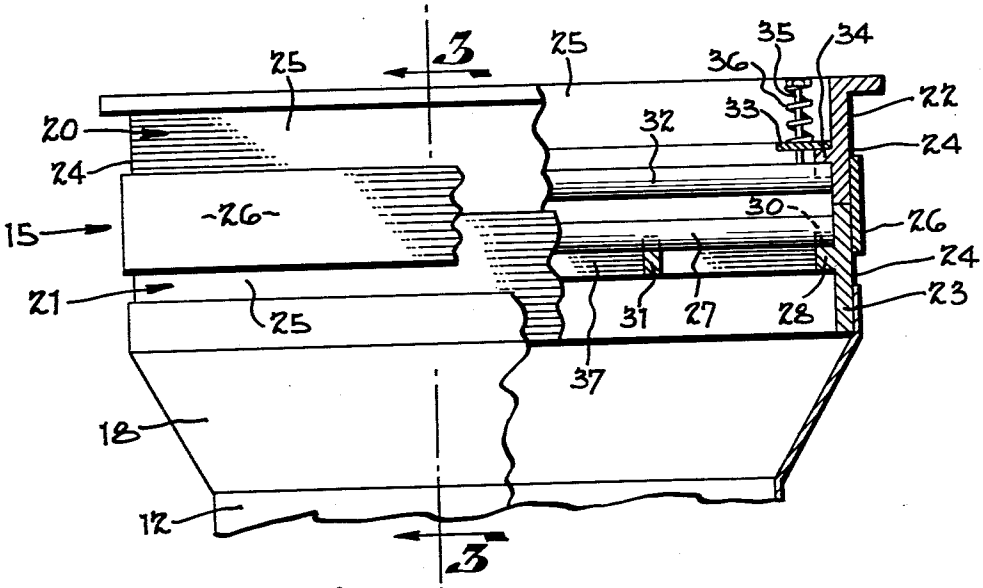


Fig. 2

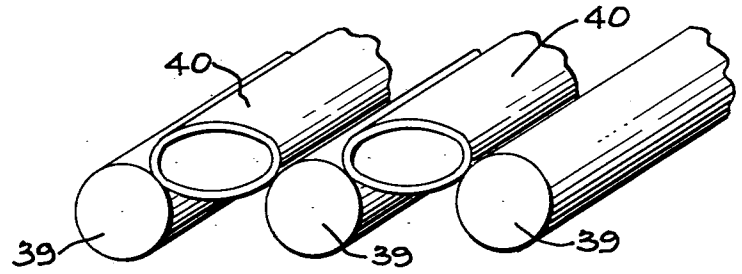


Fig. 5

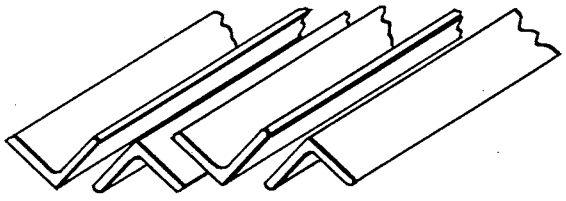


Fig. 6

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BLAST CLOSURE

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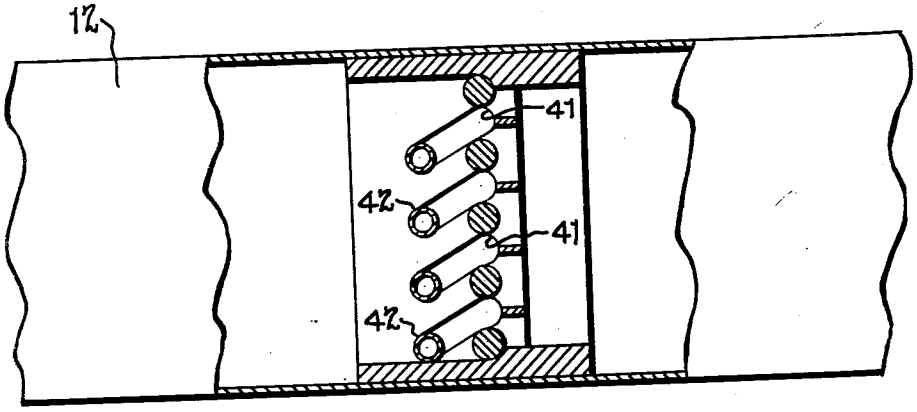


Fig. 7

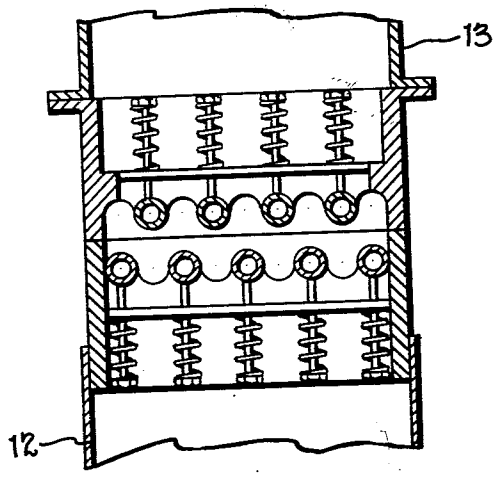


Fig. 8

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3,015,342

BLAST CLOSURE

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8 Claims. (Cl. 137—512.1)

This invention is concerned with blast closures, which are devices for closing ventilation air ducts to high pressure waves such as occur in explosions or atomic blasts.

The potential hazards of modern warfare have required the development of shelters capable of withstanding the effects of atomic blasts. Such shelters are usually located underground so as to minimize the effects of radiation.

Because it may be necessary that such a shelter be occupied for an extended period of time, for example, until the intensity of radiation on the outside reaches a tolerable level, means must be provided, among other things, for the admission of a supply of fresh and uncontaminated air into the shelter. It is contemplated that outside air is suitable for this purpose, provided that it is highly filtered to remove all traces of foreign matter, such as dust which may be radioactive. Filters have been developed for this purpose which display excellent filtration characteristics. However, filters of this type are inevitably very delicate and subject to injury.

To draw outside air into the shelter and, if necessary, to exhaust inside air, one or more air shafts may communicate between the shelter and the outside atmosphere. Such shafts may be used in conjunction with fans to circulate the air at an increased rate. A filter of the type described is preferably mounted in the intake duct to remove radioactive particles from the air passing through it.

In an atomic blast or, for that matter, any explosion of great magnitude, a shock wave is produced which is of severe intensity. A wave of this type travels at the speed of sound and, measured across it, the pressure may arise from normal atmospheric pressure to as much as 100 p.s.i.; due to the velocity at which the wave travels, the pressure on an object in the path of the oncoming wave may change this much in a few thousandths of a second. The effects of a shock wave at such pressure both on humans and mechanical devices are, of course, extremely severe.

The air shaft communicating from the outside atmosphere to the inside of a bomb shelter acts as a conduit for shock waves. Although some pressure drop will, of course, occur as the wave passes along the shaft, still when it enters the shelter it possesses sufficient energy to exert deadly force on the occupants. In addition, it is also strong enough to wreck or damage the air filter, so that even though the shock wave does not reach the inside of the shelter, the occupants therein are nonetheless exposed to atomic radiation.

Frequently, although not always, following the shock wave and period of high pressure, ensues a period of near-vacuum conditions. This sub-normal pressure is damaging in its own respect.

To protect the occupants of the shelter from exposure to these extremes of pressure, this invention provides a blast valve or closure for installaiton in the air shaft which demonstrates the capability of automatically sealing the duct to both high and low pressure phases of a blast, yet which is ordinarily open to permit air at normal pressure to move in the duct.

The blast closure of this invention is at once simple and effective. It has high reliability in that it may remain inactive without actuation for years, but will close nearly instantly when a sharp change in pressure occurs. Furthermore, the closure seals the shelter to external conditions of either high or low pressure. Thus, it prevents high pressure air from entering the shelter and, after the termination of the high pressure phase of the blast, retains the air at atmospheric pressure within the shelter during the period of below-normal outside pressure. At the termination of the period of blast—disturbed air pressure, the valve automatically re-opens the air shaft and permits the ventilating system to operate in the normal manner.

A significant feature of the closure is its instant readiness. It needs no actuation by other means, but rather is closed by the pressure gradient itself. Likewise it automatically restores itself to an open condition. It will close, open and reclose rapidly should conditions so require. While of great effectiveness in insulating downstream locations from blast conditions, it is simple and inexpensive to manufacture and thus is readily adapted to production for mass markets should the need ever arise.

Briefly put, the blast closure of this invention comprises spaced sets of parallel rods. When open, that is, under normal conditions, the sets of rods are spaced longitudinally from one another in the air shaft, so that moderate air flow between the rods of each set is permitted. As a shock wave impinges, the rods of the upstream set are urged by the blast into new positions in which they are intermediate the rods of the downstream set, so that virtually a solid barrier is imposed to the shock wave in the form of a series of rods in side-by-side relationship with one another. During the period in which there are excessive pressures on the upstream side of the closure with respect to the pressure inside the shelter, the two sets of rods are held in this interspaced relationship by the positive external pressure. The closure is extremely quick acting, so that it closes rapidly as the shock wave impinges on it, and thus the damaging effects of the wave are borne by the closure, thereby maintaining a relatively constant pressure downstream.

At the end of the period of high pressure, the external and internal pressure on the closures become more nearly equal. At this time, the normally upstream set of rods is returned to its starting position, in which it is spaced from the downstream set, being moved by springs or like biasing means. The air passageway is now again open to permit a moderate flow of air in the shaft to the shelter which moves around and between individually spaced rods.

To function in the manner described, i.e., to close upon actuation by high external pressures, it is only necessary that the outermost, or upstream, set of rods be movable toward the inner, or downstream, set of rods; that is, the latter set may be fixed in the shaft. To adapt the closure for actuation of both positive and negative external pressures, it is only additionally required that the downstream set of rods be translationally movable toward the rods of the upstream set. Upon the occurrence of negative outside pressures, the air inside the chamber tends to rush outwardly, creating a reverse flow in the air shaft. As this rush of air impinges on the inner set of rods, it urges them toward the now stationary outer set of rods, so that a barrier similar to that already described is again presented, and air is retained inside the shelter at normal pressure.

The details of the invention and its further advantages are best described in relation to the accompanying drawings, in which:

FIGURE 1 is a perspective diagrammatic view of an underground bomb shelter having an air duct communicating from the ground surface to the shelter;

FIGURE 2 is a side view, partly broken away, of a

preferred embodiment of the blast closure of this invention;

FIGURE 3 is a cross-sectional view, taken on line 3—3 of FIGURE 2, showing the valve in its normal, or open, attitude;

FIGURE 4 is a cross-section similar to FIGURE 3, but showing the valve in its closed position;

FIGURE 5 shows in diagrammatic perspective an alternative configuration of the closure in which the movable members are elliptical;

FIGURE 6 shows in diagrammatic perspective another alternative embodiment of the closure in which the movable members constitute angle irons;

FIGURE 7 is a cross-sectional view showing an alternative method of biasing the closure members; and

FIGURE 8 is a cross-sectional view showing an embodiment in which the valve is responsive to blasts in either direction.

In FIGURE 1, an underground blast-proof shelter is generally indicated at **10**. This shelted is of conventional design and of itself forms no part of the present invention. Although in the drawings the shelter is indicated as being beneath the surface of the ground **11**, the principles of this invention are equally applicable whatever the location of the shelter.

To provide for the circulation of outside air through the shelter, an air duct **12** is employed, extending from an air intake generally indicated at **13** above the ground to an opening into the shelter at **14**. The air intake may be provided with a hood or other protective device if desired. To permit the withdrawal of stale air from the shelter, a second air duct leading to the outside atmosphere may also be employed. Such additional ducts may also be fitted with the blast closure of this invention, but inasmuch as they are generally similar to duct **12**, additional air ducts are not shown in the drawings.

In duct **12**, the blast closure of this invention is generally indicated at **15**. A blower to increase the rate of air flow in the duct, the inclusion of which is optional, is indicated at **16**. A filter **17** is disposed in the duct to remove dust and other bits of solid matter from the air moving into the shelter. As has been pointed out, this filter is relatively delicate of construction and would be injured so as to function improperly should air pressures of blast magnitude impinge upon it. To this end, it is important that the blast closure be mounted in the air duct at a location which is upstream, that is, in the direction of the blast, of the filter so that the air shaft is closed ahead of the filter upon the incidence of ultra high velocity air.

Where the duct is of a size or section different than that of the closure, a transition piece **18** may be used to connect the duct to the closure. In this regard, it should be noted that while a rectangular duct is shown in the drawings, the shape of the duct is not important insofar as this invention is concerned, nor is the shape of the transition piece, should one be employed at all.

A preferred embodiment of the blast closure is illustrated in detail in FIGURES 2, 3 and 4. The closure comprises two cooperating halves, an upstream half **20** and a downstream half **21**. In practice, both "halves" are physically united. The reference herein to them as separate portions of the closure is only for descriptive purposes. Each half of the closure comprises a generally rectangular hollow frame, as indicated at **22** and **23** respectively, each of which is preferably fabricated from steel so as to be capable of withstanding the loads imposed during a blast. The frames **22** and **23** comprise end walls **24** and side walls **25**. The two frames are fastened together by connecting plates **26**. The upstream frame **22** mounts movable members which, upon actuation by high velocity air, move downstream to coact with stationary members presented in the downstream frame **23** to effect a closure of the valve.

A series of parallel members spaced apart from one another is secured across the interior of the downstream frame **23**. In the preferred embodiment shown, these spaced members comprise solid metal bars or rods **27**, circular in section, which are spaced from one another by an amount equal to their own diameter. These rods **27** are mounted at each end on inwardly extending brackets **28**, presented by the end walls **24** of the frame, which brackets are configurated with a series of half circular recesses **30**. The rods **27** are received in alternate recesses in the manner shown in FIGURE 3. The significance of the cutouts **30** in the brackets between adjacent rods will become apparent. It is preferable that the rods **27** be mounted to these brackets by means of screws (not shown). Additional transverse supports **31** for the rods **27** are configurated similary to the brackets **28** and are stationed at intermediate points in the frame as indicated in FIGURE 2. The spacing of the intermediate supports **31** will depend upon the length of the rods and their relative rigidity; relatively short, rigid rods will require no intermediate support, whereas, support is desirable for long rods of relatively small diameter.

The upstream frame **22** carries movable closure members **32**, which, in the preferred embodiment, constitute hollow round rods of diameter equal to that of the downstream rods **27**. The rods **32** are mounted in planar spaced parallel relationship with one another and, relative to the downstream rods **27**, are positioned intermediate the latter. The longitudinal spacing of the two sets of parallel rods **27** and **32**, that is, the spacing along the air shaft, is somewhat greater than one rod diameter. The rods **32** may be of seamless steel tubing, ground so as to be of precise diameter. The ends of the rods may be plugged for additional strength, if desired.

The upstream closure members **32** are adjustably spring mounted at each end from brackets **33** extending inwardly from ledges **34** presented on the inside of the frame end walls **24**. Connecting pins **35** threaded into each rod **32** extend through openings in the brackets **33**. Springs **36** encircling the pins **35** are held between the enlarged heads of the pins and the bracket **33**; the compression of the springs may be adjusted by threading the pins **35** either further into or out of the rods **32**. The springs **36** being under compression, the rods **32** are normally biased away from the downstream rods **27**. It is preferable, although not requisite, that each rod **32** be individually spring mounted.

When a force in the downstream direction of magnitude sufficient to compress the springs **36** acts on the upstream rods **32**, each rod **32** is caused to move toward the downstream rods and into new positions as indicated in FIGURE 4, in which each rod **32** lies immediately between each rod **27**, and is in tangential contact with it. In the attitude shown in FIGURE 4, the rods **27** and **32** therefore constitute an assemblage which blocks the internal opening in the downstream frame, so that the valve is closed.

The constants of the springs **36** are chosen so that the action of a normal or mild current of air flowing between the upstream rods **32** in the path indicated by the arrows in FIGURE 3 is not sufficient to compress the springs appreciably. Under these circumstances, the two sets of rods remain spaced from each other and the air current is permitted to continue. However, when air at blast pressures impinges upon the upstream rods, this high velocity air exerts sufficient drag on the rods so that the rods **32** are thrown by the air almost immediately into the positions shown in FIGURE 4, whereby the closure presents a virtually solid array of parallel rods. So long as pressures continue to exist which are of a magnitude sufficient to hold the rods against the counter bias of the springs, the rods **32** remain in their closed positions and downstream points are shielded from the blast.

Extending between the two end walls **24** of the down-

stream frame **23** parallel to and between the rods **27** are support strips **37**. The function of these is to provide support for the upstream rods **32** when those rods are actuated to positions in which they lie between the rods **27**. The supporting strips are relatively thin, so as to permit free air flow past them when the valve is open. These strips are fastened at either end to the frame **21** by welds, for example. The upstream surface **38** of each strip **37** may be ground concave to a radius corresponding to that of the rods **32** so that the strips will support the rods over an area of contact rather than along a line of contact.

The closure of this invention is effective to operate within a period of .006 second; that is, no more than .006 second elapse between the moment when the high pressure air first impinges upon the upstream rods and the moment when the valve is completely closed. Depending of course upon the spring constants, the valve may be made responsive to pressures as low as two p.s.i. acting on the upstream rods. In general, the heavier the springs, the longer the closure time of the valve, since the rods must be moved against greater retarding forces.

At the end of the period of high pressures the springs are effective to return the upstream rods to their original positions, whereby the valve is automatically opened to permit air at normal pressures to move in the duct.

I have found that a closure of the type described is effective to seal the duct to air at pressures in excess of 100 p.s.i. Furthermore, the closure is repetitively operable upon actuation by successive blasts of such magnitude.

Air moving in the duct **12** at normal pressures flows between adjacent upstream rods **32** and then between adjacent downstream rods **27**. The spacing between adjacent rods of both the upstream and downstream sets, as well as the longitudinal spacing between the two sets of rods, must be sufficient to permit this air to move past the closure at a normal rate without exerting so much drag on the upstream rods as to cause the valve to close. In this regard, due allowance must be made for the increase in rate of flow where a blower **16** is included in the ventilating system. I have found that the use of round closure-forming members **27** and **32** permits a relatively higher rate of normal air flow at a given spacing than can be attained with other shapes. I have further found that by making the upstream rods **32** hollow, they will accelerate more rapidly toward the downstream rods upon actuation by air flow at blast pressures. Tests made on a closure having hollow round rods indicate that the rods are not seriously deformed as they are slammed into contact with the arresting stops **30**, transverse supports **31**, and support strips **37**.

In FIGURES 5 and 6 are illustrated alternative embodiments for the closure forming members. In FIGURE 5, solid round rods **38** comprise the downstream members, while the upstream members comprise hollow elliptical rods **40** which have a major axis somewhat greater than the spacing between adjacent downstream rods, so as to be actuated into tight engagement with the downstream rods. This provides a good seal, although the upstream rods must be somewhat stronger to withstand the additional compressional forces exerted upon them by the nature of their engagement with the downstream rods. Alternatively, half-cylindrical or half-elliptical rods might similarly be used to seal in tight engagement against the surface of the stationary members **39**. Embodiments sealing in this manner have the advantage of being less liable to become stuck or wedged between the stationary members under severe pressures.

I have found that an adequate seal against blast shock waves is provided when, under normal conditions of pressure, the spacing between the circular rods of the preferred embodiment is about .002 inch. In other words, when round rods of the type shown in FIGURES 2, 3 and 4 comprise the closure-forming members, an adequate seal is formed when the spacing between each upstream rod **32** and its adjacent downstream rod **27** in closed position is .002 inch. At blast pressures, the tubing deforms slightly, thereby reducing the normal clearance of .002 inch.

In FIGURE 6, the closure-forming members comprise angle irons. Other shapes such as triangular or rectangular bars might also be substituted for the round rods of the preferred embodiment, and I do not wish to be limited to those enumerated.

In the preferred embodiment shown, the upstream rods are biased away from the downstream rods by means of coil springs. Alternatively, leaf springs might be employed, or rubber or elastic pads. A variety of other biasing means is also suitable. For example, where the valve is mounted in a horizontal length of duct, rather than in a vertical length, the plane of each set of rods being vertical rather than horizontal, the upstream rods can be mounted in inclined slots provided in the frame, as is shown in FIGURE 7, the downstream ends **41** of the slots being relatively higher than the upstream ends **42**. At normal air pressures each upstream rod would be held under gravity at the low ends of its associated slots, away from the downstream rods, while under the impact of high pressure air, the rods would roll up the slots to closed positions in which they are intermediate the downstream rods.

As has been noted, it may be desired to provide a valve which is effective to close upon actuation by either high outside or high inside pressure, that is, to close on both the high pressure and negative pressure phases of a blast. My invention is readily adaptable to this requirement. This can most easily be effected by mounting two blast closures of the type shown in FIGURES 2, 3 and 4, in back-to-back relationship, that is, by adding to one valve a second valve reversed in direction with respect to the first, having its movable rods **32** downstream (under normal conditions of air flow) of its fixed rods **27**. When a high pressure shock wave impinges on such a double valve, the first valve closes in the manner already described, the second (reversely oriented) valve remaining open. When the outside pressure is negative with respect to the pressure inside the shelter, the reversely oriented valve is effective to close the shaft to outrushing air, since the rods **32** are then upstream with respect to the direction of the air movement; the other valve will remain open.

Another method by which the same two-directional operability might be accomplished is by spring mounting the rods **27** in a manner similar to that in which the rods **32** are mounted as is shown in FIGURE 8. In this embodiment, each set of rods is movable toward stops associated with the other, each set being biased away from the other. Whichever direction the shock waves move in the air passageway, one set of rods will move toward the other, which will remain stationary, so that a double-acting closure is provided. The details of this embodiment are very similar to those already described, in connection with FIGURES 2, 3 and 4, and need not be further specified.

It should be noted that, while the invention has been disclosed in connection with an air ventilation duct including a dust filter and leading to a bomb shelter, the closure is not limited to use in this particular manner. For example, it may be advantageously employed in intake and exhaust stacks for power plants, gasoline or diesel motor generator sets or the like, to protect machinery and other equipment from damaging pressures. As another example, it may, of course, be used in the absence of a filter, or in other instances where the permissible downstream pressure is somewhat greater. The invention is well suited for such varied purposes without departure from its principles.

Having described my invention, I claim:

1. A blast valve comprising, a set of bars, frame means mounting said bars in spaced parallel relationship, spaces for the flow of air normally being defined between said

bars, a set of cylindrical rods parallel to and normally spaced from said bars, spaces for the flow of air normally being defined between said rods, said rods being staggered with respect to said bars, the diameters of said rods being substantially equal to the width of the spaces between said bars, yieldable means holding said rods away from said bars when air at low velocity flows between said rods toward said bars but yielding when air at high velocity impinges on said rods to permit the rods to be moved to positions between the respective bars, and strips mounted edgewise in said frame means parallel to and between said bars, the widths of said strips being substantially less than the widths of the spaces between said bars whereby air can normally flow between said strips and bars, said strips being positioned to support said rods, when said rods are moved between said bars, in positions such that said rods touch said bars at diametrically opposed points.

2. A blast valve comprising, a set of cylindrical bars arranged in spaced parallel relationship, spaces for the flow of air normally being defined between said bars, a set of hollow cylindrical tubes disposed parallel to and normally spaced from said bars, spaces for the flow of air normally being defined between said tubes, said tubes being aligned with the spaces between said bars, the diameters of said tubes being substantially equal to the width of the spaces between said bars, spring means holding said tubes away from said bars when air at low velocity flows around said tubes toward said bars but yielding when air at high velocities impinges on said tubes whereby said tubes are moved toward the spaces between the respective bars, and strips mounted edgewise parallel to and between said bars, the widths of said strips being substantially less than the widths of the spaces between said bars, whereby air can normally flow between said strips and bars, said strips presenting concave faces toward said tubes of substantially the same radius as said tubes, said strips being positioned to support said tubes when said tubes are moved toward said bars and to support said tubes in positions such that the axes of said tubes and bars substantially lie in a common plane whereby said tubes and bars will block the flow of air past them.

3. A blast valve in accordance with claim 2 wherein said tubes are thin-walled whereby when said tubes are positioned between said bars, air at high velocities impinging thereon will cause said tubes to flatten slightly and form a tight diametral seal with said bars to the flow of air.

4. A blast valve in accordance with claim 3 wherein the diameter of said tubes is about 0.002" less than the width of the spaces between said bars.

5. A blast valve in accordance with claim 2 wherein the width of the spaces between said bars is substantially equal to the diameter of said bars.

6. A blast valve in accordance with claim 2 wherein

said tubes are normally spaced from said bars by an amount approximately equal to their diameter.

7. A blast valve comprising, a set of cylindrical bars, frame means mounting said bars in spaced parallel relationship, spaces for the flow of air normally being defined between said bars, a set of cylindrical rods parallel to and normally spaced from said bars, spaces for the flow of air normally being defined between said rods, the diameters of said rods being substantially equal to the width of the spaces between said bars, means urging said rods away from said bars whereby air at low velocity can flow between said rods toward said bars but whereby when air at high velocities impinges on said rods, said rods are moved to positions between the respective bars, and strips mounted edge wise in said frame means parallel to and between said bars, the widths of said strips being substantially less than the widths of the spaces between said bars whereby air can normally flow between said strips and bars, said strips being positioned to support said rods, when said rods are moved between said bars, in positions such that the axes of said rods and bars substantially lie in a common plane.

8. A blast valve comprising, a set of cylindrical bars in spaced parallel relationship, a set of cylindrical rods parallel to and normally spaced from said bars, spaces for the flow of air normally being defined between said rods and bars, said rods being aligned with the spaces between said bars, the widths of said bars being substantially equal to the widths of the spaces between said rods, means movably mounting said rods for movement toward the spaces between said bars and separate means movably mounting said bars for movement toward the spaces between said rods, means urging said rods and bars relatively apart, said rods being movable into positions between said bars by air at high pressure first acting on said rods, said bars being movable into positions between said rods by air at high pressure first acting on said bars, means to support said rods between said bars such that said bars and rods will contact each other at diametrically opposite points, and means to support said bars between said rods such that said rods and bars will contact each other at diametrically opposite points.

References Cited in the file of this patent

UNITED STATES PATENTS

39,568	Hardick	Aug. 18, 1863
1,029,726	Sprado	June 18, 1912
1,402,082	Moran	Jan. 3, 1922
1,751,230	Briggs	Mar. 18, 1930
2,704,983	Van Dronkelaar	Mar. 29, 1955
2,718,902	Nutter	Sept. 27, 1955
2,776,056	Douglas	Jan. 1, 1957
2,926,694	MacGlashan	Mar. 1, 1960