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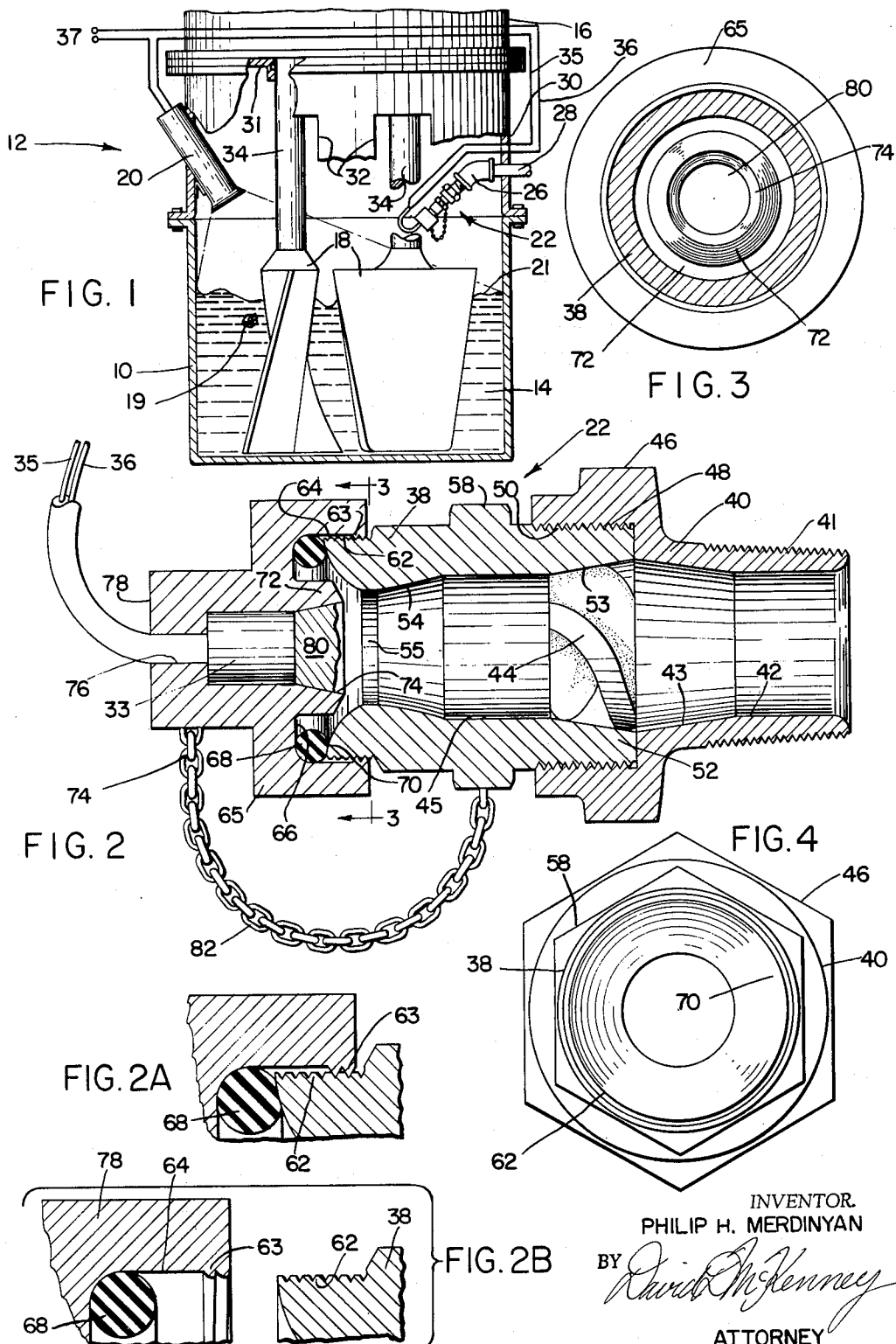
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3,261,404

FIRE PROTECTION SYSTEM AND NOZZLE-VALVE ASSEMBLY THEREFOR

Original Filed July 22, 1963

2 Sheets-Sheet 1



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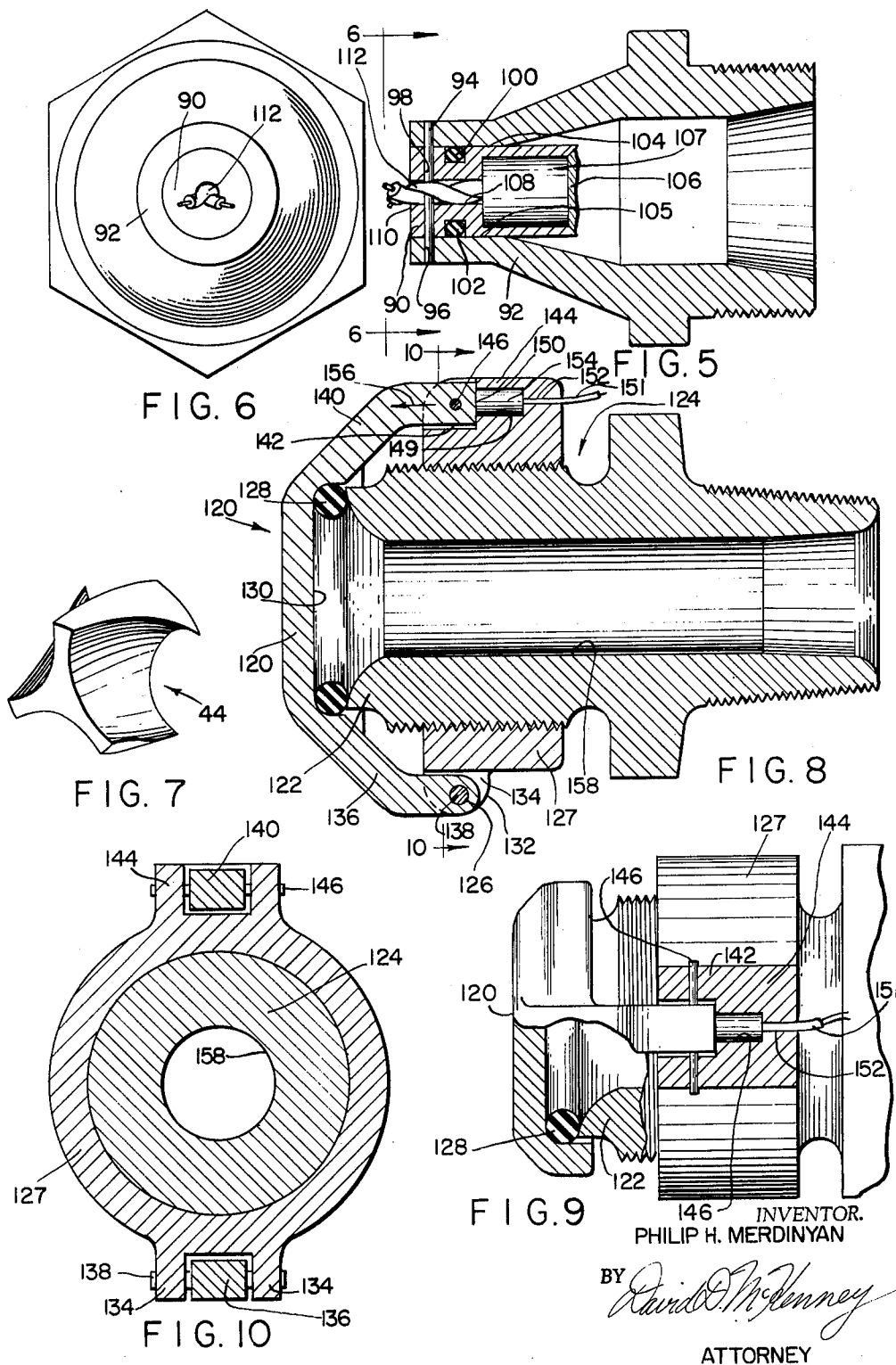
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FIRE PROTECTION SYSTEM AND NOZZLE-VALVE ASSEMBLY THEREFOR

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Continuation of application Ser. No. 296,767, July 22, 1963. This application June 9, 1965, Ser. No. 469,023 16 Claims. (Cl. 169-19)

This application is a continuation of my application Serial No. 296,767, filed on July 22, 1963, and entitled Fire Protection System and Nozzle-Valve Assembly Therefor, now abandoned.

This invention relates to improvements in fire protection systems and components therefor. More particularly, it has to do with a novel fire protection system of the kind which employs very rapid detection of the fire and very rapid delivery of an extinguishing medium onto the fire in response to such detection.

Rapid detection of a fire and rapid delivery of an extinguishing medium to the seat thereof, are, of course, objectives in every fire protection system, and the conventional systems most widely used in dwellings, office buildings, factories, and the like, have detection and delivery rates which put the extinguishing medium onto the fire within a few seconds of its origin time. A delay of this order of magnitude can be tolerated where the rate of fire growth in those few seconds is not unusually great, but for many years there have been certain industries in which the materials handled burn so fiercely that the required detection and delivery rates have not been obtainable from any of these conventional systems.

Detection and delivery within a few seconds might seem to be rapid enough for any fire, even in fast burning materials, but the need for extraordinary speed will be better understood when it is realized that such fires not only grow rapidly in size, in addition, they develop a pressure condition which can quickly exceed the pressure of the delivered medium and thereby prevent this medium from reaching the center of the fire. Accordingly, the delivery must occur before the delivery pressure is exceeded, and the delivery pressure can be exceeded in some of the materials used in these industries in a period of time substantially less than one second.

To accommodate these particular industries, there has been in existence for some time a type of system (1) which combines an electronic flame detector with a conduit system completely filled with an extinguishing medium from the high pressure supply to the discharge nozzle, (2) in which a valve is located between the supply and the nozzle to hold the high pressure back when the system is not in use, and (3) in which this valve is unlatched by an explosive device responding to actuation of the detector. The result of this arrangement is that when the valve is opened by the pressure of the supply, this pressure propels the extinguishing medium onto the fire at high speed and without delay. These systems have been extremely successful, particularly in those industries which manufacture solid propellant material for rocket motors, because if such propellant material is accidentally ignited during manufacture or handling, these systems sufficiently retard the fire and sufficiently cool the objects in the area to protect the expensive manufacturing and handling equipment. In some cases the fire may be completely extinguished.

In this connection, the retardation of a fire is a growing field of "fire protection" and has considerable merit where the complete extinguishment of the fire is not practical or, because the equipment is saved, not necessary. The extremely volatile hydro-carbons such as butadiene and those chemicals containing their own combustion-

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supporting oxygen are examples of hazardous materials calling for this technique. The mediums used in this field of fire retardation are still referred to as "extinguishing mediums," and, because of its reasonable cost and advantageous properties, water is still the most common. Other mediums such as the chemical and mechanical foams are admittedly better than the water for controlling fires in certain materials under certain conditions, but even they will not extinguish fires in some of the materials above referred to, and for merely saving the equipment water is often as good as, or superior to, foam.

One difficulty with these described special systems has resulted from the complexity and size of the explosively actuated valves which have been used heretofore. This complexity and size has been due primarily to the fact that a conventional globe valve design was selected to take advantage of its known characteristics of reliability and strength. Accordingly, to incorporate the explosive unlatching these valves have had their closure members connected by some suitable strut or linkage arrangement to an explosive device mounted on the exterior of the valve, and as a result of these modifications these valves have been so bulky and large, relatively speaking, that it has not been feasible to locate them at or near the discharge nozzle which is usually positioned as close to the expected location of the fire as possible. Consequently, each known prior installation has had an intermediate conduit of substantial length between the valve and the nozzle.

Since this intermediate conduit length has had to be kept completely filled with the extinguishing medium, and since, in most cases, the nozzle has been directed downwardly, a second valve has been required at the nozzle to keep the conduit length completely full. For simplicity this second valve has usually been a simple blow-off cap held closed against the very low pressure of the intermediate conduit by a frictional engagement with the external surface of the nozzle, and the difficulty referred to has arisen from the fact that this blow-off cap has had to be a loose enough fit on the nozzle to be immediately blown off by the pressure to which it is exposed when the explosively actuated valve opens. Such a loose fit is liable to some leakage which introduces water where it is definitely not wanted and which enables air to enter and be trapped in the system. Even a small amount of trapped air retards the rate of delivery considerably when the system operates, because it acts as an air cushion in the system and prevents the pressure in the intermediate conduit length from rising immediately to full line pressure when the explosively released valve opens.

This second valve has sometimes been a rupture disc strong enough to hold the low pressure of the intermediate conduit, but ruptured by the supply pressure. This disc has not been subject to leaks, but it has been very difficult to control disc manufacture so that it will perform as intended.

In the case of both of these designs for the second valve, there has been concern and doubt about their ability to withstand shocks or heavy vibrations.

Another difficulty with the special systems used previously arises from the necessity for moving the medium in the intermediate conduit when the explosively-actuated valve opens. Besides the problem of entrapped air mentioned already there is the unpredictability of the effect of bends and fittings on the flow of the medium. Each installation is usually different from others in the number of bends and the orientation of the pipe lengths between them, and although it might seem that once the explosively-actuated valve opens the pressure in the intermediate length immediately rises to the supply pressure, there is considerable reason to believe that the configuration of the intermediate conduit is a more significant fac-

tor in the rate of water delivery in the prior systems than in a system having the same configuration but with full supply pressure up to the nozzle.

Applicant has discovered a system and components which overcome these difficulties by providing a novel explosively opened valve which is compact enough to be located right at the nozzle and which can perform the functions of both the explosive valve and blow-off cap. With such a nozzle-valve combination an intermediate conduit filled with extinguishing medium at relatively low pressure is unnecessary, and the supply pressure can be made available right up to the nozzle itself.

To handle this pressure and still be opened instantly by the explosive device some embodiments of the novel nozzle-valve combination have closure members which can be adjusted toward and away from their seats (and can thus be seated with one of a range of forces), but which are exploded open at substantially the same rate of speed regardless of the closure member position and seating force employed. Other embodiments have closure members which engage their seat members with substantially the same sealing force in any of a range of positions but which are also exploded open at the same rate regardless of the closure member position within such range. These features enable the provision of a relatively inexpensive valve because close machining tolerances need not be maintained.

In addition, the novel nozzle-valve combination of this invention is arranged so that the components destroyed or damaged by the explosive actuation are those which are the most easily and inexpensively replaced when the system is reset.

One of the objects of the present invention is to provide a fire protection system which has a novel explosively actuated valve at the discharge nozzle.

Another object is to provide such a system in which the valve holds back the full supply pressure of the extinguishing medium.

Another object is to provide such a system in which the explosive charge is set off by a separate electrical detector which "sees" the fire.

Another object is to provide such a system in which the force of the explosive charge actually pushes the valve member into its open position.

Another object is to provide such a system in which the position of the valve closure member is adjustable with respect to its seat.

Another object is to provide such a system in which both the valve closure member and valve seat member are held together in sealing engagement by a securing means which is purposely ruptured by the explosion to break the hold.

Another object is to provide such a system in which the securing means is a pin which is sheared by the explosion.

Another object is to provide such a system in which the securing means is a thread engagement which is stripped by the explosion.

Another object is to provide such a system in which the securing means is a threaded engagement and in which one of the threads is purposely weakened.

Another object is to provide such a system in which the valve is opened by an explosive charge reacting directly against the extinguishing medium.

Other objects will appear hereinafter.

The best modes in which I have contemplated applying the principles of my improvements are shown in the accompanying drawings, but these are to be deemed primarily illustrative for it is intended that the patent shall cover by suitable expression in the appended claims whatever of patentable novelty exists in the invention disclosed.

In the drawings:

FIGURE 1 is a somewhat diagrammatic cross-sectioned side elevation view of a system in accordance with the

present invention, this system being shown protecting a solid propellant mixing vat;

FIGURE 2 is an enlarged cross-sectioned view of the novel combined nozzle and explosively-actuated valve assembly shown in the system of FIG. 1;

FIGURE 2A is an enlarged view of the portion of the nozzle-valve assembly of FIG. 2 before the valve is actuated;

FIGURE 2B is a view like FIG. 2A but showing the positions of the parts after the explosion;

FIGURE 3 is an end elevation view of the valve closure member;

FIGURE 4 is an end elevation view of the combined valve seat member and nozzle part;

FIGURE 5 is a cross-sectioned side elevation view of another novel combined nozzle and valve assembly which can be used in the system of the present invention;

FIGURE 6 is an end elevation view taken on line 6—6 of FIG. 5;

FIGURE 7 is an enlarged perspective view of the scroll member used in the nozzle-valve assembly;

FIGURE 8 is a cross-sectioned side elevation view of another novel combined nozzle and valve assembly which can be used in the system of the present invention;

FIGURE 9 is a top plan view of a portion of the nozzle-valve assembly of FIG. 8 with parts broken away and cross-sectioned; and

FIGURE 10 is a cross-sectioned end view taken on line 10—10 of FIG. 8.

Referring now more particularly to the drawings, FIG. 1 shows a system which is according to the present invention and which is mounted to detect and control fire in the vat 10 of a machine 12 for mixing the solid propellant ingredients 14 used in rocket motors. The upper part 16 of this machine houses the motor and reduction gear equipment (not shown) for driving a pair of paddles 18 extending down into the vat 10.

The ingredients 14 are of such composition that once the mixture of them is ignited it burns with a rapidity almost amounting to an explosion. The reason for this is that, like an explosive, this mixture contains its own oxygen releasing compounds and is kept from being an explosive merely by the addition of certain inert materials. The mixture is unstable in the sense that even a very small spark, caused, for example, by one of the paddles 18 striking a piece of tramp metal 19 in the mixture, can cause an ignition.

As a consequence of these characteristics of the material being mixed, it is desirable to have the detecting and spraying components installed as close as possible to the probable location of any fire, and in the system of the drawings this is accomplished by placing these components right in the mixing area adjacent the paddles and just above the surface of the propellant. These components include some form of electric eye device 20, positioned so as to be able to "see" the entire surface 21 of the material 14 being mixed, and they further include a combined nozzle-valve assembly which is generally designated at 22 and which will be described in more detail hereinafter. In this case, the nozzle-valve assembly is threaded directly into one end of a pipe elbow 26 which, in turn, is threaded onto a pipe section 28 leading through the wall 30 of the mixing machine. The purpose of the elbow 26 is to direct the nozzle downwardly at the material 14. Although only one nozzle-valve assembly is shown in FIG. 1, it will be understood that a plurality of such assemblies may be located in the region where assembly 22 is shown. Such a plurality would be advantageous where the discharge from one nozzle-valve did not cover the entire surface of the mixture. The wall 30 connects the mixing vat 10 to the upper housing part 16 and is provided with large side openings 32 to prevent the kind of destructive pressure increase within the mixing equipment which would be likely to occur even in case of a fire which was promptly controlled by the system. A

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plate 31 separates the equipment in the upper housing parts from the components below. Shafts 34 for driving the paddles 18 pass sealingly through this plate.

Also passing through the wall 30 are electrical leads 35 and 36 extending from an electricity source 37 to the electric eye device 20 and to the nozzle-valve assembly 22. The electric eye device 20 is not by itself a part of this invention, and persons skilled in this art will know how to construct one or select one of those now available. It is essentially a switch which closes an electric circuit to a small explosive element 33 located in the nozzle-valve assembly to ignite this explosive device and thereby explode open the valve of the nozzle-valve assembly in the manner which will be described.

Turning now to FIG. 2, this is a cross-sectioned side elevation view of the nozzle-valve assembly 22 showing that, in general, the nozzle is made up of two parts 38 and 40, the latter having an externally threaded end 41 which, in this case, is connected to the elbow 26 and having a passage 42 therethrough with an outwardly tapered section 43 at the end thereof opposite the end 41. A scroll member 44 (best shown in FIG. 7) is located in the path of the flow passage 45 of the other nozzle part 38 to give the fluid passing into it from the member 40 a swirling action which has been found to improve the discharge pattern. Externally the member 40 is provided with the usual flat wrench faces 46 for tightening the threaded connection between member 40 and the elbow 26 and for tightening the threaded connection between the members 38 and 40. More particularly, the member 40 has internal threads 43 for receiving the external threads 50 on the adjacent end 52 of the member 38. At this end the passage 45 is tapered, as at 53, to receive the scroll member 44 which has an external surface correspondingly shaped. The other end 54 of the passage 45 is first gradually reduced to a throat 55 and then abruptly flared out to further achieve a particular discharge pattern which has been found to be most suitable in the application of FIG. 1. The shape of the internal flow passageway 45 is not critical, and it will be understood that other shapes may be used.

Externally, the member 38 is also provided with flat wrench faces 58 for tightening the threaded connection between members 38 and 40. At the discharge end the nozzle member 38 has a cylindrical external surface provided with untapered machine threads 62 which have had their top portions cut away down to substantially one half the thread depth leaving the appearance shown particularly well in FIGS. 2A and 2B.

In the assembled position of the nozzle-valve, these half-threads are engaged by several full, untapered machine threads 63 formed on the cylindrical internal surface 64 of a cup-shaped valve member 65 which has bottom wall 66 supporting a soft sealing member 68, for example, a rubber O-ring. The valve member 65 is threaded onto the nozzle end far enough to cause the outer nozzle rim 70 to sealingly squeeze the O-ring 68 against the bottom wall 66 and prevent leakage past the threads 62 and 63, such leakage being very likely to take place because there are only a few threads 63, because threads 62 have been cut away and because of the high pressures employed. The center of the valve member bottom wall 66 is provided with an upstanding boss 72 having therein a deep recess 74 with a small central passage 76 leading therefrom completely through the wall 66 to the external surface 78. This passage 76 accommodates the electrical leads 35 and 36 which bring electric energy to the explosive squib 33 located in the recess 74. This squib may be a Mark 131, Model 0 "Primer" of the Hercules Powder Company of Wilmington, Delaware. A sealing material 80 may be located in the region indicated to prevent leakage past the explosive squib and through passage 76. Bees wax will serve as the material 80.

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A short length of chain 82 connected at one end to the valve member 65 and at the other end to the nozzle member 38 prevents the valve member from being lost after the squib is fired. Valve member 65 is not usually reusable because of the distortion of the threads 63, but it is preferred to not have this valve member strike the mixing equipment or be lost. It is also preferred not to have wires 34 and 35 broken.

FIGURE 2B illustrates what happens when the explosive squib 33 is fired. The force of the explosion, reacting against the water which completely fills the passages 45 and 42 and the cup 65 (and is at high pressure for example, 75 p.s.i.), drives the cup member away from the nozzle with enough force to shear off or distort the threads 63 in the cup member and permit this member to move to the position illustrated.

Merely as a guide in design, the inside diameter of the nozzle member 38, at its throat 55, may be one half inch for a primer as previously suggested. Other dimensions may be generally in the proportions shown.

FIGURE 5 illustrates another embodiment of the nozzle-valve assembly of the present invention in which the valve member 90 is held in place with respect to the nozzle member 92 by a shear pin 94 located partially in a passage 96 of the nozzle member and partially in a passage 98 of the valve member. As in the earlier embodiments, an O-ring seal 100 is employed to prevent leakage of the extinguishing medium past the valve member, but in this case the O-ring acts in the manner of a piston ring lying in an external groove 102 formed in the cylindrical wall of the valve member 90. By this arrangement the axial position of the valve member 90 along the nozzle flow passageway 105 may vary considerably without affecting the tightness of the seal provided by the O-ring, and as a result no great care is required in providing alignments of the passages 96 and 98. Also it is not important that the shear pin 94 may be a relatively loose fit in one or both of these passages. Preferably, of course, the shear pin is arranged so as not to drop out, for example, by having its ends peened over, or by being a press fit in at least one of the passages 96 and 98. When pressure is on the system the shear pin would be very securely held in position.

The valve member 90 has a recess 106 at its inner end to accommodate the primer 107, and a passage 108, leading from this recess to the outer end 110 of the valve member, accommodates the primer wires 112.

FIGURES 8, 9, and 10 show another embodiment of a nozzle-valve assembly in accordance with the present invention which may be used in a system in accordance with the present invention. More specifically in this embodiment, the valve member 120 is essentially a cover for the end 122 of the nozzle member 124 which acts as the valve seat and which is hinged at 126 to a ring member 127 threaded onto the exterior of the nozzle member 124. Fluid-tight seating is achieved by an O-ring 128 between the nozzle-member end 122 and the inner wall 130 of the cover 120. This O-ring is compressed by threading the ring 127 farther onto the nozzle.

The hinge at 126 is accomplished by a bracket 132 standing out radially from the ring member and having a bifurcated portion 134 which receives an arm 136 extending from one side of the cover 120. The bifurcated portion and arm are provided with aligned transverse journals for a hinge pin 138.

On the side of the ring member 127 opposite the arm 136 there is a second corresponding arm 140 which also fits into the bifurcated portion 142 of a second outstanding bracket 144. A shear pin 146 passes through aligned openings in portion 142 and arm 140 in a manner similar to the hinge pin 148. However, in the case of bracket 144 there is an extending portion which accommodates a squib chamber 149 opening against the end 150 of the arm 140. Wires 151 lead through a narrow passage 152 at the opposite end of this chamber.

From the foregoing it will be seen that when the squib 154 is exploded it drives the arm 140 in the direction of arrow 156, shearing pin 146 and causing cover 120 to be flung open with considerable force which is in addition to the force exerted on the cover by the pressure of the fluid in passage 158.

Another advantage is that any change in the position of the valve member in a direction opposite to its opening movement at least maintains the tightness of its sealing engagement with the nozzle member and, in some embodiments, will actually increase that tightness. As a result no special provision need be made in the manufacture of the members to make sure that assembly automatically locates the valve member in one position along the opening path (relative to the nozzle member), and during assembly the relative position of the valve member which provides a seal is assured when it is not possible to move the valve member any farther in said opposite direction.

One of the advantages of each of the above-described embodiments is that the nozzle-valve assembly is compact enough to be located in places where the space is limited. Accordingly, it can be located closer to the expected location of the fire than would be the case of the prior art constructions.

Another advantage is that there are no exposed linkages which would be subject to accidental tripping and no linkages which would require considerable space.

Another advantage is that the force of the explosion actually pushes the valve member to its open position, rather than merely release the valve member and permit it to be opened by the force of the water pressure.

Another advantage is that the valve member can be adjusted with respect to the seat member in a range of positions to achieve the liquid tight seal but at the same time the rate at which the valve member is opened by the explosive force remains substantially the same.

A common feature of all the above-described embodiments is the arrangement of the valve and nozzle members so that when the former is as far upstream as it will go relative to the latter a tight seal is assured. In the embodiments of FIGS. 2 and 8 the valve member is adjustable in this direction, (and downstream as well) and adjustment as far upstream as possible tightens the seal. In the embodiment of FIG. 5 the valve member is not adjustable and is therefore in its farthest upstream position when assembled. In this position a tight seal is assured because of the kind of seal that it is.

Another advantage is that this construction readily lends itself to modification to prevent accidental opening by large vibrations and shocks in those installations subject to such conditions. It is a simple matter to provide a valve member like 65 in FIG. 1 with more threads 63, or to provide a nozzle-part like 38 in FIG. 1 with less than half of the threads 62 cut away, or to use a larger shear pin 94 in a construction like that of FIG. 5, or to provide a larger shear pin 146 in a construction like that of FIG. 8. By doing these things the danger of accidental opening by heavy shocks or vibrations can be greatly diminished and at the same time opening at the desired time can be assured by merely choosing a primer of large enough size to provide the required opening force.

An advantage of some embodiments is that the explosion takes place in the passageway and directly against the extinguishing medium which greatly simplifies the construction and develops in the medium an instantaneous pressure far greater than that of the supply.

An advantage of some other embodiments is that the force required to open the valve can be closely regulated in an inexpensive way by the use of shear pins or the like which can be made with very close tolerances.

What I claim is:

1. A fire protection system comprising:

(I) a conduit which:

(A) is adapted to have one end connected to a

source of fire extinguishing fluid under substantial pressure,

(B) is adapted to have an opposite end in a region to be protected from fire,

(II) a nozzle member which:

(A) is mounted on said opposite conduit end,

(B) has a flow passage therethrough,

(C) has a discharge opening at one end of said passage,

(D) has a seating portion adjacent said discharge opening,

(III) a valve member which:

(A) in the valve-closed position:

(1) extends across said nozzle member flow passage,

(2) sealingly engages said nozzle member seating portion,

(B) in the valve-open position:

(1) is removed from said nozzle member flow passage,

(2) is out of engagement with said nozzle member seating portion,

(C) during any movement from said valve-closed position to said valve-open position travels in one direction along a certain path,

(D) during any movement from said valve-closed position in the opposite direction along said path maintains said sealing engagement with said nozzle member seating portion,

(IV) means which:

(A) are associated with both said nozzle member and said valve member,

(B) are rupturable by a predetermined force exerted on said valve member along said path of movement

for holding said valve-member in sealing engagement with said nozzle member seating portion,

(V) an explosive member which:

(A) in the valve-closed position is located on the side of the valve member remote from the valve-open position of said member,

(B) when exploded exerts said predetermined force on said valve member and therethrough on said rupturable means,

(VI) means which:

(A) is located in said region,

(B) is separate from said valve member,

(C) is connected to said explosive member, for detecting the presence of fire in said region and for exploding said explosive member in response thereto.

2. For a fire protection system a nozzle-valve assembly comprising:

(I) a nozzle member having:

(A) a generally cylindrical body with:

(1) an inlet opening at one end thereof,

(2) a discharge opening at the other end thereof,

(B) a flow passage which:

(1) extends through said body,

(2) extends between said inlet and discharge openings,

(C) a seating portion which:

(1) is on said body adjacent said discharge opening,

(2) surrounds said flow passage,

(II) a valve member which:

(A) is movable along a path between valve-closed and valve-open positions,

(B) extends across said nozzle member passage and sealingly engages said nozzle member seating portion in the valve-closed position,

(C) is removed from said nozzle member passage and out of engagement with said nozzle member seating portion in the valve-open position,

(III) means which:

(A) are associated with both said nozzle member and said valve member,

(B) provide adjustment of said valve member along said path to vary the force exerted by said valve member on said seating portion,

(C) include means which are rupturable by a predetermined force exerted on said valve member along said path of movement,

for holding said valve member in the valve-closed position,

(IV) an explosive member which:

(A) in the valve-closed position is located on the side of said valve member remote from the valve-open position of said member,

(B) when exploded exerts said predetermined force on said valve member and therethrough on said rupturable means,

(V) means connected to said explosive member for conducting energy to said explosive member to explode said explosive member.

3. A nozzle-valve assembly according to claim 2 in which said adjustable means comprise threads on said nozzle member and additional cooperating threads on said valve member.

4. A nozzle-valve assembly according to claim 3 in which the said threads on one of said members are modified to weaken the threaded connection, and in which said weakened threaded connection also serves as said rupturable holding means.

5. A nozzle-valve assembly according to claim 4 in which the modified threads are on the nozzle member and in which said modification comprises the elimination of the top portions of the threads.

6. A nozzle-valve assembly according to claim 2 in which said adjustable means comprises a separate nozzle member portion threaded on said nozzle member body and movable with respect thereto along said path and in which said rupturable holding means connects said valve member to said movable nozzle member portion.

7. A nozzle-valve assembly according to claim 6 in which said valve member has a portion which is adjacent said movable nozzle-member portion and in which said rupturable holding means comprises a shear pin passing through said movable nozzle member portion and said adjacent valve member portion.

8. A nozzle-valve assembly according to claim 7 in which said explosive member is mounted on said movable nozzle member portion.

9. A nozzle-valve assembly according to claim 8 in which said explosive member is housed in a chamber

defined on one side by said valve member and defined on all other sides by said movable nozzle member portion.

10. A nozzle-valve assembly according to claim 9 in which the said one side of said chamber is defined by said adjacent valve member portion, and in which said one side of said chamber is presented in a direction substantially parallel to said path.

11. A nozzle-valve assembly according to claim 10 in which said valve member is hinged to said nozzle member.

12. A nozzle-valve assembly according to claim 5 in which said valve member has a wall presented in a direction away from said path and upstream along the nozzle member flow passage, in which said wall has a chamber, and in which said explosive member is housed in said chamber.

13. A nozzle-valve assembly according to claim 12 in which said valve member has an exterior surface and a passage connecting said chamber with said exterior surface, and in which means for conducting energy to said explosive means are located in said passage.

14. A nozzle-valve assembly according to claim 2 in which said nozzle member and valve member seating portions are formed on substantially parallel cylindrical surfaces of said nozzle and valve members, and in which said resilient sealing member is confined between said surfaces in the nature of a piston ring.

15. A nozzle-valve assembly according to claim 14 in which said nozzle member cylindrical seating portion surface forms a part of said flow passage adjacent said discharge opening, in which said valve member cylindrical seating portion surface is formed on a valve member part which lies within said flow passage part, and in which said valve member part has a chamber housing said explosive member.

16. A nozzle-valve assembly according to claim 15 in which said chamber has one open side presented upstream along said nozzle member flow passage, and in which said rupturable holding means comprises a shear pin passing through both said nozzle and valve members.

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EVERETT W. KIRBY, *Primary Examiner.*