Sept. 4, 1962 H. V. WILLIAMSON ET AL 3,052,304

FIRE EXTINGUISHING SYSTEM

Filed April 29, 1959 7 Sheets-Sheet 1

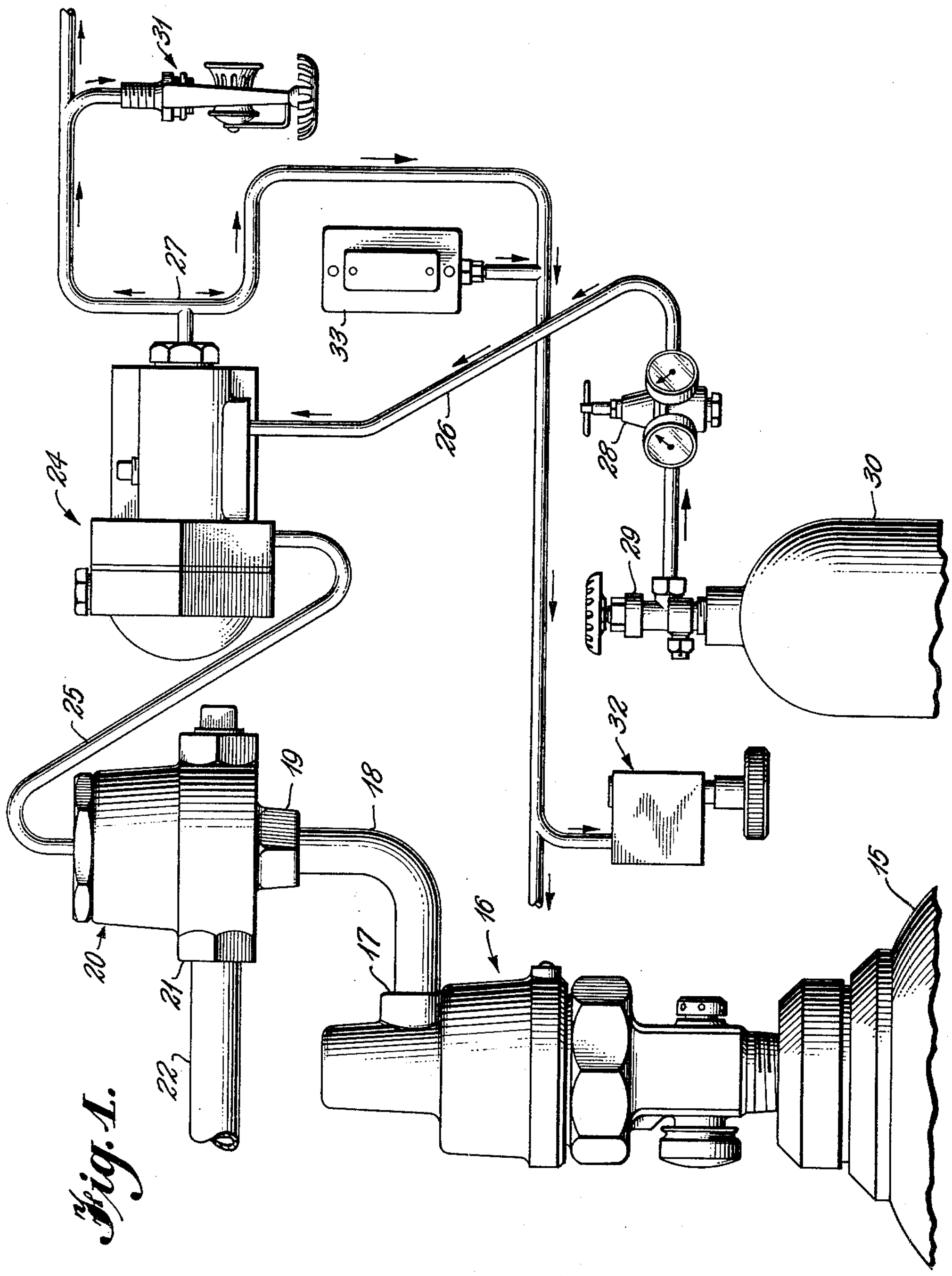
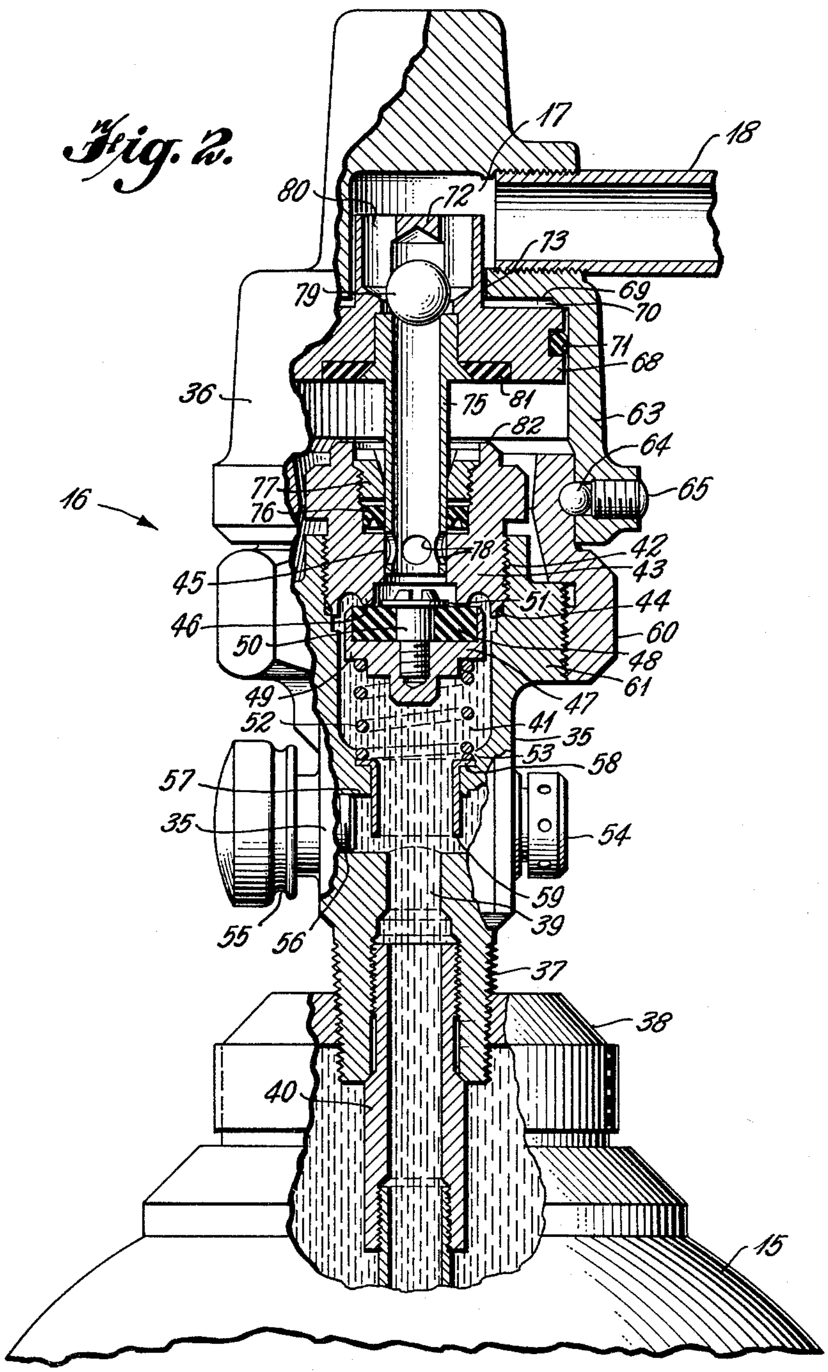


Fig. 1.

Fig. 2.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FIRE EXTINGUISHING SYSTEM

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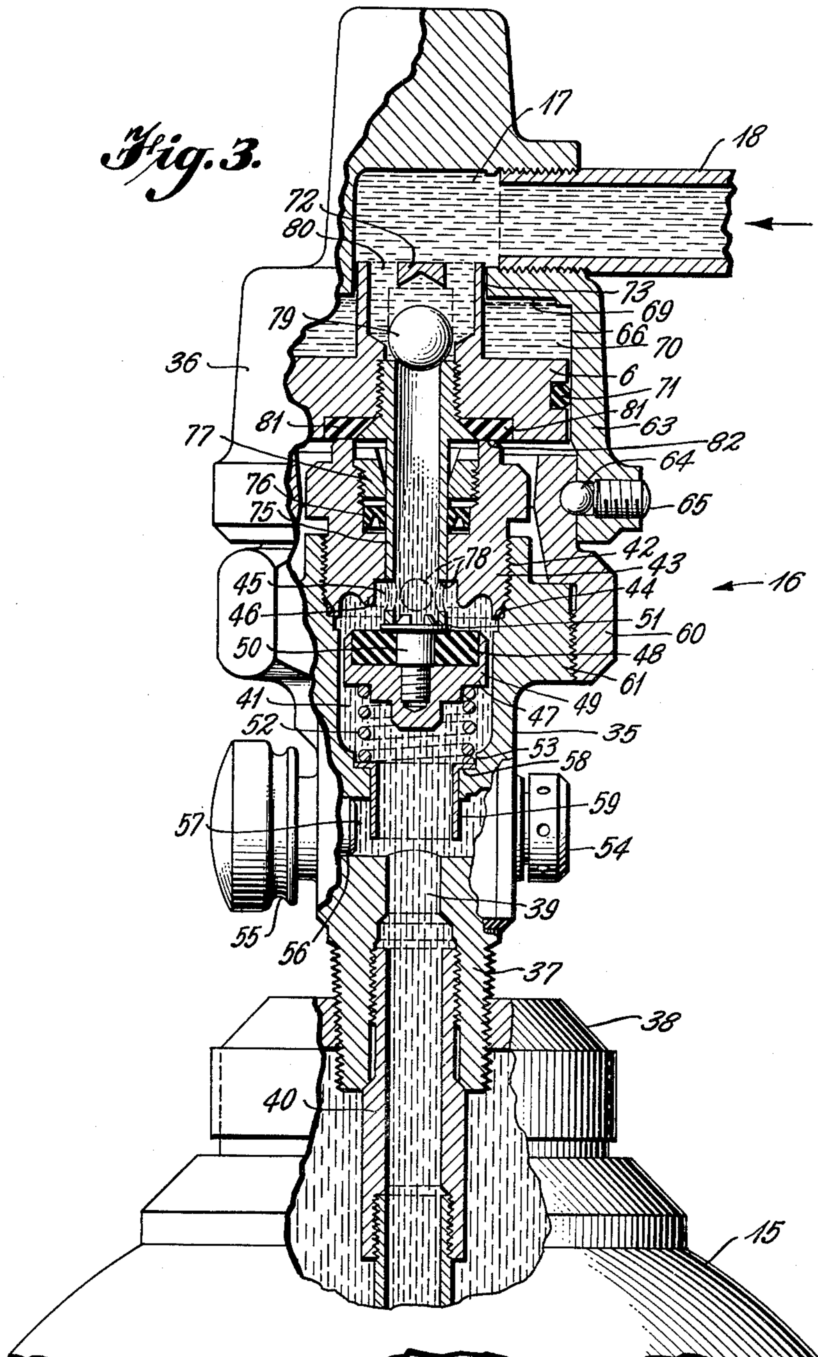
Fig. 3.



FIRE EXTINGUISHING SYSTEM

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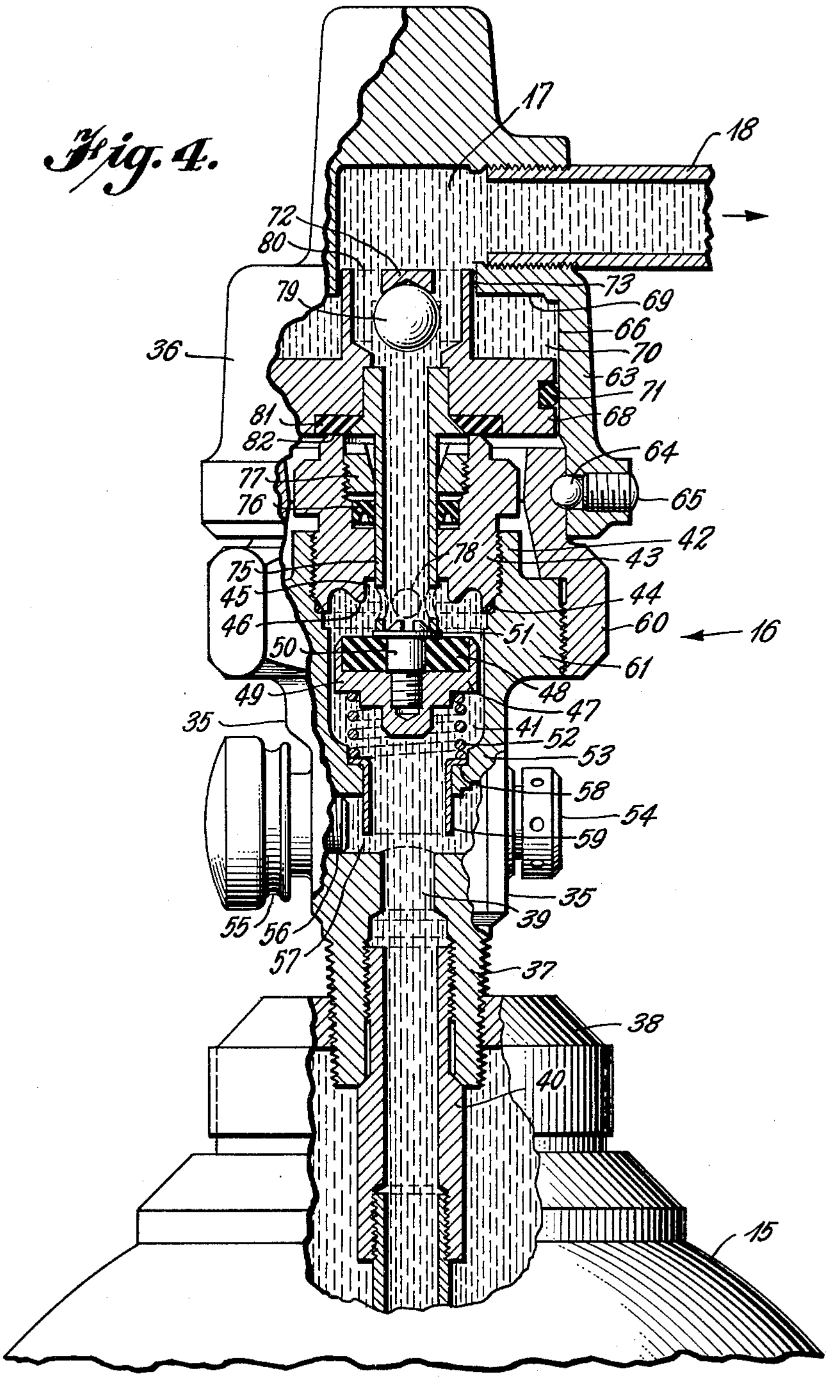
Fig. 4.



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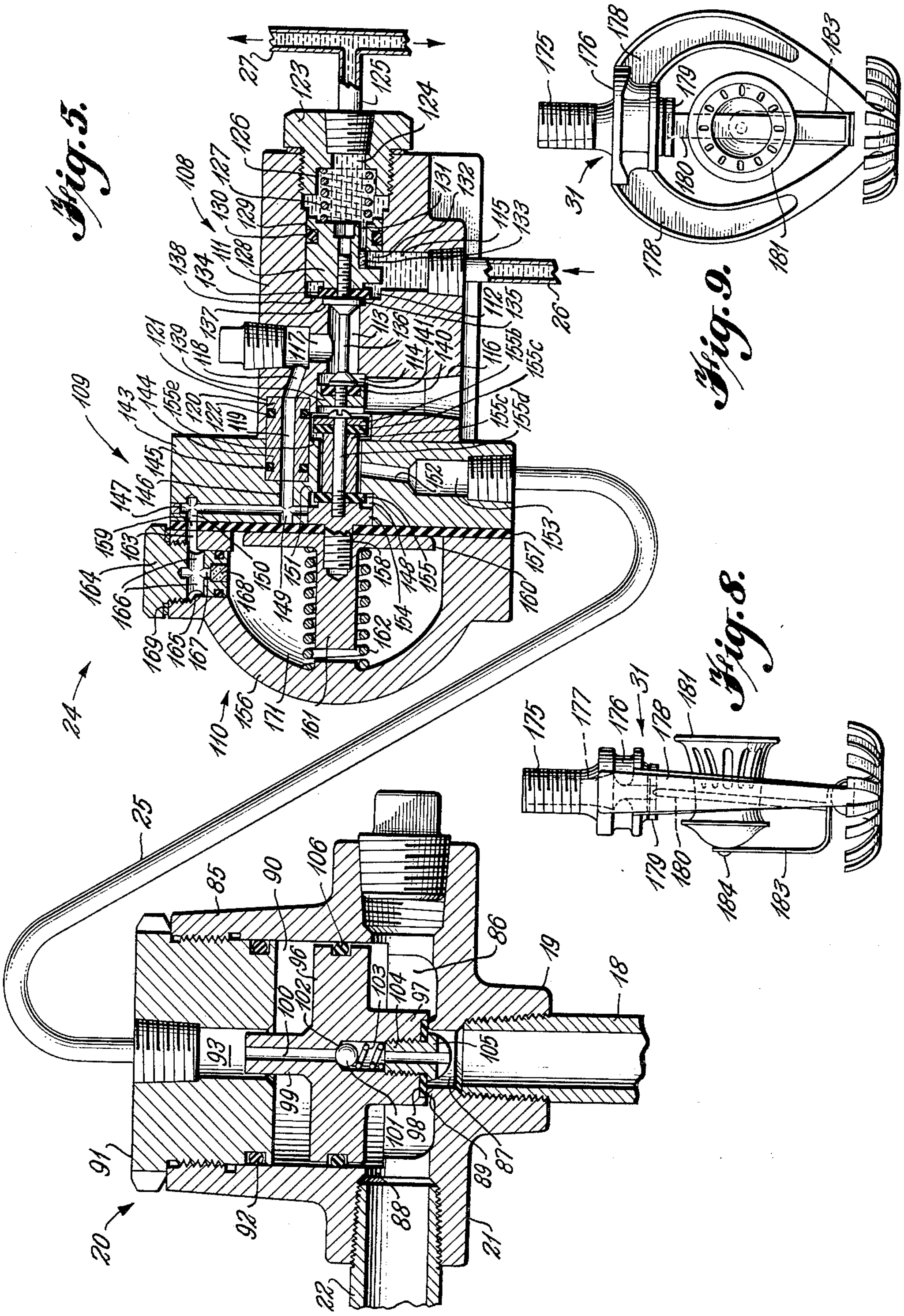
FIRE EXTINGUISHING SYSTEM

Filed April 29, 1959

7 Sheets-Sheet 5



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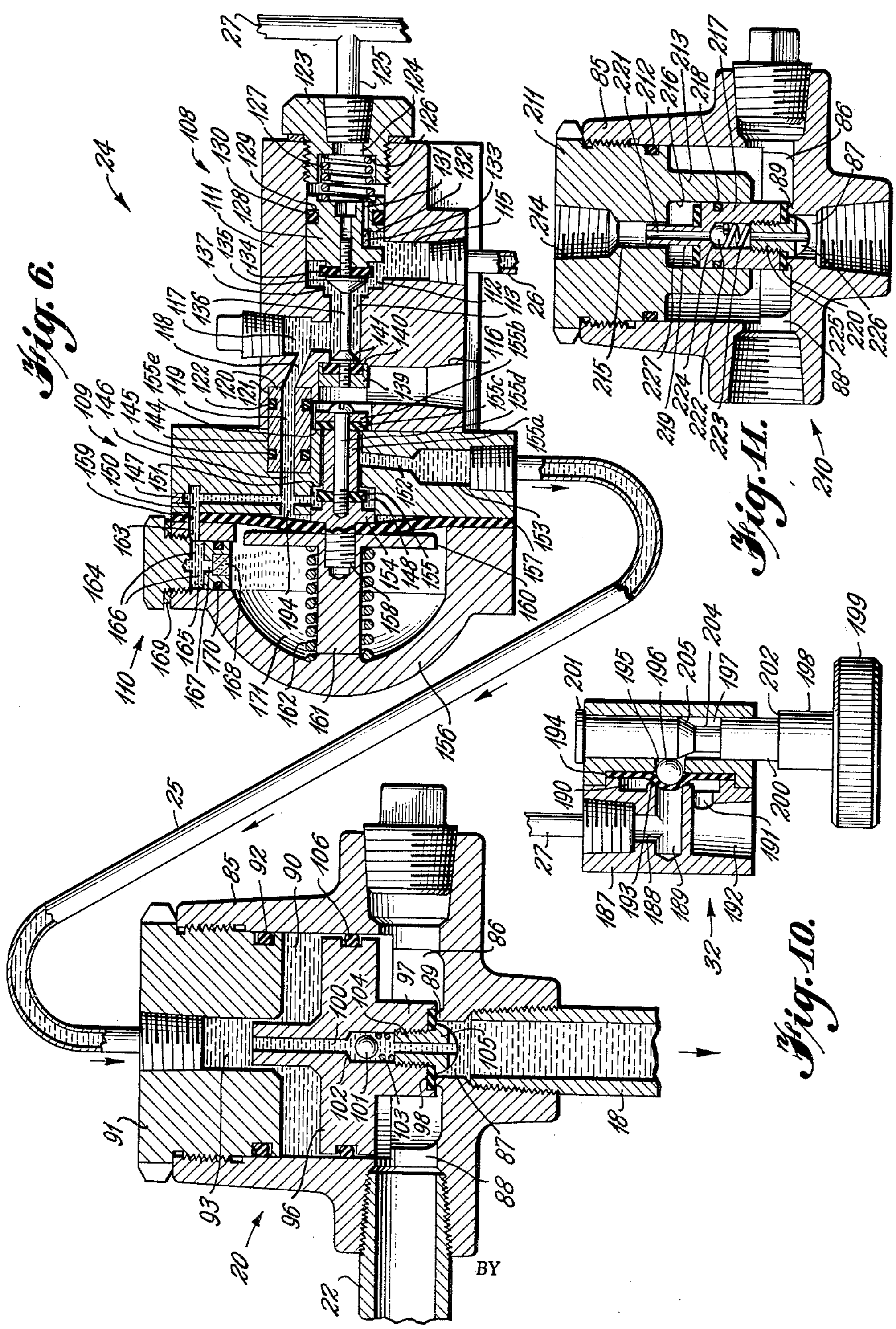
FIRE EXTINGUISHING SYSTEM

Filed April 29, 1959 7 Sheets-Sheet 6



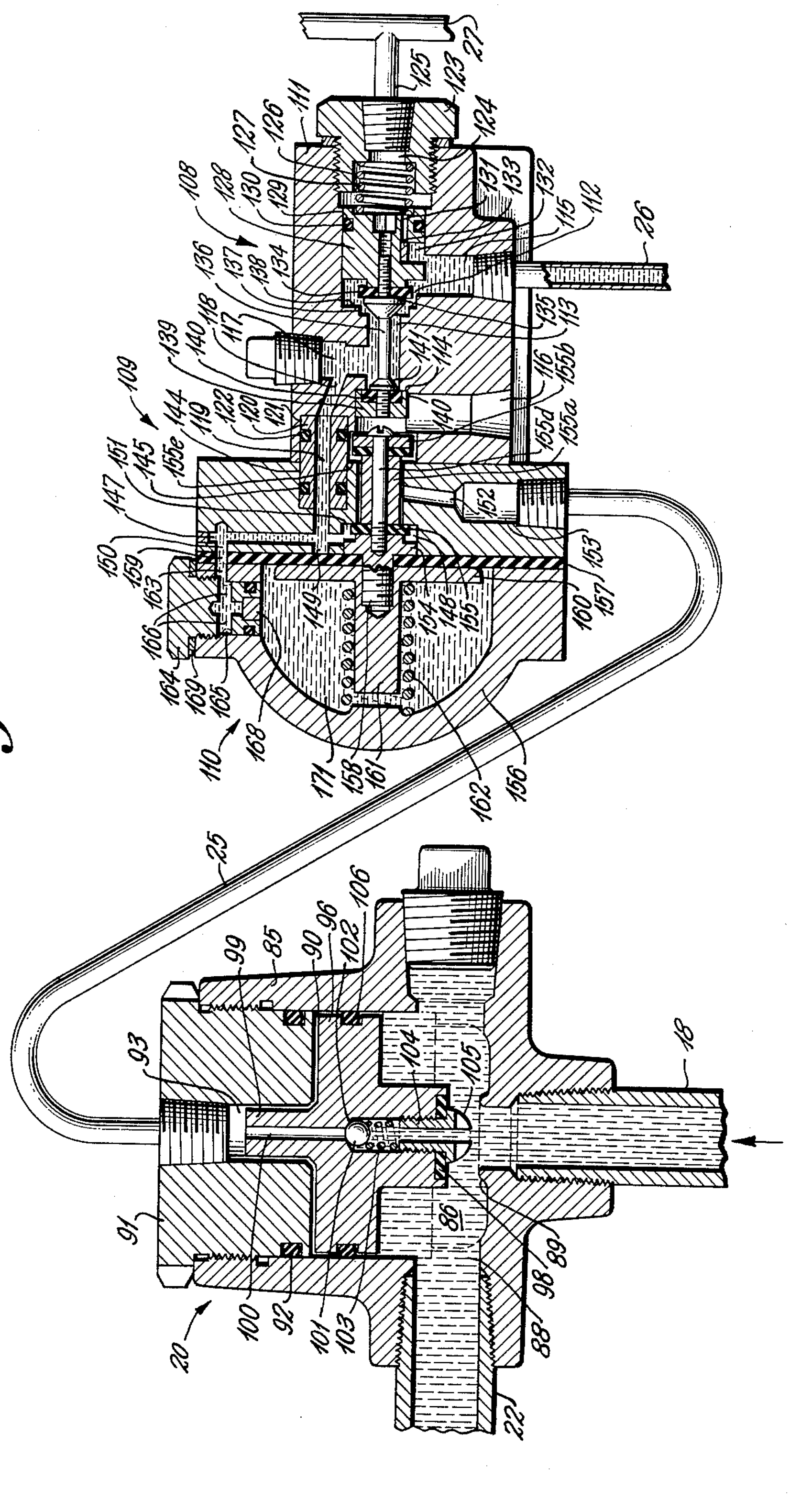


Fig. 7.

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3,052,304

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3,052,304
FIRE EXTINGUISHING SYSTEM

Hilding V. Williamson, Chicago, and Edward H. Horn, Flossmoor, Ill., assignors to Chemetron Corporation, Chicago, Ill., a corporation of Delaware

Filed Apr. 29, 1959, Ser. No. 809,662
12 Claims. (Cl. 169—11)

This invention relates to new and useful improvements in fire extinguishing systems, and deals more particularly with systems in which the extinguishing medium is stored at ambient temperature and its corresponding vapor pressure.

In fire extinguishing systems employing an inert gas, such as carbon dioxide, as the extinguishing medium, the latter is frequently stored at ambient temperature in one or more high pressure cylinders which are connected to a common supply manifold which will deliver the extinguishing medium to the hazard, or hazards, to be protected. The discharge of the extinguishing medium is usually automatically controlled in response to the detection of a fire at a hazard, and often is delayed for a short period of time, following the detection, to permit personnel in or near the affected hazard sufficient time to leave the area before the discharge is initiated.

In the past, the automatic controls employed in such systems have generally used, for purposes of fire detection, predischarge timing and discharge initiation devices operated either by electrical power or by high pressure fluid obtained directly from the storage cylinders. For one reason or another, these automatic controls have not proven entirely satisfactory. In the case of controls dependent on a source of electrical power, failure of the source, which often occurs in the event of a fire, prevents automatic operation of the extinguishing system. On the other hand, controls depending on the high fluid pressure of the storage containers for their operating power require extra strong piping, special fittings and very efficient seals at all joints because the control elements of the system must be subjected at all times to hte high pressure at which the fluid is stored.

It is the primary object of this invention to provide a fire extinguishing system employing high pressure carbon dioxide as the extinguishing medium and substantially lower pressure carbon dioxide for actuating the automatic control portion of the system.

A further object of this invention is to provide a fire extinguishing system using carbon dioxide stored at a high vapor pressure as the extinguishing medium, and in which the discharge of the extinguishing medium is automatically delayed for a predetermined period after the system is placed in operation.

Still another object of this invention is to provide a fluid pressure operated fire detection and discharge control mechanism for fire extinguishing systems which is powered from a source of pressure separate from the supply of extinguishing medium, which is entirely independent of a source of electrical power, and for which the operating pressure required is sufficiently low to avoid the necessity of special high pressure piping, fittings and seals.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same,

FIGURE 1 is an elevational view of the part of a fire extinguishing system embodying this invention,

FIGURE 2 is a partly sectional and partly elevational view of the valve used to control the discharge from the storage containers, the valve being shown in the ready

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condition assumed when installed in the system in FIG. 1 and prepared for operation,

FIGURE 3 is a view similar to FIG. 2, but with the valve being shown in the predischarge condition assumed shortly after the detection of a fire and at the start of the operating cycle,

FIGURE 4 is a view similar to FIG. 2, but with the valve being shown in the discharge condition assumed after the detection of a fire and the lapse of the predischarge delay period,

FIGURE 5 is a sectional view of the two valve assemblies used to effect a predischarge delay, the assemblies being shown in the ready condition assumed when installed in the system of FIG. 1 and prepared for operation,

FIGURE 6 is a sectional view similar to FIG. 5, with the valve assemblies being shown in the predischarge condition assumed shortly after the detection of a fire and after the start of the operating cycle,

FIGURE 7 is a sectional view similar to FIG. 5, but with the valve assemblies being shown in the discharge condition assumed after the detection of a fire and the lapse of the predischarge delay period,

FIGURE 8 is a side elevational view of a device employed for automatically detecting a fire and actuating the control system,

FIGURE 9 is a front elevational view of the device illustrated in FIG. 8,

FIGURE 10 is a sectional view of a valve for manually actuating the control system, and

FIGURE 11 is a sectional view of a pilot valve which may be employed in the system to provide an immediate discharge after the detection of a fire.

In the drawings, wherein for the purpose of illustration is shown the preferred embodiment of this invention, and first particularly referring to FIG. 1, reference numeral **15** designates a high pressure cylinder for storing a quantity of liquid carbon dioxide at ambient temperature and its corresponding vapor pressure. The vapor pressure, of course, will vary with the ambient temperature. However, at 70° F. the pressure will be approximately 854 pounds per square inch, absolute, while a pressure in excess of 1000 pounds per square inch, absolute, will prevail if the ambient temperature reaches 85° F.

The cylinder **15**, usually of 50 pounds capacity, may comprise the entire source of carbon dioxide used as the extinguishing medium for the system, or it may be a master cylinder controlling a bank of other similar cylinders. In the latter case the other cylinders of the bank (not shown) are discharged in response to the discharge of the cylinder **15** in a manner which will hereinafter be made apparent.

The controls for effecting the discharge of carbon dioxide from the cylinder **15** include a cylinder head valve **16** connected to the neck of the cylinder. The outlet port **17** of this valve is connected by means of a duct **18** to the bottom port **19** of a pilot valve **20** which has a side port **21** communicating with a manifold pipe **22** which leads to the hazard or hazards to be protected and to which any desired number of carbon dioxide supply cylinders may be connected.

As will hereinafter be described, the pilot valve **20** is, in the event of fire, operated by actuating carbon dioxide supplied thereto at a controlled pressure of about 300 p.s.i. from a predischarge timer **24** through a duct **25**. Attached to the predischarge timer **24** is a control pressure supply duct **26** and a detection line **27**. The control pressure supply duct **26** is connected through a pressure reducer **28** and a hand valve **29** to a control cylinder **30** which contains a quantity, preferably about 10 pounds, of actuating fluid such as carbon dioxide or nitrogen under pressure for use in operating the various controls of the system. Although the pressure within the cylinder **30** will correspond with the ambient temperature, it is reduced by the pressure regulator 28 to the control pressure of about 300 p.s.i. at the outlet side of the regulator.

The detection line 27 is normally pressurized at the control pressure of about 300 p.s.i. with actuating fluid flowing through the supply duct 26 and the predischarge timer 24. Connected to the detection line 27 are one or more detecting devices 31 which are located at the hazard or hazards to be protected and which operate in response to the heat of a fire to vent the detection line to the atmosphere. The detection line may also be vented by operation of a manual valve 32 therein and located at a conveniently reached place either near to or remote from the hazard or hazards.

To provide for supervision of the pressure in the detection line 27 and/or a fire alarm, a pressure sensitive switch 33 may also be connected to the detection line. The illustrated switch 33 is a standard pressure operated electric switch adapted to actuate an audible alarm or a visual indicator when the pressure in the detection line 27 falls below the pressure normally required to actuate the controls of the system, thereby indicating an inadequate supply of actuating fluid in the control cylinder 30. It could also be set for operation at a somewhat lower pressure and be used to actuate a fire alarm in response to the detection line being vented by operation of the heat responsive device 31 or the manual valve 32.

Referring now to FIGS. 2, 3 and 4 for a detail description of the cylinder head valve 16, and wherein the parts of the valve are shown by the various figures in the different positions assumed at different times during the operation of the system, it is seen that the valve 16 is divided into two sections; a bottom section 35 and an upper section or discharge head 36. The bottom section 35 normally remains with the cylinder 15 and is threaded at its lower end 37 into the neck 38 thereof. A bore 39 is formed through the section 35 and, attached to it, is a dip tube 40 which communicates with the bore 39 and extends downwardly into the cylinder 15 so as to withdraw carbon dioxide liquid from the bottom of the cylinder.

Near the upper end of the lower section 35, the bore 39 is enlarged to form a valve chamber 41, and above this chamber 41, the bore 39 is still further enlarged and internally threaded as at 42 to receive a bushing 43 which engages a gasket 44 to effect a seal between the bottom section 35 and the bushing. An axial bore 45 is formed through the bushing in alignment with the bore 39 of the lower section and a valve seat 46 provided in the lower part of the bushing surrounds the opening defined by the bore. A valve member 47 is carried within the valve chamber 41 and cooperates with the valve seat 46 to control the flow of carbon dioxide from the valve chamber to the bore 45. The valve member 47 includes a resilient disc 48 adapted to engage the valve seat 46, a disc retainer 49 and a bolt 50 which fits through the disc and threads into the retainer to fasten together the latter two pieces.

Normally the valve member 47 is held in closed relationship with the valve seat 46 by a helical spring 52 compressed between the valve member 47 and the base 53 of the valve chamber 41, and by the pressure of the carbon dioxide which enters the valve chamber 41 from the cylinder 15.

The lower section 35 of the cylinder head valve 16 also includes a safety device 54, having a disc exposed to the pressure in the bore 39, which will rupture and release the contents of the cylinder 15 if an excessive pressure develops therein. It also includes a cylinder filling connection 55 comprising a valve member 56 located in a lateral passageway 57 communicating with the bore 39. A retainer 58 having a tubular extension 59 which partially covers the inner entrance of the passageway 57 prevents the valve member 56 from being displaced from the passageway.

The discharge head 36 is mounted on the lower section 35 by means of a union nut 60 which threadedly engages an enlargement 61 on the outer surface of the lower section. A bonnet 63 is attached to the upper end of the union nut 60 by means of a swivel joint comprising a circular series of balls 64 disposed in mating grooves formed in the two members and retained therein by the closure plug 65.

Interiorly, the bonnet 63 has a cylindrical bore 66 in which a piston 68 is movably disposed. The upper end of the cylindrical bore 66 is partially closed by an end wall 69 to provide a fluid pressure chamber 70 for the piston 68. An O-ring 71, carried by the piston 68, provides a sliding seal between the piston and the cylindrical bore. On its upper side, the piston 68 has a central extension 72 which fits loosely through an opening 73 formed in the upper wall 69, and the opening 73 leads to the discharge port 17 to which the duct 18 is attached.

The piston 68 is provided with a depending, centrally located hollow stem 75 which extends through the bore 45 of the bushing 43. A packing 76, retained in the upper end of the bushing 43 by a nut 77, provides a sliding seal between the stem 75 and the bushing 43. At its lower end, the stem 75 is provided with a number of lateral openings 78, and at its upper end is a ball check valve 79 for controlling the flow of carbon dioxide between the bore of the stem 75 and the passageway 80 in the extension 72. The bottom side of the piston 68 also includes a resilient disc 81, surrounding the stem 75, which engages a seat 82 on the upper end of the bushing 43 when the piston is moved to its lowest position.

FIG. 2 illustrates the condition of the cylinder head valve 16 when the valve member 47 is closed, or is engaging the seat 46. The broken vertical lines shown in this figure are intended to illustrate the presence of the high pressure carbon dioxide from the cylinder 15 up to the valve member 47 and the application of such fluid pressure and the pressure of the spring 52 to maintain the valve member seated until a greater force is applied to the upper side of the valve member.

Referring now to FIG. 3, the broken horizontal lines in the duct 18 and the chamber 70 above the piston 68 are intended to illustrate the presence of the control pressure carbon dioxide obtained from the cylinder 30 as a result of the operation of the control part of the system which will be described in detail at a later point.

To open the cylinder head valve 16, the control pressure actuating fluid flows to the port 17 through the duct 18. This actuating fluid pressure forces the ball check valve 79 against its seat to close the valve stem 75 and the actuating fluid enters the piston operating chamber 70 through the space between the opening 73 and the piston extension 72. The pressure of the actuating fluid in the chamber 70 acts on the upper side of the piston and drives it and the connected valve stem 75 downward. As it moves downward, the bottom end of the stem 75 engages the radial flange 51 of the bolt 50 and by further movement displaces the valve member 47 from the seat 46.

At this point, it should be noted that the upper surface of the piston 68 has a considerably larger effective area than that of the seat 46 and, therefore, the pressure of the actuating fluid employed to open the valve may be considerably lower than the relatively high pressure of the fluid within the cylinder 15. The position of the various parts of the cylinder head valve 16 at the instant the valve is opened is shown in FIG. 3.

As illustrated in FIG. 4, after the valve member 47 is moved off of its seat 46, carbon dioxide from the cylinder 15 enters the stem 75 through the openings 78, unseats the ball check valve 79, and flows through the port 17 and connecting duct 18. At the same time, the pressure of the carbon dioxide in the cylinder 15 will be present in the piston operating chamber 70 and will maintain the valve 47 in its open condition so long as an appreciable amount of pressure remains in the cylinder 15.

Referring now to FIGS. 5, 6 and 7 for a detail description of the pilot valve 20 and the predischarge timer 24, and wherein the devices are shown at various periods of operation of the system, it is seen that the pilot valve 20 includes a body 85 having a valve chamber 86, a bottom port 87 to which the duct 18 is connected, and a side port 88 to which the manifold 22 is connected. The ports 87 and 88 communicate with the valve chamber 86 and a valve seat 89 is formed in the base of the chamber around the bottom port 87.

The upper portion of the pilot valve body 85 includes a cylindrical piston operating chamber 90 which is closed at its upper end by a head assembly 91 that is threaded into the top of the body and provided with an O-ring 92 for effecting a seal between the head assembly 91 and the valve body 85. Through its central portion, the head assembly 91 has an aperture providing at its outer end a control pressure port 93 to which the duct 25 is connected.

Between the piston operating chamber 90 and the valve chamber 86 is a piston 96 having a lower stem 97 which extends into the valve chamber. The stem 97 is recessed at its lower end to receive a valve disc 98 which cooperates with the seat 89 to close and open the lower port 87 with respect to the valve chamber 86 in response to movements of the piston 96. The upper side of the piston 96 has another stem 99 extending upwardly therefrom which fits loosely in the port 93 and serves as a guide for the piston. To enable actuating fluid from the duct 25 to pass through the piston 96 to the connecting duct 18, the piston has formed therethrough a central passageway 100, and to prevent reverse flow through this passageway there is provided a check valve comprising a ball 101 which seats against a conical shoulder 102 formed in the passageway. The ball 101 is urged towards the shoulder 102 by a spring 103 that is held in place by an apertured retainer 104 threaded into the passageway 100. The retainer 104 also serves to hold the disc 98 in place on the end of the stem 97 by means of an enlarged head 105. An O-ring 106, carried by the piston 96, serves to effect a sliding seal between the piston and the wall of the piston operating chamber 90. In the case of the illustrated pilot valve 20 it will be noted that the upper surface of the piston 96 is considerably larger in area than the area of the seat 89 and that, therefore, the valve may be held closed by actuating fluid at a pressure considerably lower than the pressure of the carbon dioxide in the duct 18.

The predischarge timer 24 comprises three sections stacked one on top of the other; namely, an actuating section 108, a control valve section 109, and a control valve operating section 110. The actuating section 108 has a body 111 formed with an inlet chamber 112, an outlet chamber 113 and an exhaust chamber 114. The inlet chamber 112 is connected through an inlet port 115 to the duct 26 which communicates through the pressure reducer 28 to the control cylinder 30. An exhaust port 116 provides open communication between the exhaust chamber 114 and the atmosphere and an outlet port 117 provides communication between the outlet chamber 113 and a passageway 118 that is formed in the valve body 111. The outer end of the passageway 118 is aligned with the bore 119 of a coupling sleeve 120 which is seated in a recess 121 formed in the top of the valve body 111. A seal is provided between the sleeve 120 and the recess wall by an O-ring 122.

The outer end opening of the inlet chamber 112 has threaded therein an adapter 123 having a passageway 124 while the outer end portion of the passageway 124 has a branch 125 of the detection line 27 connected thereto by suitable coupling means. The inner end portion of the passageway 124 in the adapter 123 is counterbored, as at 126, to provide a seat for a spring 127 which is compressed between the adapter and a piston 128 located in the inlet chamber 112.

The piston 128 is provided with a circumferential groove 129 for receiving an O-ring 130 for effecting a seal between the piston and the wall of the inlet chamber 112. The portions of the chamber 112 on opposite sides of the piston 128 are in restricted communication with each other, however, through passageways 131 and 132 which extend through the piston, the passageway 132 having positioned therein a porous plug 133. The inner end of the piston 128 has mounted thereon a valve formed by the disc 134 which is clamped against the end of the piston by an abutment 135 formed adjacent the lower end portion of an operating rod 136 which is threaded into the piston 128. The abutment 135 is adapted to seat in a counterbored portion 137 of the outlet chamber 113 to permit the disc 134 to seat against the end wall 138 of the inlet chamber 112 to seal between the inlet and the outlet chambers.

Threaded onto the upper end portion of the operating rod 136 is an exhaust valve 139 which has a disc 140 mounted thereon between the inner end of the valve 139 and an abutment 141 formed on the upper end portion of the operating rod 136. By reference to FIG. 5, it will be noted that the length of the operating rod 136 is such that when the piston 128 is in the normal position shown with the disc 134 seated against the end wall 138 of the inlet chamber 112, the disc 140 will be held in spaced relationship with the end wall 142 of the exhaust chamber 114 so that the exhaust and outlet ports 116 and 117, respectively, will be in open communication with each other. Movement of the piston 128 to move the disc 134 away from its seated position against the end wall 138, however, will cause the disc 140 to engage the end wall 142 of the exhaust chamber 114 to seal between the outlet and exhaust chambers 113 and 114, respectively, and to place the inlet chamber 112 in open communication with the outlet chamber, as shown in FIGS. 6 and 7.

The piston 128 is moved between the two positions described above in the following manner:

Assuming first that the detection line 27 is closed so that the flow of actuating fluid thereto will be trapped and the pressure of the fluid will be increased, then actuating fluid flowing through the porous plug 133 and through the passageways 131 and 132 in the piston 128 will substantially equalize the pressures on opposite sides of the piston in the inlet chamber 112. The force exerted on the piston 128 by the spring 127 and by the pressure of the actuating fluid acting on the larger exposed area of the piston in the lower portion of the inlet chamber 112 will cause the piston to move to a position at which the disc 134 is seated against the end wall 138 of the inlet chamber 112 to provide a seal between the inlet chamber 112 and the outlet chamber 113.

The piston 128 will be held in this position even though there is a slight unintentional leakage of actuating fluid from the detection line 27 because the actuating fluid flowing through the plug 133 and the passageways 131 and 132 will maintain the pressure in the lower portion of the inlet chamber 112 substantially equal to that on the opposite sides of the piston.

A sudden discharge of the pressure fluid from the detection line 27, however, will reduce the forces acting on the outer end of the piston 128 to such an extent that the force exerted on the inner end of the piston by the pressure of the fluid in the adjacent portion of the inlet chamber 112 will move the piston to unseat the disc 134 from the end wall 138 and to cause the disc 140 of the exhaust valve 139 to seat against the end wall 142 of the exhaust chamber 114. Actuating fluid from the inlet chamber 112 will thereupon flow into the outlet chamber 113 and through the outlet port 117 into the passageway 118 and the bore 119 of the coupling sleeve 120. The piston 128 will remain in this position to unseat the disc **134** for so long as the flow of fluid from the detection line **27** exceeds the rate of flow of vapor through the plug **133** and through the passageways **131** and **132** in the piston.

The control valve section **109** of the predischarge timer **24** comprises a body **143** which has a recess **144** formed therein for receiving one end of the coupling sleeve **120**. An O-ring **145** forms a seal between the sleeve **120** and the recess **144**. Aligned with the bore of the sleeve **120** is a passageway **146** which forms an inlet for the control valve section. The inlet passageway **146** communicates with a header **147** that is formed in the body **143** and communicates with an inlet chamber **148**, a passageway **149** which leads to the upper surface of the body and a branch passageway **150** which leads to the control valve operating section **110**, as will be later described.

The wall of the inlet chamber **148** is formed with a shoulder **151** which functions as a valve seat, and the portion of the chamber below the shoulder communicates with an outlet passageway **152** and with the exhaust chamber **114** of the actuating section **108**. The header **147** communicates with that portion of the chamber **148** which is above the shoulder **151**. At its outer end, the outlet passageway **152** is enlarged to provide an outlet port **153** to which the duct **25** is connected.

Mounted in the inlet chamber **148** is a piston type valve **154**, called the control valve, which carries a disc **155** that is clamped between the control valve **154** and a spacer **155*a*** located in the lower part of the inlet chamber **148**. At the lower end of the spacer **155*a*** is a pilot exhaust valve **155*b*** which carries a disc **155*c*** clamped between the pilot exhaust valve **155*b*** and the spacer **155*a*** by a bolt **155*d*** passing through the pilot exhaust valve **155*b***, the spacer **155*a***, and the discs **155** and **155*c***, and threaded into the control valve **154**. The disc **155** is moveable into seated relationship with the shoulder **151** to provide a seat between the upper and lower portions of the inlet chamber **148** which communicate with the header **147** and the outlet passageway **152**, respectively. The pilot exhaust valve **155*b*** is moveable into seated relationship with an abutment **155*e*** to provide a seal between the lower portion of the inlet chamber **148** and the exhaust chamber **114**. By reference to FIG. 5, it will be noted that the spacer **155*a*** is of such a length that the pilot exhaust valve **155*b*** is unseated from the abutment **155*e*** to provide communication between the lower portion of the inlet chamber **148** and the exhaust chamber when the control valve is seated against the shoulder **151** closing the lower portion of the inlet chamber from the header **147**. Movement of the control valve to unseat the disc **155** from the abutment **151** will cause the pilot exhaust valve to be closed by seating the disc **155*c*** on the abutment **155*e***.

The control valve operating section **110** includes a dome-shaped housing **156** mounted on top of the control valve body **143** and a diaphragm **157** clamped between the control valve body and the housing in overlying relationship with the top surface of the valve body. The diaphragm **157** has a central opening through which a threaded upper end portion **158** of the valve **154** projects. A second aperture **159** is formed in the diaphragm **157** and is aligned with the passageway **150** from the header **147**. Threaded onto the upper end portion **158** of the valve **154** is a disc **160** which clamps the diaphragm therebetween. A spring guide **161** projects from the disc **160** and receives a spring **162** that is compresssed between the disc and the upper portion of the housing **156**.

The housing **156** has formed therein a passageway **163** that is aligned with the passageway **150** of the control valve body **143** and the opening **159** in the diaphragm **157** for the free flow of actuating fluid from the header **147** to the passageway **163**. A plug **164** is threaded into a tapped opening in the housing **156** and has a circumferential groove **165** formed therein in alignment with

the passageway **163**. Extending radially inwardly from the groove **165** are a plurality of passageways **166** which terminate at an axially arranged inwardly extending passageway **167**. The passageway **167** has positioned therein a porous plug **168** which provides a resistance to the flow of actuating fluid through the passageway. The plug **164** is sealed against the side of the housing **156** by a disc **169** and is sealed inwardly of the groove **165** by an O-ring gasket **170**.

The operation of the control valve section **109** and the control valve operating section **110** will be described together as follows:

Assuming first that the piston **128** of the actuating valve section **108** is in the normally closed position, as shown in FIG. 5, the upper portion of the inlet chamber **148** of the control valve section **109** will then be in open communication with the atmosphere through the header **147**, inlet passage **146**, the bore **119** of the coupling sleeve **120**, passageway **118** in the body **111**, the outlet chamber **113** and the exhaust chamber **114**. The lower portion of the inlet chamber **148** will be in open communication with the atmosphere directly through the exhaust chamber **114**. The chamber **171** within the dome-shaped housing **156** is also in communication with the atmosphere through the porous plug **168**, passageways **166** and **167**, passageway **163**, opening **159** in the diaphragm **157**, passageway **150**, header **147**, inlet passageway **146**, the bore **119** of the sleeve **120**, passageway **118** and through the outlet and exhaust chambers **113** and **114**, respectively. The pressure on the opposite sides of the diaphragm **157** being equal, therefore, the spring **162** will maintain the disc **155** in seated engagement with the shoulder **151** to prevent the flow of actuating fluid into the outlet passage **152** of the control valve section **109**.

When the piston **128** of the actuating valve section **108** is moved to its second position, as shown in FIGS. 6 and 7, actuating fluid is admitted to the outlet port **117** of the actuating valve section for flow through the passageway **118**, bore **119** of the sleeve **120**, inlet passageway **146** and header **147** to the inlet chamber **148** and, through the passageway **149**, to the undersurface of the diaphragm **157**. The pressure of the actuating fluid admitted through the passageway **149** and acting upon the entire undersurface of the diaphragm will move the disc **160** and the attached control valve **154**, and pilot exhaust valve **155*b***, against the force of the spring **162** to open the control valve and close the pilot exhaust valve by removing the disc **155** from the shoulder **151** and bringing the disc **155*c*** into seated engagement with the abutment **155*e***. As a result of this opening of the control valve and closing of the pilot exhaust valve, actuating fluid will flow freely from the header **147** into the outlet passageway **152** and into the duct **25**.

The condition of the predischarge timer **24** at this point in the operation of the control valve section **109** and the control valve operating section **110** is as shown in FIG. 6. From this latter figure it will be apparent that simultaneously with the admission of actuating fluid to the undersurface of the diaphragm **157**, additional fluid is admitted, at a retarded rate, to the chamber **171** in the dome-shaped housing **156**. This restricted flow will gradually increase the pressure within the chamber to a value at which the force exerted by the fluid on the upper side of the diaphragm **157** combined with the force exerted by the spring **162** will move the disc **160** to reclose the control valve **154** and reopen the pilot exhaust valve **155*b*** by seating the disc **155** against the shoulder **151** and removing the disc **155*c*** from the abutment **155*e***. At this point in its operation, the condition of the predischarge timer **24** is as illustrated in FIG. 7. The control valve **154** will remain in its closed position so that no actuating fluid can flow from the header **147** to the outlet passage **152**. The pilot exhaust valve will remain open so that the duct **25** is vented to atmosphere through the lower portion of the inlet chamber **148** and the exhaust chamber 114 until the upper portion of the inlet chamber 148 and the chamber 171 within the housing 156 have been vented to the atmosphere through the exhaust port 144 of the actuating valve section 109 by the piston 128 being returned to its normal position which will move the washer 140 from engagement with the end wall 142 and open the outlet port 117 to the exhaust port 116.

Referring now to FIGS. 8 and 9 for a detail description of the detection device 31 for automatically venting the detection line 27 in response to the presence of a predetermined degree of temperature in the hazard to be protected by the system, the device has a threaded end 175 enabling it to be connected to the detection line 27 by suitable coupling means (not shown). The threaded end 175 extends from a body portion 176 and a passageway 177 extends axially through both the threaded end and the body portion. From opposite sides of the body portion 176, arms 178 extend arcuately outwardly and downwardly and are joined in axially spaced relationship from the outer end of the passageway 177.

Positioned across the outer end of the passageway 177, in sealing relationship with the body portion 176, is a metal disc 179 which is held in place by a link 180 that extends from the disc through a heat collecting bell 181. The lower end of the link 180 is supported by engagement with an L-shaped lever 183, one end of which is supported at the point of juncture between the two arms 178 and the opposite end of which is soldered to the heat collecting bell 181 with a soldered connection 184 having a predetermined melting temperature equal to the desired temperature at which the system is to be actuated.

When sufficient heated air of proper temperature flows around the heat collecting bell 181, the solder at the connection 184 will be melted to release one end of the lever 183. This lever will then fall away releasing the link 180 so that the disc 179 will fall away from, and open the outer end of, the passageway 177 so that the detection line 27 will be quickly vented to reduce the pressure therein.

Referring now to FIG. 10 for a detail description of the push button device 32 for manually venting the detection line 27, it will be noted that the device includes a body 187 having an inlet passageway 188 to which the detection line 27 is connected. At its inner end the inlet passageway 188 communicates with a lateral passageway 189 leading to an exhaust chamber 190 that is open to the atmosphere through another passageway 191 and an exhaust port 192.

At one side of the exhaust chamber 190, a valve seat 193 is formed around the opening defined by the lateral passageway 189 and at the other side of the exhaust chamber 190 is a diaphragm 194 which serves as a valve member cooperating with the seat 193. On the opposite side of the chamber 190 from the passageway 189, and in alignment therewith, is an opening 195 in the valve body which receives a ball 196 and which communicates with a larger opening 197 formed entirely through the valve body. The plunger 198 is provided with a head or button 199 at its forward end and a stem 200 which fits loosely within the opening 197 for reciprocating movement of the plunger relative thereto between limits defined by a rear shoulder 201 and a forward shoulder 202 on the stem that are adapted to engage the valve body. With the plunger 198 in the normal position illustrated in FIG. 10; that is, with the rear shoulder 201 in engagement with the surface of the valve body 187, it will be noted that the portion of the stem 200 aligned with the opening 195 is of a full diameter substantially equal to that of the opening 197 and that the ball 196 which engages this portion of the stem is held thereby in such a position as to urge the diaphragm 194 into tight engagement with the seat 193, thereby sealing the passageway 189 from the exhaust chamber 190.

Forwardly of the opening 195, however, the stem 200 is provided with a reduced diameter portion 204 and a conical transition portion 205. The location of the reduced diameter portion 204 is such that it will become aligned with the opening 195 when the plunger 198 is moved, by manually pushing the button 199, to a position at which the forward shoulder 202 engages the valve body 187. In this new position of the plunger 198, the ball 196 will occupy the space provided by the reduced diameter portion 204 and the diaphragm 194 will be moved from the seat 193 permitting the detection line 27 to vent through the passageways 188 and 189, the exhaust chamber 190, the passageway 191 and the exhaust port 192.

The operation of the system, in automatically detecting a fire, providing a predischarge delay period and releasing the extinguishing medium for flow to the affected hazard, will now be described as follows:

In the normal ready or stand-by condition of the system the movable parts of the control devices are positioned as shown in FIGS. 2 and 5. In the cylinder head valve 16, the valve member 47 is held, by the pressure of the carbon dioxide in the cylinder 15 and the spring 52, in its closed relation to the seat 46 and the carbon dioxide which is used as the extinguishing medium is thereby retained entirely within the cylinder 15. In the predischarge timer 24, the piston 128 is held with the disc 134 in engagement with the end wall 138 by the pressure of the actuating fluid, supplied from the control cylinder 30, acting on the bottom of the piston together with the force of the spring 127. The pilot valve 20, the control valve section 109 and the control valve operating section 110 of the predischarge timer are at this time in an inactive condition.

Assuming next that a fire breaks out at a protected hazard, the detecting device 31, which is located at the hazard, will be actuated by the heat of the fire to vent the detection line 27 at a rate faster than additional actuating fluid can be supplied to the line through the porous plug 133 in the piston 128 of the predischarge timer. As a result, a difference in pressures is established across the piston 128 sufficient to move the latter against the force of the spring 127, thereby removing the disc 134 from the end wall 138 and permitting actuating fluid from the line 26 to enter the outlet chamber 113. From the outlet chamber 113, part of the actuating fluid is directed to the undersurface of the diaphragm 157 causing the disc 160 and the attached control valve 154, and pilot exhaust valve 155*b*, to be moved upwardly against the force of the spring 162, unseating the disc 155 from the abutment 151, which opens the inlet chamber 148 to the outlet passageway 152, and seating the disc 155*c* on the abutment 155*e*, which seals the lower portion of the inlet chamber 148 from the exhaust chamber 114. Additional actuating fluid from the outlet chamber 113 is admitted to the inlet chamber 148 and, since the control valve 154 is opened and the pilot exhaust valve 155*b* is closed, the fluid will pass through the inlet chamber 148 to the outlet passageway 152 and from the latter through the duct 25 to the control pressure port 93 of the pilot valve 20.

In the pilot valve 20 part of the actuating fluid supplied thereto by the duct 25 enters the piston operating chamber 90 and, due to its pressure, will move the piston 96 to close the disc 98 on the seat 89. Another portion of the actuating fluid enters the passageway 100 in the piston 96, unseats the ball 101 from the conical seat 102, and passes through the piston into the connecting duct 18.

The actuating fluid which passes through the piston 96 of the pilot valve 20 is transmitted by the connecting duct 18 to the port 17 of the cylinder head valve 16, and from the port 17 it enters the piston operating chamber 70. The pressure of the actuating fluid in the chamber 70 produces a force on the upper side of the piston 68 which will move the piston downwardly and brings the lower end of the stem 75 into engagement with the valve member 47. Furthermore, due to the relatively large area of the piston 68 with respect to the area of the seat 46, the valve member 47 will be moved from the seat 46 by further movement of the piston despite the fact that the pressure of the actuating fluid in the cylinder 15, which acts on the bottom of the valve member 47, may be considerably greater than the pressure of the actuating fluid in the chamber 70. After the valve member 47 is moved from the seat 46, carbon dioxide from the cylinder 15 will flow past the seat 46, enter the openings 78 in the stem 75, and travel upwardly through the hollow bore of the stem.

FIGS. 3 and 6 taken together show the condition of the controls at this point in the operating cycle of the system, just after the valve member 47 has been removed from the seat 46 and the carbon dioxide from the cylinder 15 has begun to enter the bore of the stem 75.

From FIGS. 3 and 6, it will be readily apparent that the carbon dioxide from the cylinder 15, which flows into the bore of the stem 75, will unseat the ball 79 at the top of the stem and that some of it will enter the piston operating chamber 70 and the connecting duct 18, bringing the pressure in the chamber and the connecting duct up to that of the cylinder 15. The increased pressure in the connecting duct 18 is immediately transmited to the lower port 87 of the pilot valve 20, however, the carbon dioxide in the duct 18 is prevented from entering the valve chamber 86 of the pilot valve by the disc 98 which is held on the seat 89 by the pressure of the actuating fluid applied to the upper side of the piston 96. The carbon dioxide from the connecting duct 18 is also prevented from passing through the piston 96, by way of the passageway 100, by the ball check valve 101 which will be urged against the conical seat 102 by the higher pressure of the carbon dioxide in the connecting duct 18. Therefore, although the cylinder head valve 16 is opened almost instantaneously after the detection line 27 is vented, the flow of carbon dioxide from the cylinder 15 to the delivery pipe or manifold 22 after the cylinder head valve is opened is initially prevented by the pilot valve 20.

The operation of the pilot valve 20 in preventing the flow of carbon dioxide from the connecting duct 18 to the delivery pipe or manifold 22 is, however, only temporary, the pilot valve remaining closed only for a given amount of time, as predetermined by the predischarge timer 24, to provide a discharge delay period between the detection of the fire and the initiation of discharge at the affected hazard. From FIG. 6, it will be noted that when some of the actuating fluid is applied to the undersurface of the diaphragm 157 in the control valve operating section 110 of the predischarge timer 24, additional fluid is admitted to the chamber 171 at a restricted rate through the porous plug 168. After a predetermined period of time, this admission of fluid to the chamber 171 will increase the pressure within the chamber to a value at which the force exerted on the upper side of the diaphragm, together with the force of the spring 162, are sufficient to move the diaphragm 157 and disc 160 downwardly and cause the disc 155 of the control valve 154 to be reseated against the shoulder 151, closing the upper portion of the inlet chamber 148 from the outlet passageway 152 and preventing further flow of actuating fluid to the outer passageway. Simultaneously with the reseating of the disc 155, the downward movement of the disc 160 causes the disc 155*c* to be removed from the abutment 155*e*, opening the outlet passageway 152 to the atmosphere through the lower portion of the inlet chamber 148 and exhaust chamber 114 and venting the actuating fluid from the duct 25 and the piston operating chamber 90 of the pilot valve 20.

After enough actuating fluid is vented from the piston operating chamber 90 of the pilot valve, the high pressure carbon dioxide in the connecting duct 18 acting on the lower end of the piston 96 will move the piston to remove the disc 98 from the seat 89 to permit the flow of high pressure carbon dioxide to the valve chamber 86. Once in the valve chamber 86, the high pressure carbon dioxide is applied to the entire undersurface of the piston 96 and the latter will thereby be held in a fully raised position so long as the high pressure is maintained in the valve chamber. From the valve chamber 86 the high pressure carbon dioxide will flow through the side port 88 to the delivery pipe or manifold 22 and be transmitted thereby to the affected hazard. At this point in the operation of the system, after the pilot valve has been opened to release high pressure carbon dioxide to the delivery pipe or manifold, the condition of the controls are as shown in FIGS. 4 and 7.

Once the high pressure carbon dioxide has entered the delivery pipe or manifold 22, the cylinder head valve 16 and the pilot valve 20 will remain open, due to the high pressure carbon dioxide acting on the pistons 68 and 96, respectively, until the supply of carbon dioxide in the cylinder 15 is exhausted to such a point that the pressure thereof acting on the piston 68 of the cylinder head valve is insufficient to maintain the valve member 47 open against the force of the spring 52.

As described above, the system illustrated in FIGS. 1 to 10 operates to provide a delay period between the detection of a fire at a hazard and the initiation of the discharge. In some cases, however, it may be desirable to eliminate this predischarge delay period and to have the extinguishing medium supplied to the hazard almost immediately upon the detection of a fire. With the present system such a change in operation can be readily accomplished by using a pilot valve having a piston with a substantially smaller effective area than the piston 96 of the pilot valve 20.

In FIG. 11 there is shown a pilot valve 210 which may be substituted for the pilot valve 20 in the system of FIG. 1 to provide for an immediate rather than a delayed discharge. The body of the pilot valve 210 is similar to the body 85 of the pilot valve 20 and therefore the same reference numerals have been applied to the various parts thereof and no further description is believed necessary.

In addition to the body 85, the pilot valve 210 includes a head assembly 211 threaded into the top of the body and provided with an O-ring 212 to establish a seal between the body and the head assembly. Below the O-ring 212 the head assembly 211 has a portion 213 of reduced diameter that extends downwardly into the valve chamber 86. An axial bore is formed through the head assembly 211 and consists of an outer portion 214 threaded to receive a fitting for the duct 25, a central portion 215, and an enlarged inner portion 216 which receives a piston 217.

The piston 217 fits in the enlarged bore portion 216 and a sliding seal is effected between the bore and the piston by an O-ring 218 located in a circumferential groove formed in the outer surface of the piston. At its upper end the piston 217 has an extension 219 adapted to fit loosely in the central bore portion 215, and at its lower end is a valve disc 220 which cooperates with the seat 89 to control fluid flow between the lower port 87 and the valve chamber 86. A passageway 221 is formed through the length of the piston 217 and flow through this passageway is controlled by a check valve consisting of a ball 222 urged by a spring 223 against a conical seat 224. The spring 223 is held in place in the piston 217 by a retainer 225 threaded into the lower end of the passageway 221, the retainer having an enlarged head 226 for clamping the valve disc 220 to the piston.

In operation, actuating fluid is supplied to the pilot valve 210 by the duct 25 upon the venting of the detection line 27. This actuating fluid will pass through the outer bore portion 214, enter the central bore portion 215 and flow between the bore and the piston extension 219 to the operating chamber 227 located above the piston 217. The pressure of the actuating fluid in the operating chamber 227 will urge the piston downwardly and hold the valve disc 220 against the seat 89 to seal the valve chamber 86 from the lower port 87. In addition, actuating fluid from the central bore portion 215 will pass through the passageway 221 in the piston, move the ball 222 from the seat 224 and flow to the lower port 87. From the lower port 87 the actuating fluid passes through the duct 18 to the cylinder head valve 16 and effects the opening thereof as previously described.

At this point it should be noted that the effective area of the piston 217 is only slightly larger than the effective area of the lower port 87. Therefore, when the cylinder pressure is applied to the lower port 87 the force produced by the actuating fluid, which is at a substantially lower pressure than the fluid in the cylinder, acting over the effective area of the piston will be insufficient to hold the piston closed against the force produced by the pressure of the cylinder fluid acting on the area of the piston exposed by the port 87, and the piston will be moved to an open position despite the existence of the actuating pressure in the operating chamber 227.

In other words, when actuating fluid is supplied to the pilot valve 210, the piston 217 is held in a closed position only for so long as is required to attain a pressure in the lower port 87 and in the duct 18 sufficient to cause the opening of the cylinder head valve 16. Once the cylinder head valve is opened the pressure of the cylinder is applied to the duct 18 and lower port 87 and the piston 217 will be moved to an open position by this pressure. The time required for the build up of the actuating pressure in the duct 18 is relatively short so that the discharge of the extinguishing medium to the manifold pipe 22 is virtually simultaneous with the application of the actuating pressure to the pilot valve, and may be said to occur immediately thereafter.

In the event the cylinder 15 is too small to store an adequate supply of carbon dioxide to afford proper protection, additional cylinders similar to the cylinder 15 may be added to the system. These additional cylinders may be attached to the delivery pipe or manifold 22 by means of branch ducts similar to the connecting duct 18 and through cylinder head valves similar to the cylinder head valve 16. Therefore, when the carbon dioxide from the cylinder 15 enters the delivery pipe or manifold 22 it will flow through the branch ducts and actuate the cylinder head valves of any additional cylinders connected thereto and thereby release the contents of the additional cylinders to supplement the contents of the cylinder 15.

It is to be understood that the forms of this invention herewith shown and described are to be taken as preferred examples of the same and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described the invention, we claim:

1. A fire extinguishing system, comprising a source of fire extinguishing fluid confined under its own vapor pressure, a delivery line for carrying fire extinguishing fluid from said source to a hazard, a normally closed main valve between said source and said delivery line, a source of actuating fluid, first pressure responsive means for opening said main valve in response to the application of actuating pressure fluid thereto at a control pressure substantially below the vapor pressure of the extinguishing fluid and for thereafter maintaining said main valve in an open condition by the application of extinguishing fluid from said source, a pilot valve between said delivery line and said main valve, second pressure responsive means for closing said pilot valve in response to the application of actuating pressure fluid thereto, means for simultaneously applying actuating pressure fluid to said first and second pressure responsive means to simultaneously open said main valve and close said pilot valve, and means for subsequently terminating the application of actuating pressure fluid to said second pressure responsive means and for venting the remaining actuating pressure fluid therefrom to open said pilot valve and permit the extinguishing fluid to flow to said delivery line.

2. A fire extinguishing system, comprising a source of fire extinguishing fluid confined under its own vapor pressure, an entirely separate source of actuating fluid supplied to the system at a control pressure substantially lower than the vapor pressure of the extinguishing fluid, a delivery line, a normally closed main valve between said source of extinguishing fluid and said delivery line, a pilot valve between said main valve and said delivery line including a valve seat and a moveable disc therefor, an operator for said main valve responsive to the application of actuating fluid thereto at the control pressure to open said main valve, an operator for said pilot valve responsive to the application of actuating fluid thereto at the control pressure to hold said disc closed on its seat against the vapor pressure of the extinguishing fluid acting across the effective area of said seat, means for applying the actuating fluid at the control pressure to both of said valve operators to open said main valve and hold closed said pilot valve, and time delay means for relieving the pressure of the actuating fluid applied to the pilot valve operator at a predetermined time after the initiation of its application thereto to permit the extinguishing fluid acting across said seat to open said pilot valve at said predetermined time and to flow from said source to said delivery line.

3. A fire extinguishing system, comprising a source of fire extinguishing fluid confined under its own vapor pressure, an entirely separate source of actuating fluid supplied to the system at a control pressure substantially lower than the vapor pressure of the extinguishing fluid, a delivery line for conducting extinguishing fluid to a hazard to be protected, a normally closed main valve between said source of extinguishing fluid and said delivery line, a pilot valve between said main valve and said delivery line including a valve seat and a moveable disc therefor, an operator for said main valve responsive to the application of actuating fluid thereto at the control pressure to open said main valve, an operator for said pilot valve responsive to the application of actuating fluid thereto at the control pressure to hold said disc closed on its seat against the higher vapor pressure of the extinguishing fluid acting across the effective area of said seat, a normally closed fire detection line supplied with actuating fluid and normally maintained thereby at the control pressure, means at the hazard for venting the detection line in response to the heat of a fire, means responsive to the venting of the detection line for simultaneously applying actuating fluid at the control pressure to both of said valve operators to open said main valve and hold closed said pilot valve, and time delay means for relieving the pressure of the actuating fluid applied to the pilot valve operator at a predetermined time after the initiation of its application thereto to permit the extinguishing fluid acting across said seat to move said disc therefrom at said predetermined time and to flow to the hazard through said delivery line.

4. A fire extinguishing system, comprising container means for storing a quantity of liquid carbon dioxide at ambient temperature and its corresponding vapor pressure, a source of actuating pressure fluid supplied to the system at a control pressure substantially lower than the vapor pressure of the extinguishing fluid, a normally closed pressure actuated main valve for said container means having a common port for the admission of actuating pressure fluid thereto to open the valve and for the discharge of carbon dioxide therefrom after the valve is opened, a duct connected to said common port, a delivery line communicating with said duct for conducting carbon dioxide to a hazard to be protected, a pilot valve between said duct and delivery line, valve operator means for said pilot valve responsive to the application of

actuating pressure fluid thereto to close said pilot valve, means for conducting actuating pressure fluid from said valve operator means to said duct to open said main valve and release carbon dioxide to said duct while said pilot valve is held closed by said valve operator means, said pilot valve being movable to an open position by the pressure of carbon dioxide in said duct after the pressure of the actuating fluid is relieved from said valve operator means, means for applying actuating pressure fluid to said valve operator means in response to the detection of a fire at the hazard, and means operable at a predetermined time subsequent to the initiation of flow of actuating pressure fluid to said valve operator means for relieving the pressure of the actuating fluid applied to said operator means.

5. A fire extinguishing system, comprising container means for storing a quantity of liquid carbon dioxide at ambient temperature and its corresponding vapor pressure, a source of actuating pressure fluid supplied to the system at a control pressure substantially lower than the vapor pressure of the extinguishing fluid, a normally closed valve for said container means having a pressure responsive operator and a common port for the admission of actuating pressure fluid to said operator to open said valve and for the discharge of carbon dioxide after said valve is opened, a delivery line for conducting carbon dioxide to a hazard to be protected, a duct between the common port of said container means valve and said delivery line, a pilot valve between said duct and said delivery line for controlling the flow of carbon dioxide from said duct to said delivery line, said pilot valve being movable to an open position by the pressure of carbon dioxide in said duct, operator means for said pilot valve responsive to the application of actuating pressure fluid thereto to close said pilot valve, means forming a passageway between said pilot valve operator means and said duct enabling actuating fluid to flow from said pilot valve operator means to said duct and container valve operator while said duct is closed from said delivery line by said pilot valve, a check valve in said passageway for preventing the flow of carbon dioxide therethrough in the reverse direction to the pilot valve operator means, and means for applying actuating pressure fluid from said source to said pilot valve operator means in response to a fire at said hazard.

6. A fire extinguishing system as defined in claim 5 further characterized by said pilot valve operator being operative to hold said pilot valve closed against the pressure of carbon dioxide in said duct as long as actuating pressure fluid is applied thereto, and means operative at a predetermined time after the initiation of the application of actuating pressure fluid to said pilot valve operator for terminating said application and relieving the pressure of said actuating fluid from said pilot valve operator to permit the carbon dioxide in said duct to open said pilot valve and flow to said delivery line.

7. A fire extinguishing system as defined in claim 5 further characterized by said means for applying actuating pressure fluid from said source to said pilot valve operator comprising a normally closed detection line filled with said actuating pressure fluid, means for venting said detection line in response to a fire at said hazard, and means for applying actuating pressure fluid to said pilot valve operator in response to the venting of said detection line.

8. A fire extinguishing system comprising, a container for storing a quantity of liquid carbon dioxide at ambient temperature and its corresponding vapor pressure, a source of supply of actuating pressure fluid supplied to the system at a control pressure substantially lower than the vapor pressure of the extinguishing fluid, a normally closed valve for said container means having a pressure responsive operator and a common port for the admission of actuating pressure fluid to said operator to open said valve and for the discharge of carbon dioxide after said valve is opened, a delivery line for conducting carbon dioxide to a hazard to be protected, a first duct between the common port of said container valve and said delivery line, a pilot valve between said first duct and said delivery line including a valve element movable between open and closed positions for permitting and preventing, respectively, the flow of carbon dioxide from said duct to said delivery line and arranged to be urged toward said open position by the pressure of carbon dioxide in said first duct, operator means for said pilot valve for urging said valve element toward its closed position in response to the application of actuating pressure fluid thereto, a normally closed fire detection line in restricted communication with said source of actuating pressure fluid and normally filled with said fluid, heat responsive means for venting said detection line in the event of a fire at said hazard, a control duct between said actuating pressure fluid source and said pilot valve operator means, a normally closed actuating valve in said control duct, a pressure responsive means for opening said actuating valve when said detection line is vented, a control valve in said control duct between said pilot valve operating means and said actuating valve, a diaphragm operator for said control valve, a spring urging said control valve into closed position when the pressures on the opposite sides of the diaphragm operator are equal, means for rapidly admitting actuating pressure fluid to one side of said diaphragm operator when said actuating valve is opened to open said control valve and permit the flow of pressure fluid through said control duct to the pilot valve operating means to close said pilot valve, means for admitting actuating pressure fluid at a retarded rate to the other side of diaphragm operator to gradually equalize the pressure on the opposite sides thereof and cause said spring to reclose the control valve at a predetermined time after the latter is opened, and means for releasing actuating pressure fluid from said pilot valve operator means after said control valve is reclosed to enable the carbon dioxide from said container means to open said pilot valve and flow through said delivery line to the hazard.

9. The combination as defined in claim 8 further characterized by said means for releasing actuating pressure fluid from said pilot valve operator means comprising means defining a passageway between the atmosphere and a point in said control duct between said control valve and said pilot valve operator means, and an exhaust valve for said passageway operated by said diaphragm operator in conjunction with said control valve to close said passageway when said control valve is open and open said passageway when said control valve is closed.

10. A fire extinguishing system, comprising: supply means for storing in a liquid state a quantity of normally gaseous fire extinguishing fluid at ambient temperature and at its corresponding vapor pressure; a delivery line for conducting extinguishing fluid from said supply means to a hazard to be protected; a normally closed valve for releasing extinguishing fluid from said supply means to said delivery line; a source of actuating fluid separate from said supply means; a normally closed detection line, said source of actuating fluid filling said detection line with fluid at a pressure lower than the pressure of the extinguishing fluid in said supply means; means for venting said detection line; a pressure responsive means for operating said valve; means responsive to the venting of said detection line for positively applying actuating fluid to said pressure responsive means to open said valve and to thereby cause the release of extinguishing fluid to said delivery line.

11. A fire extinguishing system comprising: a supply means for storing in a liquid state a quantity of normally gaseous fire extinguishing fluid at ambient temperature and its corresponding vapor pressure; a delivery line for conducting extinguishing fluid from said supply means to

a hazard to be protected; a normally closed valve for releasing extinguishing fluid from said supply means to said delivery line; a source of actuating fluid separate from said supply means; a normally closed detection line; means for venting said detection line; a flow path between said source of actuating fluid and said detection line; a pressure reducer in said flow path for maintaining a preselected control pressure in said detection line at a lower value than the pressure of the extinguishing fluid; a pressure responsive means for operating said valve in response to the application of actuating fluid thereto; duct means communicating with said flow path between said pressure reducer and said detection line for supplying actuating fluid at said control pressure to said pressure responsive means; a normally closed valve in said duct means for preventing the flow of actuating fluid to said pressure responsive means; and means responsive to the venting of said detection line for opening said normally closed valve to permit the positive flow of actuating fluid to said pressure responsive means to open said main valve and to cause the release of extinguishing fluid to said delivery line.

12. A fire extinguishing system, comprising a source of fire extinguishing fluid confined at ambient temperature and its corresponding vapor pressure, a delivery line for carrying fire extinguishing fluid from said source to a hazard to be protected, a normally closed main valve between said source and said delivery line, a source of actuating fluid separate from the source of fire extinguishing fluid, first pressure responsive means for operating said main valve in response to the application of actuating fluid thereto at a control pressure substantially below the pressure of the extinguishing fluid and for thereafter maintaining said main valve in an open condition by the application of fire extinguishing fluid from said source, a pilot valve between said delivery line and said main valve, second pressure responsive means for closing said pilot valve in response to the application of actuating fluid thereto, means for applying actuating fluid to said second pressure responsive means when said first pressure responsive means is actuated to open said main valve and to close said pilot valve to prevent the flow of extinguishing fluid to said delivery line despite the opening of said main valve, and means for subsequently terminating the application of actuating fluid to said second pressure responsive means and for venting the remaining actuating fluid therefrom to open said pilot valve and permit the extinguishing fluid to flow to said delivery line.

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