United States Patent

Livingston

[15] **3,645,338**

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[54] FIXED FIRE-EXTINGUISHING SYSTEM

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[73] Assignee: **Factory Mutual Research Corporation,** Norwood, Mass.

[22] Filed: **Oct. 8, 1969**

[21] Appl. No.: **864,612**

[52] **U.S. Cl.** **169/16,** 169/42

[51] **Int. Cl.** **A62c 35/00**

[58] **Field of Search** 169/1, 2, 16, 15, 14, 42; 239/DIG. 1, 570

[56] **References Cited**

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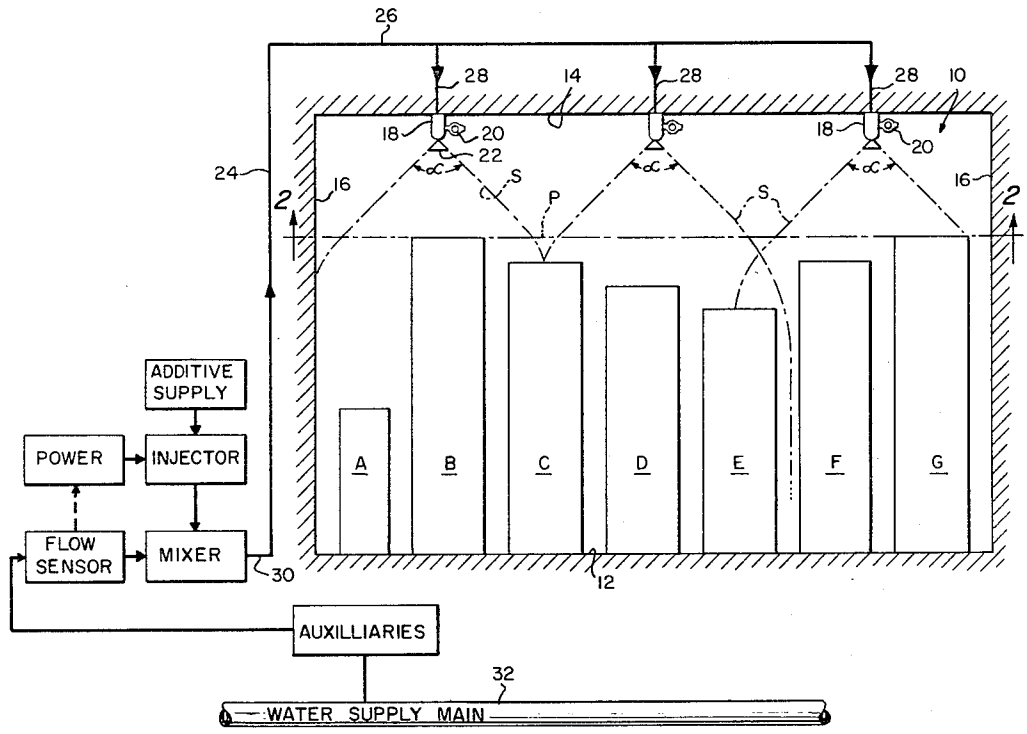
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[57] **ABSTRACT**

A fixed fire protection system and method by which discrete areas of extinguishant coverage are selected for each of several nozzle heads on the basis of the maximum elevation of fuel surfaces in the space protected.

10 Claims, 6 Drawing Figures



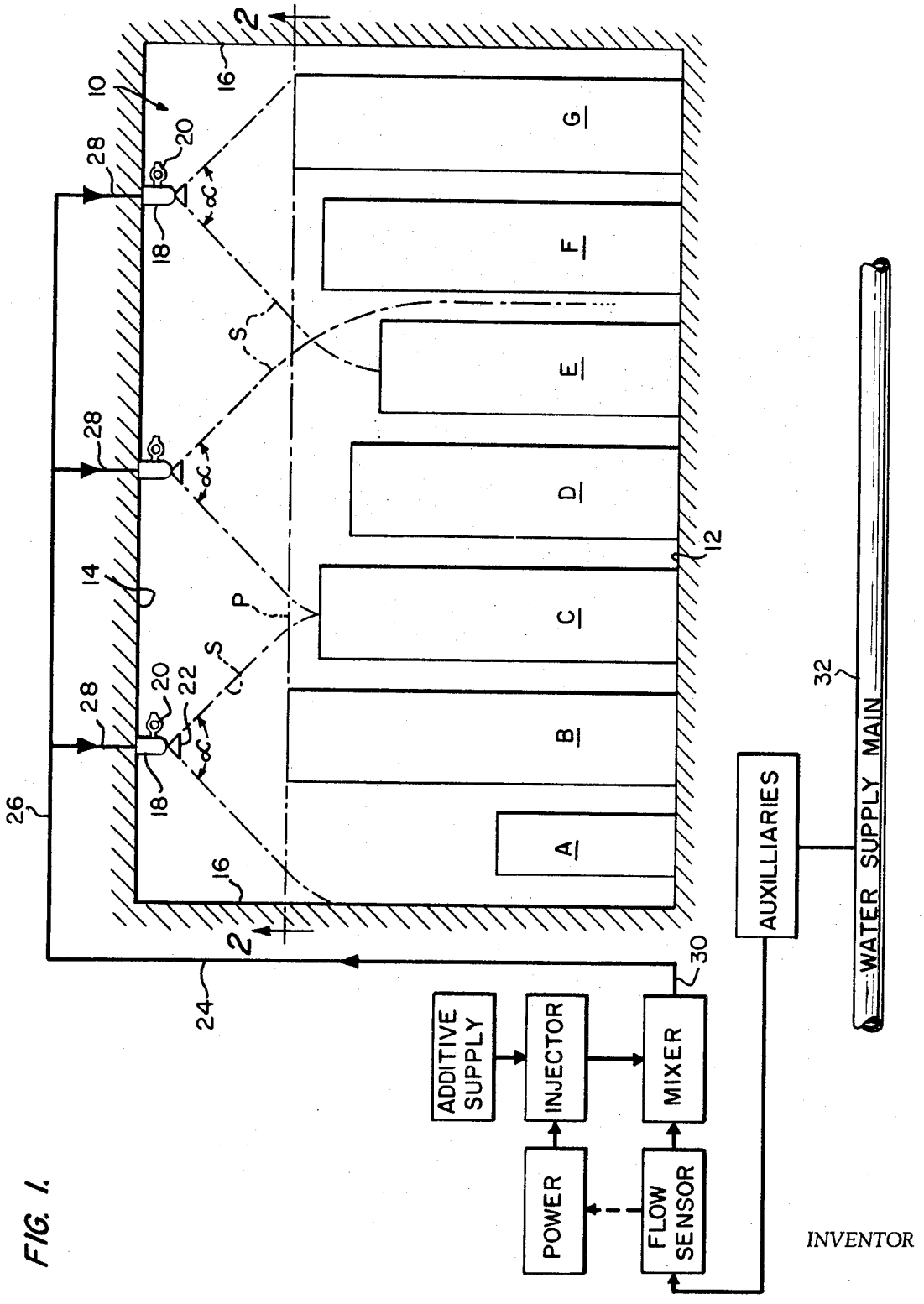


FIG. 1.

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FIG. 2.

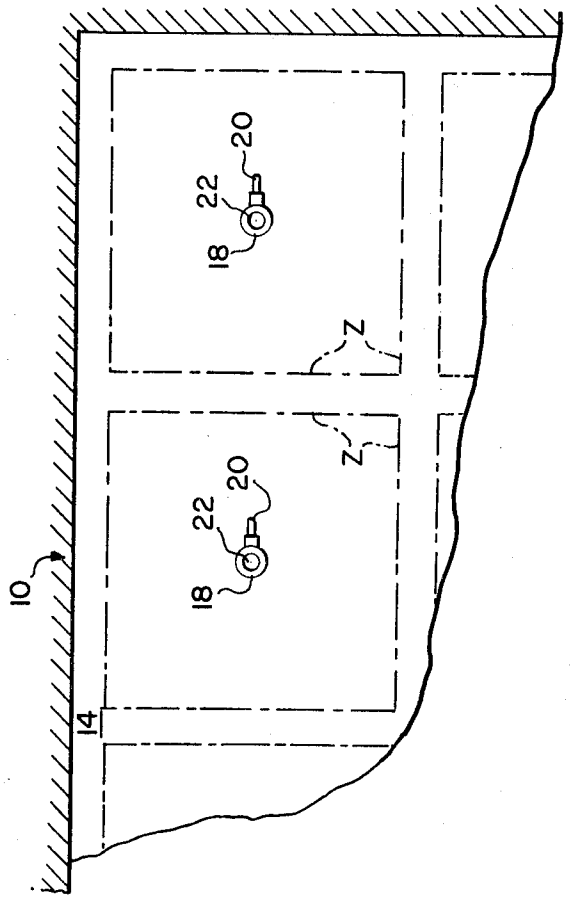


FIG. 3.

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FIG. 4.

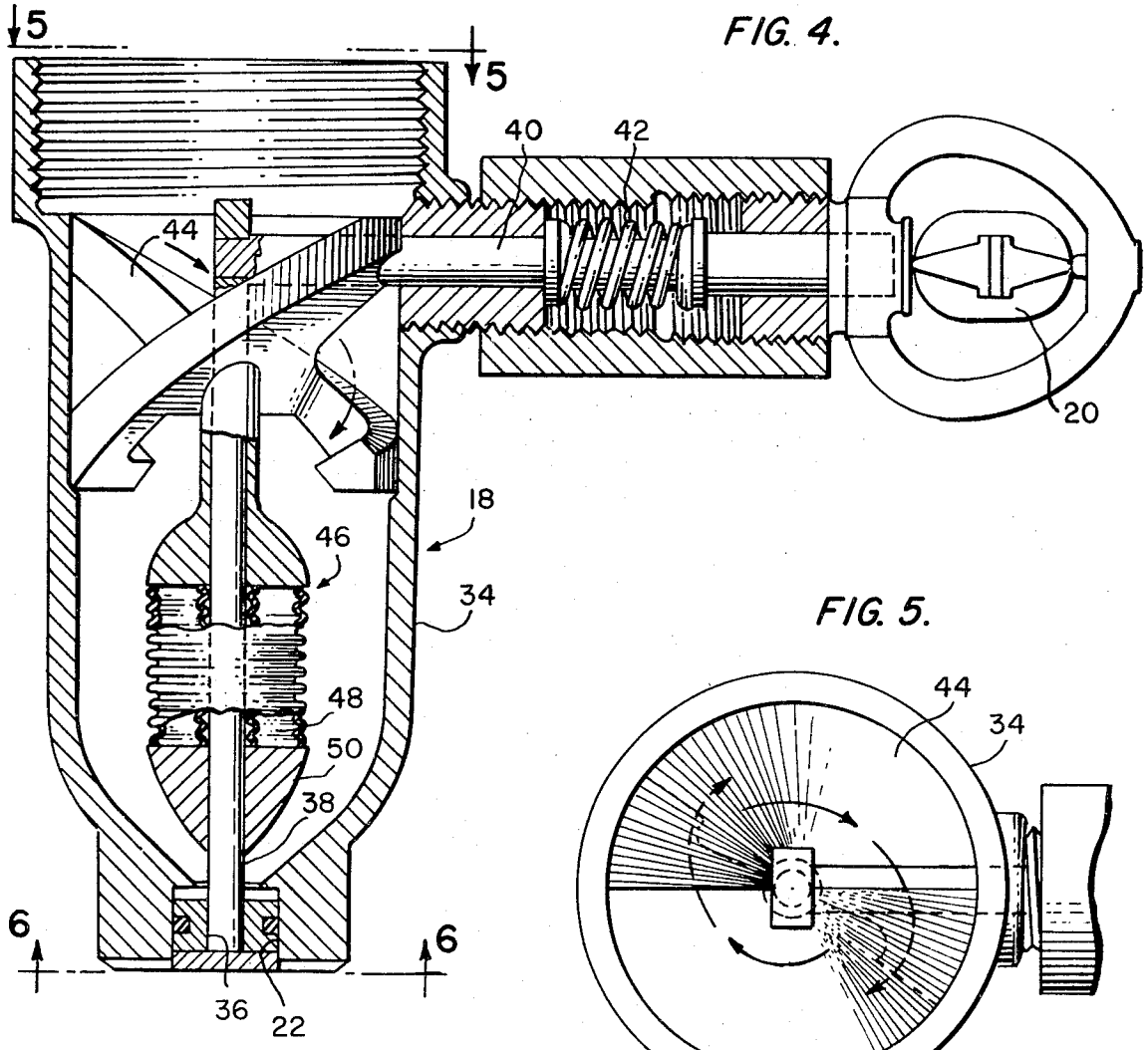
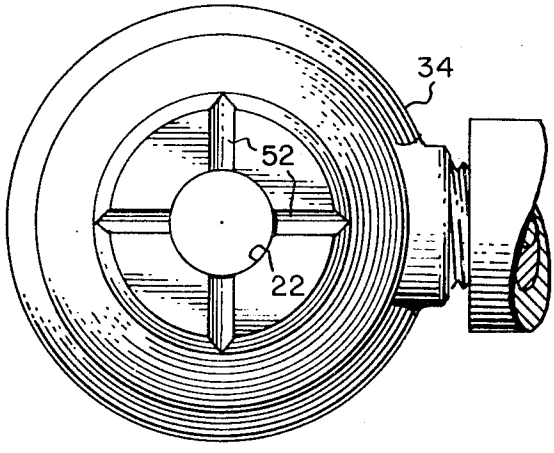


FIG. 5.

FIG. 6.



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FIXED FIRE-EXTINGUISHING SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

Method of Controlling Fire—Ser. No. 766,475, filed Oct. 10, 1968 by William L. Livingston and Russell W. Pierce;

Additive Injection System—Ser. No. 864,757, filed concurrently herewith, by William L. Livingston;

Fire Responsive Sprinkler Head—Ser. No. 864,756, filed concurrently herewith, by William L. Livingston and S. D. Tine.

BACKGROUND OF THE INVENTION

This invention relates to improvements in fixed fire-extinguishing systems and methods. More particularly, it concerns a unique method of fire protection and a novel arrangement of extinguishant disbursing, independently actuated spray heads by which enhanced fire-extinguishing capability is imparted both to each head individually and to a plurality of such heads operating concurrently upon the existence of a fire in the space protected by the system.

In traditional fixed fire-extinguishing systems of the type in which water or other suitable extinguishant is supplied automatically to one or more prepositioned sprinkler heads by actuation of a fire-responsive device associated with each head, the spray developed by each head is a result of impinging a jet of water, either upwardly or downwardly, against a deflector disc or plate to develop an initially lateral trajectory of extinguishant over the area to be wetted by each head. The heads in such systems are usually spaced by design so that the area to be wetted by one head overlaps substantially the area wetted by adjacent heads, principally to insure that all portions of the space protected will lie within an area to which extinguishant can be delivered by one or more heads. One of the principal design considerations for such systems is to deliver an ample quantity of extinguishant over a sufficiently large area so that upon the existence of a fire, lateral spreading of the fire will be prevented. Such systems have been found in practice to be reasonably well suited for the protection of building spaces where the overall floor-to-ceiling height of the space is on the order of 10 feet or less. Inasmuch as the height of combustible materials or fuel in such space, as well as the supply of air therein is limited, the danger of a high-intensity, laterally localized fire is not presented.

In building spaces higher than 10 feet, such as warehouses and the like, which may be as high as 30 feet or more, and containing piles of combustible materials exceeding 90 percent of the height of the space, conventional fire-extinguishing systems of the type referred to have been found ineffective in terms of capability to extinguish the fires. Several basic design deficiencies are believed to be responsible for such ineffectiveness. In the first place, a fire in such a space, once started, is able to develop very rapidly in a vertical direction because of the availability of fuel and oxygen to support a relatively localized, but high-temperature, column of combustion. While the sprinkler head or heads positioned directly above the column will be quickly actuated and begin to disburse the available extinguishant, the density of extinguishant delivered to the burning fuel surface is inadequate because of the relatively large area for which the first head to be actuated is responsible. As a result, before the extinguishant can be effective to put out such a fire, the fire has developed sufficiently so as to bring to bear extremely strong convective effects tending to throw the droplets of extinguishant passing from the head off to the side of the burning fuel. Also, it often occurs that the combined effects of convection and the relatively flat trajectory of extinguishant from the deflector disc, cause extinguishant from one head to strike and wet the thermal release devices of adjacent heads, thereby delaying actuation of adjacent heads so vitally needed to bring enough extinguishant to the burning fuel. While additional heads will in time be actuated, the fire by that time will have developed to such an extent that the basic structure defining the space in which the fuel is located may be damaged to the point of failure whereupon pipe breakage and other system hardware failures result. Also, it should be borne in mind that with the opening of each additional head, there results a corresponding pressure drop in line pressure on extinguishant available to each head previously opened in response to a fire column most in need of extinguishant from those previously opened heads. Hence, the result of such systems is that less and less extinguishant is delivered to the burning fuel surfaces as the fire grows to actuate more and more heads.

The development of refined fixed fire-extinguishing techniques such as that disclosed in copending application Ser. No. 766,475, filed Oct. 10, 1968 have contributed significantly to solving the problems referred to in the preceding paragraphs. In such systems, a swellable polymer gelling agent is introduced to the water main supplying the sprinkler heads of the system upon actuation thereof in the event of a fire, so that the extinguishant supplied to and disbursed from the heads is an ablative gel. Such ablative gel extinguishants have been found not only to be greatly more effective than plain water in extinguishing a fire because of enhanced thermal-absorption characteristics, but also the relatively high viscosity of such extinguishants contributes materially to the penetration of a rising fire plume with large droplets of extinguishant which adhere to burning fuel surfaces even though such surfaces may be disposed vertically, or otherwise disposed such that plain water would run off. In spite of such developments, there remains an acute need for a sprinkler head system by which the extinguishant, whether water, ablative gel, or other suitable materials, is delivered in an efficient manner to fuel surfaces on which a fire has developed, particularly in spaces of sufficient height where vertical fire columns may develop.

SUMMARY OF THE PRESENT INVENTION

In accordance with the present invention, there is provided an improved fixed fire-extinguishing system in which one or more independently actuated spray nozzles, positioned near the top of a protected space containing combustible materials or fuel, are capable of delivering a downwardly directed divergent spray of extinguishant in such a manner that a preestablished minimum density of extinguishant is delivered to an area defined by the intersection of the vertically directed spray with a horizontal reference plane positioned near the uppermost surface of fuel intended to occupy the space. Because of the downwardly divergent configuration of the spray, fuel surfaces presented progressively lower than the reference plane aforementioned will be within wetted areas of increasing size and hence will receive lower densities of extinguishant. However, because the potential hazards of fuel surfaces at lower elevations also diminishes for reasons give above, efficiency of the extinguishant spray delivered by each head is optimized. Also, the adjacent perimeters of the areas assigned to adjacent spray nozzles are spaced in the horizontal reference plane of the design to insure that the extinguishant delivered from the first head or nozzle to be actuated does not in any way impede the release of adjacent heads. While such underlap of areas leaves spaces which seemingly are not protected, in practice, a sufficient amount of spattering occurs to cover the space between the assigned areas for each head at least where the uppermost fuel surfaces lie near the reference plane. Where the surfaces are positioned lower than the horizontal plane for which the assigned areas are designed, adequate coverage is provided by the ultimate overlap of adjacent nozzle sprays due to the downwardly divergent configuration of each spray.

It is therefore, a principal object of the present invention to provide an improved fixed fire-extinguishing system by which the problems heretofore encountered are substantially overcome.

Another object of the present invention is to provide such a fixed fire-extinguishing system in which the density of the extinguishant delivered to burning fuel surfaces in the space protected, in terms of quantity of extinguishant per unit area,

is correlated to the elevation of such surfaces in the space and thus optimized.

Still another object of the present invention is to provide a fixed fire-extinguishing system of the type referred to in which the thermal release of one head of the system is in no way affected by the spray of extinguishant being delivered by a previously actuated head, thereby to avoid the problem of head skipping and resulting inadequate supply of extinguishant to burning fuel surfaces.

A further object of this invention is to provide a fixed fire-extinguishing system which is adaptable to the use of different types of extinguishants, particularly both plain water and an ablative gel formed by introducing a swellable polymer gelling agent into water being supplied to the head nozzles.

Other objects and further scope of applicability of the present invention will become apparent in the detailed description to follow taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing of the fire extinguishing system of this invention on a vertical cross section through a space protected thereby;

FIG. 2 is a fragmentary cross section on line 2—2 of FIG 1;

FIG. 3 is a graph plotting density ratios against corresponding wetted area ratios;

FIG. 4 is a vertical cross section through a nozzle head preferred for use with the system of the present invention;

FIG. 5 is a plan view on line 5—5 of FIG. 4; and

FIG. 6 is a lower end plan view as seen from lines 6—6 of FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1 of the drawing, the fire extinguishing system of the present invention is depicted as installed in a building space generally designated by the reference numeral 10 and defined by a floor 12, a ceiling 14 and sidewalls 16. The stacks or piles bearing reference letters A, B, C, D, E, F and G represent combustible materials or fuel piles to be stored within the space 10, in the manner of a conventional warehouse, storage facility or the like. Supported in depending fashion from the ceiling 14 are a plurality of spaced nozzle heads 18 each having a thermally responsive fusible link 20 and a discharge orifice 22. Although the structural details of the nozzles 18 will be described more fully below, it will suffice, for purposes of a general understanding of the system depicted by FIGS. 1 and 2, to note that when the ambient temperature in the vicinity of a fusible release 20 a head 18 reaches a preestablished point, the discharge orifice 22 on that head is opened to disburse a spray S of extinguishant. The extinguishant is delivered to the respective nozzles by a riser 24, branch line 26 and lines 28 connecting the respective heads 18 to the branch line 26. While the lines supplying the sprinkler heads are in themselves conventional, it will be appreciated in practice, the design of the lines, in terms of their flow capacity, will be important to proper operation of the nozzles 18.

Preferably, the fire-extinguishing system of this invention incorporates the additive injection system disclosed in copending application Ser. No. 864,757, filed concurrently herewith, by which an additive slurry of water swellable polymer or gelling agent is injected automatically into a line 30 supplying the riser 24 with water from a water supply main 32 through auxiliaries such as cutoff valves and the like. Inasmuch as the additive injection system, by which an ablative gel is formed in the riser 24, is fully disclosed in the aforementioned copending application, further detailed description thereof is deemed unnecessary herein. In general, however, and as depicted by the legend-bearing blocks in FIG. 1, the system operates to sense the flow of water called for by the opening of a sprinkler head 18 and to energize a power source, such as a motor, to pump or inject the additive through a mixer to the line 30. As is fully described in the aforementioned copending application, the injection system operates on a no-inject failure mode to insure that an adequate supply of at least plain water will pass from the water supply main 32 through the line 30, riser 24 and branch line 26 and to the heads 18.

The particular structure of each of the nozzle heads 18 may vary considerably without departing from the spirit and scope of the present invention, but the nozzle head illustrated and described in copending application Ser. No. 864,756, filed concurrently herewith, is preferred. Although a more complete understanding of such a nozzle may be had by reference to this copending application, the basic operating components of the nozzle are shown in FIGS. 4–6 to include a pendant body 34 terminating in the discharge orifice 22 normally retained closed by an expellable plug 36 having a shank 38 extending upwardly to be engaged by a laterally slidable rod 40 biased by a compression spring 42 against the fusible link 20 so when the latter collapses as a result of preestablished ambient temperatures, the rod 40 moves outwardly or to the right as shown in FIG. 4, permitting line pressure to expel the plug 36 from the discharge orifice 22 and activate the head. Each of the heads 18 further include a helical swirl member 44 as well as a line pressure responsive discharge orifice regulator generally designated by the reference numeral 46. As described in the last- mentioned copending application, the regulator 46 includes an hermetically sealed annular bellows 48 which operates to elevate or lower an orifice cone 50 relative to the discharge orifice 22 to maintain the same spray geometry issuing from the orifice 22 regardless of fluctuations in line pressure at each head 18. Also, the base of the discharge orifice 22 is provided with radiating slots or grooves 52 to impart a rectangular or generally downwardly diverging pyramid-shaped spray. Although this particular configuration of the spray is not essential to the present invention, it is desirable that the area developed at the intersection of the spray with a horizontal plane define a polygon capable of complementing adjacent similarly configured areas.

To facilitate a clearer understanding of the fire-extinguishing system of this invention and its objectives, reference is made to the graph in FIG. 3 of the drawings. In the graph, the ratio of actual or delivered density by the extinguishant, to design or optimum density in those terms is assigned numerical values on the ordinate, whereas the ratio of actual area of coverage to design or optimum area of coverage for a spray head operating under given conditions of orifice size and line pressure, is indicated numerically on the abscissa. A curve X in the graph is plotted for a single spray head delivering extinguishant at uniform flow rates. Thus, at the point 0 on the curve X, where actual to design density and actual to design of area coverage are at unity, optimum efficiencies are achieved in terms of nozzle operation corresponding to design parameters. If however, the actual area increases relative to the area for which the plotted nozzle is designed, the ratio of actual to design densities falls off quickly as indicated by that portion of the curve to the lower right of the point O. On the other hand, where the ratio of actual area covered to design area of coverage is less than 1, the actual density increases relative to design density quite sharply as indicated by the curve upwardly of the point 0. In terms of the curve illustrated in FIG. 3 therefore, the present invention departs from traditional fixed fire-extinguishing systems of the type heretofore available, by operating each spray nozzle in the portion of the curve to the upper left of the point 0, or in a manner such that any error or departure from design parameters is toward the side of increasing the density of extinguishant reaching the fuel surfaces even though some area of coverage may be sacrificed.

The manner in which the principles expressed by the curve in FIG. 3 are carried out in practice according to the present invention may be seen by reference again to FIGS. 1 and 2 of

the drawings. As previously indicated, each of the nozzles **18** delivers a downwardly diverging pyramid-shaped spray S, the angle of divergence being designated in FIG. **1** by the reference α. As the spray S intersects a horizontal reference plane depicted by the dash line P in FIG. **1**, it establishes in the reference plane an area of coverage Z or an area of head responsibility as shown in FIG. **2** of the drawings. It is important in the practice of the present invention that the reference plane P be selected so that it lies at or near the uppermost surface of fuel within the space **10** to be protected, and that the perimeters of the areas of responsibility Z for each nozzle be spaced from the perimeters of corresponding areas for adjacent nozzles as may readily be seen in FIGS. **1** and **2** of the drawings. Such spacing or underlap between the areas Z may vary depending on the spray angle α of the nozzles **18**. For example, if the spray angle is less than 90°, the spacing between the areas or the underlap may be on the order of 1½ feet whereas if the spray angle is more than 90°, the underlap may be increased upwardly to amounts on the order of 2½ feet. Also, it should be noted that the minimum spray angle to be used in the practice of the present invention will be determined by the height of the space to be protected. For example, in extremely high buildings where large fire hazards exist, it may be desirable to arrange a large number of spray nozzles having very small spray angles, so that they are located relatively close to one another; e.g., 3 feet. The maximum spray angle on the other hand, is necessarily limited in the interest of preventing the extinguishant spray from one head first actuated to interfere in any way with the thermally released fuse link **20** on another adjacent head. While the precise maximum angle may vary somewhat, it is contemplated that the maximum spray angle to be used for most efficient operation of the system is 140° for each head.

In the operation of the system, assuming a fire develops in the fuel pile B, the temperature above the burning fuel will increase quickly to release the fuse **20** on the nozzle head directly above the pile B. Because the density of spray S issuing from the actuated nozzle head is designed for the highest fuel pile in the space **10**, extinguishant at densities at least as great as the design density will be delivered directly down on the pile to extinguish the fire. Should a fire develop in a lower pile, such as for example, the pile A as shown in FIG. **1** of the drawings, the extinguishant reaching the pile A from the same head will be at substantially lower densities due to the spread of the extinguishant as it falls downwardly. Because the lower height of the pile A constitutes a significantly lower fire hazard as compared with the pile B, the falloff in density will be of little or no consequence in terms of extinguishing the fire.

Thus it will be appreciated that as a result of this invention, there is provided an extremely effective fire-extinguishing system by which the above-mentioned objectives are completely fulfilled. In contradistinction to fixed sprinkler systems preceding this invention, and in which primary design consideration has been given to maximizing the area protected by each sprinkler head, the present invention enables a maximum quantity of extinguishant to be delivered by each head directly to the burning fuel surfaces which caused each such respective head to open. Consequently, a fire in the space protected by the system of the present invention is extinguished quickly and as such, prevented from growing and spreading. This technique is accomplished by the disclosed embodiment as a result of the described organization of nozzle heads, supply of extinguishant to the heads and dispursal of extinguishant therefrom in relation to the intended use of the space to be protected. Since variations in the disclosed embodiment are contemplated, it is expressly intended that the foregoing description is illustrative of a preferred embodiment only, and not limiting or exclusive of variations falling within the true spirit and scope of the present invention.

I claim:

1. An automatically operated fixed fire-extinguishing system of the type in which fluid extinguishant is supplied to a fire which may develop at a random location in a space to be protected containing combustible materials or fuel spread over a large area, said system comprising a plurality of branch lines supported at an elevated position in said space and supplied with extinguishant from a common source, each of said branch lines having a plurality of discharge heads connected thereto, each of said discharge heads being arranged and constructed to deliver a downwardly directed spray of said extinguishant at a predetermined spray angle, and means associated with said discharge heads for selectively opening said discharge heads in a logical sequence dictated by information received from a fire in said space, said discharge heads being spaced from one another a predetermined distance, said predetermined spray angle and said predetermined distance being related to one another so that the extinguishant from the discharge heads will not wet said opening means in a manner to alter the opening of the discharge heads in said logical sequence.

2. The system as recited in claim **1** wherein said predetermined spray angle is a maximum of about 140°.

3. The system recited in claim **1** wherein each of said discharge heads is a direct discharge nozzle.

4. The system recited in claim **1** wherein substantially all of the extinguishant from each of said discharge heads passes through a different assigned area in a horizontal reference plane, said reference plane being located at an elevated position within said space and being spaced below said discharge heads, said assigned areas being spaced from one another with each assigned area being located directly beneath its corresponding discharge head.

5. The system recited in claim **4** wherein said reference plane is positioned at the uppermost level of fuel that can be stored in said space.

6. The system recited in claim **4** wherein said predetermined spray angle is a maximum of about 140°, each of said discharge heads is a direct discharge nozzle, and said opening means comprises thermal means mounted on each of said nozzles for independently controlling the opening of the nozzle in response to the heat of a fire in said space.

7. The system recited in claim **1** wherein said opening means comprises thermal means mounted on each of said discharge heads for independently controlling the opening of the discharge head in response to the heat of a fire in said space.

8. The system recited in claim **1** wherein said extinguishant is an ablative gel.

9. The system recited in claim **1** wherein said predetermined spray angle is less than 90°.

10. The system recited in claim **9** wherein said predetermined distance is about 3 feet.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,645,338 Dated February 29, 1972

Inventor(s) William L. Livingston

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 48, "give" should read --given--.

Column 6, line 2, "dispursal" should read --dispersal--.

Signed and sealed this 5th day of September 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents