United States Patent [19]

Kehr et al.

[11] **3,854,535**

[45] **Dec. 17, 1974**

[54] **FIRE INHIBITING FOAM SYSTEM**

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[52] **U.S. Cl.** ..... **169/48,** 169/5, 239/208, 260/2.5 AD

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

[58] **Field of Search** ..... 169/2 R, 16, 5, 1 A, 48, 169/54; 239/207, 208, 209; 52/220, 221, 241; 260/2.5 AD

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[57] **ABSTRACT**

The invention disclosed relates to a foam which is capable of absorbing and retaining significant amounts of water and which is disposed as part of a structure in association with fire-extinguishing water outlets such that the foam inhibits fire by absorbing and retaining significant amounts of water released from the water outlets during a fire.

6 Claims, 6 Drawing Figures

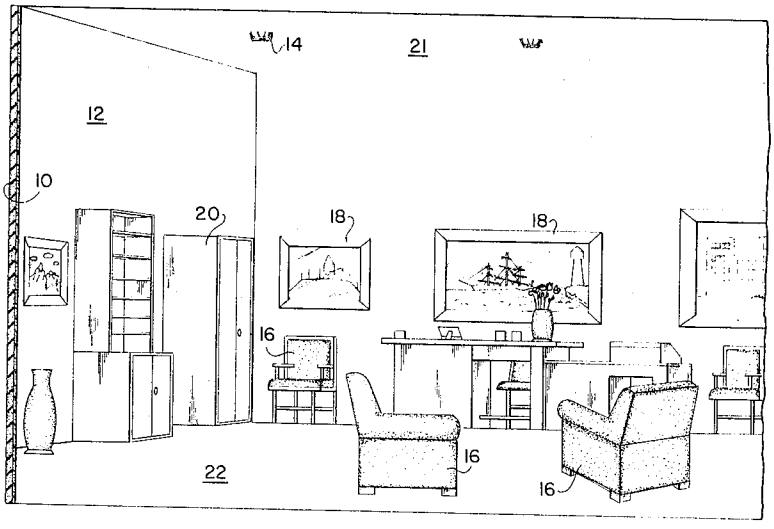


FIG. 1

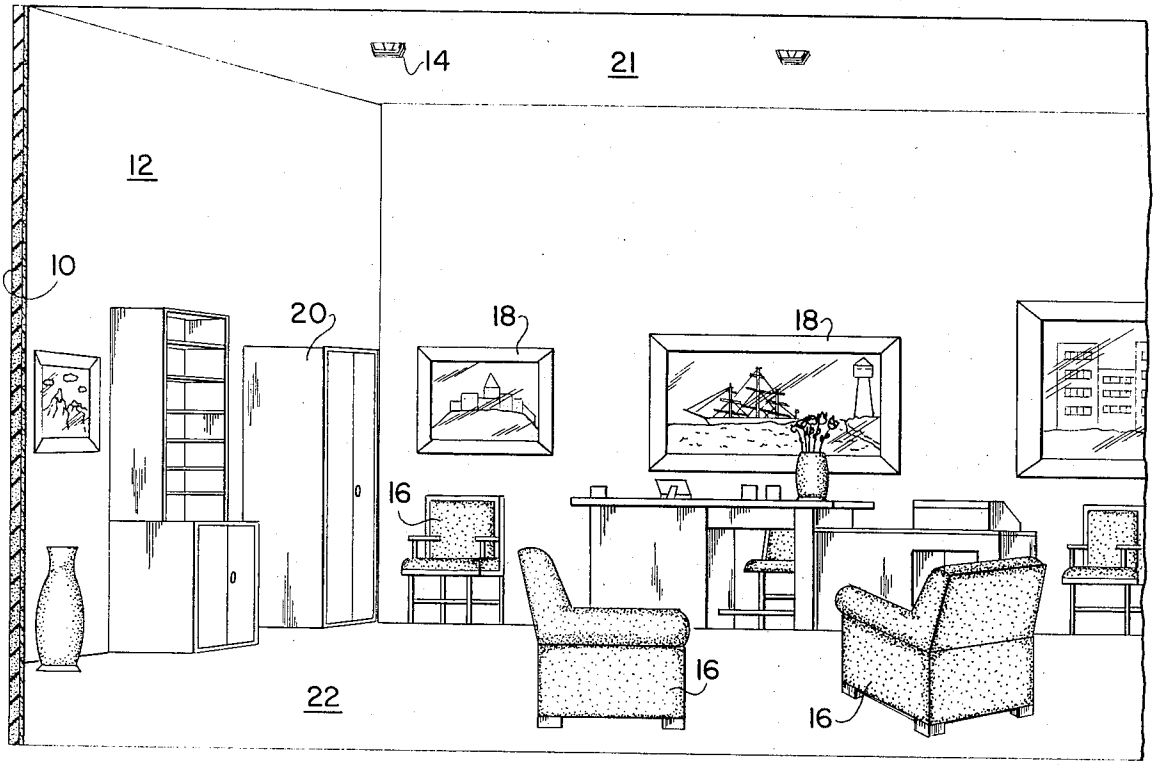


FIG. 2

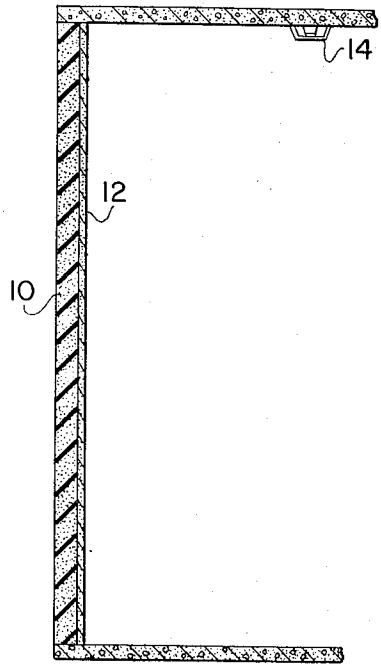
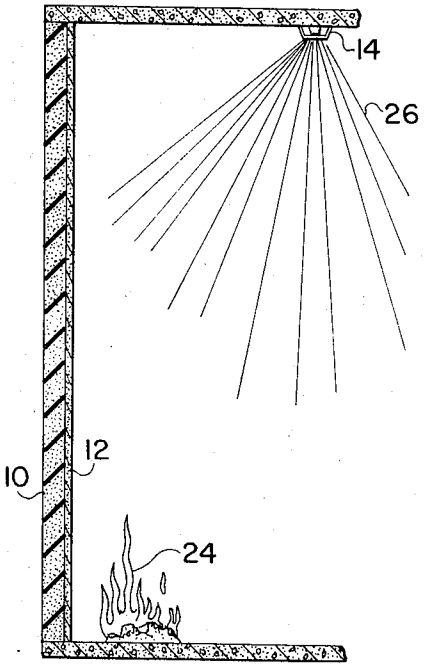


FIG. 3



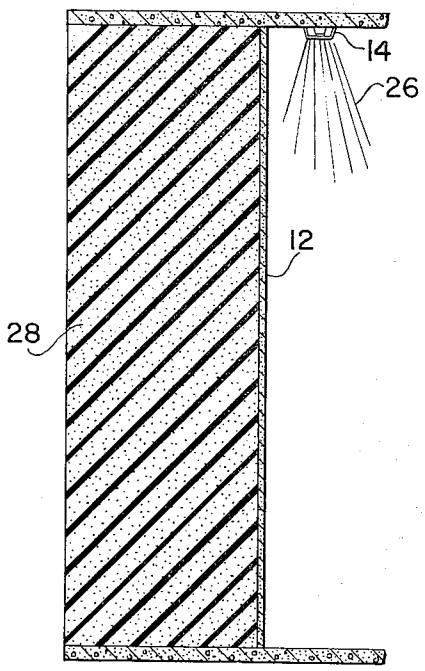


FIG. 4

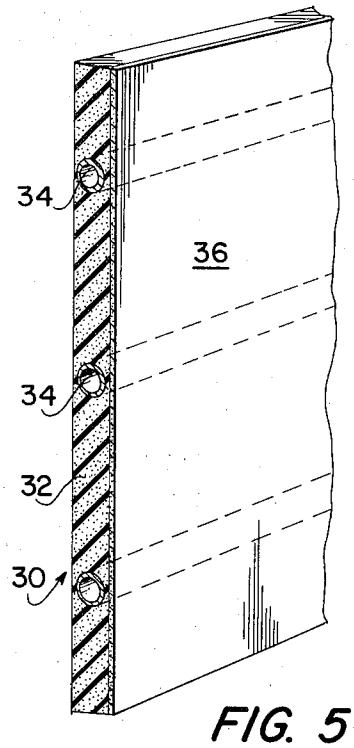


FIG. 5

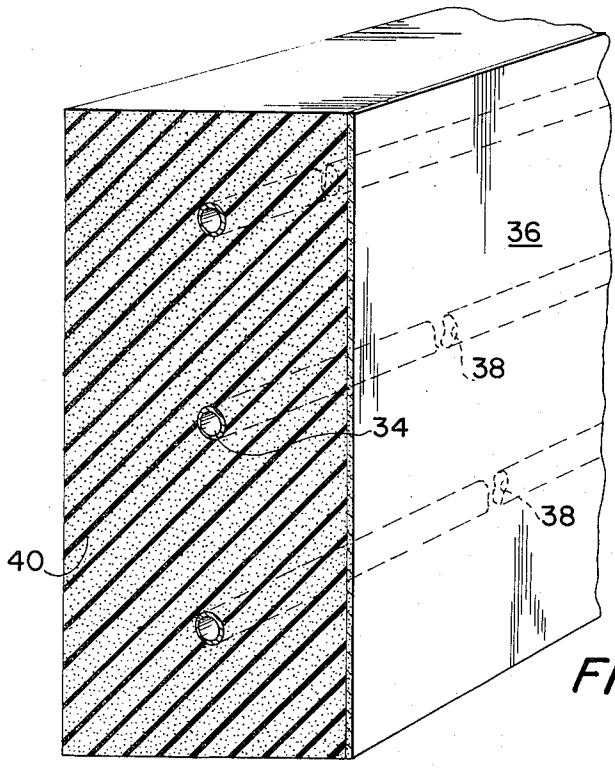


FIG. 6

FIRE INHIBITING FOAM SYSTEM

This invention relates to a fire inhibiting foam system and more particularly to a new hydrophilic foam which is capable of absorbing and retaining significant amounts of water from fire-extinguishing water outlets during a fire.

Numerous attempts have been made in the prior art in constructing fire retarding materials. Typically, and in the case of porous foams, chemicals have been added which are characterized with a hydrophilic tendency. Thus, by the tendency to absorb water, incorporated chemicals provide limited fire retarding properties. However, significant disadvantages are present in such prior art attempts in that there is a need for incorporating large amounts of hydrophilic chemicals into the porous structure, weight and expense factors became significant, and more importantly, the resultant product has limited effectiveness in retarding fire.

One of the most effective materials for control of fire throughout the years has been water with fire control being based on the ability of providing water at a fire location as soon as possible after fire initiation. Water sprinkler systems which are activated by heat have effectively limited fire damage as compared with other manual fire-extinguishing techniques, by providing an immediate source of water in relatively short time after fire outbreak. However, because conventional building structures include significant amounts of fire combustible materials, spread of fire and resultant damage remains a severe problem even where water sprinkler systems are employed.

It has now been found, however, that by practice of the present invention, there results a fire inhibiting foam system which overcomes many of the disadvantages of prior art attempts at fire control while controlling spread of fire and resultant damage.

Generally, the present invention provides a method and a combination of associated elements for inhibiting fire by means of a new improved foam. Upon activation of a sprinkler system, water is absorbed into the foam in significant amounts such that fire is retarded from advancing beyond the water filled foam structure.

The nature of the present foam is significant, the foam being capable of absorbing between about 5 to about 50 times its dry weight of water. Also, the foam may be configurated as desired such as by direct introduction between walls where the foam serves also as a thermal or acoustic insulating material under non-fire conditions, or alternately as a wall panel in which instance the panel may have a decorative surface layer as desired.

When a sprinkler system is used, the water spray may be supplied or directed such that the foam, as opposed to the fire, receives a significant amount of water within a very short period of time.

By specially positioning the extinguisher means which desirably are temperature or smoke activated, rapid and selective extinguishing of a fire may be effected without total saturation of areas not affected by fire.

A large variety of foams are usefully employed in practice of the present invention. Desirably, the foams are characterized by having high water absorbency and retention values. It is also desirable that the foams be sufficiently strong to permit use in building materials without undue need for special support members.

Foam materials which are compressible are also useful in that a minimum amount of space is occupied during normal conditions with expansion during water absorbency resulting only under water-release conditions by a fire.

Practice of the present invention will become more apparent from the following detailed description taken in conjunction with the drawings wherein:

FIG. **1** illustrates a room with areas and structures having water-absorptive foams of the present invention as a portion thereof;

FIG. **2** illustrates diagramatically, normal conditions of a sprinkler relative to a wall structure;

FIG. **3** illustrates association of elements of FIG. **2** under fire conditions;

FIG. **4** further illustrates the association of elements of FIG. **2** except with the wall structure in expanded, water-filled condition;

FIG. **5** is an embodiment wall panel taken in partial perspective view having wall panel with interior, heat, smoke or manually activated water release pipes; and

FIG. **6** illustrates the panel of FIG. **5** except in expanded, water-filled condition following activation of the water lines.

In the figures wherein the same elements are identified by similar numerals throughout the several views, FIG. **1** generally illustrates the present system and the various locations at which the present foams may be employed. Wall panels **10** having a water-permeable decorative cover **12** are positioned such that upon release of water from sprinklers **14**, the wall panels will absorb and retain significant amounts of water. In this fashion, any attempt by a fire to spread to other areas is retarded and fire related damage is restricted.

In addition to being used as a wall surface, the present foams may be included within the construction of furniture **16**, frames **18**, cabinets **20** and the like, thus providing fire retardant locations in addition to that of the building structure. Also, for example; the ceiling **21** and carpets **22** may include the present foams as a component which retards fire tendency and thereby limits fire damage.

Foam useful in preparing structures for use in the present invention generally may absorb and retain water by a number of means. For example, water absorption may be by means of open cell structure, or by hydrophilicity of the foam. Also, the foam may be either compressed and water expandable or otherwise may be simply used in the normal expanded condition.

A preferred foam may be characterized with an equilibrium moisture content of about 2 to 4 percent by weight at 50 percent relative humidity, about 6 to 8 percent by weight at 75 percent relative humidity and about 15 to 30 percent by weight at **100** percent relative humidity. Thus, under these moisture content conditions, ignition by heat or flame becomes difficult and when the source of the flame is removed, the foams typically self-extinguish. For limited fire conditions, the present foams when having a moisture content in high relative humidity locations effectively retard fire spread even without need for the sprinkler system. For major fires and where humidity conditions constantly remain low or otherwise vary greatly, the need for the sprinkler remains significant.

FIGS. 2–4 diagrammatically illustrate how the present invention retards and prevents fire damage. Wall panels **10** and cover **12** are shown relative to sprinkler **14**, all in a normal condition. In FIG. **2**, however, fire **24** causes water **26** to be sprayed from sprinkler **14** upon activation of an alarm or detection means by either heat of smoke.

In FIG. **4**, however, wall panel **10** of FIGS. **2–3** has expanded and is now maintained as water-saturated-panel **28**. Because the amount of water in panel **28** may be as much as about 5 to 50 times or more of the dry panel weight, i.e. the water content is significant, it becomes virtually impossible for the fire to spread beyond the water-foam barrier and to a subsequent location.

FIG. **5** illustrates an embodiment wall panel **30** having a foam portion **32** through which heat-activated pipes **34** pass and contain water. Panel **30** may optionally include a decorative surface **36** if desired, in which case the decorative surface need not be water-permeable because water originates from within the structure during fire conditions.

Fire conditions for the panel of FIG. **5** are illustrated in FIG. **6**. Upon heat breakage of pipes **34**, at location **38** by means of a fire, water is released and is absorbed and contained within the foam layer, i.e. water-filled, expanded foam layer **40**.

A number of known polymeric foams may be employed in practice of the present invention provided these foams are characterized with the ability to absorb and retain water in amounts for about 5 to about 50 times the dry weight of the foam.

One group of useful foams are those disclosed in copending, commonly assigned U.S. patent application Ser. No. 250,012 filed May 3, 1972, the effective portions of the disclosure of which are incorporated herein by reference. Generally, these foams are crosslinked polyurethane foams prepared by using a capped polyoxyethylene glycol reactant and massive amounts of water.

Particularly useful foams may be prepared by first capping a polyoxyethylene polyol with a polyisocyanate such that the capped product has a reaction functionality greater than two. Thereafter, the resin is reacted by combining with water such that a crosslinked foam result. It is also possible to use a capped polyoxyethylene polyol having a functionality approximating 2 in which case a polyfunctional reactive member such as one having 3, or up to about 8 reactive amine, hydroxy, thiol, or carboxylate sites per average molecule is included to form a three dimensional crosslinked product. Useful polyfunctional reactive members include materials such as diethylenetriamine, triethylenetetramine, tetraethylenepentamine, polyethyleneimine, glycerol, trimethylolpropane, pentaerythritol, tolylene-2,4,6 -triamine, ethylenediamine, aminothanol, trimethylenediamine, tetramethylenediamine, pentamethylenediamine, hexamethylenediamine, aminoethanol, diethanolamine, hydrazine, triethanolamine, benzene-1,2,4-tricarboxylic acid, nitrilotriacetic acid, citric acid, 4,4'-methylenebis (o-chloraniline), and the like.

Polyoxyethylene polyol used as a reactant in preparing the capped product to be foamed may have a weight average molecular weight of about 200 to about 20,000, and preferably between about 600 to about 6,000 with a hydroxyl functionality of about 2 or greater, preferably from about 2 to about 6.

Polyoxyethylene polyol is capped by reaction with a polyisocyanate or polyisothiocyanates. The capping materials include PAPI (a polyaryl polyisocyanate as defined in U.S. Pat. No. 2,683,730), tolylene diisocyanate, triphenylmethane-4,4',4'',-triisocyanate, benzene-1,3,5-triisocyanate, toluene-2,4,6-triisocyanate, diphenyl-2,3,3'-triisocyanate, hexamethylene diisocyanate, xylene diisocyanate, chlorophenylene diisocyanate, diphenylmethane-4,4'-diisocyanate, naphthalene-1,5-diisocyanate, xylene-alpha, alpha'diisothiocyanate, 3,3'-dimethyl-4,4'-biphenylene diisocyanate, 3,3'dimethoxy-4,4-biphenylene diisocyanate, 2,2' 5,5'-tetramethyl-4, 4'-biphenylene diisocyanate, 4,4'-methylenebis (phenylisocyanate), 4,4'-sulfonylbis (phenylisocyanate), 4,4'-methylene diorthotolylisocyanate, ethylene diisocyanate, ethylene diisothiocyanate, trimethylenediisocyanate and the like.

Capping of the polyoxyethylene polyol may be effected using either stoichiometric amounts of reactants or an excess of isocyanate to insure complete capping of the polyol.

To effect foaming and preparation of the crosslinked network polymer, the component including the isocyanate capped polyoxyethylene polyol having a functionality about 2 or greater is simply combined with water by most any suitable means such that a crosslinked hydrophilic foam results.

Although foaming of the present resin reactant is effected simply, it is also possible to add, although not necessary, supplemental foaming materials such as those well known to the artificial sponge foaming art.

A particularly useful material for preparing compressed foam may be obtained using polyethylene glycol 600 to prepare the prepolymer for foaming. The resultant foam can be readily compressed at temperatures from about 25 to about 60°C. to give a plasterboard type structure having a density of from about 12 to about 60 lbs/ft^3. The expanded foam density is correspondingly about 2 to about 6 lbs/ft^3. Mixed copolymer systems using polyethylene glycol 600 and 1000, polyethylene glycol 600 and 800, and polyethylene glycol 400 and 1000 may be used to prepare the prepolymer if desired.

Another category of useful foams is that described in U.S. Pat. No. 3,694,385, to Salyer et al. Here, open-cell rigid polyurethane foams are prepared from polyether polyols using, as a pneumatogen, cyclopentane-acetone mixtures with water and as a nucleating agent, finely divided polyethylene particles. The disclosure of this Salyer et al. patent is also incorporated herein by reference as describing useful hydrophilic foams in practice of the present invention.

Yet another category of useful foams is that described in U.S. Pat. No. 3,511,764, to Marans et al. who teach crosslinked polyacrylamide foams prepared as the decomposition product of polyoxymethylene. Acrylamide and trioxane are blended, irradiated, heated to complete the polymerization and then heated to a higher temperature to decompose the polyoxymethylene. This disclosure by Marans et al. is also incorporated herein by reference as disclosing useful foams in practice of the present invention.

Calvin J. Benning, in the publication "Plastic Foams: the physics and chemistry of product performance and process technology" by Wiley — Interscience division of John Wiley and Sons, New York, Vol. 1, 1969, also

teaches a number of useful foams for practice of the present invention. Such useful materials include urea-formaldehyde foams, polyvinyl alcohol-formaldehyde foams, acrylic foams such as those prepared by reacting acrylonitrile, acrylamide and acrylic acid to form a copolymer which is then irradiated and thereafter post-cured at high temperature, carboxylated styrene-butadiene foams, and the like. All of these further categories of foams are suitable for use herein as are other foams well known to the art. It is important, however, that the foams used herein be characterized with the ability to absorb and retain water in amount from about 5 to about 50 times the dry weight of the sponge and preferably from about 8 to about 40 times on the same weight basis.

After the foams have been prepared, they may be compressed by any one of a variety of techniques well known to the art.

The following examples will aid in explaining, but should not be deemed as limiting practice of the present invention. In all cases, unless otherwise noted, all parts and percentages are by weight.

EXAMPLE 1

In order to demonstrate the effectiveness of the present foam system in fire prevention and control, a hydrophilic foam was prepared by first reacting in 2:1 mole ratio, polyoxyethylene glycol 1000 and trimethylolpropane with 7.7 moles of 80/20 mixture of 2,4/2,6 isomer of tolylene diisocyanate. The product was thereafter combined in an amount of 25 grams with 2.5 grams of tolylene diisocyanate having an 80/20 mixture of 2,4 isomer/2,6 isomer, 0.25 gram silicone surfactant commercially available under the mark **L-520** by Union Carbide, and 25 grams water. The foam which resulted was a mat having a 14 × 41/2 inch size. The mat was dried in an oven at 80°C. The dry mat was simultaneously exposed to a spray of water and a Meker burner with a flame temperature of about 600°C. for 5 minutes. No burning of the mat was experienced.

EXAMPLE 2

A hydrophilic foam was prepared by first reacting in a 2:1 mole ratio polyoxyethylene glycol 600 and trimethylolpropane with 7.7 moles of an 80/20 mixture of the 2,4 and 2,6 isomers of tolylenediisocyanate. To 100 grams of this mixture was then added 1 gram of silicone surfactant **L-520** by Union Carbide and 50 grams of water. The mixture was rapidly stirred until homogenized, i.e. about 30 seconds, and the foaming mass then poured into a mold 6 × 6 inches. The resultant foam was dried and found to have a density about 2.5 lbs/ft^3. At a temperature of 45°C., and a pressure of 2,000 psi the sample was compacted to a flat structure having a density of 25 lbs/ft^3. Wetting with water at 25°C. gave expansion to the original dimensions. A water absorption of approximately 20 times the weight of polymer was noted. Again, no burning of the mat was experienced during 5 minutes of heating after expansion using the procedure of Example 1.

EXAMPLE 3

A hydrophilic foam was prepared using 1 mole of polyoxyethylene glycol 400, 1 mole of polyoxyethylene glycol 1000, 1 mole of trimethylolpropane and 7.7 moles of the mixed isomers of 2,4 and 2,6 tolylenediisocyanate. The foam prepared as in Example 2 was compressed at 60°C and 2,000 psi. Wetting with water gave a 10 times weight increase at 25°C. Again no burning of the mat was experienced with 5 minutes of heating after expansion.

EXAMPLE 4

A hydrophilic foam was prepared using 1 mole of polyoxyethylene glycol 1000, 1 mole of di(2-hydroxyethyl) dimethylhydantoin, and 7.7 moles of an 80/20 mixed isomers of 2,4 and 2,6 tolylenediisocyanate. Wetting with water of the foam previously compressed at 45°C and 2,000 psi, gave over a 10 times weight increase by water absorption at 25°C. Again no burning of the mat was experienced with 5 minutes of heating after expansion using the procedure of Example 1.

EXAMPLE 5

Polyacrylamide foam was prepared using the method described in U.S. Pat. No. 3,511,764 using 100 parts by weight of acrylamide and 90 parts by weight of trioxame. The finally prepared foam absorbed and retained 10 times its dry weight of water and using the burning procedure of Example **1**, did not burn for 5 minutes following water absorption.

EXAMPLE 6

The procedure of Example 5 was repeated except using additionally 50 parts by weight of acrylic acid. Corresponding results were realized.

EXAMPLE 7

A urea-formaldehyde foam was prepared using conventional techniques disclosed by Benning, supra. The foam was found to absorb in excess of 11 times its weight of water and performed comparably to the foam of Example 5 in the fire test.

EXAMPLE 8

Polyvinyl alcohol-formaldehyde foam was prepared using conventional techniques disclosed by Benning, supra. The foam was found to absorb in excess of 10 times its weight of water and performed comparably to the foam of Example 5 in the fire test.

EXAMPLE 9

Rigid, open-cell polyurethane foam prepared using the method described in U.S. Pat. No. 3,694,385. The finally prepared foam absorbed and retained 8 times its dry weight of water and using the burning procedure of Example 1, did not burn for at least 5 minutes following water absorption.

It is understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made therein without departing from the spirit of this invention.

What is claimed is:

1. A fire inhibiting system which comprises in combination, a water outlet disposed to release water under fire or smoke conditions, a water-retaining foam structure disposed to receive water from said outlet, said foam being capable of absorbing and retaining from about 5 to about 50 times its dry weight of water, and wherein the water outlet is disposed within the foam structure.

2. The fire inhibiting system of claim **1** wherein the foam is hydrophilic, and the structure is a portion of a

building wall, said water outlet being a fire-extinguishing sprinkler.

3. The fire inhibiting system of claim **1** wherein the foam is hydrophilic and is disposed as a portion of a furniture structure.

4. The fire inhibiting system of claim **1** wherein the foam is prepared using a polyisocyanate capped polyoxyethylene polyol, said foam having a crosslinked hydrophilic character.

5. The fire inhibiting system of claim **1** wherein the foam is compressed and expands to normal size upon receiving water.

6. The fire inhibiting foam system of claim **1** wherein the foam is polyurethane.

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