

May 8, 1951

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2,551,919

METHOD OF EXTINGUISHING OR PREVENTING FIRES

Filed July 23, 1946

2 Sheets-Sheet 1

Fig. 1.

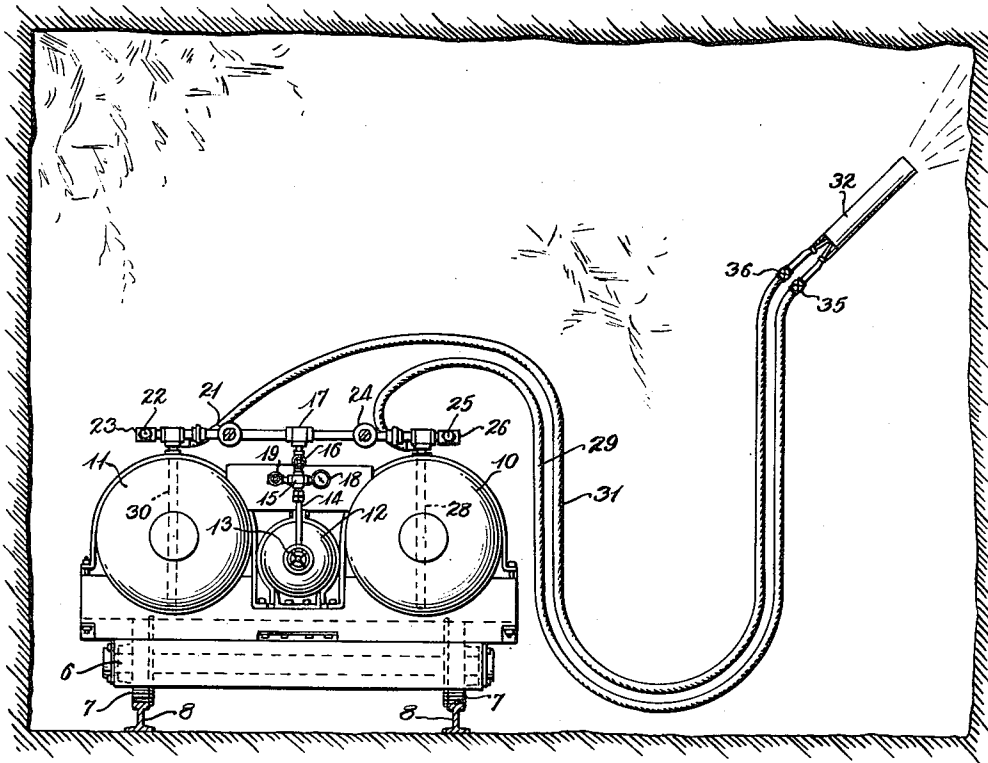
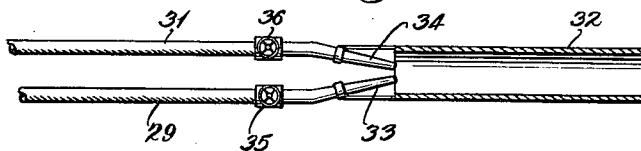


Fig. 2.



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2 Sheets-Sheet 2

Fig. 3.

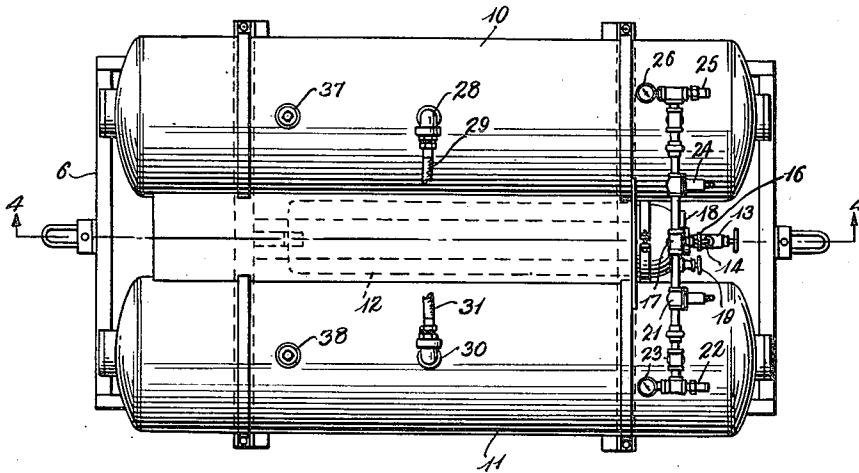
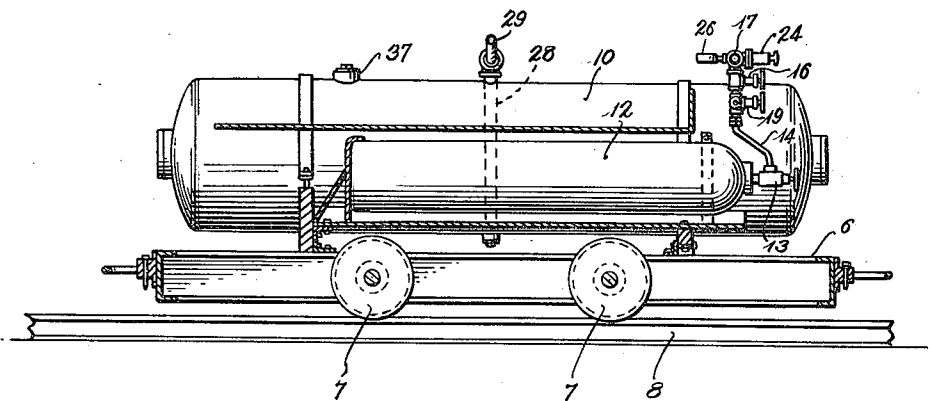


Fig. 4.



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UNITED STATES PATENT OFFICE

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METHOD OF EXTINGUISHING OR
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24 Claims. (Cl. 169—14)

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This invention relates to a method of extinguishing or preventing fires by the application of a very novel form of coating to the exposed surfaces of the ignited or the ignitable materials for the purpose of preventing combustion supporting oxygen from reaching the materials.

The invention has special application to the extinguishment or the prevention of fires in underground coal mines, but it is to be understood that the invention may be applied with equally as effective results to other combustible materials. In describing the invention, specific reference will be made to its application to underground coal mines, but it will be appreciated that the same advantages will be obtained when used with other combustible materials.

The more serious fires in underground coal mines involve burning coal that has not been dislodged from the floor, the side walls or the roof of tunnels, break-throughs, rooms, and the like.

As a result of the present invention, it has been discovered that to be satisfactory for its intended purpose, this coating must have certain physical properties. Also, it has been found that the composition which produces this coating must possess certain physical properties. As the physical properties of the coating are quite different from the physical properties of the solutions employed for producing the coating, as will hereinafter appear, it is apparent that the problems presented by this invention call for a two-fold solution.

Considering further, this aspect of the invention, it may be pointed out that among the properties required of the coating, is that it be of gel-like or rubbery character, and that it be penetrant to some extent into the cracks, crevices or indentures of the inflammable material. It is apparent that the coating cannot be applied as a solid. In accordance with this invention the novel coating is produced by simultaneously applying to the surfaces of the combustible material two solutions which are mixed as they are being applied and which become transformed into the desired gel-like coating almost the instant they contact the surfaces being treated.

By applying the coating in the form of solutions that are mixed at the time of application, the liquid composition thus formed can be ejected as a stream from a hose or other conduit. As a consequence, it is not necessary to closely approach burning material to effect extinguishment of a fire. Moreover, this use of such a liquid composition to form the desired gel-like coating

has the additional advantage that the starting solutions may be discharged by simply placing them under pressure.

Another important advantage derived from producing a gel-like coating by the application of the mixed solutions as a liquid stream, and just prior to gelling, is that the coating material will be allowed to flow to the exact extent desired over the surfaces of the inflammable material and into the cracks, crevices and indentures thereof. Consequently, the coating which is formed conforms to the contour of the exposed surfaces of the inflammable material and tightly adheres thereto. The coating thus very effectively seals the exposed surfaces from the atmosphere.

As a further important feature of the invention, it has been determined that the character of gel-like coating found to be most effective in extinguishing or preventing fires can only be produced by the use of two or more solutions which will set-up or solidify within a small fractional part of a minute after they are mixed. Consequently, it is imperative that the two or more solutions be stored in separate containers and be combined or mixed at the time of their discharge for application onto the surfaces of the combustible material being protected from fire.

An advantage of storing the liquid composition as separate solutions is that its components can be selected more readily to produce the gel-like coating in the desired interval of time. This is important when it is realized that to prevent the liquid composition from running off of the inflammable material before it solidifies into a gel, this transformation must take place within a relatively short interval of time. On the other hand, it will be appreciated that the liquid must not become converted to a gel before the liquid has had time to reach the inflammable material and spread thereover.

This period within which the liquid composition must gel, is of very short duration. The instant before which it should not gel, and the instant after which it should not still be a liquid, is moreover determined by a number of variable factors. Thus, the elapsed time between the initial intermixing of the solutions and the moment at which the mixed solutions reach the surfaces of the inflammable material, must be considered. This is dependent upon the time of flight of the mixed solutions from the applying nozzle to the combustible material and this in turn is dependent upon the distance between the nozzle and the

combustible material and upon the velocity of travel of the liquid stream.

In considering the present invention in its more detailed aspects, the properties essential for the coating first will be presented. It should be clearly understood that the primary function of the gel-like coating is to exclude combustion supporting oxygen from the fire so that it will be smothered. For this reason, a continuous coating which will prevent the entrance of any air produces the optimum results.

The gel-like coating should be somewhat plastic or rubbery to minimize cracking; should not flow excessively under its own weight; should adhere to vertical walls and ceilings of coal, wood and similar materials; and should form a sealing layer impervious to air. When applied to burning materials, it should not show excessive cracking during cooling of the hot materials. The gel should continue to adhere to hot walls and ceiling during their cooling period even after it has dried out. As a further discussion of what is meant by excessive cracking, it might be said that an average of a single crack one foot long and not more than $\frac{1}{8}$ in. wide in every square foot of surface, about one hour after application of the coating, and without resealing with additional gel, is as much cracking as should occur. If the initial cracks are resealed, by the application of additional coating material, the ultimate coating will be practically free of cracks.

The thickness of the deposit required to extinguish a fire should be sufficient to provide a continuous coating regardless of the contour of the surface being treated. On a smooth surface the deposit need be only about $\frac{1}{16}$ inch in thickness. For more irregular surfaces, the thickness of the coating may have to be as much as one inch. The temperature of the surfaces, being coated also is a factor that must be considered. For instance, if coal has been burning for several hours and a high temperature has developed it may be necessary to provide a coating thickness of several inches. However, it has been found that a coating thickness of from $\frac{1}{8}$ inch to 1 inch is sufficient for most ordinary types of fires.

It is desirable that a sufficient coating of gel be applied to the exposed surfaces of the burning material that the fire be extinguished before the coating is completely dry. It will be appreciated, of course, that the amount of cracking becomes more severe as the gel dries out and that for a fresh gel only $\frac{1}{2}$ hour old or so, there is no appreciable amount of cracking unless it has been applied in too thin a layer for the intensity of the fire involved.

The extent to which the coating material should be allowed to settle into large cracks or crevices is important. If it flows too deeply into such openings while still in a liquid state, excessive steaming will occur. Therefore, the coating material will run into cracks and crevices that are not too deep and will either form a covering that will follow the contour of the surface area or will fill in the depressions. If a crack or crevice is so deep that the coating material will solidify before reaching its bottom, the coating material will build up and will bridge across, thereby sealing off the crack or crevice.

The action of the deposited layer in effecting extinguishment of the fire is as follows:

(a) The entrance of air to the fire zone is prevented and, hence, combustion is stopped.

(b) The water in the gel forming material

tends to cool the surface of the burning material due to evaporation.

(c) The heat is conducted into adjacent unburning areas to aid in cooling the burning area.

(d) The involved surfaces are cooled due to conduction of heat from the burning material thru the gel coating to the outside atmosphere.

It has been stated above that the invention involves the provision of two or more solutions which, when mixed or combined, will become transformed into the above described gel-like coating within a very small fraction of a minute after the mixture is applied to the surfaces of the burning material. This phase of the invention now will be considered in detail.

It has already been mentioned that the solutions to be mixed are stored in separate containers until they are to be applied to involved surfaces to form the desired coating.

The two gel forming solutions are mixed by being brought together in a spray gun and the resultant stream is directed onto the surfaces to be coated. The spray gun may, for example consist of a cluster of any even number of nozzle tips, one-half of which are for one of the solutions while the other one-half are for the other solution. These nozzle tips are directed slightly toward each other so that the slant of their discharged jets is such that the solutions impinge at a point about 6 inches ahead of the tips. It has been found that if the jets impinge too close to the nozzle tips, there is danger of gelling action and clogging in the spray gun.

The gun is provided with an air aspirating and mixing tube which surrounds the impingement area of the gun. The solutions start to mix at the point of impingement and the mixing becomes more thorough as the resultant stream travels to the surfaces to be coated.

The gelling time may be such that some mixing takes place on the surfaces being coated as the solutions flow slightly before gelling. The time it takes the solutions to move from the nozzle tips, or point of impingement, to the surfaces depends on several factors, among them being the distance and velocity at which these solutions are sprayed. This time will vary from about $\frac{1}{4}$ second or less for short distances up to $\frac{1}{2}$ to 1 second for distances of 30 to 50 feet. In other words, the time of flight of the stream may vary between a very small fraction of 1 second for very short distances up to one second for the maximum projection range of the discharged stream. The gelling time should be such that the mixed solutions will actually contact the surfaces to be coated before gelling takes place. In the majority of cases, the time of flight is $\frac{1}{2}$ second or less.

As the mixed solutions gel or set after they contact the surfaces to be coated, it is obvious that the gelling time must at least be as long as the time of flight of the stream. It will be appreciated, of course, that the gelling time is somewhat affected by the degree of mixing which occurs at the point of impingement of the solution jets. It has been found that gelling times of from zero to 4 seconds after the mixed solutions have been applied to the surfaces have given satisfactory results, however, a gelling time of $\frac{1}{8}$ to 3 seconds after contact gives optimum all-round results.

The best gelling time for optimum results depends somewhat on the nature of the surfaces being coated. For instance, if the surface to be coated is a smooth vertical wall of coal, a gelling

time, after contact, in the neighborhood or $\frac{1}{8}$ to $\frac{1}{2}$ second is optimum, whereas if the surface is a horizontal one with ragged pieces of coal, a gelling time, after contact, of one second or more gives optimum results because, in this instance, it is desirable that the mixed solutions flow a little more before setting.

Since all types of surfaces may be encountered in extinguishing a given fire, and since the distance of projection (and, hence, the time of flight) will vary, the exact gelling time must be in the nature of a compromise. For example, if the stream is projected on an average of about 25 feet and a gelling time of $\frac{5}{8}$ of a second to, 3 seconds after mixing is employed, satisfactory results will be obtained.

As the solutions impinge together and travel through the air, their viscosity tends to increase as the mixing becomes more thorough. It is desirable that the viscosity of the mixed solutions, as they strike the surfaces to be coated, and just before they gel or set, be less than the viscosity of a No. 60 S. A. E. oil at 100° F. or less than about 450 centipoises.

It has been established that good results can be obtained when the gelling time, after the mixed solutions strike the surfaces, is such that the solutions run as much as 3 feet on a vertical smooth coal surface before setting. However, optimum results are obtained when the solutions run between a small fraction of one inch up to one foot on vertical surfaces before setting.

The gelling time is uniform if uniform mixing is provided. Therefore, by employing a nozzle which provides uniform mixing, the solutions set uniformly throughout their mass after being applied. It will be appreciated, of course, that the gel-like coating may be built up layer-by-layer as the mixed solutions are applied. For instance, if the stream is directed against a vertical wall, a thin film of a few fractions of an inch is initially placed on the wall and, after running a slight distance, the extent of which depends upon the gelling time, sets giving a thin layer of gel. As the stream continues to be directed against the wall, an additional thin layer forms on top of the previously formed layer and sets so that the final thickness of the gel is determined by how long the stream is directed on the same location.

Immediately after the gel is set it is somewhat rubbery or plastic and contains considerable water. As further setting takes place, the gel becomes slightly more rigid and less plastic or rubbery; however, the biggest change in the gel as time goes on is caused by the evaporation or drying out of water. As the water dries out, the gel becomes harder and more brittle. When considerable water has dried out a small amount of cracking may occur; however, this cracking is at a minimum, as has been described. After the water has almost completely dried out of the gel, a hard substance remains which adheres to and covers the surfaces. Complete drying out may occur in about 24 hours if a relatively cool surface is coated.

When a gas pressure such as steam or coal gas develops beneath the layer of deposited gel material, small blow holes appear in the gel to relieve this pressure. It will be appreciated that if these blow holes did not form the layer of gel would be pushed away from the coal surface by the pressure which would develop. The blow holes relieve this pressure and, since the gas such as steam is coming out of the holes, air cannot enter the holes at this time and the effective-

ness of the deposited layer is therefore not reduced. The blow holes which form may be a matter of one blow hole $\frac{1}{2}$ inch in diameter for every 2 or 3 square feet of covered surface. If the fire is extremely hot when the gel layer is originally formed on the burning surfaces, the blow holes formed may be more numerous since considerable gas is developed within the hot burning material. As the hot burning material cools off, less gas is formed and, therefore, less blow holes are required to vent the gas. At this point, the fire is usually not considered to be completely extinguished and additional gel material is sprayed on the surfaces to cover up or close the blow holes and thus prevent the entrance of air after the blow holes are no longer required to relieve gas pressure. In other words, in extinguishing a fire the operator applying the gel should stay with it until the fire is extinguished to seal the blow holes and any cracks which might develop. It will be appreciated, of course, that any shifting of the coal surface will cause cracks to appear in the gel coating even though the gel deposit had no tendency to form cracks because of its own shrinkage.

It has been found to be preferable to add to either one of the starting solutions a chemical of the type that is known in the mechanical foam extinguishing art as a foam stabilizer. The addition of a foam stabilizer does not affect the gelling time noticeably. In other words, the gelling time is the same, regardless of whether or not a foam stabilizer is used. The characteristics of the gel coating are affected as follows:

(a) By the addition of a foam stabilizer, the volume of the gel usually is increased up to 50 percent due to entrainment of air. In other words, about $\frac{1}{3}$ of the volume of the gel when the stabilizer is used is air. This permits greater coverage when the same layer thickness is used.

(b) The incorporated air, due to the foam stabilizer, appears to give a slight reduction in cracking tendency.

The primary importance of the addition of the foam stabilizer is to obtain increased coverage due to increased volume. The drying out time of the gel is not noticeably affected by the addition of the foam stabilizer.

There is not too much difference in the appearance of the gel coating with or without the addition of the stabilizer. It particularly should be noted that when the stabilizer is added the gel coating does not in any way resemble any conventional form of fire extinguishing foam blanket and it is difficult to tell, just by looking at the gel coating, whether or not a stabilizer has been added. The main differences between foam blankets as formed by the present fire extinguishing foams and the gel deposit provided by this invention when stabilizer is added are as follows:

(a) The amount of entrained air is very much less. For instance, in regular mechanical air foam blankets, the foam solution has its volume increased 600 to 700 percent due to the incorporation of air; whereas in the present invention the gel volume is increased only about 50 to 150 percent. The regular foams have a foamy, frothy appearance, whereas the present gel material with the stabilizer and entrained air does not have this appearance.

(b) The ordinary foam blankets are composed of bubbles of air which are surrounded by very thin watery membranes; whereas the present gel material with entrained air is gel-like in appearance and the bubbles of air are very small and

are surrounded by substantial amounts of gel material.

(c) The regular foam blankets are runny and watery and, because of the thin watery membrane surrounding, the air bubbles break down readily due to heat, whereas the present gel material with incorporated air is firm and plastic and resistant to heat.

(d) Regular foam blankets will not adhere to vertical walls in a stationary position in appreciable thickness when heat is present, whereas the present gel material will.

Suitable solutions to produce the liquid composition of the invention, are set forth in the following examples.

Example 1

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.205 is combined with twenty five volumes of an aqueous solution containing 15.6% potassium bicarbonate by weight. These solutions produce a gel within one to two seconds.

Example 2

Forty volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.205 is combined with thirteen volumes of an aqueous solution containing 19.5% potassium bicarbonate by weight. These solutions produce a gel within two to three seconds.

Example 3

Fifteen volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.39 is combined with fifty volumes of an aqueous solution containing 10% potassium bicarbonate by weight. These solutions produce a gel within one to two seconds.

Example 4

Fifty volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.153 is combined with sixteen volumes of an aqueous solution containing 19.5% potassium bicarbonate by weight. These solutions produce a gel within four seconds.

Example 5

Fifty volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.153 is combined with twenty five volumes of an aqueous solution containing 19.5% potassium bicarbonate by weight. These solutions produce a gel within one second.

Example 6

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.39 is combined with twenty five volumes of an aqueous solution containing 21% sodium chloride by weight. These solutions produce a gel within one second.

Example 7

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.39 is combined with twenty volumes of an aqueous solution containing 26% sodium chloride by weight. These solutions produce a gel within one to two seconds.

Example 8

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific

gravity of 1.39 is combined with fifteen volumes of an aqueous solution containing 26% sodium chloride by weight. These solutions produce a gel within two seconds.

Example 9

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.304 is combined with twenty five volumes of an aqueous solution containing 26% sodium chloride by weight. These solutions produce a gel within one to two seconds.

Example 10

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.304 is combined with thirty five volumes of an aqueous solution containing 26% sodium chloride by weight. These solutions produce a gel within two seconds.

Example 11

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.205 is combined with twenty five volumes of an aqueous solution containing 10% sodium aluminate by weight. These solutions produce a gel within one second.

Example 12

Seventy five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.15 is combined with fifty volumes of an aqueous solution containing 10% sodium aluminate by weight. These solutions produce a gel within one to two seconds.

Example 13

Twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.15 is combined with twenty five volumes of an aqueous solution containing 10% sodium aluminate by weight. These solutions produce a gel within one to two seconds.

Example 14

Fifty volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.205 is combined with seventy five volumes of an aqueous solution containing 7½% sodium aluminate by weight. These solutions produce a gel within one to two seconds.

Example 15

Fifty volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.205 is combined with seventy five volumes of an aqueous solution containing 5% sodium aluminate by weight. These solutions produce a gel within four seconds.

Example 16

One hundred twenty five volumes of an aqueous solution of sodium silicate ($\text{Na}_2\text{O} \cdot 3\frac{1}{4}\text{SiO}_2$) having a specific gravity of 1.391 is combined with two hundred seventy five volumes of an aqueous solution containing 9% sodium bicarbonate by weight. These solutions produce a gel within two and eight tenths seconds.

In any one of the above examples, from 1 to 5%, with 1½% preferred, by weight of the commercial foam stabilizer known as Orvis W. A. paste can be added to the silicate solution. Other commercial foam stabilizers may be substituted. Also in these examples, it may be mentioned that the preparations calling for a combination of

equal volumes of the two solutions, are preferred.

It has been established that the sodium silicate and sodium chloride solutions of Examples 6 to 10 inclusive are the best because an increase in volume up to 150 percent can be obtained when a foam stabilizer is added. Also, there is much less tendency for the gel coating to crack.

The storage of highly concentrated sodium chloride solutions in ordinary steel containers for long periods of time may cause some corrosion trouble. However, this problem can be solved by the addition of small quantities of any of the well known chromate corrosion inhibitors without affecting in any way the gelling properties of these solutions.

It is possible to employ any means for drawing or removing these solutions from their respective tanks and combining them for delivery upon the combustible material. For example, pumps may be used to draw the solutions out of their tanks and force them through separate conduits to their point of mixing and delivery upon the combustible material.

The invention, however, contemplates the use of gas pressure to expel the two solutions from their respective tanks and force them into admixture with each other and upon the combustible material. This procedure has the advantage of not requiring any local source of power such as might be required, for example, with electric motor driven pumps. The use of gas pressure has the additional advantage that the container for this gas under pressure may be of very small size and as a consequence the containers for the solutions and for this gas may be made into a mobile unit of compact size.

In the accompanying drawings a suitable mobile unit is illustrated containing the receptacles for the two solutions and the gas pressure tank.

In these drawings:

Figure 1 is a front elevational view of a mobile fire extinguishing unit,

Figure 2 is a sectional view through the nozzle of Figure 1,

Figure 3 is a plan view of Figure 1, and

Figure 4 is a sectional view on the line 4—4 of Figure 3.

The vehicle 6 may of any appropriate formation to provide a framework to mount the receptacles for carrying the solutions of the invention. This vehicle 6 is provided with wheels 7 which are intended to run upon the rails 8 of the usual trackway within underground mines. This wheeled support makes it possible to move the vehicle 6 readily about the mines, because of the reduced friction offered by the movement upon the rails, but it will be appreciated that it is possible to utilize any wheeled or crawler tread type of vehicle.

Secured to the framework of the vehicle 6, in any suitable manner, is a tank 10 and a tank 11. The tank 10 may contain, for example, the silicate and the foaming agent. The tank 11 would then contain the other solution. The concentrations of these ingredients in tanks 10 and 11 may be those, for example, set forth above so that their direct combination will result in the formation of an appropriate gel-like composition.

Also supported upon the framework of vehicle 6 is a tank 12 which contains gas under a high pressure. This gas is preferably an inert one, such as nitrogen. The delivery of this gas from tank 12 is controlled by a valve 13 and the gas passes through a pipe 14, then through a four-

way coupling 15 and through a valve 16 to a T-connection 17. A gage 18 is connected to the coupling 15 and a blow-down valve 19 is also connected to this coupling.

From the T-connection 17, the gas passes on one side through the pressure reducing valve 21 and into the tank 11. Pressure release valve 22 and a gage 23 are in communication with tank 11. On the other side of the T-connection 17, the gas passes through a pressure reducing valve 24 into the tank 10, and a pressure release valve 25 and gage 26 are in communication with tank 10.

The pressure reducing valves 21 and 24 are adjustable so that any desired pressure may be maintained in the tanks 10, 11 independently of each other. This is desirable to compensate for the fact that the solution in one of these tanks may be of higher viscosity than the solution in one of these tanks may be of higher viscosity than the solution in the other tank. For example, the silicate solution may require a higher pressure to force the required amount through a pipe line than is required to force the necessary amount of the other solution. However, it is possible to utilize a single pressure reducing valve to deliver the gas to both tanks 10 and 11 and to employ restricting means in the delivery of the solutions from their respective tanks. The pressure release valves 22 and 25 serve to prevent the occurrence of any damage, such as might be occasioned by faulty operation of the pressure reducing valves 21 and 24.

A dip tube 28 extends to the bottom of tank 10 and to it is connected a flexible conduit 29. A similar dip tube 30 extends to the bottom of tank 11 and a flexible conduit 31 is connected to it. The flexible conduits 29 and 31 extend to a playpipe 32. At the entry of conduits 29 and 31 into the playpipe 32, they are each provided with nozzles 33 and 34, respectively, and valves 35 and 36 are located in these conduits 29 and 31 ahead of the nozzles 33 and 34. Although each of the flexible conduits 29 and 31 is here shown to be provided with a single discharge nozzle 33 and 34, respectively, it will be understood that each of these conduits may be provided with more than one nozzle for delivery of the respective solutions into the playpipe 32 to cause a greater intermixing of these solutions in the playpipe 32.

The playpipe 32 is attached to the nozzles 33 and 34 in any suitable manner so as to be supported by them. The end of the playpipe 32 into which the nozzles 33 and 34 direct their streams should, preferably, be open as appears from Figure 2, so that air will be drawn into this open end and will be entrained into the combined solutions.

When the fire fighting unit is standing by to be used to extinguish a fire, the valve 13 will be closed to prevent leakage of gas from the gas tank 12. Also, this will relieve the tanks 10 and 11 of any pressure which might tend to cause a slight leakage of the solutions which they contain. The blow-down valve 19 should be closed and the valve 16 should be open.

Upon the occurrence of a fire, the fire fighting unit is moved to the fire and the valve 13 is opened. This immediately places the tanks 10 and 11 under pressures tending to expel their contents through the flexible conduits 29 and 31. The valves 35 and 36 are then opened so that these solutions are delivered into the playpipe 32 and upon the combustible material in which the fire is present. The operator by manipulation

of the playpipe 32 distributes this combined mixture upon the combustible material and within a few seconds it sets up to form a gel-like coating. This operation is continued until a quite thick coating is formed over the combustible material.

After a sufficient application of the fire extinguishing composition has been made, valve 13 is closed and valve 19 is opened in order to relieve any pressure within the tanks 10 and 11. The gas pressure within the tank 12 may be determined at any time by closing valves 16 and 19 and opening valve 13. Tanks 10 and 11 may be filled through the plugged openings 37 and 38, respectively.

Having thus described the invention, we claim:

1. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting there against a stream formed essentially of twenty-five volumes of an aqueous solution of sodium silicate having a specific gravity of from 1.304 to 1.39 and from fifteen to thirty-five volumes of an aqueous solution containing from twenty-one to twenty-six per cent sodium chloride by weight, which are combined and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of from one second to two seconds after being mixed.

2. The method of preventing combustible materials from being consumed by fire, comprising forming over the exposed surface of the material a gel-like coating that is built up layer-by-layer to a desired thickness by projecting against said surface a stream formed essentially of twenty-five volumes of an aqueous solution of sodium silicate having a specific gravity of from 1.304 to 1.39 and from fifteen to thirty-five volumes of an aqueous solution containing approximately twenty-six per cent sodium chloride by weight, which are combined and mixed with air after the time of their projection and each layer of which will gel sufficiently to cease flowing within a period of from one to two seconds after being applied.

3. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating which will adhere to all exposed surfaces of the material by projecting against said surfaces a stream formed essentially of twenty-five volumes of an aqueous solution of sodium silicate having a specific gravity of approximately 1.304 and from twenty-five to thirty-five volumes of an aqueous solution containing approximately twenty-six per cent sodium chloride by weight which are mixed at the time of their projection and which, as a result of being combined, will first flow over said surfaces sufficiently to fill cracks and crevices and will then gel, within a period of from one to two seconds after being mixed, to form a continuous rubbery, plastic layer.

4. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating which will adhere to all exposed surfaces of the material by projecting against said surfaces a stream formed essentially of a given volume of an aqueous solution of sodium silicate having a specific gravity of approximately 1.304 and a substantially equal volume of an aqueous solution containing approximately twenty-six percent sodium chloride by weight which are mixed at the time of their projection and which, as a result of being combined, will first flow over said surfaces sufficiently to fill

cracks and crevices and will then gel, within a period of from one to two seconds after being mixed, to form a continuous rubbery, plastic layer.

5. A fire extinguishing composition comprising essentially a given volume of an aqueous solution of sodium silicate having a specific gravity of approximately 1.304 and a substantially equal volume of a separately stored aqueous solution containing approximately twenty-six per cent sodium chloride by weight which on intermixing with the first solution will produce within one to two seconds of their intermixing, a gel-like, rubbery, non-flowing substantially continuous coating which will adhere to and conform to the surface of combustible material, and exclude the admission of air for the period required to extinguish the fire therein.

6. A fire extinguishing composition comprising essentially twenty-five volumes of an aqueous solution of sodium silicate having a specific gravity of from 1.304 to 1.39 and from fifteen to thirty-five volumes of a separately stored aqueous solution containing twenty-one to twenty-six per cent sodium chloride by weight which on intermixing with the first solution will produce within one to two seconds of their intermixing, a gel-like, rubbery, non-flowing substantially continuous coating which will adhere to and conform to the surface of combustible material, and exclude the admission of air for the period required to extinguish the fire therein.

7. A fire extinguishing composition comprising essentially twenty-five volumes of an aqueous solution of sodium silicate having a specific gravity of from 1.304 to 1.39 and from fifteen to thirty-five volumes of a separately stored aqueous solution containing approximately twenty-six per cent sodium chloride by weight which on intermixing with the first solution will produce within one to two seconds of their intermixing, a gel-like, rubbery, non-flowing substantially continuous coating which will adhere to and conform to the surface of combustible material, and exclude the admission of air for the period required to extinguish the fire therein.

8. A fire extinguishing composition comprising essentially twenty-five volumes of an aqueous solution of sodium silicate having a specific gravity of approximately 1.304 and from twenty-five to thirty-five volumes of a separately stored aqueous solution containing approximately twenty-six per cent sodium chloride by weight which on intermixing with the first solution will produce within one to two seconds of their intermixing, a gel-like, rubbery, non-flowing substantially continuous coating which will adhere to and conform to the surface of combustible material, and exclude the admission of air for the period required to extinguish the fire therein.

9. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.4 and an aqueous solution of an alkali metal salt selected from the group consisting of the chlorides, carbonates and aluminates, the volumetric ratio of said silicate solution to said salt solution being: (a) within the range of 25 parts of silicate solution to about 15 to about 35 parts of chloride solution, said chloride solution containing from about 21 to about 26 per cent by weight of chloride; (b) with-

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in the range of 25 parts of silicate solution to about 83 parts of carbonate solution, said carbonate solution containing from about 9 to about 19.5 per cent by weight of carbonate; and (c) within the range of 25 parts of silicate solution to about 25 to about 37.5 parts of aluminate solution, said aluminate solution containing from about 5 to about 10 per cent by weight of aluminate, said aqueous solutions being mixed at the time of their projection and gelling sufficiently to cease flowing over said surface within a period of from one-quarter second to four seconds after being mixed.

10. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of from about 1.1 to about 1.4 and an aqueous solution of carbonate of an alkali metal containing from about 9 to about 19.5 percent by weight of carbonate, which are combined at a volumetric ratio within the range of 25 parts of silicate solution to about 8 to about 83 parts of carbonate solution and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of 4 seconds after being mixed.

11. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.2 and an aqueous solution containing about 19.5 percent potassium bicarbonate by weight, which are combined at a volumetric ratio within the range of 25 parts of said silicate solution to about 8 to about 12.5 parts of said bicarbonate solution and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of 4 seconds after being mixed.

12. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of about 1.2 and an aqueous solution containing about 15.6 percent potassium bicarbonate by weight, which are combined at a volumetric ratio of 25 parts of silicate solution to about 25 parts of said bicarbonate solution and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of 2 seconds after being mixed.

13. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of about 1.4 and an aqueous solution containing about 9 percent sodium bicarbonate by weight, which are combined at a volumetric ratio of 25 parts of silicate solution to about 55 parts of said bicarbonate solution and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of 2.8 seconds after being mixed.

14. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed sur-

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face of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.2 and an aqueous solution containing about 5 to about 10 percent of sodium aluminate by weight, which are combined at a volumetric ratio within the range of 25 parts of silicate solution to about 33 to about 37 parts of said aluminate solution and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of 4 seconds after being mixed.

15. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.2 and an aqueous solution containing about 10 percent sodium aluminate by weight, which are combined at a volumetric ratio of 25 parts of silicate solution to about 25 parts of said aluminate solution and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of 2 seconds after being mixed.

16. The method of preventing combustible materials from being consumed by fire, comprising forming a gel-like coating over the exposed surface of the material by projecting against said surface a stream formed of an aqueous solution of sodium silicate having a specific gravity of about 1.15 and an aqueous solution containing about 10 percent sodium aluminate by weight, which are combined at a volumetric ratio of 25 parts of silicate solution to about 25 parts of said aluminate solution and mixed with air at the time of their projection and which will gel sufficiently to cease flowing over said surface within a period of 2 seconds after being mixed.

17. A fire extinguishing composition formed essentially of an aqueous solution of sodium silicate and a separately stored aqueous solution of an alkali metal salt selected from the group consisting of the chlorides, carbonates and aluminates which upon intermixing with the first solution in a volumetric ratio: (a) within the range of 25 parts of silicate solution to about 15 to about 35 parts of chloride solution, said chloride solution containing from about 21 to about 26 percent by weight of chloride; (b) within the range of 25 parts of silicate solution to about 8 to about 83 parts of carbonate solution, said carbonate solution containing from about 9 to about 19.5 percent by weight of carbonate; and (c) within the range of 25 parts of silicate solution to about 25 to about 37.5 parts of aluminate solution, said aluminate solution containing from about 5 to about 10 percent by weight of aluminate; will produce a gel-like, rubbery, non-flowing material which will adhere to and conform to the surface of combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

18. A fire extinguishing composition formed essentially of 25 volumes of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.4 and from about 8 to about 83 volumes of a separately stored aqueous solution, containing from about 9 to about 19.5 percent carbonate of an alkali metal by weight which on intermixing with the first solution will produce, within 4 seconds of their intermixing, a

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gel-like, rubbery, non-flowing, substantially continuous coating which will adhere to and conform to the surface of the combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

19. A fire extinguishing composition formed essentially of 25 volumes of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.2 and from about 8 to about 12.5 volumes of a separately stored aqueous solution containing about 19.5 percent potassium bicarbonate by weight which on intermixing with the first solution will produce, within 4 seconds of their intermixing, a gel-like, rubbery, non-flowing, substantially continuous coating which will adhere to and conform to the surface of the combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

20. A fire extinguishing composition formed essentially of 25 volumes of an aqueous solution of sodium silicate having a specific gravity of about 1.2 and about 25 volumes of a separately stored aqueous solution containing about 15.6 percent potassium bicarbonate by weight which on intermixing with the first solution will produce, within 2 seconds of their intermixing, a gel-like, rubbery, non-flowing, substantially continuous coating which will adhere to and conform to the surface of the combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

21. A fire extinguishing composition formed essentially of 25 volumes of an aqueous solution of sodium silicate having a specific gravity of about 1.4 and about 55 volumes of a separately stored aqueous solution containing about 9 percent sodium bicarbonate by weight which on intermixing with the first solution will produce, within 2.8 seconds of their intermixing, a gel-like, rubbery, non-flowing, substantially continuous coating which will adhere to and conform to the surface of the combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

22. A fire extinguishing composition formed essentially of 25 volumes of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.2 and from about 33.3 to about 37.5 volumes of a separately stored aqueous solution containing from about 5 to about 10 percent sodium aluminate by weight

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which, on intermixing with the first solution will produce, within 4 seconds of their intermixing, a gel-like, rubbery, non-flowing, substantially continuous coating which will adhere to and conform to the surface of the combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

23. A fire extinguishing composition formed essentially of 25 volumes of an aqueous solution of sodium silicate having a specific gravity of from about 1.15 to about 1.2 and about 25 volumes of a separately stored aqueous solution containing about 10 percent sodium aluminate by weight which on intermixing with the first solution will produce, within 2 seconds of their intermixing, a gel-like, rubbery, non-flowing, substantially continuous coating which will adhere to and conform to the surface of the combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

24. A fire extinguishing composition formed essentially of 25 volumes of an aqueous solution of sodium silicate having a specific gravity of about 1.15 and about 25 volumes of a separately stored aqueous solution containing about 10 percent sodium aluminate by weight which on intermixing with the first solution will produce, within 2 seconds of their intermixing, a gel-like, rubbery, non-flowing, substantially continuous coating which will adhere to and conform to the surface of the combustible material and will exclude the admission of air for the period required to extinguish the fire therein.

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