Jan. 19, 1937. J. T. WHITFIELD 2,068,119

METHOD AND APPARATUS FOR GENERATING GAS

Filed Feb. 4, 1935 3 Sheets-Sheet 1

Fig. 1.

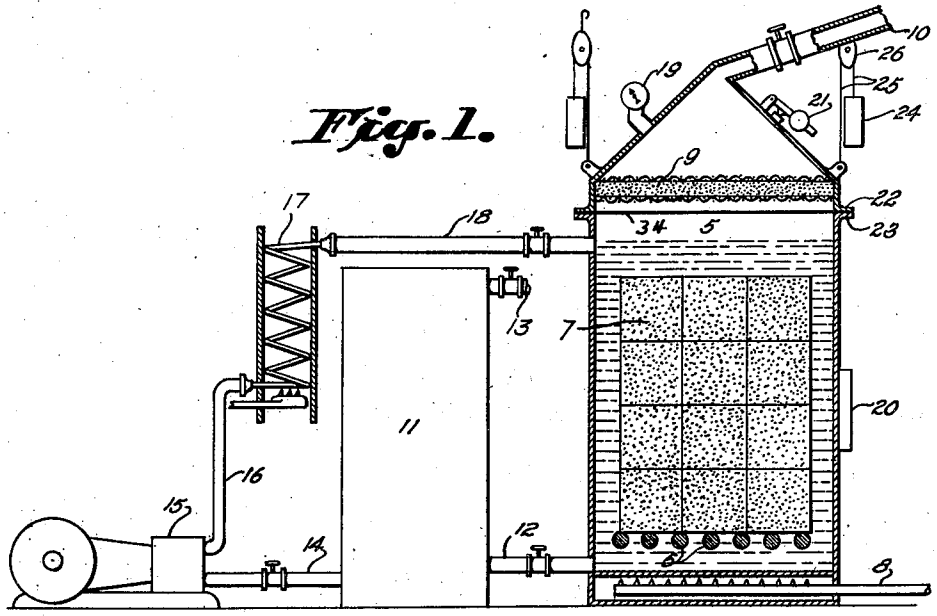


Fig. 7.

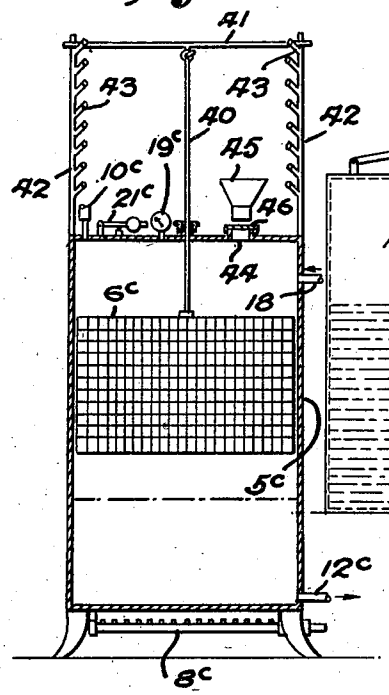
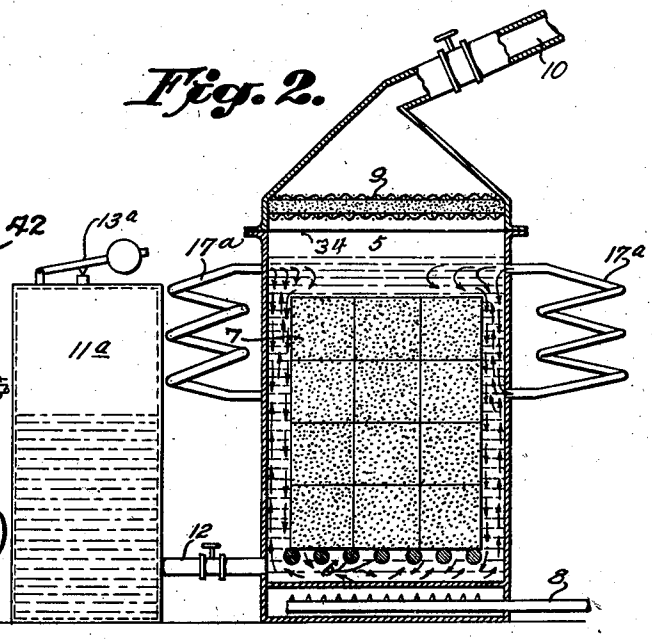


Fig. 2.



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METHOD AND APPARATUS FOR GENERATING GAS

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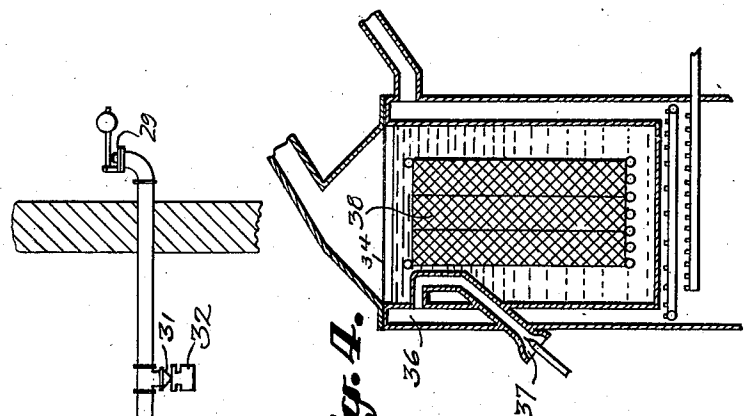


Fig. 4.

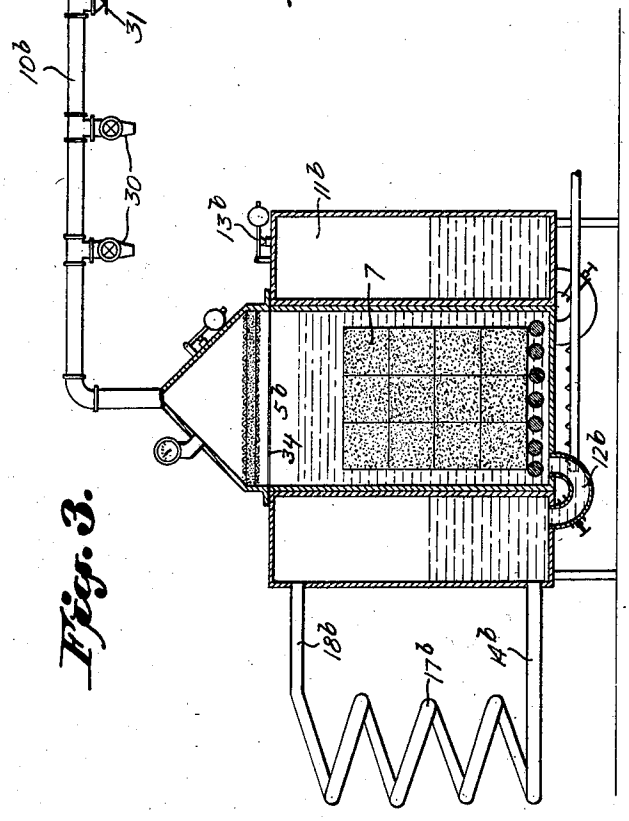


Fig. 3.

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METHOD AND APPARATUS FOR GENERATING GAS

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Fig. 5.

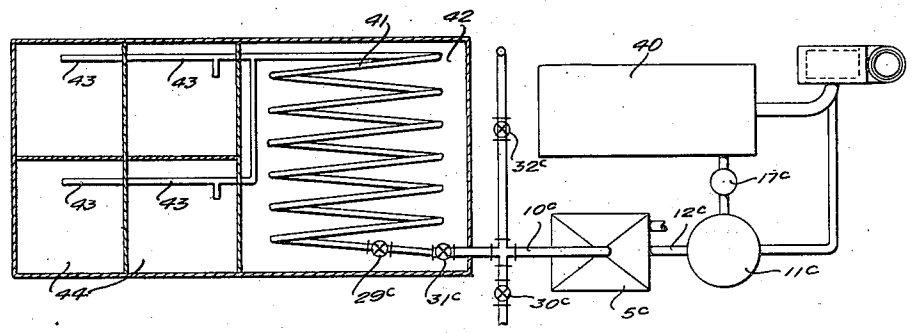
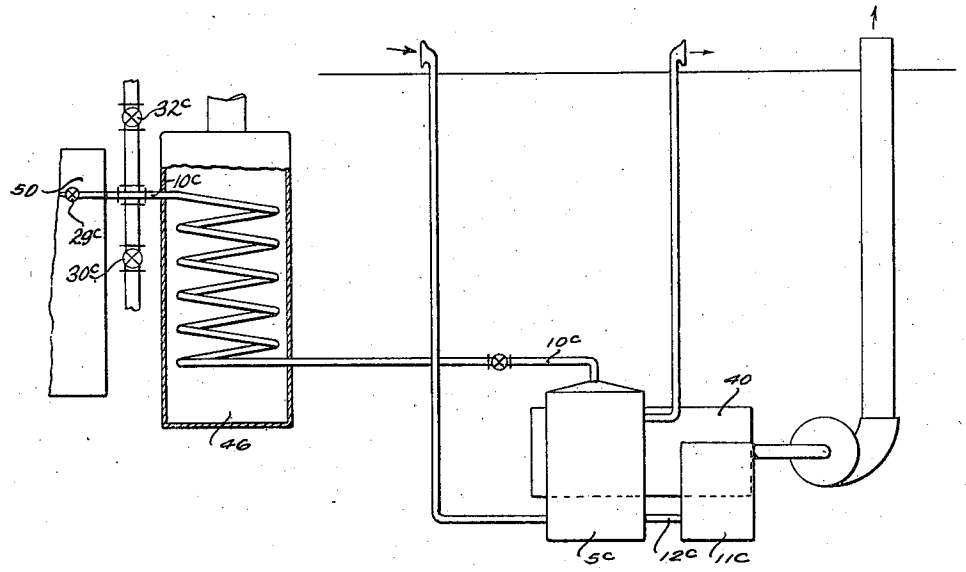


Fig. 6.



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UNITED STATES PATENT OFFICE

2,068,119

METHOD AND APPARATUS FOR GENERATING GAS

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Application February 4, 1935, Serial No. 4,980

28 Claims. (Cl. 169—11)

This invention relates to a method and apparatus for generating a gas from its solid and particularly above its critical temperature. In a more specific aspect the invention relates to a method and apparatus for extinguishing fires.

It has heretofore been known that carbondioxide gas is useful for many purposes and particularly for the extinguishing of fires. Its use, however, has been limited by the difficulty of conveying it quickly in large quantities to the places at which it is needed. Thus, in the fighting of fires carbondioxide gas has been used to a small extent in portable fire extinguishers which are filled with a strong solution of a carbonate or bicarbonate and are also supplied with a small container of an acid which is spilled into the carbonate solution when the fire extinguisher is in use. Liquid carbondioxide has also been used to some extent for extinguishing fires but in either form, whether chemically combined or liquid, the bulk and particularly the unwieldy apparatus required, places a very narrow limit on the extent to which the carbondioxide may be used in the fighting of fires.

Although it has been recognized for some time that carbondioxide gas is one of the most effective agencies for combatting fire and that a concentration as low as 17% in the atmosphere surrounding a fire will prevent combustion, nevertheless its application has been very limited and fire fighting is still done almost entirely with water or with such non-inflammable and more or less volatile liquids as carbon tetrachloride.

I have now discovered a way in which solid carbondioxide may be made to supply carbondioxide gas in large quantities and I have invented an apparatus which is no more cumbersome and extremely more effective than the present fire fighting apparatus designed for use with water.

In the accompanying drawings,

Figure 1 illustrates diagrammatically an apparatus built in accordance with my invention;

Figure 2 illustrates a modified form of a similar apparatus; and

Figure 3 illustrates diagrammatically an apparatus which is designed to combine the functions of a refrigerating apparatus and a fire extinguishing apparatus.

Figure 4 illustrates another modified form of the apparatus.

Figures 5 and 6 show diagrammatically one application of my invention to structures such as ships, storage buildings, etc.

Figure 7 shows in vertical section a modification of my invention adapted for use as a portable fire extinguisher.

Referring particularly to the drawings in which I have illustrated an embodiment of my invention which I now believe to be the most satisfactory form as applied to fire fighting apparatus. The reference character 5 indicates a pressure chamber or gas generator. In the bottom of this chamber a grating 6 is secured several inches from the bottom; for example, about 3 inches will ordinarily be sufficient. Blocks 7 of solid carbondioxide commercially known as "dry ice" are piled on the grating. The generator is then filled with a suitable liquid having a low freezing point which surrounds at least a part of the dry ice on the grating. The liquid is heated by a suitable heating means 8 positioned in heat-exchange relation to the generator. I have indicated such a heating means diagrammatically in the drawings as a gas burner under the generator, but it will be understood, of course, that any other well known type of heating device could be provided instead of the gas burner. Above the liquid level in the generator is a bubble screen 9 which, in the present instance, I have shown as consisting of two screens holding between them a dehydrating agent such as dry calcium chloride; and above the bubble scren is a valved pipe connection 10 adapted to receive a hose or other pipe.

A supplementary storage tank 11 is provided adjacent the gas generator 5 and is connected thereto by a valved pipe 12 extending from its bottom to the bottom of the generator. A relief valve 13 is provided on the tank 11 for relieving excessive gas pressures and a valved connection 14 leads from the bottom of the tank 11 to a pump 15. The pump is connected by a pipe 16 to a heating coil 17 or other suitable heat exchanger, from which a valved pipe 18 leads back to the gas generator 5.

Suitable gages are provided, e. g., a gage 19 to indicate the gas pressure and a gage to indicate the water level, etc. The gage 20 is shown diagrammatically as a dial indicator and may be any desired type of liquid level indicator. A safety valve 21 is preferably provided on the gas generator 5.

In the embodiment illustrated in Figure 1 the generator is split horizontally and is clamped together by the flanges 22 and 23 which preferably includes a sealing gasket 34 between them so as to form a gas-tight joint. The upper section in the embodiment illustrated in Figure 1 is counterbalanced by the weight 24 through chains or

cables 25 which pass over pulleys 26 on a framework (not shown) above the upper section. This counterbalancing assists in lifting and lowering the upper section for charging the pressure container with solid carbondioxide.

In operation the flanges 22 and 23 are unclamped and the upper section lifted from the lower section, after which the blocks of solid carbondioxide are placed on the grating 6. The upper section of the generator is then replaced and the flanges 22 and 23 securely clamped together so as to form a gas-tight seal and one which will withstand the operating pressure of 300 to 400 pounds per square inch.

Calcium chloride brine is then pumped into the generator 5 from the source of supply (not shown) until the solid carbondioxide is substantially covered with brine. In the meantime the burner 8 has been lighted so that the brine is being heated. This heat, however, is immediately absorbed by the gas which is liberated and by the solid CO_2, a large part of which gas is dissolved in the aqueous brine. The heat supplied to the brine should be sufficient to maintain its temperature well above its freezing point since a freezing of the brine would render the device temporarily inoperative. Above this requirement the amount of heat supplied will be to a certain extent controlled by the rate at which it is desired to generate the gas.

So long as the solid carbondioxide is completely covered with the liquid the rate at which the gas is generated will be controlled by the temperature of the liquid. Since, however, the liquid cannot be allowed to freeze without interferring with the operation of the apparatus, the control possible by varying the temperature of the liquid is limited to temperatures above its freezing point. When it is desired to further reduce the rate of gas production a different method of control must be adopted and to meet this need I provide for withdrawing liquid from the generator so that a smaller amount of the solid carbondioxide is covered with the liquid. This method obviously is also applicable to control over the entire range without changing the temperature of the liquid. In order to avoid building up of excessive pressures while the full capacity of the generator is not required, I provide the supplemental tank 11 into which the brine may be withdrawn when the working pressure is exceeded in the generator.

Thus, assuming that the valve in the pipe 10 is temporarily closed the continued evolution of gas from the solid CO_2 would very rapidly build up pressure in the generator 5. In order to prevent this from becoming excessive the valve in the connection 12 is opened and the brine or a portion thereof is permitted to escape into the supplemental tank 11. No circulating means is required to effect this removal of brine into the tank 11 since the generation of gas in the generator 5 will of itself tend to force the brine out of the generator. If the pressure in the tank 11 should be too high to permit this escape of liquid from the generator 5 the relief valve 13 on the tank 11 may be opened so as to reduce the pressure therein and permit a further amount of brine to escape into the tank from the generator. If the pipe 10 is completely closed the brine should be entirely withdrawn from contact with the solid CO_2. If, however, a continuing but smaller supply of CO_2 gas is required the level of the brine may be lowered without removing all of the brine from the generator.

In the parts of the generator where the solid CO_2 is not in contact with brine the heat contained in the gas which surrounds the solid CO_2 is very quickly consumed in the evaporation of some of the solid so that an insulating blanket of gas at a very low temperature covers the solid CO_2 and renders further evaporation of the solid extremely slow.

When all of the brine has been withdrawn from the generator the heating means under the generator may be cut off; but in practice, where the flow of the gas is only temporarily interrupted, it is not necessary to cut off the heating means since the blanket of gas forms such a poor conductor and the heat requirements for the generation of gas are so great that there will be relatively little effect on the solid CO_2 from the heating means in the absence of brine to conduct the heat into contact therewith.

When it is desired to reintroduce the brine into the generator this may be done automatically by maintaining the pressure in the supplementary tank 11 slightly above that desired in the generator and leaving the valve in the connection 12 open. With the apparatus operated in this manner the brine will be automatically forced from the generator into the supplementary tank when the desired pressure is exceeded in the generator and will be again forced back into the generator when the pressure therein again falls to or below the desired working pressure. When operated in this manner, an automatic, e. g., ordinary safety valve set to operate slightly above the desired working pressure of the generator may be used in place of the valve 13. An apparatus arranged for this automatic method of operation without the forced circulation is illustrated in Figure 2. The expansion of the gas in the tank 11 which is required to drive a large volume of the liquid back into the generator will ordinarily be taken care of by the heat which is absorbed from the atmosphere and such difference in pressure on the liquid as is caused by the expansion of the gas in the tank 11 will ordinarily not be beyond the permissible variation in working pressure of the gas delivered from the generator 5. In some cases, however, it may be desirable to supply some additional heat to the brine in the tank 11.

In some cases it may be desired to control the reintroduction of brine so that additional brine is supplied to the generator 5 from the supplemental tank 11 although the pressure in the latter is below that of the former. In such cases, of course, it is necessary to provide a positive circulating means such as the pump 15. In the embodiment of my invention which is illustrated in Figure 1, I have arranged this sequence of apparatus, that is, the generator, the supplemental tank and the pump, in series with a supplemental brine heater 17. With this system a continual circulation may be maintained so that heated brine is introduced near the surface of the liquid in the generator 5 and the level in the generator may be controlled by the relative regulation of the relief valve 13 and the valve in the connection 14. The introduction of heated brine near the surface of the brine in the generator is very important in case the generator is operated at a temperature near the freezing point of the brine. In this case the heat added to the brine near the bottom of the generator will often be completely consumed in the evaporation of the solid CO_2 before it reaches the upper part of the brine and unless additional heat is supplied adjacent the

surface the upper portion of the brine may become frozen, which would result in serious difficulties.

Instead of, or in addition to an external circulating system connected to the supplemental tank 11, as shown in Figure 1, other means for heating the brine may be provided. One or more heating coils suitably disposed around the circumference of the generator may be provided as illustrated at 17a in Figure 2, or instead of such external heating coil heating means may be provided around the exterior of the generator or through the space occupied by the liquid in the generator. Thus as shown in Figure 4, a flue from the main heater 8 might be arranged so as to supply heat to the liquid, as for example at 36, or fire tubes might be arranged through the pressure chamber of the generator so as to heat the liquid preferably adjacent its surface, e. g., as shown at 37, other heating means might be provided in the space normally occupied by the liquid. Although such means as are shown in Figures 1 and 2 are ordinarily sufficient to prevent freezing and provide for efficient operation if carefully controlled, it is advantageous to provide some heating means within the space indicated for the liquid in order that the brine may be quickly thawed in case it should become frozen because of careless operation.

In use it is desirable to regulate the intensity of heating, both at the main heater 8 and at the auxiliary heaters 17, 17a and/or 36 and 37, according to the pressure produced by the gas within the generator, until the temperature drops to a point substantially above the freezing point. Thereafter the heating should be controlled to maintain the temperature above the minimum and the level of the liquid should thereafter be controlled to maintain the desired pressure. The heater 17a in Figure 2 should preferably be shut off when the liquid level drops below the intake of its heating coil, and all heaters should ordinarily shut off when the chamber 5 is emptied of its liquid.

When the apparatus is used in fire fighting it is preferably set to operate at a pressure of around 300 to 400 pounds per square inch and one or more rubber hose which are adapted to carry such high pressure are connected to the generator and manipulated by the firemen in the same manner as the water hose are at present manipulated except, of course, that the gas is always directed at the base of the flame and should not be used to soak adjacent material to prevent it from catching fire. When the bubble screen 9 is used and particularly when a dehydrating agent is used in connection with the bubble screen either in the generator or at a separate point in the gas delivery line the possibility of injury from the use of the fire extinguishing agent is absolutely eliminated, and even without the provision of such bubble screen the damage from such mist or vapors of water as may be carried along with the gas is practically negligible.

The advantage of the use of this apparatus will be strikingly obvious when it is remembered that with present methods of fire fighting the greater part of the damage caused by fire is frequently due not to the smoke or the flames or the fire itself but to the water or chemical agent which is used to extinguish the fire. With the use of my invention all of this damage amounting to millions of dollars annually may be saved and in addition many fires may be brought under control or completely extinguished which would be hopeless of control by present fire fighting methods.

It is an additional important advantage that carbondioxide gas under pressures at which it is supplied by the apparatus of my invention can be conducted to any conceivable location at which a fire might occur. Thus on the upper floors of tall buildings where it would be impossible to provide water from any modern fire fighting apparatus, it is a simple matter to conduct a gas such as carbondioxide, the only problem being that of supporting the necessary length of hose, which problem can obviously be overcome with comparative ease as by suitably reinforcing the hose, e. g., with wire in its structure or by attaching the hose to a cable by which it is hoisted or simply by laying the hose along a stairway or a fire escape where it is supported at intervals by the building itself.

The blast which is delivered from the hose when my invention is used is not only under a pressure generated by the gas itself but is at a very low temperature due to its evaporation and its expansion when released from the hose. Thus there is combined with the smothering effect of the gas a cooling effect and the cooling effect is due both to the blast, of which the blowing out of a candle is an example, and to the very low temperature of the gas which in effect substantially freezes the fire out of existence.

In the operation of the apparatus a single charge of carbondioxide would be sufficient for any but the most serious fires. If, however, it is necessary to recharge the apparatus during its use this may readily be done by bringing additional blocks of solid CO_2 on trucks to the fire and no extraordinary precautions are necessary in transporting these blocks since the heat required to convert them into gas is so great that merely carrying them in any closed container, as in the body of a closed truck surrounds them with a blanket of low temperature air which so greatly retards the further evaportion as to make it unnecessary to use any additional insulating means. These blocks of solid carbondioxide are at present supplied as an article of commerce in the form of a compressed snow in blocks about 12 inches on an edge and weighing about 36 blocks to a ton more or less according to the extent to which they are compressed. If it is necessary to recharge at the fire there ordinarily would be more than one apparatus present so that one may be discontinued when another is being used and the upper section may be unclamped and lifted and the generator charged in the same manner as at the beginning of the operation.

For keeping the solid carbondioxide over long periods as, for example, before an alarm is received for a fire, it is necessary to provide special insulated chambers or vaults such as are ordinarily used in storing solid carbondioxide in the factories where it is made. On fireboats it may be desirable and practicable to provide such vaults in the hold so that a relatively large supply will always be on hand, but with fire trucks on which my apparatus may be mounted, it will ordinarily be preferable to carry only a supply of solid carbondioxide which is contained in the generator and to rely on additional supplies brought by truck from the factory or from a storage vault if required for continued operation.

At Figure 3 I have illustrated an apparatus which may be used as a stationary equipment in buildings or on shipboard, etc. The supply of

solid carbondioxide may be contained in a chamber 5b which is surrounded by brine in a chamber 11b. The brine will be cooled by the gradual evaporation of the solid carbondioxide and may be used in the refrigerating system of the building or the ship indicated diagrammatically at 17b. A vent from this chamber 5b may be connected with the atmosphere through a relief valve 29 which maintains a pressure suitable for fire fighting, e. g., of about 400 pounds per square inch. The vent pipe may pass through the building or ship with connections 30 at suitable points to which fire hose is or may be attached. In this manner a refrigerating system and a fire prevention system are combined. During ordinary conditions when there is no fire the solid carbondioxide gradually evaporates, cooling the brine and thus serving as a refrigerator and the gas which is formed in the storage chamber is vented to the atmosphere. In case of a small fire the pressure in the chamber may be sufficient and a hose may simply be taken from a rack beside one of the outlets from the vent pipe and cold carbondioxide gas directed against the burning material utilizing the pressure which already exists in the storage chamber. In case of a more serious fire calcium chloride brine or other suitable liquid would be run into the storage chamber and heating means applied so that it would operate as a gas generating chamber in the same manner as described above.

In the embodiment illustrated in Figure 3 I have shown the chamber 11b as built around the generator 5b and connected at its bottom with the bottom of the generator by means of openings or pipes 12b. In this embodiment I have also provided a relief valve 13b at the top of the chamber 11b which is adapted to permit sufficient escape of gas so that the pressure in the chamber 11b will be maintained sufficiently below that of the chamber 5b to keep the liquid from flowing back into contact with the solid carbondioxide. Pipes 14b and 18b connect the chamber 11b with a refrigerating coil 17b. In the operation of this device the solid carbondioxide in the chamber 5b normally serves as the refrigerant, absorbing heat through the walls of the chamber from the brine in the chamber 11b. This brine is circulated either by means of a pump, as in the circulating system of Figure 1, or by a thermosiphon circuit, as shown in Figure 3, through a refrigerating system which may be used for any purpose whether for cooling air in a ventilating system or for cooling storage vaults or refrigerators or for any other purpose where a refrigerating system is required. The heat absorbed in the refrigerating system serves to evaporate more carbondioxide and thus the refrigerating system to a certain extent replaces the auxiliary heater 17 or 17a used in Figures 1 and 2.

Outlets 31 may be provided in the pipe 10b to constitute an automatic fire protection system somewhat similar to the well known sprinkler systems used in connection with a water standpipe. Such outlets 31, may be arranged in positions such that one or another would supply carbondioxide gas to extinguish a fire in any possible location and these outlets may be controlled thermostatically, e. g., as in the case of sprinkler systems. Such a protection system would not only be more effective than water sprinkler systems but would also avoid the possibility of damage which sometimes occurs with the water sprinkler systems when an outlet is accidentally opened. In order to avoid any possibility of suffocation by excessive escape of carbondioxide in the rooms intended for human occupancy the outlets could be constructed, e. g., as shown at 32, to give a warning whistle when the carbondioxide gas is escaping therefrom. This would serve not only as a warning against suffocation to the human occupants of the building but would also serve as a fire alarm.

Figures 5 and 6 show an arrangement embodying my invention which is particularly applicable to ships, storage buildings and the like. In this arrangement, the pressure storage chamber may be essentially as shown in any of Figures 1 to 4, but is preferably heavily insulated, e. g., as shown in Figure 4, from the atmosphere and/or any other source of heat except that used for generating the gas. The bottom of the chamber 5c is connected through the pipe 12c to the insulated storage tank 11c in which it is kept hot by means of the indirect heater 17c connected to the boiler 40 of the ship or building.

The gases generated in the chamber 5c are led off through the conduit 10c, which is provided at suitable intervals with outlets for fire protection uses, each valved suitably for its location by a manual valve 30c, a thermostatic valve 31c, or a manual or thermostatic whistle valve 32c.

At one end of the conduit 10c is a pressure control valve 29c adapted to maintain a suitable fire fighting pressure in the chamber and conduit, and from this valve the relieved gas is permitted to expand into the heat exchange pipe 41 in the cold storage space 42 and finally through the conduits 43 to the closed storage rooms or hold 44.

In Figure 6 I have shown the same arrangement as in Figure 5 except that in this case an air cooler 46 has been included between the chamber 5c and the valved portion of the conduit 10c. In this figure I have also shown an air intake and stack which are closed from the lower parts of the ship so that with a suitable oil or gas firing the fire fighting apparatus could remain operative even after the engine room had filled with water, steam or smoke.

With the arrangements just described I have provided for constant utility of the device with no waste.

Under normal conditions the CO_2 evaporates very slowly from absorption of atmospheric heat through the insulation of the chamber 5c. The cold gas thus generated passes off through the conduit 10c where its low temperature is utilized in the air cooler 46 or the cold storage space 42, and eventually passes into the hold or storage rooms 44 or 50 or into partitions or other inflammable closed spaces, where it prevents fire by providing an atmosphere incapable of supporting combustion.

In case of fire a supply of hot brine is always ready to begin the rapid generation of gas and will be automatically fed to the chamber 5c as it is needed, because of the reduction of pressure therein. But even before the hot brine is used there is always a maintained pressure of the extinguishing gas in the system so that there can be no delay in its effectiveness.

In Figure 7 I have shown a still simpler form of the apparatus intended for use as an emergency extinguisher. In this case the pressure generator chamber 5c is provided with a movable basket 6c into which the solid carbon dioxide is fed when the generator is to be used.

The basket 6c is carried upon a support rod 40 which in turn is secured to the cross-bar 41. Branch rods 42 are provided at opposite sides so

that the cross-bar 41 may be held by any of the branches 43 and the basket 6c thereby supported at any desired height to immerse it partially or entirely in the heated liquid or to raise it entirely above the liquid so as to prevent freezing or excessive pressure generation when the full capacity of the generator is not being used.

A filler opening 44 is provided in the top of the chamber 5c through which the solid carbondioxide may be fed to the basket 6c, e. g., by means of the funnel 45. This opening is sealed against pressure by a cover 46 held in place by clamping means not shown.

Otherwise the generator illustrated in Figure 7 may be substantially the same in construction and operation as those already discussed above, the numerals 8c, 10c, 12c, 18c, 19c and 21c corresponding to the corresponding parts 8, 10, 12, 18, 19 and 21 on Figure 1.

Although I have illustrated and described my invention with particular reference to fire fighting, in which application my invention is capable of saving millions of dollars of destruction annually, nevertheless it is to be understood that my invention is also applicable wherever it is desirable to obtain a gas in quantity from its solid form. Thus it may be used in the chemical industries or in other situations which will at once suggest themselves to those skilled in the art.

Similarly, although I have described the apparatus as a large unit suitable to be mounted on a truck or in a boat or building, it will be understood that it may be made in small units suitable to be carried by one man for fighting fires or for other purposes and such a unit may be made so that the cooling effect of the gas generator may serve to protect the operator from the heat of the fire which he is working against.

Similarly many changes in the construction of the apparatus and of the particular materials used may be resorted to without departing from the scope or the spirit of my invention. Thus instead of piling the solid carbondioxide directly onto the grating, the solid carbon dioxide may be loaded into a basket 38 which can be lowered into or removed from the generator chamber.

For simplicity of illustration and in order that the drawings may be more easily understood, I have shown gages and indicators directly upon the apparatus. It will be readily appreciated, however, by those skilled in the art that because of the low temperatures involved and the resulting likelihood of frosting, it will ordinarily be more satisfactory to have these gages positioned at points remote from the generator.

Many different liquids may be used in the generator and these may or may not be aqueous solutions, for example, alcohol or even such liquids as carbon tetrachloride or trichlor-ethylene might be used. In general, however, it is desirable to use a liquid which is a solvent of carbondioxide gas since if the gas does not dissolve in the liquid it tends to form a blanket over the solid carbondioxide which prevents the liquid from coming into contact with it. Furthermore when the liquid is a solvent a considerable portion of the gas is conducted through the liquid in solution and evaporated from its surface, thus reducing the violent bubbling through the liquid. The dissolved gas also tends to be driven out from the solution at the heating surfaces from which bubbles rise through the liquid, thus promoting circulation in the liquid and helping to prevent any freezing due to local stagnation. The liquid which is chosen must, of course, having a freezing point substantially below the temperature at which the apparatus is designed to operate and should preferably have a relatively high specific heat. For these reasons it is ordinarily desirable to use aqueous liquids and to control the melting point by the use of a suitable solute such as calcium chloride,

The above alternatives are not, of course, exhaustive but are merely cited as exemplary of the many ways in which my apparatus could be changed within the scope of my invention.

What I claim is:

1. A fire extinguishing apparatus which comprises a pressure storage chamber with a portion thereof removable for supplying to the interior thereof a charge of solid volatile fire extinguishing substance, means for heating said charge whereby to effect rapid generation of fire extinguishing gas in said chamber, a body of liquid adapted to serve as a heat exchange medium in said chamber and a conduit adapted to deliver said gas from said chamber to locations at which fire protection is desired.

2. A fire extinguishing apparatus which comprises a pressure storage chamber with a portion thereof removable for supplying to the interior thereof a charge of solid volatile fire extinguishing substance, means for heating said charge whereby to effect rapid generation of fire extinguishing gas in said chamber, and a normally closed conduit adapted to deliver said gas from said chamber to locations at which fire protection is desired and having a valve therein to control the delivery of gas at such location, and a relief valve associated with said conduit and chamber adapted to hold a predetermined pressure therein, whereby the device may be kept always ready for instant use in emergency and gas is automatically discharged therefrom into the atmosphere as required to relieve said chamber and conduit from pressure in excess of said predetermined value.

3. An apparatus as defined in claim 2 in which the relief valve is at the end of the conduit beyond the valve which controls delivery of the gas at the protected location, whereby clogging of the line which would render it inoperative to deliver the fire extinguishing gas may be immediately made apparent by increasing pressure in the chamber.

4. An apparatus as defined in claim 2 in which a heat-exchange member is provided between the chamber and the point at which the gas from the relief valve is discharged into the atmosphere whereby gas cold from evaporation in the chamber may be warmed before passing into the atmosphere and excessive condensation or frosting at the point at which gas is discharged into the atmosphere thereby avoided.

5. An apparatus as defined in claim 2 in which an air cooling heat-exchanger is provided between the chamber and the valved portion of the conduit, whereby the necessary evaporation in said chamber serves constantly for conditioning the air in a structure protected against fire thereby.

6. In a structure subject to fire hazards and comprising spaces occupied by living persons, and closed spaces not occupied by living persons, the combination as defined in claim 1 in which the conduit normally discharges into said closed spaces whereby to maintain therein an atmosphere incapable of supporting combustion, but includes means for diverting the gas discharge

therefrom in event of fire to the space normally occupied by living persons.

7. An apparatus as defined in claim 2 in which the means for heating the charge is automatically regulated in response to pressure within the chamber whereby to maintain the desired pressure for instant and continued use in emergency.

8. A fire extinguishing apparatus which comprises a pressure storage chamber with a portion thereof removable for supplying to the interior thereof a charge of solid volatile fire extinguishing substance, means for normally storing a heat exchange liquid out of contact with the charge and for raising the level of the liquid in the chamber so as to surround said charge therein when fire extinguishing gas is required, and means for heating said liquid.

9. The apparatus as defined in claim 8 which includes means for heating the liquid while it is held away from the charge whereby it may be maintained at all times at a temperature sufficiently high so that a rapid generation of fire extinguishing gas may begin immediately when the liquid is raised to a higher level in the chamber.

10. A portable fire extinguisher having the combination as defined in claim 1 and which further comprises means providing a vertically movable false bottom within said chamber for supporting a charge of the volatile solid, and means operable from outside of said chamber for moving to and holding at various levels, above and below the liquid level in the chamber, said false bottom whereby the charge and any desired part thereof may be raised above or submerged in the heating liquid.

11. A fire extinguishing apparatus comprising a pressure-resisting container partially filled with a liquid, means therein for supporting a supply of solid carbon dioxide out of contact with the walls of the container but in contact with the liquid, means for supplying heat to the liquid, and means for conducting carbon dioxide gas from said container and directing a stream thereof against a fire.

12. A fire extinguisher comprising a pressure-resisting container, a liquid solvent of carbon dioxide gas partially filling said container, a supply of solid carbon dioxide in said container in contact with said liquid, means for maintaining the temperature of the liquid above the freezing point and means for conducting carbon dioxide gas from said container to the vicinity of a fire.

13. An apparatus as defined in claim 12 which includes a means for catching spray or bubbles and returning the liquid thereof to the container.

14. An apparatus as defined in claim 12 in which the liquid freezes substantially below 0° C.

15. A fire extinguishing apparatus comprising a container for solid CO_2, a pipe leading therefrom, a vent means for effecting escape of CO_2 gas to the atmosphere from the space defined by the container and the pipe when produced in greater quantity than is required for fire fighting and for preventing escape of gas which is required for fire fighting, valved outlets from said pipe at spaced intervals, means responsive to the withdrawal of CO_2 gas through one or more of said spaced outlets for admitting a liquid into the container to contact with the solid carbon dioxide, and means for supplying heat to said liquid.

16. An apparatus as defined in claim 15 in which the valved outlets are adapted to be operated automatically when a predetermined temperature is attained.

17. An apparatus as defined in claim 15 in which the vent means includes a relief valve adapted to maintain a super-atmospheric pressure in the container and the pipe.

18. An apparatus as defined in claim 15 in which the vent means includes a relief valve adapted to maintain a predetermined super-atmospheric pressure in the container and the pipe, and means responsive to reduction of pressure in said container for supplying a liquid to said container when the pressure therein falls below the predetermined normal but adapted to hold the liquid out of contact with the solid CO_2 in the container when the predetermined pressure is maintained.

19. An apparatus for converting a solid into a gas, comprising a gas generating pressure chamber, a gas delivery opening therefrom, means in said chamber to hold a supply of the solid in excess of the amount which can be dissolved by the liquid surrounding it, means for supplying a liquid thereto into direct contact with the solid, and means for heating the liquid.

20. An apparatus as defined in claim 19 including a supplementary chamber connected to the first so that the liquid may be drawn thereinto, and means for controlling the flow between said supplementary chamber and the gas generating chamber.

21. An apparatus as defined in claim 19 including a supplementary pressure chamber connected to the first by an opening below the supply of solid therein, and a valve adapted to release gas from the supplementary chamber when the desired pressure is exceeded, whereby the liquid will be forced into the supplementary chamber from the generating chamber by the greater pressure therein.

22. An apparatus as defined in claim 19 which includes a supplementary chamber, an open connection between the bottom of the supplementary chamber and the bottom of the generating chamber, and an automatic pressure controlled valve on the supplementary chamber adapted to release gas when the desired operating pressure of the generating chamber is exceeded.

23. An apparatus as defined in claim 19 which includes supplemental means for heating the liquid adjacent its upper surface.

24. An apparatus as defined in claim 19 which includes means for regulating the extent to which the solid is covered by the liquid in accordance with the requirements for delivery of the gas.

25. The method of evaporating a solid which comprises immersing the solid in a bath of a liquid and heating the liquid to maintain it at a temperature above its freezing point and above the critical temperature of the gas.

26. The method as defined in claim 25 in which the liquid is a solvent of the gas.

27. The method as defined in claim 25 in which the liquid is a solvent of the gas and additional heat is supplied to the liquid adjacent its evaporating surface.

28. The method as defined in claim 25 in which the rate of production of the gas is controlled by regulating the extent to which the solid is covered by the liquid.

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