

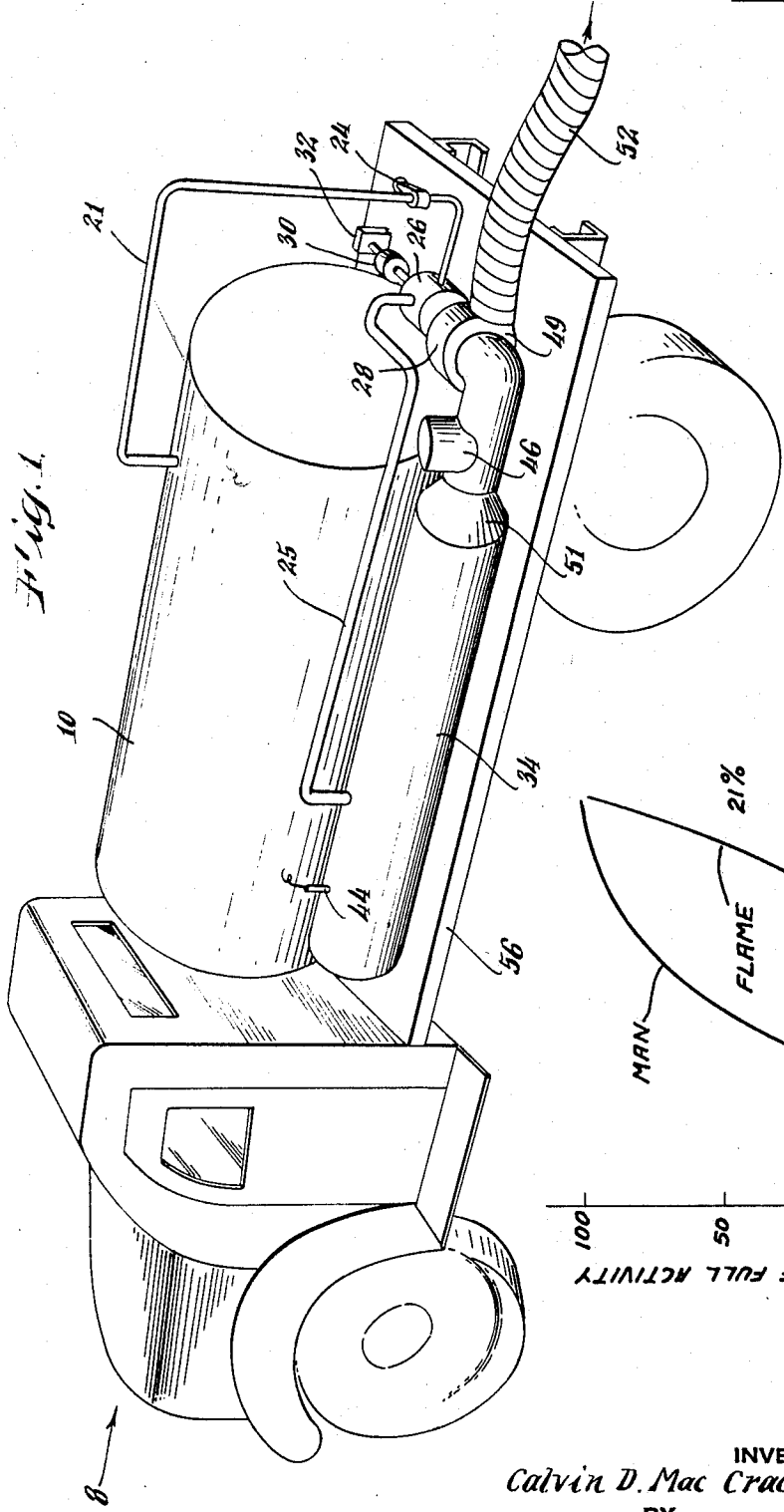
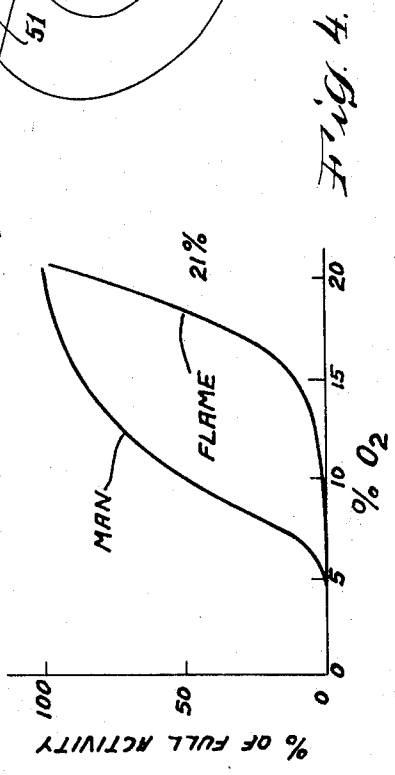
April 15, 1969

C. D. MacCRACKEN
LIFE-SUPPORTING AND PROPERTY PROTECTING
FIREFIGHTING PROCESS AND APPARATUS

3,438,445

Filed July 25, 1967

Sheet 1 of 2



INVENTOR
Calvin D. Mac Cracken
BY
Robertson, Bryan, Parmelee & Johnson
ATTORNEYS.

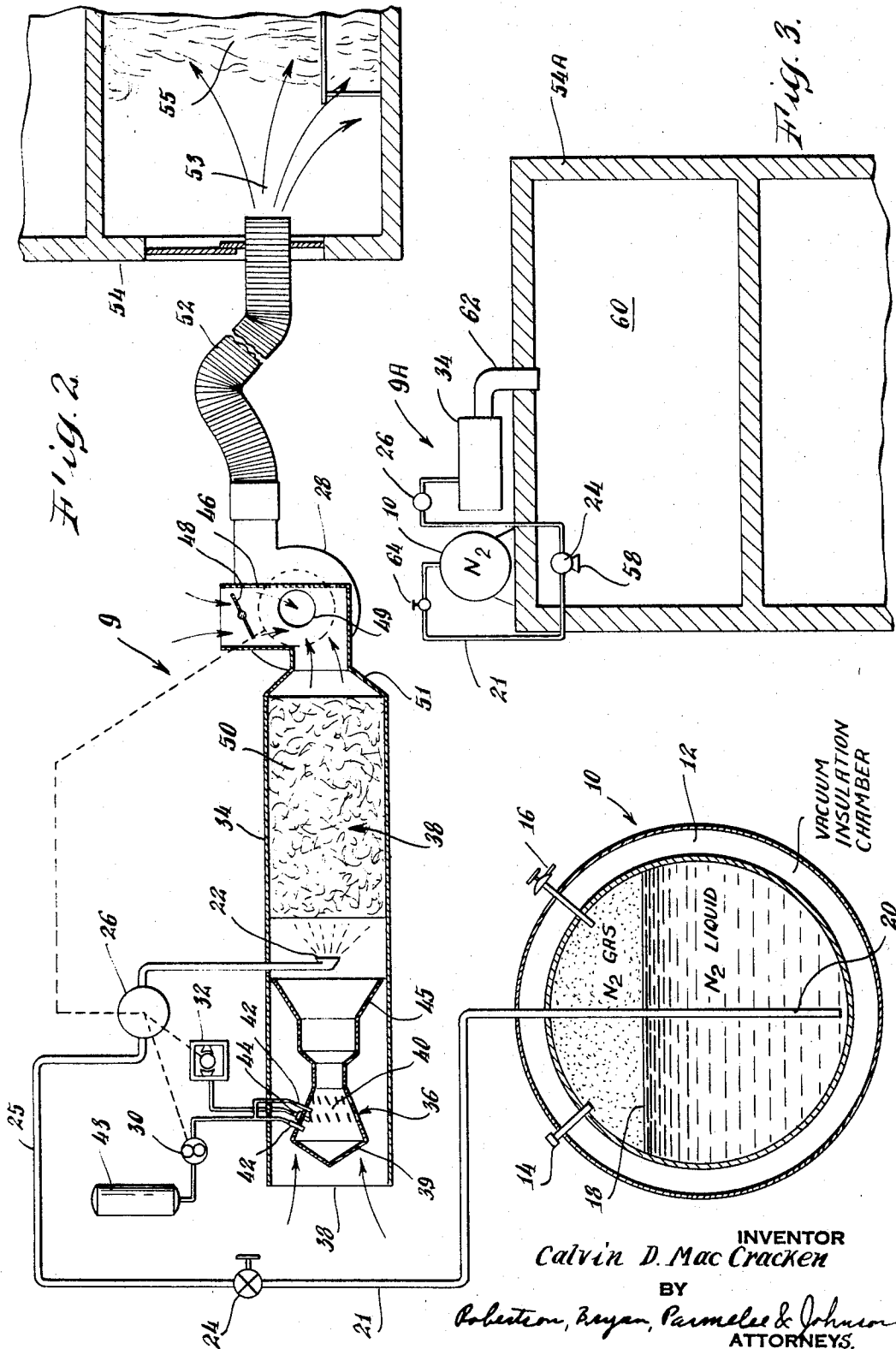
April 15, 1969

C. D. MacCRACKEN
LIFE-SUPPORTING AND PROPERTY PROTECTING
FIREFIGHTING PROCESS AND APPARATUS

3,438,445

Filed July 25, 1967

Sheet 2 of 2



INVENTOR
Calvin D. MacCracken

BY
Robertson, Ryan, Parmelee & Johnson
ATTORNEYS.

1

2

3,438,445

LIFE-SUPPORTING AND PROPERTY PROTECTING FIREFIGHTING PROCESS AND APPARATUS

Calvin D. MacCracken, Tenafly, N.J., assignor to Calmac
Manufacturing Corporation, Englewood, N.J.

Filed July 25, 1967, Ser. No. 655,792

Int. Cl. A62c 1/24, 27/16

U.S. Cl. 169—1

14 Claims

ABSTRACT OF THE DISCLOSURE

A human being has sufficient lung capacity that, in the absence of smoke and carbon monoxide, he can be active and carry out work very effectively for long periods of time in an atmosphere containing 10% oxygen, and he can remain alive for a substantial period of time in an atmosphere containing 5% oxygen. His respiratory rate and pulse rate will increase markedly, but he will live. On the other hand, the burning activity of common combustible materials, such as wood, paper, cloth, and the like, very rapidly diminishes as the oxygen content of the atmosphere is reduced below the natural level of 21%. Flames go out and only smoldering will take place below 14–15% oxygen content.

This invention enables effective utilization to be made of this differential in human and combustion activity levels occurring at reduced percentages of atmospheric oxygen content, by creating a comfortable atmosphere of reduced oxygen within a burning structure. Within this atmosphere any trapped occupants or firemen can survive and even carry out firefighting work. The firefighting process and apparatus of the invention delivers large quantities of pure, non-toxic, inert gas having low oxygen content to remote locations and to the interior of burning structures. A controlled burner which is included in the firefighting equipment produces inert gaseous products of combustion which are cooled by the evaporation of liquid nitrogen sprayed directly into these products of combustion.

The resultant comfortable inert atmosphere is controllable as to oxygen level depending upon the exigencies of a particular firefighting situation. If desired the oxygen level may be reduced below that for sustaining human life so as to smother a fire more rapidly, when the building is evacuated, and in that case the fireman can enter the comfortable atmosphere within the building by wearing oxygen masks.

Background of the invention

In my prior Patent No. 2,961,050 it is disclosed that flames can be extinguished and smoke cleared out from the interior of a burning structure by introducing large quantities of low oxygen content gas. This inert gas was created by burning fuel in a burner and then cooling the gas products of the fuel combustion by a water spray. Because of the water cooling of the hot exhaust gases there was created a very high content of steam which made human occupancy unbearable for firefighting or those being rescued. It also caused damage to the contents and decoration of the building walls, furnishings and equipment.

Description

This invention relates in general to a firefighting process and to an inert gas generator used as a firefighting and extinguishing device and particularly to an apparatus capable of delivering large quantities of pure, non-toxic inert gas having low oxygen content to remote locations and to the interior of burning structures.

In accordance with the process of this invention the firefighting equipment includes a burner for burning fuel under controlled conditions to create gaseous products having an insignificant amount of carbon monoxide therein. This invention provides a method and a structure for cooling these inert gases by the evaporation of liquid nitrogen sprayed directly into these products of combustion. Arranged in a manner to be described later and in certain proportions, an atmosphere can thus be created which, when delivered into the inside of a burning structure, will extinguish the flames, clear out the smoke fumes, be non-toxic to human life, be entirely comfortable to a person in the atmosphere so created, be at substantially room temperature and humidity, and will advantageously penetrate into the interior of partitions and other areas impenetrable to ordinary firefighting foams and other materials.

It is a general object of this invention to create a comfortable atmosphere in the burning structure which will not damage wall paper, furniture and other contents of the building and which will be at approximately normal room temperature and humidity and which is capable of supporting human life in the resultant atmosphere while suppressing the fire.

Another object is to provide a self-powered system entirely independent of electrical supply or auxiliary mechanical power of any kind.

A further object is to provide a relatively small, lightweight, inexpensive and portable system for firefighting designed to be mounted on a small truck with a flexible hose capable of being stored compactly on the truck yet easily extensible into the interior of a burning structure or into one to be protected from the danger of burning.

An additional object is to provide an apparatus which will give the operator the choice of delivering partially inert gas with an oxygen content sufficient to maintain life, while suppressing flames, or the alternative of delivering an almost totally inert gas for a quicker and more complete smothering of all combustion without the capability of sustaining life unless the occupant has an oxygen mask or its equivalent.

This invention enables mobile firefighting equipment to be provided and, also provides for fixed, i.e. permanent, equipment which can be installed in public buildings whenever desired, such as office buildings, apartment stores, trade centers, communication centers, transportation centers, and so forth.

In this specification and in the accompanying drawings, are described and shown various embodiments of the methods and apparatus of the invention and various modifications thereof are indicated, but it is to be understood that these are not intended to be exhaustive or limiting of the invention, but on the contrary, are given for the purpose of illustration in order that others skilled in the art may fully understand the invention and the manner of applying the method and apparatus for manufacturing inert gas, and so that they will understand how to modify and adapt the invention in various forms, each as may be best suited to the conditions of a particular situation or installation.

The various aspects, advantages and objects of the present invention may be more fully understood from a consideration of the following specification in conjunction with the accompanying drawings in which:

FIGURE 1 is a perspective view of a firefighting truck or portable apparatus constructed in accordance with this invention.

FIGURE 2 is a schematic diagram of the components of the firefighting apparatus constructed in accordance with this invention.

FIGURE 3 is a side view in section of a stationary or

permanently installed fire extinguishing system constructed in accordance with this invention.

FIGURE 4 is a graph or chart showing the relationship between atmospheric oxygen percentage content at sea level and the resultant level of activity of both wood flames and man, taking the level of activity occurring at a normal 21 percent oxygen as being 100%.

Referring to the drawings in particular, mobile firefighting equipment 8 embodying the present invention is shown in FIGURE 1, and a firefighting process and apparatus 9 embodying the invention is schematically illustrated in FIGURE 2. An insulated liquid nitrogen tank 10 is of the standard type commercially available through suppliers of liquid nitrogen. It contains vacuum type insulation 12 because of the extremely low temperatures, less than -300° F., at which liquid nitrogen exists. The tank 10 is pressurized and is provided with a filling means 14 and a pressure relief valve 16 venting to atmosphere to control the pressure at any desired level by the setting of the valve 16.

In this process and system the liquid nitrogen 18 is kept under sufficient pressure by the nitrogen gas so as to be able to propel itself through an outlet tube 20 and through a pipe line 21 to a spray nozzle 22 when a main control valve 24 is opened. Such pressure is, for example, of the order of 20 to 150 lbs. per square inch. The control valve 24 is of a manually operated type when used in portable or mobile equipment, but when used in a permanent firefighting installation, the valve 24 is fire-responsive, that is, it is of a type built to snap open automatically when a fusible element melts from the heat of a fire, thus allowing a spring to open the valve. Depending upon the type of installation the fire-responsive action may be produced by other means of sensing the presence of fire, such as smoke detectors which may be made to operate this main control valve 24.

A preferred embodiment of this invention includes a liquid nitrogen turbine 26 located in the pipe line 25 between valve 24 and nitrogen spray nozzle 22. By maintaining sufficient pressure in tank 10, for example in the range 75-125 lbs. per square inch, there can be 50 to 100 lbs. per square inch pressure drop available to be used in the turbine 26 for driving a blower 28, a fuel pump 30, and a magneto 32, and still there will be approximately 25 lbs. per square inch available to overcome pipe friction loss and to provide spray nozzle pressure. If the preferred embodiment is not used, the blower 28 and the fuel pump 30 may be driven by any suitable usual means, such as an electric motor or internal combustion engine (not shown).

The blower 28 induces a flow of air through it from two different paths. One path comes first through a generally cylindrical metal housing 34 which contains a fuel burner 36, the nitrogen spray nozzle 22 discussed above, and an evaporator section 38. The burner 36 may be of any generally compact type and may use any type of fuel. However, fueloil, kerosene or gasoline is more convenient for use in portable or truck-mounted applications while fueloil or natural gas would be more convenient alternatives for use in permanent type stationary installations. The burner should be a high heat-release confined space burner in order to conserve size and weight, similar to burners used for gas turbines.

One example of a suitable burner is the double vortex burner 36 as described in Patents 2,736,168 and 3,200,870. Air is pulled in by the blower 28 through an end inlet opening 38 in the housing 34 and the air flow passes over and around the outside of the burner 36 which has a burner chamber or can 39 formed of metal. The combustion air enters the combustion space inside of the burner can 39 through multiple louver openings 40 where it swirls in vortex form. Fueloil is shown being injected through a nozzle 42 after being pumped by the fuel pump 30 from a fuel tank 43. The mixture of swirling air and atomized oil is ignited by a spark plug 44 ener-

gized by the magneto 32, or by another suitable high voltage electrical source.

The flame is virtually complete by the time that the combustion mixture passes out through the diverging end 45 of the burner can 39 in the vicinity of the liquid nitrogen spray nozzle 22. Liquid nitrogen is sprayed through nozzle 22 into the mixture of combustion gases issuing from the burner 36 and passing on down through the cylindrical housing 34. The combustion gases are at an elevated temperature controlled by the air-fuel ratio through the burner 36 which in turn is controlled by a damper 48 controlling the amount of air admitted to blower 28 through the second path to said blower as defined by a by-pass air inlet duct 46. In other words, as the damper 48 is closed, there will be less by-pass air entering the inlet 46 and more combustion air entering through the opening 38, and thus the flame temperature will be lower. The intake to the blower 28 is shown at 49.

In this process, regardless of the temperature of the combustion gases issuing from the diverging outlet 45 of burner 36, the amount of liquid nitrogen which is sprayed in is regulated exactly to counteract the heat of combustion and thus to bring the combustion gas temperature back down to comfortable room temperature. This ratio of pounds of liquid nitrogen per pound of fueloil is approximately 100, since the enthalpy change of liquid nitrogen to nitrogen gas at room temperature is about 186 B.t.u.'s per pound, and the heating value of the fueloil is approximately 18,600 B.t.u.'s per pound. At elevated pressures, the enthalpy change of liquid nitrogen is less, so that the ratio will be somewhat more than 100 to 1 pounds of liquid N_2 per pound of fueloil.

In order to facilitate the evaporation of the light nitrogen into the combustion gas, an evaporator section 38 is provided which is partially filled with wire mesh 50 in order to give an extended surface on which droplets of liquid nitrogen will be caught to give more thorough mixing with the gases. The temperature of the gas stream issuing from the evaporator 38 and flowing through a coupling 51 into the inlet 49 of blower 28 will be essentially at room temperature as described above. Its oxygen and carbon dioxide content will be about 2 to 5% of the total by volume with almost all the rest being nitrogen. At or near the blower inlet 49 the by-pass air stream passing through the duct 46 will be mixed with the first stream passing through coupling 51 to bring the oxygen percentage of the resulting mixture of relatively inert gases up to the desired level for relatively safe human use, for example approximately 8%, or, if the operator does not need this safety, he may close the damper 48 and deliver gas with much lower oxygen percentage for more effective flame extinguishment.

The relatively inert gases 53 leaving the blower 28 are taken through a flexible hose or duct 52 to the inside of a building or structure 54 in which a fire 55 is located. Since a fire creates a natural draft towards its base, the gases 53 will be drawn toward the fire in large part and will snuff out the flames quickly. Smoke will be pumped out because of the ventilation advantageously produced by the large volume of comfortable, life-sustaining gases 53 pumped into the structure 54. With flames extinguished, smoke cleared out, and ambient temperature comfortable, fireman can easily locate the source of the heat and cool it down with accurately placed water or other means.

After allowing the structure to remain full of the relatively inert gases 53, by continuing the process for several minutes, then as an aid to fire location the oxygen percentage can be increased by cutting off the inert gas system 9 temporarily. As flames reappear, fireman can locate them and quench them accurately as they will be small. Should they begin to get too hot again and generate too much smoke, the system 9 can be restarted merely by reopening the liquid nitrogen control valve 24 and the process repeated until the fire is completely out, with minimum water damage, and minimum smoke damage.

One of the principal advantages of this method of fire fighting is that the gases will fill all parts of the structure including inaccessible spots, such as interiors of partitions, floors, ceilings, joist spaces, attics, cellars, basements, etc. The partial pressures of the nitrogen and oxygen components of the ambient atmosphere and of the delivered gases 53 will tend to equalize throughout the structure 54. The structure will be slightly pressurized, causing an outflow of gases through crackage, chimneys, doors, windows, etc. By these means as well as by the natural draft of the fire, distribution of the relatively insert gases 53 throughout the structure 54 will be relatively quick and the inflow of outside air will consequently be retarded or substantially blocked, depending upon the rate of inflow of the combustion suppressing gas 53.

Referring again to FIGURE 1 the mobile firefighting equipment 8 includes the various components shown diagrammatically in FIGURE 2. They are assembled and arranged on a fire truck chassis 56 of this type. The components as numbered in FIG. 1 can be identified by referring to the previous description of FIGURE 2. The liquid nitrogen tank 10 is the major component and thus the overall appearance is more that of a tank truck or fuel oil truck than a fire truck.

FIGURE 3 shows the application of the invention to a structure 54A, such as a factory, as a built-in protection system 9A replacing the common automatic water sprinkler system. Although the tank 10 is shown on the roof, it can be located wherever most convenient and connected to the rest of the apparatus merely by a pipe 21. Valve 24 has a fusible link element 58 which snaps open upon melting of a low melting point alloy holding the valve closed, similar to the operation of an automatic sprinkler head except that the fluid in the pipe 21 is not sprayed out but is merely allowed to continue in the pipe to turbine 26 and to a spray nozzle within the housing 34. The inert gases are then conducted into the protected space 60 by a duct system 62 installed as part of the structure. Heat from a fire melts the fusible link 58 and relatively inert gases then are delivered to the interior of the structure until the nitrogen supply is exhausted or a manual valve 64 in the line 21 is closed.

FIGURE 4 shows two curves "Man" and "Flame" plotted as the percent of full activity exhibited by man and by flames, from burning building interiors, at different oxygen percentages in the ambient atmosphere. The area and vertical spacing between the curves shows the differential in conditions under which man can continue to be active while flames cannot. The data on flames is obtained from laboratory test data, while the data on man is calculated from his performance in certain towns in which he lives at high altitudes in which the same partial pressure of oxygen exists although the total pressure is less. Partial pressure has been found to be the controlling factor within this range for absorption by the human lungs, while oxygen percentage by volume is the controlling factor for the activity of the fire.

For example, at 10% oxygen by volume at sea level total pressure, the balance being nitrogen, the partial pressure of O_2 is equivalent to the partial pressure of 21% oxygen at 16,000 feet altitude. Mountaineers and villagers in the Andes Mountains are estimated to have about 50% full activity at this altitude. Similar data has been estimated for Lhasa in Tibet (11,000 ft.), and Leadville, Colo. (9,000 ft.), and a zero activity point is known to occur for 30,000 feet altitude or equivalent to about 6% oxygen pressure.

While the process and system has been described with particular reference to its application for fire fighting, it should be realized that an inert gas generator may have various other applications. For example, in many instances it is desirable to maintain an atmosphere about a tank of certain liquids or chemicals in a substantially oxygen free state and for such uses the apparatus is ideal.

From the foregoing it will be understood that the methods and apparatus embodying the present invention described above are well suited to provide the advantages set forth, and since many possible embodiments may be made of the various features of this invention and as the method and apparatus herein described may be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and that in certain circumstances, some of the features of the invention may be used without a corresponding use of other features, all without departing from the scope of the invention.

What is claimed is:

1. The process of fighting a fire in a building by creating an inert atmosphere therein of reduced oxygen content and approximating room temperature comprising the steps of flowing air into a combustion space, burning fuel in said combustion space, conducting the hot gaseous products of combustion away from said combustion space, evaporating liquid nitrogen into and mixing the nitrogen with said gaseous products of combustion to cool them down approximately to room temperature, and introducing the resulting inert gaseous mixture having a reduced oxygen content and a temperature approximating room temperature into the interior of the building to control the fire and clear the smoke by virtue of which the inert gaseous mixture controls the fire, clears the smoke and penetrates into the interior of partitions and other areas impenetratable to fire fighting foams and the like to control the fire without further damaging the building and its furnishings.

2. The process of fighting a fire in a building by creating an inert atmosphere therein of reduced oxygen content and approximating room temperature as claimed in claim 1, including the steps of blowing the resulting gaseous mixture into the building to fill the structure and create a slight positive pressure therein to fill all parts of the structure including interiors of partitions, floors, ceilings, joist spaces, and similar inaccessible spots and causing an outflow of the gaseous mixture through crackage, windows, doors, chimneys, and the like, thus clearing the smoke, controlling the fire and in addition retarding the inflow of outside air into the building.

3. The process of fighting a fire in a building by creating an inert atmosphere therein of reduced oxygen content and approximating room temperature as claimed in claim 2, including the steps of aiding the firemen in locating the regions of fire by diminishing the flow of the resulting gaseous mixture after the fire has been brought generally under control, thereby to allow the flames to reappear temporarily so that the firemen can accurately quench the fire regions, and of reestablishing the full flow of the resulting inert gaseous mixture should the flames become too hot again.

4. The process of fighting a fire in a building by creating an inert atmosphere therein of reduced oxygen content, said process comprising the steps of flowing air into a combustion space, burning fuel in said combustion space, conducting the hot gaseous products of combustion away from said combustion space, evaporating liquid nitrogen into and mixing the nitrogen gas with said hot gaseous products to cool the resulting gaseous mixture, introducing atmospheric air into said gaseous mixture downstream from the combustion space to increase their volume and raise the oxygen content of the gaseous mixture to a desired level sufficient to sustain human life within the building, and introducing the resulting inert gaseous mixture into the interior of the building to control the fire and clear the smoke without further damaging the building and its furnishings.

5. The process of fighting a fire in a building by creating an atmosphere therein of reduced oxygen content as claimed in claim 4 including the steps of controlling the relative amount of atmospheric air introduced into said

gaseous mixture to raise the oxygen content to a level in the range between 5% and 14% and to produce a resulting gaseous mixture having a temperature within which a human being can survive, and introducing the resulting gaseous mixture into the interior of the building to clear the smoke and to sustain the lives of the occupants while suppressing the fire.

6. The process of fighting a fire in a building by creating an atmosphere therein of reduced oxygen content as claimed in claim 4, including the steps of controlling the amount of liquid nitrogen evaporated into the gaseous mixture downstream from said combustion space relative to the temperature of the gaseous products of combustion issuing from said combustion space as controlled by the air-fuel ratio effective in said combustion space.

7. A firefighting system for use in fighting a fire in a building by generating an inert atmosphere therein of reduced oxygen content, said inert atmosphere being non-damaging to wall paper, furnishings and furniture, said system comprising a burner, means for admitting air to said burner, fuel supply means for feeding fuel to said burner to be burned therein for producing gaseous products of combustion, means defining an evaporator chamber for receiving said gaseous products of combustion, a supply of liquid nitrogen, means introducing liquid nitrogen from said supply into said evaporator chamber for evaporating nitrogen into and mixing the nitrogen gas with said products of combustion to cool them to produce a resultant inert gaseous mixture of reduced oxygen content, duct means for conducting the resultant inert gaseous mixture into the interior of the building, and blower means for propelling the inert gaseous mixture through said duct means into the building to control the fire and clear the smoke without further damaging the building, its furnishings and contents.

8. A firefighting system for use in fighting a fire in a building by generating an inert atmosphere therein of reduced oxygen content as claimed in claim 7, in which said means introducing liquid nitrogen into said evaporator chamber includes a spray nozzle, and said evaporator chamber contains wire mesh providing an extended surface on which the droplets of liquid nitrogen are caught to yield more thorough mixing of the nitrogen gas with the gaseous products of combustion.

9. A firefighting system for use in fighting a fire in a building by generating an inert atmosphere therein of reduced oxygen content as claimed in claim 7, in which said system is self-contained, said supply of liquid nitrogen including a container having a pressure relief valve maintaining the liquid nitrogen under pressure, said means for introducing liquid nitrogen from said supply into said evaporator chamber including a feed line extending from said container to said evaporator chamber, a liquid-nitrogen turbine located in said line, said turbine being connected to said blower means for driving the blower, said fuel supply means including a fuel pump driven by said liquid-nitrogen turbine, and said burner including ignition means energized by said turbine for igniting the fuel in said burner.

10. A self-contained firefighting system as claimed in claim 9 and which is automatically responsive to the existence of a fire including valve means in said liquid-nitrogen feed line, and control means sensing the existence of fire, smoke or the like, for opening said valve means.

11. A firefighting system for use in fighting a fire in a building by generating an inert atmosphere therein of reduced oxygen content, said inert atmosphere being approximately at room temperature and being non-damaging to a building, its furnishings and contents and said inert atmosphere containing sufficient oxygen to sustain human life within the building, said system comprising an evaporator chamber, a blower having its intake communicating with the downstream end of said evaporator chamber, a fuel burner having its discharge communicat-

ing with the upstream end of said evaporator chamber, means for admitting a flow of air to said burner when said blower is operating, fuel supply means for feeding fuel into said burner to be burned, ignition means for igniting the fuel in said burner causing hot gaseous products of combustion to be discharged into said evaporator chamber, a supply of liquid nitrogen, means introducing liquid nitrogen from said supply into said evaporator chamber for evaporating nitrogen into and mixing the nitrogen gas with said hot gaseous products of combustion to cool them and produce an inert gaseous mixture of reduced oxygen content, alternative flow path communicating with the intake to the blower at a point downstream from said evaporator chamber for mixing the air with said inert gaseous mixture for raising the oxygen content thereof to a level sufficient to sustain human life while controlling flames, valve means for controlling said alternative flow path to regulate the amount of air admitted therethrough, and a duct extending from the outlet of said blower for conducting said inert gaseous mixture to the interior of the building for dispersing the smoke therein and for controlling the fire without further damaging the building, its furnishings and contents, while sustaining the lives of any occupants therein.

12. A firefighting system as claimed in claim 11, in which said evaporator chamber has a generally cylindrical housing extending upstream from said evaporator chamber, and a high heat-release confined space burner therein having a diverging outlet connecting with the upstream end of the evaporator chamber, and a liquid nitrogen spray nozzle introducing liquid nitrogen into the hot gaseous products of combustion issuing from said burner outlet.

13. A mobile firefighting system comprising a vehicle, a thermally insulated tank for containing liquid nitrogen mounted on said vehicle, an evaporator section on said vehicle for evaporating liquid nitrogen therein, feed means for feeding liquid nitrogen from said tank to said evaporator section, a burner on said vehicle having a discharge communicating with said evaporator section, fuel supply means on said vehicle for supplying fuel to said burner, ignition means for igniting the fuel in said burner for discharging hot gaseous products of combustion into said evaporator section to be mixed with and cooled by the nitrogen evaporating therein to produce an inert gas mixture of reduced oxygen content, blower means on said vehicle for pumping said inert gas mixture of reduced oxygen content, and duct means for conducting said inert gas mixture from said vehicle into a burning building for controlling the fire and dispersing the smoke in the building, said inert gas mixture being non-damaging to the building, its furnishings and contents.

14. A mobile firefighting system as claimed in claim 13, in which said blower means is located downstream from said evaporator section and has its intake communicating with said evaporator section, a by-pass duct on said vehicle communicating with the intake of said blower for admitting air to be mixed with said inert gas mixture for raising the oxygen content thereof to a level sufficient for sustaining human life within the building, and a control valve for controlling the amount of air admitted through said by-pass duct to regulate the oxygen content of said inert gas mixture.

References Cited

UNITED STATES PATENTS

2,961,050 11/1960 MacCracken 169—12

EVERETT W. KIRBY, *Primary Examiner*.

MICHAEL Y. MAR, *Assistant Examiner*.

U.S. Cl. X.R.

160—2, 012