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[11] 3,893,514

Carhart et al.

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[54] SUPPRESSION OF FIRES IN CONFINED SPACES BY PRESSURIZATION

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[52] U.S. Cl. 169/46; 169/11

[51] Int. Cl. A62c 1/14

[58] Field of Search 169/46, 47, 66, 68, 71, 169/74, 89, 11, 12

[56] References Cited

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2,498,512 2/1950 Thompson 169/12

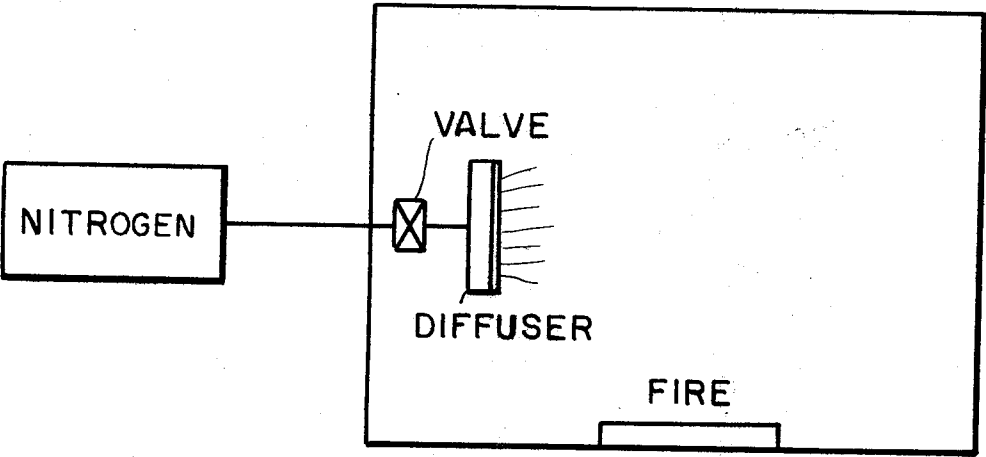
2,572,006 10/1951 Burke 169/11
3,407,880 10/1968 Davis 169/12
3,438,445 4/1969 MacCracken 169/12 X
3,486,562 12/1969 Goodloe et al. 169/11
3,783,946 1/1974 Petrinc et al. 169/11 X

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[57] ABSTRACT

A process for suppressing fires in confined spaces without damage to contained equipment or loss of habitability for personnel which comprises adding nitrogen to the area to increase the total gaseous pressure within the confined area while retaining the partial pressure of oxygen in the area at a level that will support life while the percent by volume of oxygen is not sufficient to support combustion.

1 Claim, 2 Drawing Figures



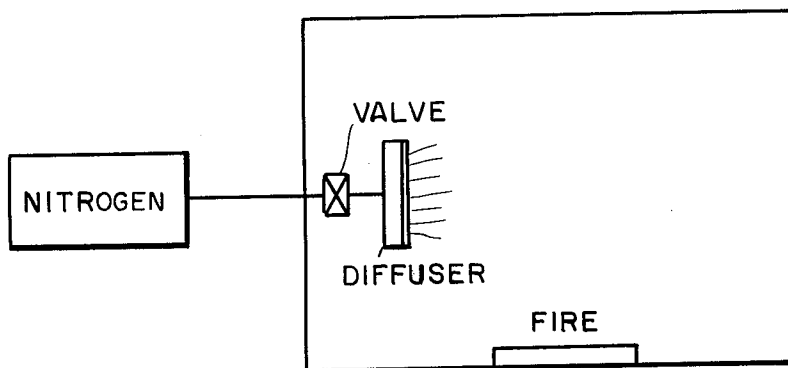


FIG. 1.

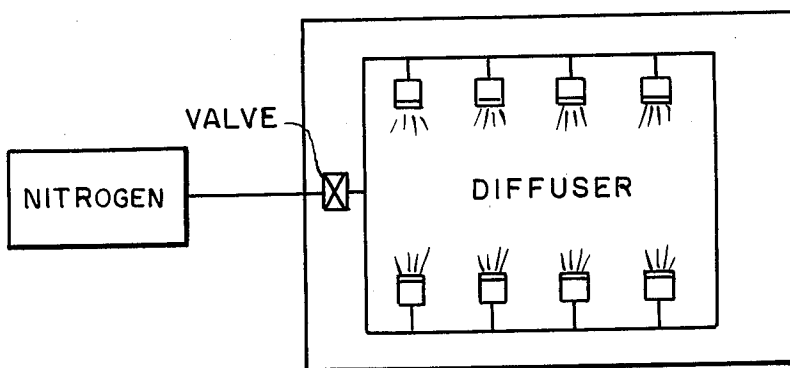


FIG. 2.

SUPPRESSION OF FIRES IN CONFINED SPACES BY PRESSURIZATION

BACKGROUND OF THE INVENTION

This invention relates to suppression of fires in confined spaces and more particularly to suppression of fires without damage to equipment while maintaining a suitable environment for normal personnel activity.

Heretofore many lives have been lost due to the lack of a safe technique for suppressing fires in pressure-tight confined spaces, such as submarines, airplanes, diving bells or spaceships. Furthermore, prior fire fighting procedures have used methods which are harmful to machinery and electrical equipment which requires great expense and time to reclaim the equipment if it is at all possible.

It is well known to those skilled in the art that fires are supported by oxygen and that by using some means to deplete the surrounding area of oxygen or lowering the percent of oxygen the fire will be suppressed. Suppression of fires in open spaces and in confined spaces require different efforts to extinguish the fire. Also, the presence of machinery, electrical equipment, and more importantly the presence of human beings within the area of a fire requires special considerations for the type of extinguishant used. While some extinguishing agents such as carbon dioxide and Halon 1301 (CF_3Br) are useful for extinguishing fires, they are toxic in the concentrations necessary to suppress fires. Therefore they are harmful for human habitation in a closed space. Water, KHCO_3 or foaming agents damage equipment. In closed spaces for human habitation, fire extinguishment must be rapid before harmful smoke and toxic gases are formed and the fire must be suppressed by a means that is not harmful to humans.

It is known that human life support depends on an oxygen partial pressure of about 0.2 – 0.3 atmospheres and that the normal atmosphere contains 0.21 atmosphere of oxygen. On the other hand combustion rates depend upon the percent of oxygen, decreasing with decreasing percentage while reaching zero combustion at some minimal value. The minimal value is a characteristic of each different type of fire. Additional lowering of the oxygen percent may be required to avoid smoldering even after the flame has been suppressed.

Heretofore, studies have been undertaken for the extinguishment of different gasoline fires, as well as for different types of materials. U.S. Pat. No. 3,438,445 teaches the use of nitrogen for extinguishing a fire within a building and in wall spaces not easily reached by other means. U.S. Pat. No. 3,486,562 discloses a system for suppressing a fire within a space vehicle. Each of these systems make use of nitrogen as a fire suppressant. These systems are not adequate to support human life in the resulting environment and will reduce or eliminate their capabilities to perform their normal duties including the complete disposal of smoldering combustibles.

SUMMARY OF THE INVENTION

This invention is directed to a system and method of adding nitrogen under pressure to a confined area including a habitable atmosphere to suppress a fire without any deleterious effects on humans within the environment in which the fire is suppressed. In adding nitrogen to the confined area the partial pressure of oxygen remains the same to support human life, if neces-

sary, whereas the percent by volume of oxygen is lowered to a point which is not sufficient to support combustion of the burning elements. Therefore, life is sustained while the fire is suppressed without any harmful effect on humans.

It is therefore an object of the present invention to suppress a fire in a closed chamber while maintaining an environment suitable for human activity.

Another object is to suppress a fire within a closed chamber in sufficient time to prevent harmful effects from smoke or toxic effects due to the suppressant.

Still another object is to permit humans in a closed environment to function in as nearly as possible all activities which include smoking, as if they were in a non-closed environment under normal atmospheric conditions while maintaining a fire suppressant system ready for use when necessary.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates a single diffuser for admitting nitrogen into a chamber, and

FIG. 2 illustrates a diffuser including a plurality of ports for admitting nitrogen into a large area.

DESCRIPTION OF THE DISCLOSURE

It is well known that the sustenance of comfortable human life for carrying out normal regular activities requires a partial pressure of oxygen of about 0.2–0.3 atmospheres, regardless of the total atmospheric pressure at least up to about 20 atmospheres. At lower partial pressures, man suffers lethargy and nausea, at higher levels, lightheadedness. Combustion rates that sustain fire are markedly dependent upon the oxygen mole fraction. In a compartment open to the earth's lower atmosphere where the total pressure is one atmosphere, the oxygen fraction and partial pressure are equal and, in general, a habitable gas mixture is a combustion-supporting gas mixture. In an enclosed vessel, chamber or compartment possibly above the earth's lower atmosphere, or under water, the habitable gas mixture and combustion supporting gas mixture may be variable. In supporting life in a habitable vessel with a controlled environment, it is desirable for the personnel to function within an atmosphere which will permit the same activities as in a non-controlled environment under atmospheric conditions. Areas of concern include ones ability to smoke a cigar or cigarette when desired and the freedom from entrance and exit air locks. In some controlled environments smoking is not permitted because of the presence of combustible gases or possible because of an overpressurized atmosphere which does not support combustion. Areas of interest are habitable vessels such as submarines, airplanes, diving capsules for underwater exploration, spaceships, confined storage areas such as a room-type safe or machine room that require a controlled environment. The present system may be used for any controlled habitable environment which is either an enclosed area or an area which may be closed by closing of a door or window.

The method of suppressing a fire in a confined space with a controlled environment at one atmosphere involves the addition of a nitrogen gas to the enclosure

which increases the total pressure of the enclosure from one atmosphere to 1.5–2.0 atmospheres. Nitrogen is used because in addition to being inert, it is stable, inexpensive harmless to both man and equipment, and return to a normal atmosphere is relatively easy once the fire has been extinguished. Experimentation has determined that both class A and B fires of the type which might be encountered within a submarine or areas previously mentioned will be suppressed by pressurization with nitrogen to raise the pressure of the enclosure to at least 1.5 atmospheres while maintaining the partial pressure of oxygen at 0.2–0.3 atmosphere.

It has been determined that the amount of oxygen available for combustion, the amount of nitrogen necessary for suppression, and the concentrations of the fire products are all linear functions of the enclosure volume. As an example, if it is necessary to pressurize an entire submarine of 100,000 cubic feet in order to suppress a fire, the weight of nitrogen needed is about 3,000 lbs. If the nitrogen is stored as a cryogenic liquid, it would occupy a volume of about 60 cubic feet. However, the nitrogen may be stored as a gas at high pressure or in some other manner.

Submarines or other confined areas may be made as one space or divided into several separate spaces which need to be protected against fires. It has been determined that for habitable areas, means must be used to ensure that the nitrogen mixes with the oxygen and does not separate into separate areas containing the different gases. Thus, for a small area of space, a single diffuser or baffle may be used as shown in FIG. 1 which directs the nitrogen gas in all directions to bring about good mixing. For large areas such as in an entire submarine, several diffusers may be used as shown in FIG. 2.

The nitrogen may be stored in any suitable gaseous liquid or solid state in any suitable means such that when a fire needs to be suppressed, nitrogen gas is available for mixing with the normal atmosphere and increasing the atmospheric pressure of the area involved. Such systems may be initiated automatically by the fire as in a water sprinkler system, may be controlled manually or by any preferred means that allows the nitrogen to enter the confined area, mix with the volume of oxygen and increase the atmospheric pressure sufficiently to suppress the fire. The partial pressure of oxygen remains the same for sustaining life, while the volume concentration of oxygen along with the increased pressure suppresses the fire. Thus, the fire is extinguished while human beings are able to perform their normal duties without harmful effects due to the nitrogen or a lack of oxygen. With the above system, fires are suppressed before sufficient oxygen is burned to affect human life. During experimentation, it has been determined that fires in a contained area may be suppressed in less than 30 seconds. Examples of extinguishing fires under controlled situations have been set forth in a published article "Pressurization with Nitrogen as an Extinguishment for Fires in Confined Spaces" by Patricia A. Tatem, Richard G. Gann and Homer W. Carhart, published in *Combustion Science and Technology*, Vol. 7, pp 123–128, 1973.

The fluid dynamics of the nitrogen delivery into the area of concern must not result in either a pressure shock wave or substantial localized pockets of reduced

oxygen content. Either of these effects could render portions of the chamber uninhabitable, thus negating the purpose of the technique. Therefore, the diffuser illustrated in FIGS. 1 and 2 is made of a porous material that will diffuse the nitrogen with the proper diffusing and pressure rate. The proper diffusing and pressure rate may be determined by use of suitable oxygen samplers and pressure devices at the time the system is installed. Once the system has been installed the different parameters of nitrogen flow will be set and will function accordingly.

It is well known that noxious CO and CO₂ are produced by smoldering material long after visible flames have been quenched. Nitrogen pressurization reduces the danger of smoldering in two ways: (1) by quenching the rapidly spreading (flaming) fire, (2) by imposing an increased thermal load of cool gas on the hot fuel. Thus, nitrogen gas not only suppresses flames from fires but aids in preventing smoldering hazards.

Suppression of fires by nitrogen pressurization enables humans to function in the area with the nitrogen. Nitrogen is not harmful to equipment or articles within the area, it may be stored for long periods of time, and the area affected may be easily restored to normal by depressurization and simultaneous addition of oxygen to the area.

This method may be carried out for the protection of bank vaults, walk-in safes, storage areas, submarines, airplanes, diving bells, or any other controlled environment areas which may be pressurized by the addition of nitrogen with the lowering of the volume % of oxygen within the confined area.

With this method, one may carry out their normal duties within a confined area without restrictions to their egress or smoking privileges except during the time of the fire extinguishment when one could not smoke because of the fire extinguishing features of the nitrogen.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A method of extinguishing a fire in a habitable space while maintaining an environment suitable for human sustenance and activity therein, which comprises:

- sealing off the space to prevent gas escapement;
 - diffusing nitrogen gas at a pressure greater than ambient into said space initially at ambient pressure and uniformly mixing said nitrogen with the gases within said habitable space and
 - adding said diffused nitrogen gas into said confined space until the oxygen % by volume is from 10–15% with a partial pressure of oxygen of from 0.2–0.3 atmospheres with an increase in total gas pressure to 1.5 to 2.0 atmospheres;
- whereby the reduced oxygen % by volume is sufficient to extinguish the fire and the partial pressure of oxygen is sufficient to sustain human life and permit work activity within the increased pressure environment.

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