

[54] **CARBON MONOXIDE BURNER FOR UNDERSEA HABITATS**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy**

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[51] Int. Cl. **B01j 9/04**

[58] Field of Search **23/288 F, 288 J, 281, 277 C, 23/150; 165/158**

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[57] **ABSTRACT**

Disclosed herewith is a burner system for removing carbon monoxide and other spurious impurities from gaseous atmospheres intended to be breathed by human beings while they are living and working in enclosed pressurized chambers or habitats located undersea or within other environments requiring life-support equipment. Included therein is a burner a burner system is disclosed as having a boiler-tube type heat exchanger for preheating the gaseous atmospheres supplied thereto for purification and for cooling the purified portions thereof immediately prior to their being exhausted into the habitat thereby. An atmospheric gas conduction passageway is operatively associated with said heat exchanger, and a compartment containing an oxidizing catalyst is disposed with respect thereto, so as to receive the atmospheric gas flowing through said passageway and supply it to the cooling portion of said heat exchanger. A heater is disposed for simultaneously heating said passageway and said catalyst, and a thermally insulated housing encapsulates all of the aforesaid components in order to contain them as a unit that is suitable for being located within said habitat. An instrumented temperature control system is also employed to sense and control the temperature of said passageway, and a blower is employed to supply the atmospheric gas to be purified to said burner at quantities and pressures required for any given operational circumstances.

11 Claims, 2 Drawing Figures

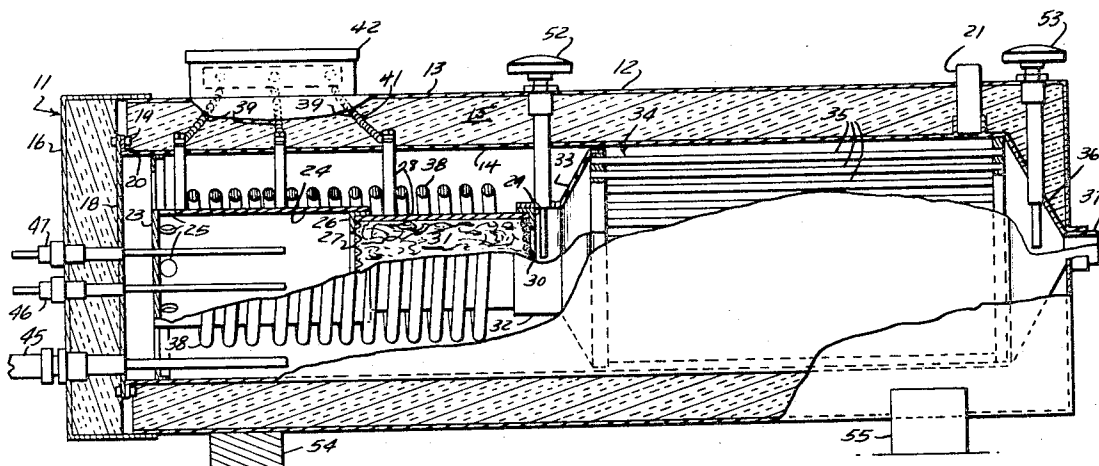
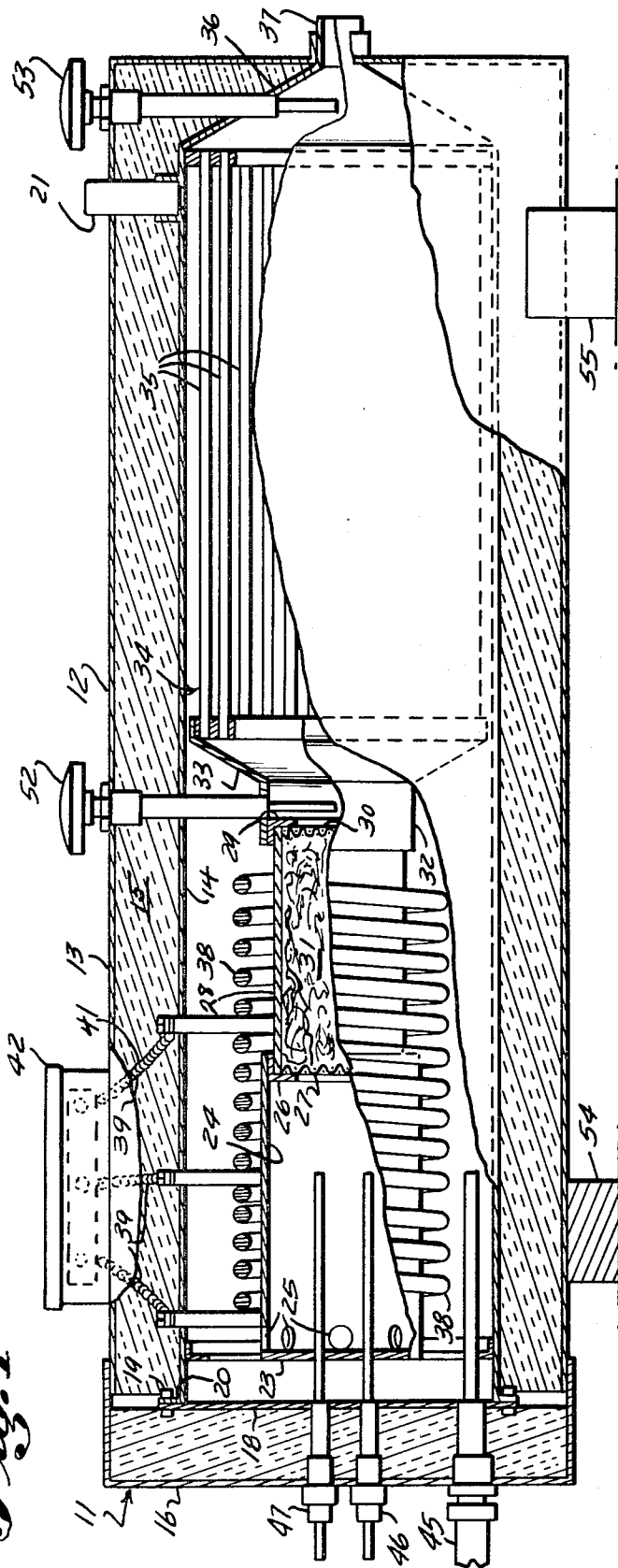


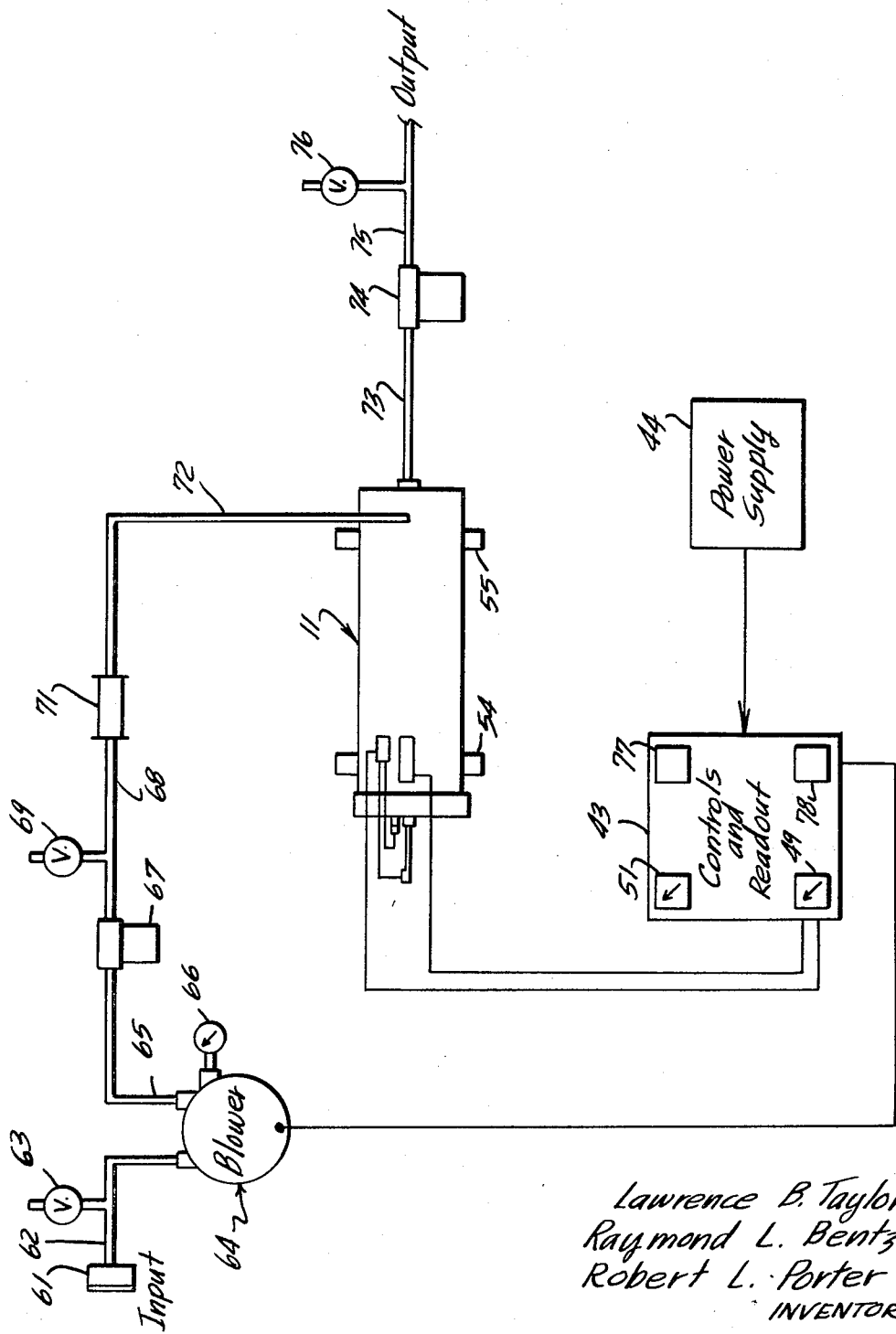
Fig. 1



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Fig. 2



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CARBON MONOXIDE BURNER FOR UNDERSEA HABITATS

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

FIELD OF THE INVENTION

The present invention relates, in general, to atmospheric regeneration systems and, in particular, is a system for removing carbon monoxide from a pressurized helium atmosphere.

DESCRIPTION OF PRIOR ART

To date, there has been very little experience with respect to deeply submerged habitats and, thus, the employment and control of atmospheres therein which will sustain life in a reasonably comfortable and healthy manner have been considerably less efficient than desired.

It has been determined, for example, that carbon monoxide (CO) concentrations which are acceptable for breathing at the ocean surface atmospheric environment are not satisfactory in such devices as the deeply submerged U. S. Navy's SeaLab which are under great pressure and, therefore, must contain a pressurized helium atmosphere therein during the human operation thereof. For instance, if 25 ppm of carbon monoxide is acceptable for adequate human breathing at one atmosphere of pressure, than at, say, 19 atmospheres pressure, 25 or only 1.3 ppm thereof would be the acceptable. Hence, it may readily be seen that, in a breathable atmosphere, the amount of carbon monoxide that a human can tolerate and still function normally is considerably reduced as the ambient atmospheric pressure is increased. Accordingly, because it has only been in relatively recent times that human beings have endeavored to survive and work at great ocean depths, satisfactory scrubbing equipment that will maintain an acceptably low level of CO for human life in a pressurized helium environment have not, heretofore, been developed to the degree of sophistication desired. However, in the past, for some lesser demanding purposes, the combustion of carbon monoxide has been achieved in atmosphere pressure air along with burning hydrogen vapor.

In addition, various catalyst systems have been used in combination with room ventilating systems at normal room temperatures and pressures to reduce the carbon monoxide concentration of the air being processed therein, but when the room pressures are increased, it has been found that the catalyst incorporated therein very quickly becomes fouled with water vapor and hydrocarbons, unless additional heat is added to maintain proper operational temperatures.

None of the known atmospheric regeneration systems, including those mentioned above, are satisfactory for use in a highly pressurized helium atmosphere, such as is required for a human habitat located on the sea floor at considerable ocean depth, although, as previously suggested, they may be adequate for many lesser demanding operational situations, especially in a predominantly air atmosphere.

SUMMARY OF THE INVENTION

The subject invention, in brief, is a burner system for removing carbon monoxide and other spurious impurities from gaseous atmospheres intended to be breathed by human beings while they are living and working in enclosed pressurized chambers or habitats located undersea or within other environments requiring life-support equipment. As such, it overcomes many of the disadvantages of the aforementioned prior art, especially since it facilitates the accurate control of said carbon monoxide concentration and other waste or unwanted elements within such gaseous mediums.

It is, therefore, an object of this invention to provide a new and unique method and means for removing carbon monoxide from a pressurized helium atmosphere.

Another object of this invention is to provide an improved atmospheric regeneration system.

Still another object of this invention is to provide a compact device for efficiently burning carbon monoxide, hydrogen, hydrogen vapor, and hydrocarbons existing within an air effluent in such manner as to produce carbon dioxide and water vapor in an air effluent.

A further object of this invention is to provide an improved system for producing a regenerated atmosphere within a closed pressurized container, such as within a deep sea habitat, which will support and sustain the lives of people living and working therein.

Another object of this invention is to provide an improved method and means of substantially removing waste materials that would otherwise pollute atmospheres such as air and helium within a large of pressure conditions, and even when they are pressurized at nineteen or more atmospheres of pressure.

Another object of this invention is to provide closed atmospheres which are safe to breathe by human beings within pressurized deep ocean running submarine boats, deep diving bells, deep diving suits, and any other vehicles or devices which require an artificial life sustaining atmosphere therein.

A further object of this invention is to provide an improved controllable method and means for supplying a breathable atmosphere to a human being whenever he is located at some place, either near or far, where it is naturally or otherwise available.

Another object of this invention is to provide an improved method and means for catalytically purifying exhaust gases containing toxic, malodorous, and other unwanted constituents, so as to make them safe, breathable, innocuous, and odorless, as well as non-toxic to human beings.

Another object of this invention is to provide an improved method and means for economically maintaining certain desired temperatures within a catalysis bed operating at hyperbaric pressures.

Another object of this invention is to provide an atmosphere regeneration system that is compact in size and is easily and economically constructed, operated, and maintained.

Other objects and many of the attendant advantages will be readily appreciated as the subject invention becomes better understood by reference to the following detailed description, when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic representation of the carbon monoxide burner unit of the subject invention;

FIG. 2 is a diagrammatical representation of a carbon monoxide burner system incorporating the burner unit of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown a carbon monoxide, retort-like, burner unit 11 having a housing 12 which has outer and inner metallic walls 13 and 14 with suitable heat insulation 15, such as asbestos, a ceramic, or the like, disposed therebetween. A removable cap 16 is incorporated in housing 12 in such appropriate conventional manner as will provide thermal insulation at the end thereof. For such purpose, for example, an end plate 18 may, by means of bolts 19, be bolted to a flange portion 20 integrally connected to the aforesaid inner wall 14 of housing 12. At the end of housing 12 opposite the end connected to cap 16 is an aperture through which entrance pipe 21 is inserted and another aperture through which the discharge of the effluent or regenerated atmosphere is effected, as will be explained further below.

A centering and support end plate 23 is releasably or slidably connected to inner wall 14 of housing 12, and attached thereto, as by threading or mechanical fasteners, or the like, is a hollow tube 24. A plurality of holes 25 are located around the periphery of said tube 24 adjacent the end thereof connected to support plate 23. Telescopically disposed within the other end of tube 24 and releasably connected thereto by screw threads or the like is cup-shaped end cap 26 which contains a stainless steel screen 27 adapted for allowing a gas to pass therethrough. Another pipe 28 is friction fitted or threaded in the cup portion of end cap 26, and still another cup-shaped end cap 29 is friction fitted or threaded thereon at the other end thereof, and, of course, it, too, contains a stainless steel screen 30 adapted for allowing a gas to pass through it.

Disposed within the chamber effected by tube 28 and screened end caps 26 and 29 is a catalyst 31 which is a mixture of copper oxide (CuO) and manganese dioxide (MnO_2). The specific quantities of said compounds may be varied to the extent necessary to effect optimization of the efficiency thereof for any given temperatures and pressures of the gas being processed therethrough and thereby and to give it long life due to its not absorbing moisture and hydrocarbons. It, of course, would be well within the purview of one skilled in the art having the benefit of the teachings presented herewith to make the proper selection of said compounds, so as to provide the best catalyst for any given operational circumstances. In addition, it may be noteworthy that a catalyst composed of a mixture of copper oxide and manganese dioxide, named Hopcalite, is manufactured by and is commercially available from the Mine Safety Appliance Company, and it may be used as catalyst 31 in the subject invention, if so desired.

End cap 29 is preferably connected by screw threads to the rear end of a pipe or conduit 32 which, in turn, is attached to a diverging funnel 33 of a boiler tube type of heat exchanger 34. As will be discussed more fully

subsequently in conjunction with the explanation of the operation of the invention, heat exchanger 34 has a dual purpose and acts as both a preheater and after-cooler of gas being processed by the burner unit of the subject invention. Such unique operation is, of course, effected due to the unique structural combination within which heat exchanger 34 is incorporated. Tubes 35 are connected between a header plate funnel 33 and another header plate funnel 36 which, in turn, has an exit or effluent pipe 37 connected thereto which extends through housing 12.

Disposed around the aforesaid tube 24 and catalyst bed container tube 28 is a resistance type electrical heating coil, such as nickel-chromium wire 38, which is capable of producing sufficient heat threat in response to electrical current being supplied thereto. For such purpose, insulated electrical leads 39 are respectively threaded through pluralities of glass beads 41 for the flexible supporting and insulation thereof. Said leads 39 are, of course, connected to a suitable terminal box assembly 42 which, in turn, is connected through an electrical control unit and readout 43 to a 440 volt, 3-phase power supply 44, depicted in FIG. 2.

For the purpose of controlling and indicating the temperatures occurring at various locations within burner unit 11, a plurality of temperature probes and thermometers are installed in such manner as to extend through the insulated wall thereof. Although it should be understood that any number thereof may be so employed, for most practical purposes it has been determined experimentally that a high temperature cutoff sensor 45 which extends into the passageway adjacent to entrance pipe 24 is definitely desirable for the safe operation of the invention. In addition, a temperature controlling sensor 46 is likewise disposed in the heated gas flow path of pipe 24 in such manner that it will, in conjunction with the aforementioned control unit 43, regulate the temperature of the gas flowing therethrough by controlling the current supplied to heater coil 38. A temperature sensor 47 is also inserted through the wall of housing 11 in such manner that it extends into the gas flow chamber effected by pipe 24, and it is this sensor which is preferably used to indicate the temperature therein at some remote location and at the panel board 43, illustrated schematically in FIG. 2. Each of the aforesaid temperature sensors may be of any suitable types which would facilitate the operation thereof; for example, they may be thermistors, thermocouples, or the like, which are adapted to being electrically connected to any compatible control and/or readout devices, such as the aforesaid electrical control unit 43 and meters 49 and 51, respectively.

A direct reading thermometer 52 extends through housing 12 into pipe 32 in such manner that temperature of the gas being processed that has passed through catalyst 31 is measured and indicated thereby. Also, another direct readout thermometer 53 is inserted through the walls of housing 12 and funnel 36, in order to measure the temperature of the gas being processed after it has been cooled by heat exchanger 34 and being exhausted from exit pipe 37.

A pair of mounting brackets 54 and 55 are attached to housing 12 for the purpose of securing it to any desired mounting location, including within any predetermined deep sea habitat intended to be occupied by divers, aquanauts, or others.

FIG. 2 is a system which incorporates burner unit 11 to an advantage, in order to purify a predominantly helium-oxygen-carbon monoxide atmosphere in such manner that the carbon monoxide is deleted therefrom to the extent that the remaining gas will sustain human life within a predetermined environment, including one under great pressure. Disclosed therein is an atmosphere intake filter 61 adapted for receiving and filtering the gas to be processed to remove solid particles therefrom. A pipe 62 having a gas sampling valve 63 is connected to the input of a blower 64. Another pipe 65 containing a static pressure gauge 66 is connected between the output of blower 64 and a liquid removing filter 67. Another pipe 68 containing a gas sampling valve 69 is connected between the output of filter 67 and the input of a flowmeter 71, the output of which is connected to the input pipe 21 of the aforesaid carbon monoxide burner unit 11 by means of a pipe 72. The purified gas output 37 of carbon monoxide burner unit 11 is connected by means of a pipe 73 to a filter 74, the output of which is connected to a discharge pipe 75 and another gas sampling valve 76.

Burner unit 11 and the aforesaid blower 64 are turned on and off and regulated, respectively, as desired, at controls 43 by control switches 77 and 78. It should, of course, be understood that controls 43 and the various instruments thereof may be physically located within the habitat where the atmosphere is being controlled, some remote place, or both, by means of duplicate controls and appropriate selector switches. However, in order to keep this disclosure as simple as possible, only one thereof has been illustrated and discussed.

In addition, it should be understood that each of the components incorporated in this invention, with the possible exception of the catalyst, are conventional and well known per se; consequently, it is their unique structural arrangement, interconnections, and interactions that constitute the new and improved carbon dioxide system herewith disclosed and effects the new and improved results produced thereby.

MODE OF OPERATION

The operation of the subject invention will now be discussed briefly in conjunction with both of the figures of the drawing.

Referring first to the carbon monoxide burner unit of FIG. 1, the atmospheric gas to be purified is supplied to intake pipe 21. In this particular preferred embodiment, burner 11 is intended to practically eliminate carbon dioxide from a pressurized atmosphere gaseous mixture of approximately ninety per cent helium (He) by volume, with the remainder thereof including oxygen (O₂) and perhaps traces or small quantities of air or other gases. Such mixture is employed, of course, because it has been experimentally found to work well in sustaining human life, inasmuch as it is breathable at great pressures—say, of the order of nineteen atmospheres of pressure—the pressures that are found to exist in habitats, such as, for example, the Navy's SEALAB, that are deployed on the floor of the deep ocean.

In such a habitat, for the purpose of carbon monoxide removal, it has been determined that it is desirable to recirculate the air, so that it is a self-contained unit, and thus not dependent on being supplied similarly

treated breathable air or gas from some remote or inaccessible source. Perhaps it is also noteworthy that, although the preferred embodiment of the instant invention pertains to and concerns an underwater habitat or device, it may be employed in space or any other place where such a habitat requires removal of carbon monoxide from its breathable air.

Hence, from the foregoing, it may be readily appreciated that the gas supplied to intake pipe 21 is that which contains unwanted carbon monoxide due to its having been generated by various and sundry processes occurring within the habitat, and, therefore, it must be recirculated and purified properly, if it is to be used again.

Obviously, if burner unit 11 is to function properly to purify carbon monoxide poisoned gas, it must be turned on—that is, supplied electrical current, so that heater coil 38 will have the right temperature. However, it may also be adjusted during the operation thereof to provide as much functional efficiency as possible. Assuming that it is working normally, the gas which passes through pipe 21 makes contact with the outside surface of the pipes 35 of heat exchanger 34 where it receives heat therefrom and, thus, becomes preheated to about 400° F. It then passes over heater coils 38 where the heat content thereof is raised to approximately 600° F., and then it is guided through holes 25 into pipe 24 where it contacts temperature controlling sensor 46 and remote readout temperature sensor 47. From pipe 24, it passes through screen 27 of cup 26 into catalyst bed 31 where, as a result of the action thereof in conjunction with the aforesaid high temperatures, the carbon monoxide content thereof is “burned” or oxidized in such manner as to cause another oxygen atom to be combined therewith to thus form carbon dioxide, a gaseous compound that can be tolerated in larger quantities by human beings. In the presently discussed predominantly helium gaseous mixture, the amount of carbon dioxide that exists therein after purification is not sufficient to be dangerous to human life, nor will it adversely affect the functioning of human beings when working in and breathing it. Hence, it is purified gas that passes through the inside of tubes 35 of heat exchanger 34, where it is cooled to approximately 240° F., before passing out of exhaust pipe 37.

The aforementioned actions and reactions occur in burner unit 11, which, of course, is a very important component of the atmosphere recirculation system of FIG. 2. In such system, the air or atmosphere to be purified enters at and is filtered by filter 61 to insure that no deleterious particles of solid matter exist therein, from which it is sucked into blower 64 and pressurized thereby, so as to be forced through moisture filter 67 and flowmeter 71 to burner 11. Blower speed and, hence, output pressure may be controlled by regulator 78 at controls 43. The static pressure thereof is indicated by gauge 66. As the gas is pumped through burner 11 the carbon monoxide therein is removed, as described previously. After exhausting therefrom, it again is filtered to remove excess moisture therefrom, and then it is then discharged within the habitat as breathable gas for the occupants thereof. During such process, the quality of the gas may be monitored at the various stages by selecting samples thereof from valves

63, 69 and 76 and further processing it as warranted by operational circumstances. Control instrument 49 in cooperation with temperature sensor 46 maintains the proper gas temperature within burner 11 in the conventional negative feedback control manner. Moreover, high temperature sensor 45 in conjunction with controller 49 will cause the entire unit to be shut down, in the event the temperature exceeds some preset safe temperature, as is conventionally done in most of such control systems. Thermometers 52 and 53 provide a means by which human operators may monitor the internal temperatures at important stages of the gas purification process.

From the foregoing, it may readily be seen that the subject invention constitutes a considerable advancement in the art of maintaining breathable atmospheres within highly pressurized vessels and, particularly, with respect to human habitats located on the floor of the deep ocean which require that the breathable gas therein may be about ninety per cent helium by volume combined with air at temperatures of approximately 250 pounds per square inch or perhaps even greater.

Obviously, other embodiments and modifications of the subject invention will readily come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing description and the drawings. It is, therefore, to be understood that this invention is not to be limited thereto and that said modifications and embodiments are intended to be included within the scope of the appended claims.

What is claimed is:

1. A burner for removing carbon monoxide, hydrogen, and hydrocarbons from gaseous mixtures containing carbon monoxide, hydrogen, hydrocarbons, helium, oxygen, and other trace elements at predetermined pressures, comprising in combination:

a heat insulating housing;

means connected to said heat insulating housing for conducting the aforesaid gaseous mixtures to the inside thereof;

heat exchanger means, having a gas entrance means, a gas exit means extending through the wall of said heat insulating housing, and a thermal transfer gas flow path therebetween, disposed within said heat insulating housing for simultaneously preheating and after-cooling portions of the aforesaid gaseous mixtures respectively external and internal thereof as a result of the internal portion thereof effectively giving up some of its heat to the external portion thereof without the occurrence of actual mixture of said portions or physical contact therebetween;

first chamber means located within said heat insulating housing for directing said gaseous mixtures along a predetermined path therein, said first chamber means including a pipe having an open exit end, a closed entrance end, and a plurality of holes located in the wall of said pipe in contiguous disposition with the closed entrance end thereof;

a second chamber means effectively connected between the open exit end of the pipe of said first chamber means and the entrance end of said heat exchanger means in such manner that said gaseous mixture may flow therethrough;

a catalyst including a predetermined mixture of copper oxide and manganese dioxide contained

within said second chamber means for facilitating the oxidation and removal of the aforesaid carbon monoxide, hydrogen, and hydrocarbons from said gaseous mixtures; and

heater means disposed around the aforesaid first and second chamber means for simultaneously heating the aforesaid catalyst and the gaseous mixtures passing therethrough to a predetermined temperature.

2. The device of claim 1, wherein said heat insulating housing comprises:

a plurality of metallic walls; and

a ceramic type insulation inserted between said plurality of metallic walls.

3. The device of claim 1, wherein said heat exchanger means is a boiler tube type of heat exchanger comprising:

a first header plate funnel;

a second header plate funnel; and

a plurality of pipes connected between said first and second header plate funnels in such manner that gas may pass therethrough and through said gas entrance and gas exit means substantially without resistance.

4. The device of claim 1, wherein said second chamber means comprises:

an open-ended pipe; and

a pair of screens, each of which has a mesh sufficiently small to prevent said catalyst from passing therethrough but sufficiently large to pass said gaseous mixture therethrough, connected to the open ends of said open-ended pipe, respectively.

5. The device of claim 1, wherein said heater means comprises:

a coil of nickel-chromium wire; and

a plurality of electrical leads connected thereto adapted for being connected to a predetermined electrical power supply.

6. The device of claim 1, wherein said helium of the aforesaid gaseous mixtures constitutes ninety per cent thereof by volume.

7. The device of claim 1, wherein said means connected to said heat insulating housing for conducting the aforesaid gaseous mixture to the inside thereof comprises an intake pipe.

8. The invention for claim 7 further characterized by a regulatable blower means connected to said intake pipe for supplying the aforesaid gaseous mixtures thereto in predetermined quantities and predetermined pressures.

9. A burner for removing carbon monoxide from a pressurized gaseous mixture of helium and air, comprising in combination:

an insulated housing;

a boiler tube type 2 heat exchanger disposed in said housing;

an entrance pipe extending through the wall of said insulated housing in such manner that a gas passing therethrough impinges on the external surfaces of the tubes of said boiler tube type heat exchanger;

a first chamber supported within said insulated housing, said first chamber having a closed end and an open end;

a plurality of holes located in the wall of said first chamber at the end opposite the open end thereof;

a first screen connected across the open end of said first chamber;
a second chamber having open ends, with one of the open ends thereof connected to said first screen;
a second screen connected across the other open end of said second chamber;
a catalyst containing a predetermined mixture of copper oxide and manganese dioxide disposed in said second chamber between said first and second screens;
means contiguously disposed with said first and second chambers for heating a gas passing therethrough and said catalyst;
a conduit means connected between said second screen and the gas entrance of the aforesaid boiler tube type heat exchanger; and
an exhaust pipe connected to the output of said boiler tube type heat exchanger extending through

the wall of said insulated housing.

10. The invention of claim 9 further characterized by:

a temperature sensor extending through the wall of said insulated housing and into said first chamber for sensing the temperature of the gas passing therethrough; and

means connected between said temperature sensor and the aforesaid gas heating means for controlling the temperature of the gaseous mixtures passing through said first chamber at a preset temperature.

11. The invention of claim 10 further characterized by blower means connected to the aforesaid entrance pipe for supplying said gaseous mixtures thereto in predetermined quantities and at predetermined pressures.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,706,535

Dated December 19, 1972

Inventor(s) Lawrence B. Taylor, Raymond L. Bentz, & Robert B. Porter

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Abstract, lines 1 through 7, delete the following:

"Disclosed herewith is a burner system for removing carbon monoxide and other spurious impurities from gaseous atmospheres intended to be breathed by human beings while they are living and working in enclosed pressurized chambers or habitats located undersea or within other environments requiring life support equipment. Included therein is a burner a burner"

and substitute the term --A burner-- therefor.

Signed and sealed this 27th day of November 1973.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents