

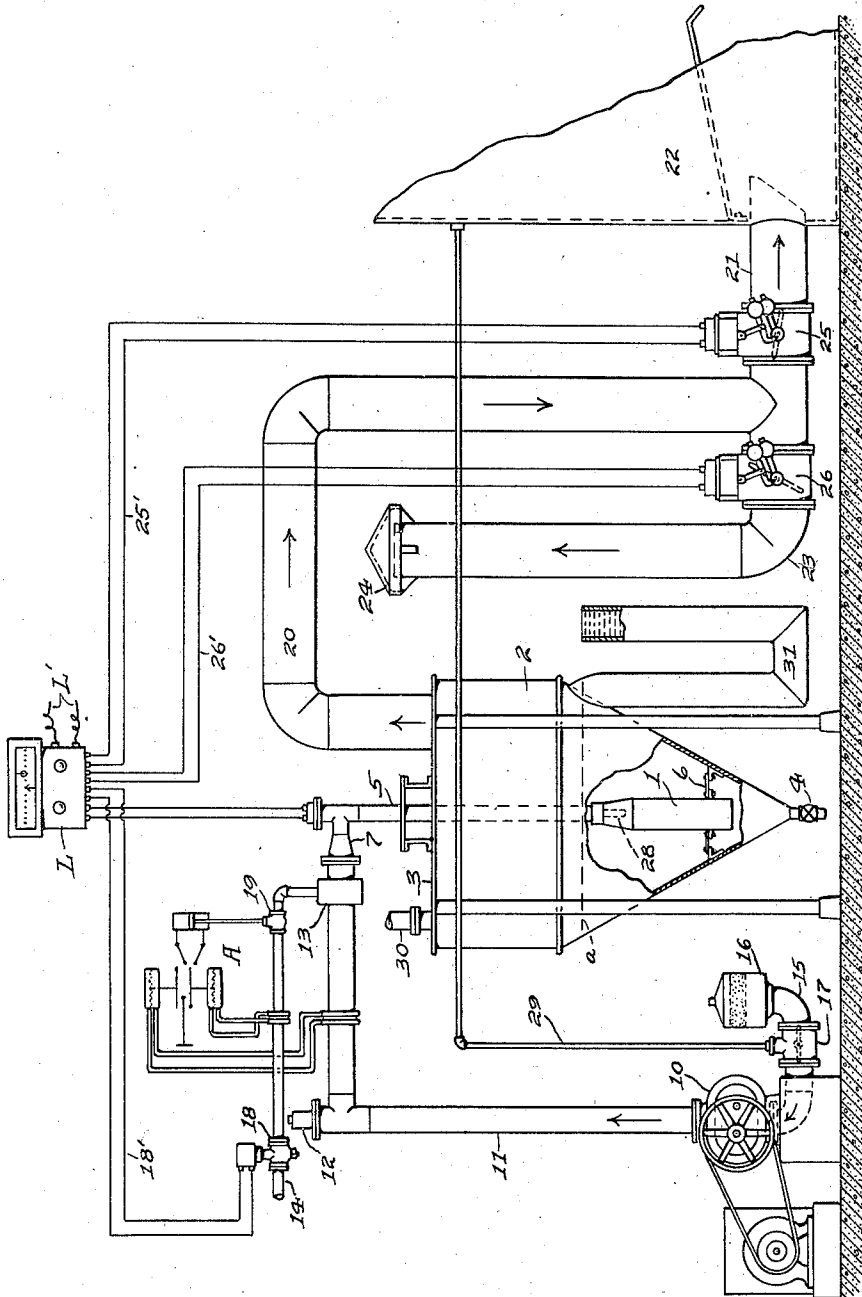
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APPARATUS AND METHOD FOR PRODUCING INERT GAS

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APPARATUS AND METHOD FOR PRODUCING
INERT GAS

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Inert gas is being employed in increasing quantities in various industrial applications but the apparatus heretofore utilized for generating the gas by combustion of suitable fuel in the air is frequently not particularly efficient from the standpoints of convenience, operating economy and the like.

It is therefore an object of our invention to provide an apparatus for producing inert gas, normally consisting principally of nitrogen, carbon dioxide and a small amount of water vapor and devoid or substantially devoid of nitric oxide, by the submerged combustion of a gaseous fuel.

A further object of the invention is the provision of apparatus of the character aforesaid so designed that it is substantially automatic in operation and thus requires little or no attention over long periods of time, but which in case of accidental failure of the gas generating flame is effective to prevent contamination of the previously generated gas by unconsumed combustible mixture during the interval before it is shut off from the burner.

A still further object is to provide such apparatus in which the volume of air and gas passing to the burner is automatically controlled in accordance with the pressure in the receiving tank or gasometer containing the generated inert gas so that the latter is produced at a variable rate and without loss of fuel, in accord with the ultimate requirements.

Other important features comprehended by the apparatus of our invention are ability to control the temperature of the inert gas as it is generated; to control the quantity of CO₂ therein, and to prevent the entrance of residual unburned gas and air to the gasometer when the apparatus is started up after an interval of disuse, as well as other objects, advantages and novel features of design, construction and arrangement hereinafter particularly mentioned or which will be apparent to those skilled in the art from the following description of one form of said apparatus which is illustrated, more or less diagrammatically, in the accompanying drawing in which the single figure is a side elevation thereof with certain parts broken away to better show internal construction.

More particularly, a submerged burner 1, preferably of the character of that forming the subject of United States Letters Patent 2,159,759 granted May 23, 1939, is suspended in a tank 2 of which the lower part is desirably conical and the upper part cylindrical and which is provided with a tight cover 3 and at its lower end with a

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drain connection 4. An inlet pipe 5 extends upwardly from the burner, the lower end of which may be steadied within the tank by a spider 6, to a suitable point above the cover, where it receives a connection 7 for directing into it the combustible mixture of air and a suitable gas, such as natural gas.

For supplying the air component of the mixture a fan or blower 10 conveniently motor driven is disposed at a suitable point and an air inlet pipe 11, which may be provided with a relief valve 12, extended therefrom to a mixing device 13 proximate the connection 7 which device may be of any suitable character for properly mixing the air and gas supplied to the device through the gas inlet pipe 14. Air is drawn into the blower through a duct 15 desirably provided with an air filter 16 at its inlet end; in this duct a pressure responsive valve 17 is disposed to control the volume of air passing to the blower as hereinafter described.

In the gas inlet pipe 14 is an electrically operated shutoff valve 18 which when open permits a full head of gas from any suitable source of supply to enter the pipe and thence pass to the mixing device 13 and when closed prevents the passage of any gas thereto.

The amount of gas entering the mixing device when the apparatus is in operation is controlled in proportion to the air supply by any means, generally designated as A, suitable for the purpose such, for example and as diagrammatically illustrated, as the device commercially known as an "Askania" regulator #S-185 marketed by the Askania Regulator Company of Chicago, Illinois, which is effective to meter the gas through a metering valve 19 located between shutoff valve 18 and the mixer; as the details of construction and operation of this regulator or of any other which may be employed in lieu thereof form no part of the present invention and are well understood by those familiar with the art, further description thereof would be superfluous.

For conveying the inert gas from tank 2 as it is generated therein by the submerged combustion of the combustible mixture, a conduit 20 is extended from the lid of the tank to any suitable point and thence branched, one branch 21 being extended to a storage tank or gasometer 22 and the other branch 23 to any convenient point desirably above the level of the tank 2 where it is vented to the atmosphere beneath a hood 24. Branch conduit 21 is preferably directed into the gasometer near its base and a baffle may be disposed above the conduit to con-

trol the direction of the entering gases. In branch 21 and thus between conduit 20 and the gasometer is located a quick acting electrically operated butterfly valve 25 and in the other branch 23 a like valve 26, these valves being preferably disposed equidistantly from conduit 20 and so arranged that when one is open the other is closed; they may be of any suitable construction as long as they are effective to prevent the passage of gaseous fluids when closed and allow such passage when they are open and are desirably solenoid operated. When the apparatus is functioning normally, valve 26 is closed and valves 18, 25 are open.

These valves are respectively connected by suitable leads 18', 25', 26' with an electrically actuated control device of any specific construction suitable for the performance of its intended function, one well known commercial instrument adapted for this purpose being that marketed by the Wheelco Instrument Company of Chicago, Illinois, under the name of "Limitrol" Model T. C. B. 721 and generally designated in the drawing as L; it receives its actuating current through leads L' extending to a suitable source of current supply. It is also connected with a thermo-couple 28 disposed at some suitable point proximate the burner, as below inlet pipe 5, and, speaking generally, the function of the device L, whatever may be its specific construction, is to actuate valves 18, 25, 26 in accordance with the operation of this thermo-couple in such manner that when some unusual condition resulting in extinguishment of burner 1 occurs, the normal positions of these valves are automatically reversed so that 26 is opened and 18 and 25 closed as hereinafter more fully explained.

Mention has been made of the pressure responsive valve 17 which controls the volume of air entering blower 10. This valve may be of any suitable construction adapted for the performance of its intended function and is connected by a pipe 29 with the gasometer so that if the pressure in the latter rises due to less inert gas being withdrawn from it than is being then generated, valve 17 will operate to decrease the volume of air passing to the blower and thence to the air inlet pipe 11 and, in turn, to the mixing device 13 and vice versa, and as gas regulator A operates to meter the gas in accordance with changes in air supply as above noted the proper relative proportions of air and gas in the mixture passing to the burner are constantly preserved.

Water is supplied to tank 2 through a water inlet 30 extending from its cover 3 to any suitable source of supply, the flow therethrough being manually controlled by a suitably positioned valve (not shown) so that more or less water can be admitted to the tank per unit of time, the water level being preferably maintained somewhat above the burner as indicated by line *a* by a U-shaped overflow pipe 31 connected into the side of the tank.

It will be noted from inspection of the drawing that conduit 20 is of relatively great diameter and length with the result that a correspondingly long column of the inert gas is maintained therein whenever the apparatus is in normal operation; this is a very important feature of the invention as will hereinafter more fully appear.

When starting up the apparatus for the first time or after an interval of non-use, water is admitted to tank 2 substantially to the level *a*, blower 10 actuated and gas valve 18 opened either manually or through operation of the control

mechanism L. Valves 25, 26 are next brought to positions the reverse of those shown in the drawing if not already therein, so that valve 25 is closed and valve 26 open. The burner is then lighted, conveniently by electric ignition mechanism (not shown) interconnected therewith, and the combustible mixture flowing thru it is thus burned beneath the surface of the water in the tank and the products of combustion rise through the water into the upper portion of the tank and thence pass into conduit 20 through which they continue toward its branches 21, 23, driving any air within the conduit before them. But since valve 25 is now closed, this residual air and the somewhat air-diluted inert gas following it cannot pass to the gasometer but instead is directed through valve 26 into vent 23 and thence into the atmosphere until the upper part of the tank and the conduit are swept clean of air and impure gas, which requires only a comparatively short interval of time. Valves 25, 26 are then reversed from their previous positions so as to close vent 23 and open branch 21 and thereafter as long as conditions remain constant the products of combustion, i. e. the inert gas, generated by the burner, ultimately pass to the gasometer. The reversal of valves 25, 26 to their normal operating position, to which reference has just been made, may be effected manually or thru operation of control mechanism L depending upon the construction of the valves; when those of the character illustrated are employed it is done in the former way by lifting the counterbalances until the valves are latched in the desired position from which they can be subsequently released by the electrical tripping means actuated by said mechanism. Thus, none of the residual air in the upper part of the tank and in the conduit nor any of the first-generated inert gas which may to some extent be diluted thereby can reach the gasometer until normal conditions of operation are established, pending which, of course, a relatively low pressure obtains in the gasometer and in consequence valve 17 is maintained fully open so as to allow the maximum volume of air to pass to blower 10 and thence into air inlet pipe 11.

The apparatus will now continue to function without further attention as long as the said normal conditions are maintained, the volume of combustible mixture supplied to the burner automatically varying as above explained in accordance with the pressure in the gasometer through operation of valve 17 and the gas metering device A. However, if through accident or any other reason burner 1 should be extinguished, the ensuing drop in temperature proximate the thermo-couple almost immediately causes the latter to open or close the circuit to control mechanism L which then operates to close gas shutoff valve 18 and trip valves 25, 26, thus closing conduit branch 21 extending to the gasometer and opening vent branch 23. But during the time lag required for these operations the unconsumed combustible mixture is passing from the burner into the tank and thence into conduit 20 and could therefore reach the gasometer and contaminate the pure inert gas therein were it not for the fact that the column of the gas within conduit 20 and branch 21 is of such length that valves 25, 26 reverse their respective positions before any of the unburned mixture can reach valve 25 while it is still open; it results that contamination of the gas within the gasometer is thus automatically prevented in case of any interruption of the normal operation of the apparatus and, of course,

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substantially coincident with the closing of valve 25 and opening of valve 26, gas shutoff valve 18 is also closed, so no wastage of fuel gas occurs following cessation of generation of the inert gas.

By changing the temperature and/or volume of feed water entering the tank, the temperature of the inert gas resulting from the combustion of the mixture in the burner may be varied within limits, while the amount of CO₂ contained in the gas may also be controlled in the same way to an appreciable degree since the greater the amount of water supplied per unit of time the greater is the amount of CO₂ absorbed therein as the products of combustion pass through it on their way to conduit 20; it also can be controlled by varying the amount of alkali in the feed water or a secondary alkali wash can be used for its complete removal.

Moreover, the amount of nitric oxide in the inert gas, which is objectionable even in very small quantities because it reacts with water to form nitric acid which attacks the iron mains and other apparatus through which the gas may be conducted, is dependent to a marked degree on the length of time the combustible mixture is in process of combustion in the burner as, in general, the shorter this time the smaller the amount of NO produced. Thus by employing a burner designed to reduce the combustion time as far as practicable, an inert gas substantially devoid of NO may be obtained and so of much greater freedom from this impurity than the inert gases generated in the manner and by the means hitherto customarily employed. This constitutes an important feature of our invention.

It will now be apparent that through the medium of the latter we are enabled to produce inert gas in a convenient way which, as far as we are aware, has not hitherto been proposed, namely by the use of submerged combustion, and that our apparatus is well adapted for the purpose and embodies many advantages and novel features which render it extremely desirable from an operating and maintenance standpoint.

Further, while we have herein described with considerable particularity one form of that apparatus, we do not intend thereby to restrict or confine ourselves specifically thereto, as numerous modifications and changes of design, construction, arrangement and assembly of the various instrumentalities comprised therein may be made if desired without departing from the spirit and scope of the invention as defined in the appended claims.

Having thus described our invention, we claim and desire to protect by Letters Patent of the United States:

1. Apparatus of the class described comprising a closed tank, means including an inlet and an outlet adapted to maintain a body of water therein at a predetermined level, a burner disposed in the tank with its outlet below said level, means for conducting a gaseous combustible mixture to the burner, a gasometer remote from the tank, a conduit adapted to conduct the products of combustion from the upper part of the tank and branched adjacent the gasometer with one branch connected therewith and the other opening to the atmosphere, an electrically actuated normally open shutoff valve in the first branch, a normally closed shutoff valve in the other branch, and thermo-electrically actuated means, including a thermo-responsive element proximate the burner, connected with said valves and automatically operative upon extinguishment of the burn-

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er to reverse the normal positions of the valves and thereby close that branch of the conduit connected with the gasometer and open the other branch, the length of said conduit being such as to permit said reversal to take place before any unburned mixture discharged from the burner can reach the gasometer.

2. Apparatus of the class described comprising a closed tank having an overflow outlet adapted to limit the depth of water therein and means for supplying water to the tank, a burner disposed in the tank with its outlet below said overflow outlet, means for directing a combustible gaseous mixture to the burner, a gasometer remote from the tank, a conduit extending from the upper part of the latter and branched proximate the gasometer, one branch connecting therewith and the other opening to the atmosphere, a normally open electrically actuated shutoff valve in the first branch, a similar but normally closed shutoff valve in the second branch, automatic mechanism actuated by thermally responsive means proximate the burner arranged to effect simultaneous alternate operation of said last mentioned valves whereby under normal conditions of operation the products of combustion from the burner pass through the water, thence into the conduit and ultimately through its first branch to the gasometer but are vented to the atmosphere through its other branch upon extinguishment of the burner.

3. Apparatus of the character described comprising a closed tank having means for supplying water to the tank and an overflow outlet determining the maximum level of water contained therein, a burner disposed in the tank having its outlet below said level, an inlet pipe extending from the burner outwardly of the tank, a mixing device connected therewith for mixing air and gaseous fuel to form a combustible mixture, an air inlet pipe connected with said device, means for supplying air under pressure to said pipe including a pressure responsive valve controlling the volume of said air, a gas inlet pipe for conducting gaseous fuel to said device, means automatically regulating the flow of gas to the device in accordance with the volume of air delivered thereto, a gasometer, a conduit leading from the tank for delivering to the gasometer the products of combustion generated in the tank, and a connection between the gasometer and the pressure responsive valve to vary the opening of said valve in accordance with the pressure in the gasometer and so correspondingly control the volume of air delivered to the mixing device.

4. Apparatus of the character described comprising a closed tank having an overflow outlet effective to determine the maximum level of water in the tank and means for supplying water thereto, a burner disposed in the tank having its outlet below said level, an inlet pipe extending from the burner outwardly of the tank, a mixing device connected therewith, an air inlet pipe extending to the mixing device, means for supplying air under pressure through said pipe, a pressure responsive valve associated with said means for controlling the volume of air so supplied, a gas inlet pipe extending to said device, an electrically actuated shutoff valve therein, means between said valve and said device for metering the gas passing to the latter when the shutoff valve is open in accordance with the volume of air delivered to the device, a gasometer remote from the tank, a conduit leading from the tank toward the gasometer and branched proximate

thereto, one branch being connected with the gasometer and the other opening to the atmosphere, a similar but normally open electrically actuated shutoff valve in the branch extending to the gasometer, a normally closed shutoff valve in the other branch, a thermo-couple proximate the burner, electrical control means connected therewith and with each of the shutoff valves operative when the thermo-couple is actuated by a decrease in its temperature to close the shutoff valve in the gas inlet pipe and reverse the positions of the shutoff valves in the conduit branches, and a connection between the gasometer and the pressure responsive valve to control the degree of opening of the latter in correspondence to variations in pressure in the gasometer and thereby vary the volume of air delivered to the mixing device, the length of the conduit being such as to permit the reversal of the valves in the conduit branches following actuation of the thermo-couple before any unburned mixture discharged from the burner can reach the gasometer.

5. In apparatus of the class described, a closed tank, a burner supported therein in the lower portion thereof, a gasometer, a conduit connecting the upper portion of the tank with the gasometer, a mixing device supplying the burner, conduits for gaseous fuel and air leading to said mixing device, pressure responsive valve means in said air conduit, valve means in said gaseous fuel conduit, means for automatically operating said last named valve, including pressure responsive connections to the air and gaseous fuel conduits whereby the flow of gaseous fuel is proportioned to the flow of air, and a connection between said gasometer and said valve in the air conduit arranged to operate said valve in response to pressure variations in the gasometer.

6. The method of producing relatively inert gas substantially free of oxides of nitrogen which comprises continuously admitting to a substantially closed chamber and withdrawing therefrom through a sealed overflow a non-combustible liquid capable of absorbing said oxides from combustion products, continuously introducing into the chamber a combustible mixture of gaseous fuel and air, effecting combustion of said mixture beneath the surface of the liquid and discharging the products of combustion into the liquid beneath its surface a distance adequate to insure substantially complete absorption by the liquid of said oxides contained in said products, collecting the unabsorbed gaseous products after their passage through the liquid, initially directing them through a conduit and into the atmosphere until they have filled the conduit, and then diverting them after passage through the conduit into a substantially air-free reservoir while excluding air from the chamber, conduit and reservoir.

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