The present invention relates to new and useful improvements in submerged exhaust combustion units for use as gas heat exchangers and the like. More particularly, the present invention is directed to apparatus comprising a burner and an exhaust tube associated therewith which is immersed in a liquid so that the products of combustion may be discharged through the tube beneath the level of the liquid, for example, to transfer heat to the liquid. The combustion gases to obtain cool inert gases, or to carry out a step in a chemical process. A principal object of the present invention is to provide a novel gas generator, heat exchanger or the like wherein combustion may be completed over a wide range of heat release.

Another object of the present invention is to provide a novel gas generator wherein any desired composition of combustion products may be obtained and wherein the combustion gases may be cooled to any desired temperature.

A further object of the present invention is to provide a novel gas generator, heat exchanger, or the like, having a burner which may be operated efficiently and effectively at any desired normal rate.

A still further object of the present invention is to provide a novel apparatus of the above type wherein inert gases may be produced with a minimum of impurities.

A still further object of the present invention is to provide a novel gas generator, heat exchanger, or the like, wherein products of combustion are discharged beneath the level of a liquid through a discharge tube integrally associated with the burner and wherein the depth of submergence of the exhaust tube is determined independently of the rate of flow of the liquid.

Still another object of the present invention is to provide novel apparatus of the type described which is of relatively simplified construction, may be manufactured easily and cheaply, and is entirely efficient and effective in operation and use.

These and other objects of the present invention and the various features and details of the operation and construction thereof are hereinafter more fully set forth and described with reference to the accompanying drawings in which:

FIG. 1 is a longitudinal sectional view of a submerged exhaust combustion unit made in accordance with the present invention;

FIG. 2 is a transverse sectional view taken along line 2-2 of FIG. 1; and

FIG. 3 is a transverse sectional view taken along line 3-3 of FIG. 1.

Referring more specifically to the drawings and particularly to FIG. 1 thereof, reference numeral 10 designates a housing forming an enclosed chamber 11. A burner 13 is mounted exteriorly of the housing 10 in communication with the chamber 11 so that the products of combustion may be discharged directly into the chamber. The burner is preferably of the type shown in Patents Nos. 2,701,608, issued February 8, 1955, or 2,839,128, issued June 17, 1958, but may be any conventional type of burner employing either a gaseous or a liquid fuel or both in combination wherein combustion is substantially completed within the burner and substantially complete products of combustion are discharged from the burner at relatively high velocity. A downcomer tube 14, which is in fluid communication with the discharge end of the burner, is mounted in the housing 10 preferably extending through the upper wall of the housing and terminating at its lower end adjacent the bottom of the chamber 11. Accordingly, the combustion gases are discharged from the burner 13 through the downcomer tube 14 into the chamber 11.

Since complete combustion of the fuel is generally not achieved in the burner, a downcomer tube 14 of sufficient length is provided so that combustion is completed prior to discharge of the exhaust gases from the downcomer tube into the chamber 11. It has been found that approximately 4 to 5 feet is the optimum length for the downcomer tube in order to complete combustion of the fuel.

As illustrated in the drawings, the discharge end of the downcomer tube 14 is immersed in a liquid so that the products of combustion discharged from the downcomer tube must pass through the liquid prior to entering the chamber 11. The liquid may be a liquid coolant, such as water, for the purpose of cooling the exhaust gases, it may be a medium that is to be heated by the exhaust gases, or it may be a reactant or reactant medium for use as a step in carrying out a chemical process. In accordance with the present invention, it is extremely important to closely control the depth of submergence of the charge end of the downcomer tube in the liquid in order to maintain the total pressure drop across the burner and downcomer tube substantially constant.

In prior apparatus of this type, when changing operation of the burner, that is, increasing or decreasing the rate of fuel consumption, equilibrium conditions at the discharge end of the downcomer tube are disturbed to the surging and turbulence of the liquid. The surging results in a fluctuating back pressure head until equilibrium is established and in the prior apparatus of this type this pressure head many times will increase the back pressure to an amount sufficient to damp out the burner. This is prevented in the present invention by the provision of a spill basin formed by an annular wall 17 at the bottom of the chamber 11 surrounding and coaxial with the downcomer tube 14 and spaced from the tube 14 and the housing to provide free overflow space around the upper edge of the annular wall 17. The downcomer tube 14 projects into the spill basin so that when the basin is filled with a liquid the discharge end of the downcomer tube is immersed therein. It has been found that the depth of submergence of the downcomer tube in the spill basin should be between 1 to 6 inches, and preferably 3 to 4 inches, to permit the maximum amount of burner turn-down without adversely affecting operation of the burner. With this depth of submergence, the burner can be efficiently and effectively operated over a wide output range and changes from one range to another can be effected without deleterious influence from surging and turbulence of the liquid. During operation, the effect of surging is minimized as any surging will merely cause the liquid to spill over the edge of the spill basin as compared to prior apparatus wherein some separate control means were utilized to control depth of the liquid.

Accordingly, it may be seen that substantially complete products of combustion are discharged into the...
downcomer tube wherein combustion is completed. The products of combustion then pass through the liquid into the chamber 11 and are exhausted from the chamber 11 through an outlet opening 18 in the upper end of the housing 10.

When the apparatus of the present invention is used for generation of inert gases and the like, it is important to cool the gases to as low a temperature as possible so that there is a minimum of water vapor in the gases as they leave the chamber. To this end, a liquid coolant supply chamber 19 is mounted adjacent the upper end of the chamber 11 surrounding the upper portion of the downcomer tube 14. The liquid coolant is supplied to the chamber 19 at any desired controlled rate through an inlet pipe 20 and is discharged from the supply chamber 19 through a series of openings 21 in the base of the supply chamber surrounding and adjacent to the downcomer tube. The openings 21 are so arranged that the liquid coolant is caused to flow downwardly along the exterior surface of the downcomer tube into the spill basin maintaining the temperature of the downcomer tube relatively low and cooling the products of combustion. Further cooling of the products of combustion is accomplished as the gases pass through the liquid in the spill basin and also causing the gases to pass upwardly in the chamber 11 through a liquid spray. As illustrated in FIGS. 1 and 2, a series of spray nozzles 22 connected to a conduit 23 are mounted within the housing 10 adjacent the upper end of the chamber 11 and discharge a liquid coolant into the path of the products of combustion. From FIG. 1 it is seen that the spray nozzles 22 are located at least as high as the gas outlet 18 so as to contact the gases for the full distance of their upward travel.

With this above described cooling system, the temperature of the products of combustion is lowered from approximately 3000° to 3500° F. at the burner to approximately 70° to 80° F. when they leave the chamber 11. The gases are initially cooled from the range of 3000° to 3500° F. at the burner to about 2500° F. upon entry into the spill basin by means of the liquid coolant surrounding the downcomer tube. Passage through the liquid coolant in the basin further reduces the temperature of the gases to about 200° F. and as the gases travel upwardly through the chamber 11 the liquid spray causes a final reduction to a temperature approximately equal to the temperature of the spray, which may be 70° to 80° F. or lower.

When the apparatus of the present invention is used as a heat transfer apparatus to heat liquid or is used to carry out a step in a chemical process, the liquid to be heated or the reactant medium may be supplied to the chamber 11 in any desired manner. The liquid may be supplied through the spray nozzles 22, or through the chamber 19, or both, or it may be supplied directly into the chamber 11 through a separate supply pipe. After the products of combustion or other gases leave the chamber 11 through the discharge opening 18 they pass through an entrainment separator 24 carried by a housing 25 mounted adjacent the housing 10. The entrainment separator may be of conventional construction and operates to remove entrained liquid from the gases. The removed liquid is then directed back into the chamber 11 by means of a conduit 26 which interconnects the base of the housing 25 with the bottom portion of the chamber 11. This conduit 26 may also serve as a balancing leg to balance the pressure between the bottom of the chamber 11 and the chamber discharge opening 18 to prevent any sudden surges in pressure from disrupting the operation of the apparatus.

After the gases pass through the entrainment separator 24, they are conveyed to some further treating apparatus or the like.

To provide for continuous passage of the liquid through the system, drain means are connected to the base of the chamber 11 to withdraw fluid therefrom. The drain means must be so designed to preclude the combustion products or other gases from escaping with the liquid. To this end, a discharge pipe 28 is mounted in the chamber 11 with its outlet end 29 disposed beneath the level of the spill basin, as shown in FIG. 1. The inlet end 30 of the discharge pipe extends substantially below the level of the spill basin and, as illustrated, is immersed in a drop leg 31 to thereby provide a gas trap. The vertical distance between the discharge and inlet ends of the outlet pipe is so designed that the maximum expected pressure in the chamber 11 will not cause the liquid level in the drop leg to go below the inlet end of the outlet pipe. However, all of the outlet means described, any conventional outlet means may also be employed to carry off the fluid. For example, an outlet may be disposed adjacent the spill basin so that liquid as well as solid particles may be discharged directly from the spill basin.

From the foregoing, it will be apparent that the present invention provides novel improvements in apparatus which may be employed effectively and efficiently as a gas generator, heat exchanger, or the like and which will operate continuously at any normal rate of operation of the burner.

While particular embodiments of the present invention have been illustrated and described herein, it is not intended to limit the invention to such a disclosure and changes and modifications may be incorporated and embodied therein within the scope of the following claims.

We claim:

1. A submerged exhaust combustion unit comprising in combination, an enclosed housing having a closed base, a fuel burner mounted adjacent the top of said housing and extending in a direction toward the base of said housing, said burner being adapted to burn fuel and exhaust the products of combustion downwardly in said housing, an elongated combustion gas discharge tube being connected to said housing and extending to the lower end thereof for communicating with and surrounding said burner and projecting downwardly into said housing along the base thereof, said discharge tube terminating at a predetermined distance above the base of said housing, said discharge tube being bare of lining interiorly and exteriorly and being operable to direct the products of combustion from said burner to the discharge end of said tube and adjacent the base of said housing, a liquid chamber surrounding said discharge tube at the region of the burner for holding a body of cooling liquid, means for supplying cooling liquid to said chamber, means for supplying cooling liquid from said chamber and down the outside surface of said tube while keeping the inside of said tube free from liquid, a gas outlet for cooled combustion gas near the upper end of said housing, means disposed at least as high as the height of said gas outlet for supplying a cooling liquid spray to the interior of said housing into upfowling combustion gas, an open topped spill basin positioned at the base of said housing around the discharge end of said tube and for a limited height above the lower end of the tube, said spill basin being formed by an annular wall having a top overflow edge spaced away from said housing, said spill basin being arranged to receive downfowling liquid supplied in said housing to maintain a liquid level at the top overflow edge of said annular spill basin wall and above the lower end of said combustion gas tube, and a liquid sealed gas trap and liquid overflow pipe located in the housing below the overflow edge of said annular spill basin wall to permit gas against escape at the base of the housing while permitting liquid overflow from said spill basin and escape of liquid from said housing.

2. Apparatus as set forth in claim 1, which further comprises a pressure balancing gas bypass conduit between the lower end of said housing adjacent said spill basin and said gas outlet at the upper end of said housing, said bypass conduit being relatively small as compared to the
gas upflow space in said housing around said combustion gas tube.

**References Cited in the file of this patent**

<table>
<thead>
<tr>
<th>UNITED STATES PATENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>517,297</td>
<td>Reiss ---------------</td>
</tr>
<tr>
<td>1,730,440</td>
<td>Smith ---------------</td>
</tr>
<tr>
<td>2,070,578</td>
<td>Bowman -------------</td>
</tr>
<tr>
<td>2,607,661</td>
<td>See ---------------</td>
</tr>
<tr>
<td>2,638,895</td>
<td>Swindlin -----------</td>
</tr>
<tr>
<td>2,640,761</td>
<td>Wiseman -----------</td>
</tr>
<tr>
<td>2,677,368</td>
<td>Janecek -----------</td>
</tr>
<tr>
<td>2,767,784</td>
<td>Dean --------------</td>
</tr>
<tr>
<td>2,865,620</td>
<td>Woodland ----------</td>
</tr>
</tbody>
</table>