Aug. 14, 1962 J. H. GEIGER 3,048,982

CLOSED CYCLE GASEOUS MEDIUM SYSTEM AND METHOD

Filed Oct. 31, 1960

Fig. 1

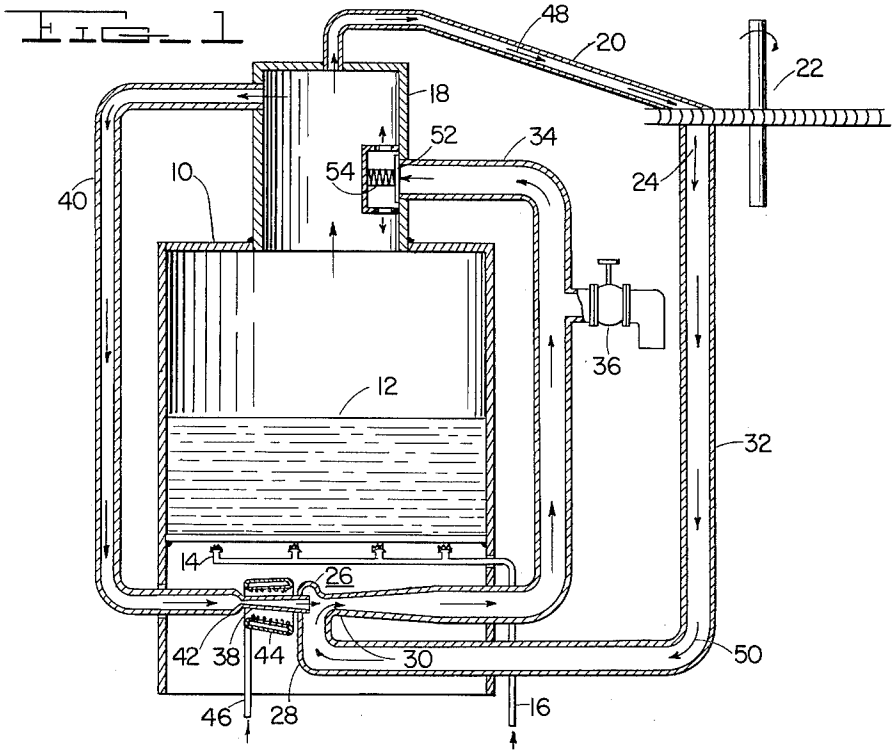
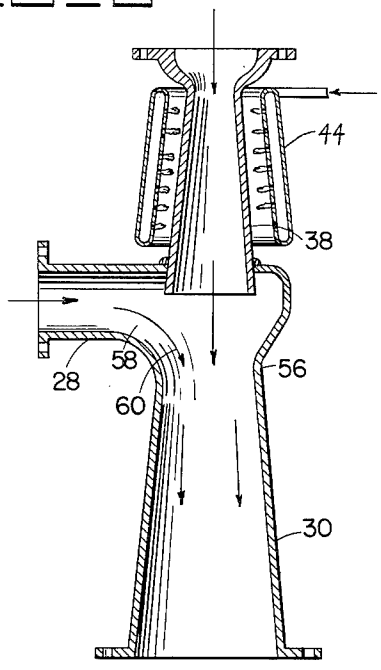


Fig. 2



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United States Patent Office

3,048,982

Patented Aug. 14, 1962

3,048,982

CLOSED CYCLE GASEOUS MEDIUM SYSTEM AND METHOD

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Filed Oct. 31, 1960, Ser. No. 66,092
10 Claims. (Cl. 60—108)

This invention relates generally to systems and methods employing a gaseous medium such as steam, and more particularly to a closed cycle steam system and method for returning low pressure steam to a boiler.

In conventional steam systems incorporating a steam utilization device of the type in which a pressure drop occurs from its inlet to its exhaust, such as steam turbine or steam radiator, the low pressure exhaust steam is either exhausted to the atmosphere, or condensed and returned to the boiler. In either system, the heat required to convert the water in the boiler into steam is completely lost, thus accounting for the relatively low thermal efficiency of such prior steam systems. This loss of energy could be substantially reduced if the low pressure exhaust steam exhausted by the utilization device could be returned to the boiler. While many arrangements have been proposed for returning low pressure steam to the boiler, to the best of the present applicant's knowledge, none of these arrangements have been practical since none added sufficient energy to the exhaust steam to permit overcoming the relatively high pressure in the boiler thus to establish a continuous flow of steam from the boiler to the utilization device and in turn from the utilization device back to the boiler.

It is accordingly an object of my invention to provide a closed cycle steam system.

Another object of my invention is to provide a closed cycle gaseous medium system.

A further object of my invention is to provide a method for injecting low pressure gaseous medium into an accumulator having gaseous medium therein at a higher pressure.

A still further object of my invention is to provide a method for returning low pressure steam to a boiler having higher pressure steam therein.

Further objects and advantages of my invention will become apparent by reference to the following description and the accompanying drawings, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

My invention in its broader aspects provides a method of injecting a low pressure gaseous medium, such as steam, into an accumulator or boiler having gaseous medium therein at a pressure higher than that of the low pressure gaseous medium by injecting high pressure gaseous medium from the accumulator into a stream of low pressure gaseous medium and heating the high pressure gaseous medium prior to its injection thereby increasing its velocity and kinetic energy so that its final pressure is higher than its initial pressure, i.e. the pressure within the accumulator. The injected gaseous medium is returned to the accumulator since it is at a pressure higher than the internal pressure within the accumulator, the low pressure medium uniting with and being forced by the injected gaseous medium into the accumulator. In a closed cycle system incorporating my invention, a boiler is provided for generating high pressure steam and a high pressure steam line connects the boiler to the inlet of a steam utilizing device of the type which has a drop in steam pressure between its inlet and exhaust such as a steam turbine. An exhaust steam line connects the exhaust of the steam utilizing device to the boiler for returning the low pressure exhaust steam thereto. The exhaust steam line has an injector therein including another high pressure steam line connected to the boiler and having a portion extending into the exhaust steam line for injecting high pressure steam from the boiler into the stream of low pressure steam from the steam utilizing device. Check valve means is provided in the exhaust steam line between the injector and the boiler for preventing the flow of steam from the boiler into the exhaust steam line, but permitting flow of steam from the exhaust line into the boiler when the pressure in the exhaust line exceeds the internal pressure in the boiler by a predetermined amount. Means are provided for applying heat to the other steam line exteriorly of the injector thereby to increase the velocity and kinetic energy of the steam injected into the exhaust steam line so that the injected steam at the check valve has a pressure higher than the steam pressure in the boiler thereby opening the check valve. The portion of the other steam line which extends into the exhaust steam line forms an aspirator with the exhaust steam line thereby producing a partial vacuum at the exhaust of the steam utilizing device so that the exhaust steam is drawn from the utilizing device and unites with or is entrained by the injected steam, being forced thereby into the boiler to provide a continuous flow of steam and thus closed cycle operation.

In the drawings,

FIG. 1 is a schematic view, partially in cross-section, illustrating the system and method of my invention; and

FIG. 2 is a view in cross-section illustrating the exhaust injector employed in practicing my invention.

According to Charles' general gas law, the volume of a given quantity of gas at constant pressure is directly proportional to temperature. Thus, if the temperature of the gas is increased with the pressure remaining constant, the volume is correspondingly increased. Therefore, if steam at a constant pressure is permitted to flow through a pipe and the pipe is heated, the heat will be imparted to the steam flowing therein thus increasing its volume in accordance with the general gas law and in turn increasing its velocity and kinetic energy. This increased velocity and kinetic energy may be converted to increased pressure to provide a system in which the final steam pressure is greater than the initial boiler pressure.

Referring now to the figures of the drawing, there is shown a boiler, generally identified as 10 having water 12 therein heated to boiling in order to create steam in any suitable manner, as by gas jets 14 fed by gas line 16. Boiler 10 is provided with a steam dome 18 to which is connected a high pressure steam line 20 for conducting high pressure steam from the boiler 10 to steam utilizing device 22, shown as being conventional steam turbine. Thus it can be seen that heat is applied to the water 12 in boiler 10 to create steam, steam being converted into mechanical energy in the turbine 22 and thereafter being exhausted as low pressure steam by the exhaust 24 of the turbine 22.

In accordance with my invention, I provide a steam injector 26 having an upstream leg 28 and a downstream leg 30 respectively joined in a right angle bend, as shown. The upstream leg 28 of injector 26 is connected to exhaust 24 of turbine 22 by a low pressure exhaust steam line 32 while the downstream leg 30 of injector 26 is connected back to the steam dome 18 of boiler 10 by steam line 34. A by-pass valve 36 is connected to steam line 34 in order to discharge the exhaust therein to the atmosphere, as will be hereinafter more fully described.

Injector 26 further includes a suitable diverging nozzle 38 extending into upstream leg 28 and in alignment with downstream leg 26 so that the steam injected into the downstream leg 30 by nozzle 38 passes over the upstream

leg 28 to provide an aspirating effect, as will be hereinafter more fully described. Another high pressure steam line 40 is provided connected to a steam dome 18 and having a restriction 42 therein which terminates in nozzle 38. A gas heater 44 is provided surrounding the nozzle 38 exteriorly of the injector 26 and adapted to have gas supplied thereto through gas line 46 in order to heat nozzle 38.

As indicated, high pressure steam is generated within boiler 10 by heating water 12, this high pressure steam flowing to the steam turbine 22 through high pressure steam line 20 as indicated by the arrows 48. Low pressure steam is then exhausted from turbine 22 flowing to injector 26 through exhaust line 32 as indicated by the arrows 50. High pressure steam from boiler 12 also flows through high pressure steam line 40 passing through restriction 42 and is ejected by nozzle 38 into the stream of low pressure steam flowing in downstream leg 30 and exhausting line 34. Heating of the steam flowing in the nozzle 38 by means of a gas heater 34 increases its velocity and kinetic energy so that the pressure of the steam injected into downstream leg 30 of injector 26 and line 34 is higher than the initial pressure of the steam flowing in line 40 and the internal steam pressure in boiler 10.

A check valve 52 is provided normally biased by a spring 54 to close exhaust line 34, spring 54 being arranged so that check valve 52 will be opened thereby to permit flow of steam from line 34 into boiler 10 when the pressure in line 34 exceeds the pressure in boiler 10 by a predetermined amount, for example five pounds per square inch. Injection of the high pressure super-heated steam from nozzle 38 and over the end of upsteam leg 28 of injector 26 and into the downstream leg 30 provides an aspirating effect thereby producing a partial vacuum in upstream leg 28 so as to draw the exhaust steam from the line 32 and the turbine 22, the low pressure exhaust steam uniting or being entrained with the high pressure super-heated injected steam and being forced through the check valve 52 back into the boiler 10 by virtue of the fact that the high pressure super-heated injected steam exerts a pressure on check valve 52 which exceeds the pressure within the boiler 10 by more than the differential provided by the spring 54.

It will now be seen that with my improved system and method, the low pressure exhaust steam from the turbine or other steam utilizing device is returned to the boiler in the form of steam so that it is no longer necessary to boil water in the boiler in order to create steam following initial generation of steam in the system, it being merely necessary to add sufficient heat to the steam in the system to raise the steam pressure to that required for operation of the turbine. In actual practice, once the system is in operation, sufficient heat to supply the energy dissipated in the turbine 22 and the other losses in the system is supplied by the heater 44 which super-heats the steam supplied thereto from the boiler 10 by line 40 so that it is not necessary to heat boiler 10 by means of gas jets 14 following initial start up of the system. In order to start-up the system, the water 12 in boiler 10 is initially heated to boiling and the system is started with the valve 36 being opened thereby exhausting steam to the atmosphere in order to clear the system of air. Once the system is operating satisfactorily, the valve 36 is closed so that the super-heated high pressure steam from nozzle 38 together with the entrained steam drawn from line 32 opens valve 52 thereby returning to boiler 10.

It will be readily apparent that the restriction 42 in the steam line 40 is necessary since if this restriction were not provided and heat merely applied to line 40, the result would be merely to increase the pressure in the boiler 10 by the amount corresponding to the increase in the pressure of the steam injected into the exhaust line by the nozzle 38. Thus, no differential in steam pressure would exist between the boiler pressure and the pressure

in the line 34 and therefore the continuous recirculation of steam would not be established.

It will be readily apparent that my invention is not restricted to steam produced by boiling water, but is equally applicable to other gaseous mediums or vapors, such as a mercury vapor. It will also be readily apparent that several injectors of the type shown in FIG. 1 may be operated in series in order to provide a very high final pressure. It will be seen that the primary flow of steam in my systems as from the boiler 10 to the turbine 22 where the bulk of its heat is converted into mechanical energy, the low pressure steam exhausted from the turbine 22 flowing to the injector under the influence of the high pressure super-heated steam injected into the stream of low pressure steam by the injector. A secondary flow of high pressure steam is provided in my system from the boiler to the injector, this secondary flow of steam being superheated and united with the low pressure exhaust steam thereby forcing the same back into the boiler to establish a closed cycle. In the preferred embodiment of the invention, the injector 26 is located directly underneath the boiler, as will be seen in FIG. 1, however, it may be found expedient to locate the injector elsewhere. As indicated, after the initial boiler pressure has been established and the turbine 22 actuated, the only heat necessary to be supplied to the system will be that supplied to the injector 26 since the heat supplied to the injector will compensate for the heat loss in the turbine 22 thus establishing a balance between the heat input and heat output for continuous closed cycle operation.

Referring now specifically to FIG. 2, in the preferred embodiment of my invention, both the nozzle 38 and the downstream leg 30 are divergent with their inner surfaces being generally in alignment as shown. It will be seen that the divergent configuration of the downstream leg 30 of injector 26 provides a throat portion 56 in essence forming a venturi, thus, injection of the high pressure super-heated steam from nozzle 38 past the exit 58 of upstream leg 28 produces an aspirating effect to draw the low pressure steam from the upstream leg 28 into the downstream leg 30, as shown by the arrow 60, the venturi formed by the throat 56 and the divergent configuration of the downstream leg 30 contributing to the uniting in the downstream leg 30 of the high pressure superheated steam from the nozzle 38 and the low pressure exhaust steam from upstream leg 28.

While I have illustrated and described a specific embodiment of my invention, further modifications and improvements will occur to those skilled in the art and I desire therefore in the appended claims to cover all modifications which do not depart from the spirit and scope of my invention.

What is claimed:

1. A closed cycle steam system comprising: a boiler for generating steam; steam utilizing means of the type which has a drop in steam pressure between its inlet and exhaust; a high pressure steam line connecting said boiler to the inlet of said utilizing means for supplying high pressure steam thereto, an exhaust steam line connecting the exhaust of said utilizing means to said boiler for returning low pressure exhaust steam thereto; exhaust steam injector means in said exhaust steam line including another high pressure steam line connected to said boiler and having a portion extending into said exhaust steam line for injecting high pressure steam from said boiler into the stream of exhaust steam from said utilizing means to said boiler; check valve means in said exhaust steam line between said injector means and said boiler for preventing flow of steam from said boiler into said exhaust steam line; and means for applying heat to said other steam line exteriorly of said injector means thereby to increase the velocity and kinetic energy of the steam injected into said exhaust line whereby said injected steam at said check valve has a pressure higher than the steam pressure in said boiler thereof opening said check valve;

said other steam line portion forming an aspirator with said exhaust steam line thereby producing a partial vacuum at the exhaust of said utilizing means whereby said exhaust steam is drawn from said utilizing means and united with and forced into the boiler by said injected steam.

2. The combination of claim 1 wherein said other steam line has a restriction therein spaced from said portion, and wherein said heat-applying means applies heat to said other steam line between said restriction and said portion.

3. The combination of claim 1 wherein said steam line portion is a nozzle, said other steam line having a restriction therein terminating in said nozzle, said heat-applying means applying heat to the portion of said nozzle exterior to said injector means.

4. The combination of claim 1 wherein said injector means comprises a section of said exhaust steam line having a generally right-angle bend therein defined by upstream and downstream legs, said other steam line portion extending into said bend and partially into said upstream leg and injecting steam into said downstream leg toward said check valve.

5. A closed cycle steam system comprising: a boiler for generating steam; steam utilizing means of the type which has a drop in steam pressure between its inlet and exhaust; a high pressure steam line connecting said boiler to the inlet of said utilizing means for supplying high pressure steam thereto, an exhaust steam line connecting the exhaust of said utilizing means to said boiler for returning low pressure exhaust steam thereto; an exhaust steam injector comprising a section of steam line having upstream and downstream legs defining a generally right angle bend, said upstream leg being connected to the exhaust of said utilizing means and said downstream leg being connected to said boiler for returning low pressure steam thereto; another high pressure steam line connected to said boiler and having a restriction therein terminating in a nozzle, said nozzle extending partially into said upstream leg at said bend and being in alignment with said downstream leg for injecting a jet of high pressure steam from said boiler into the stream of exhaust steam from said utilizing means to said boiler; a check valve in said boiler normally closing the connection from said downstream leg to said boiler thereby to prevent flow of high pressure steam from said boiler into said injector, said check valve being biased to be opened responsive to a predetermined steam pressure in said connection higher than the steam pressure in said boiler; and means for applying heat to the portion of said nozzle exteriorly of said injector thereby to increase the velocity and kinetic energy of the steam injected into said injector whereby said injected steam at said check valve has a pressure higher than said predetermined pressure thereby opening said check valve to permit flow of said injected steam into said boiler; said nozzle forming an aspirator with said upstream leg thereby producing a partial vacuum therein whereby the exhaust steam from said utilizing means is drawn therefrom into said injector and united with and forced into said boiler by said injected steam.

6. The combination of claim 5 wherein said nozzle is diverging.

7. The combination of claim 5 wherein said nozzle and downstream leg are diverging with their inner walls respectively generally in alignment.

8. The combination of claim 5 wherein said injector is positioned under the boiler.

9. A closed cycle gaseous medium system comprising means for accumulating said gaseous medium at a predetermined pressure; means for utilizing said gaseous medium and being of the type having a pressure differential between its input and exhaust; a high pressure line connecting said accumulating means and said utilizing means for supplying high pressure gaseous medium thereto; an exhaust line connecting said utilizing means and said accumulating means for returning low pressure gaseous medium thereto; valve means for preventing return flow of high pressure gaseous medium from said accumulating means into said exhaust line; injector means in said exhaust line including another high pressure line connected to said accumulating means and extending into said exhaust line for injecting high pressure gaseous medium from said accumulating means into the stream of low pressure gaseous medium flowing in said exhaust line; means for applying heat to said other high pressure line thereof to increase the velocity and kinetic energy of the gaseous medium injected into said exhaust line whereby said injected medium at said valve means has a pressure higher than the pressure of the gaseous medium in said accumulating means thereby opening said valve means permitting flow of said injected medium into said accumulating means; said other high pressure line cooperating with said exhaust line to provide an aspirating action whereby said low pressure gaseous medium is drawn from said utilizing means and united with and forced into said accumulating means by said injected medium.

10. A closed cycle gaseous medium system comprising means for accumulating said gaseous medium at a predetermined pressure; means for utilizing said gaseous medium and being of the type having a pressure differential between its input and exhaust; a high pressure line connecting said accumulating means and said utilizing means for supplying high pressure gaseous medium thereto; an exhaust line connecting said utilizing means and said accumulating means for returning low pressure gaseous medium thereto; injector means in said exhaust line including another high pressure line connected to said accumulating means and extending into said exhaust line for injecting high pressure gaseous medium from said accumulating means into the stream of low pressure gaseous medium flowing in said exhaust line; means for applying heat to said other high pressure line thereof to increase the velocity and kinetic energy of the gaseous medium injected into said exhaust line whereby said injected medium has a pressure higher than the pressure of the gaseous medium in said accumulating means permittting flow of said injected medium into said accumulating means; said other high pressure line cooperating with said exhaust line to provide an aspirating action whereby said low pressure gaseous medium is drawn from said utilizing means and united with and forced into said accumulating means by said injected medium.

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