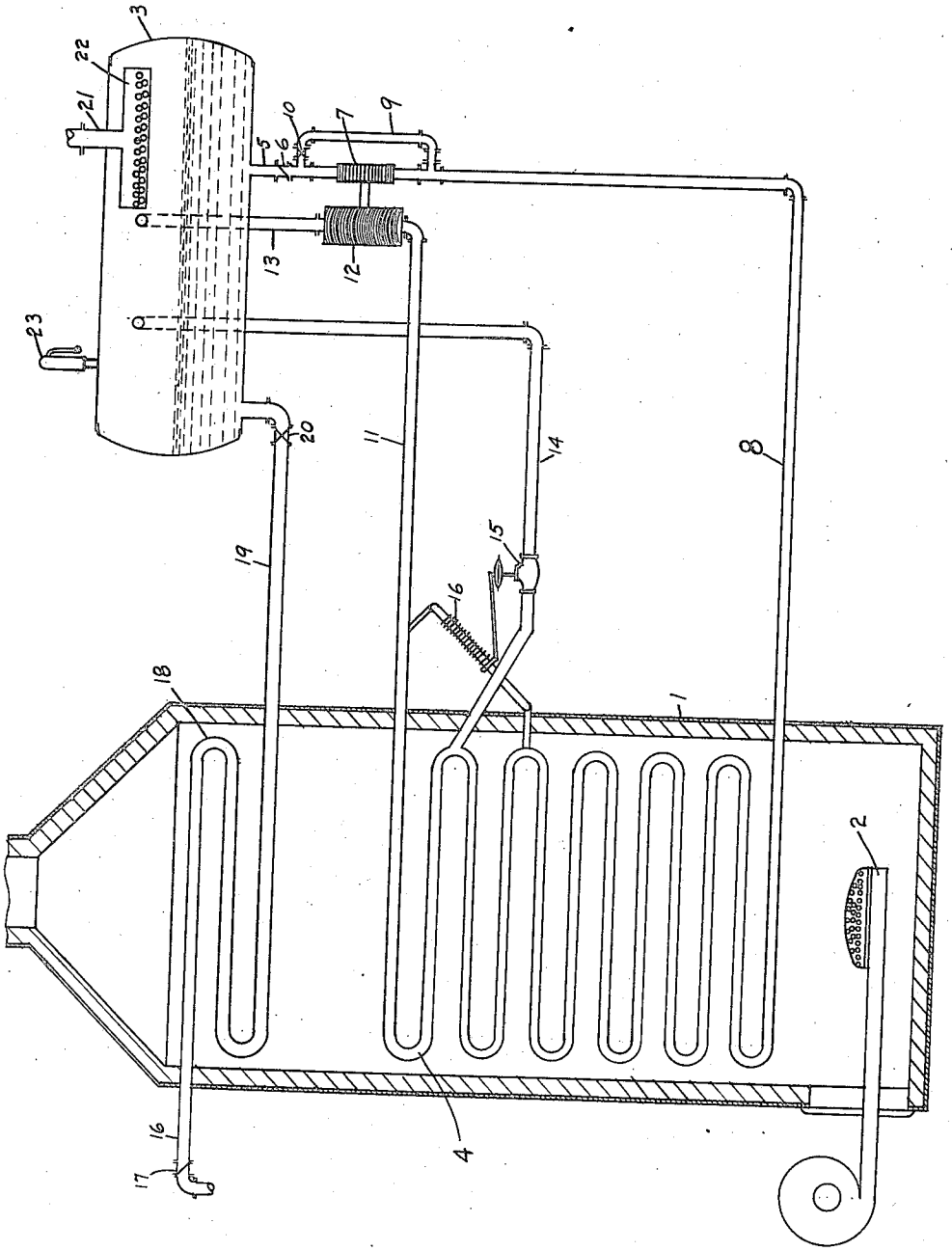
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STEAM GENERATOR

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STEAM GENERATOR.

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This invention relates to steam and other vapor generators and more particularly to tubular steam and vapor generators.

In order to provide rapid transfer of heat into a liquid to be evaporated, such as water, in a steam generator, it is desirable to provide a relatively large surface of metal exposed to the heating gases in comparison to the volume of liquid in the heating zone. This can be most effectively carried out by means of tubular generators using relatively small tubes and particularly coils of tubes. Small tubes also have the advantage that they can be used for very high pressures which are becoming of increasing importance in steam generators owing to the large economies which can be obtained by their use. Generators provided with small tubes, and particularly provided with tube coils, have hitherto been open to a number of disadvantages as the circulation in a number of small tubes is usually inadequate, particularly when the latter are coiled. This has necessitated the use of mechanical circulation or the principles of a flash boiler, that is to say a boiler in which the liquid is introduced into the heating zone in amount less than that which can be evaporated by passing through the zone. Tubular flash boilers present the very serious disadvantage that it is necessary to use practically pure water as otherwise the deposition of solids will rapidly collect on the heating elements and will reduce the heat transfer to a dangerously low point.

In the past small tubular generators have also been constructed with mechanical circulation of water, as for example motor or steam driven pumps. This type of generator presents many advantages but necessitates an external source of power which usually will not vary in exact proportion to the circulation. There is apt, therefore, to be over or under circulation with a greatly varying steam demand. A simple and elegant solution of this problem is provided in British Patent No. 232,074 of James M. Selden. In the generator shown in this patent a water steam drum is located outside the heating zone and a plurality of tubular coils disposed within the heat zone. Steam and water from each coil flows through a motor and this latter drives water pumps for each individual coil, taking their water from the drum. Thus the amount of water furnished to the heating coils varies exactly proportionately with the amount of steam and water leaving the coils so that a constant circulation is automatically obtained without the necessity for regulating pumps driven from outside power sources.

The present invention is directed to an improvement in boilers of the type shown in the British patent and obviates the only disadvantage to which these boilers are open. In the boilers of the British patent all of the steam and water flows through the driving motor and it is possible at very low steaming rates for the whole of the water entering the heating coils to become evaporated into steam with subsequent scaling difficulties and in some cases with danger of burning out tubes. At higher steaming rates this disadvantage is less noticeable as there the evolution of steam is sufficiently violent with the small tubes contemplated in the British patent to recirculate both steam and water through the motor by the gulping action of the rapidly generated steam bubbles in the small tubes, the action being somewhat similar to that of a geyser. The present invention has for its purpose the maintenance of a continuous circulation of water as well as steam at all steaming rates and one which automatically adjusts itself to various generating conditions, both on firing and on steam demands. According to the present invention a connection to the steam coils below the normal level of water therein passes direct to the steam drum by-passing the motor, thus providing a continuous circulation of water irrespective of the amount of steam evolved and passing through the motor. While in its broader aspects the invention includes any provision for maintaining a continuous water circulation, in the preferred embodiment of the present invention the amount of this circulation is automatically controlled by the level of water in the heating coils. It will be clear, of course, that the water circulation is effected due to the difference in pressure between the heating zone and the generator drum, which pressure is substantially equal to the drop in pressure through the steam and water motor.

The invention will be described in greater detail in connection with the drawing, which shows in purely diagrammatical form a steam generator embodying the principles of the present invention. For simplicity's sake,

most of the structural features and accessories of a generator installation are omitted and only a single heating coil is shown. In large installations there may be, and usually will be, many coils.

In the drawing, a generator chamber is shown at 1, heated by an oil burner 2. A steam and water drum 3 is situated outside and above the main heating zone of the generator and a heating coil 4 is mounted in the heating chamber of the generator. The steam drum 3 is connected to a pump 7 through the pipe 5, provided with a check valve 6, thence through the pipe 8, to the bottom of the heating coil. The pump is by-passed by a pipe 9, provided with a valve 10, which may be manually operated. From the top of the coil the pipe 11 leads to a motor or engine 12 capable of being actuated both by liquids and gases, shown in diagrammatic form as a gear motor. The exhaust of the motor passes through the pipe 13 into the steam space of the drum 3. From the upper portion of the coil 4, a by-pass pipe 14, provided with a pressure operated valve 15, also leads to the steam space of the drum 3. The valve 15 is actuated by a water level control 16 set for a water level slightly above where the pipe 14 joins the coil. In the drawing an S. C. regulator is shown but any other suitable type may be used.

Feed water is introduced from the feed pump, (not shown) through a pipe 16 provided with a check valve 17 into the economizer 18 located in the upper portion of the heating chamber 1, and thence through a pipe 19, controlled by a valve 20, into the water space of the drum 3. Steam from the drum 3 is taken off through the pipe 21 which is provided with a suitable perforated steam entrance chamber 22 in order to insure dry steam. A safety valve 23 of any suitable design is also provided.

In operation the drum 3 is filled to the desired level with water, the level being controllable either manually or automatically in accordance with ordinary steam generator practice. The valve 10 is then opened and water flows through the by-pass pipe 9 into the generating pipes 4, flooding the latter. The valve 10 is then closed or if desired left with a small opening to assure a supply of water in case of pump failure and the burner 2 is lighted. The coil 4 rapidly absorbs heat and the water contained in it expands and turns into steam. The pressure in the tubes 4 will, of course, become greater than that in the generator 3 and water or a mixture of steam and water will begin to flow through the pipes 14 to 11 and will start the motor 12. As soon as steam evolution sets in a water level will be established in the tubes 4 by the control 16, which tends to close the valve 15 when the level drops and open it when the level rises. In normal operation the lower portion of the coil 4 will remain full of water and in the upper portion steam and water will be discharged through the pipe 11, operating the motor 12, which in turn pumps fresh amounts of water through the pipe 8 by means of pump 7. A continuous small portion of water or steam and water will flow through the pipe 14 so that at all steaming rates there is continuous circulation through the coil, preventing the formation of scale. The amount of water pumped by pump 7 will be automatically varied with the amount of steam generated and the advantages of the generator of the Selden British patent will be obtained. At the same time, there will be a continuous by-pass flow of water through the pipe 14 which will vary with the movement of the water level in the coil 4 and which will automatically compensate for variation in steam demand, for if the water level rises the level control 16 will open the valve 15 wider and a larger amount of water will flow through the pipe 14 thus decreasing the amount of water and steam flowing through the motor 12 and correspondingly the amount of water delivered to the coil by the pump 7. As the water level falls due to the increased out-flow and decreased inflow the level control 16 will gradually close the valve 16, decreasing the amount of water flowing through the pipe 14 and correspondingly increasing the amount of steam and water flowing through the motor 12. A more or less constant flow will therefore be maintained in the coils preventing the portion of the coils exposed to the most intense heat from filling with steam with consequent danger of burning out. The continuous increased flow of water through the coil prevents scaling and enhances the efficiency of heat transfer as the rapid circulation through the small coils tends to prevent the formation or maintenance of steam pockets.

It will be seen that the present invention retains all of the advantages of the automatic water supply shown in the Selden British patent and in addition obviates the difficulties encountered in the latter generator at certain steaming rates.

In the drawing it will be noticed that the water is introduced into the portion of the coil located in the hottest zone. I prefer to use this arrangement for large installations and particularly where a very intense fire, such as oil or powdered coal is used or where the generator is to be used at very high ratings. A certain amount of heat transfer efficiency is lost due to the fact that the hottest gases encounter the coldest water but the practical advantages in large installations more than counter balance this loss in efficiency as the heat transfer of tubular coils is so great as to render counter flow unnecessary. In some cases, however, it may be de-

sirable to provide for counter flow as is shown in the Selden British patent where the coils run downwardly in the heating chamber and are provided at their ends with uptake pipes, each heating coil and its pipes forming two legs of a U. Such a construction may, of course, be used in connection with the present invention wherever the advantages in heat transfer obtained by counter flow, render it desirable.

The drawing is purely diagrammatic in nature and all suitable accessories and structural design such as the construction of superheaters and the like will be suitably chosen by the skilled engineer.

What is claimed as new is:

1. In a vapor generator, the method of causing positive circulation within the generator consisting in creating a difference in pressure between portions of the generator causing such differential pressure to operate mechanical liquid forcing means for supplying liquid from the portion of lower pressure to the portion of higher pressure by a flow of fluid from the portion of higher pressure to the portion of lower pressure and by-passing fluid from a portion of the high pressure zone normally containing liquid to a low pressure zone without passing through the pressure operated mechanical liquid forcing means.

2. A method of maintaining circulation between portions of a closed vapor generator, which consists in generating vapor in one portion of the generator at higher pressure than in the other portion, causing the differential pressure between the two portions to operate mechanical liquid forcing means to supply liquid from the low pressure portion by a flow of fluid from the portion of higher pressure to the portion of lower pressure to the high pressure portion and by-passing a part of the fluid from the high pressure portion to the low pressure portion without passing through the pressure actuated mechanical liquid forcing means.

3. A method according to claim 2, in which the amount of fluid by-pass is automatically varied in accordance with the relative proportion of liquid and vapor in the high pressure zone, the regulation causing by-passing to increase with increasing liquid proportion in the high pressure zone and to decrease with decreasing liquid proportions.

4. A method according to claim 2 in which the by-passing is taken from a portion of the high pressure zone normally containing a relatively large proportion of liquid to vapor.

5. In a vapor generator, an element of large capacity relative to its exterior surface, a vapor off-take therefrom an element of small capacity relative to its exterior surface, means for heating the exterior surface of said element of small capacity, mechanically actuated liquid circulating means interposed between the element of large capacity and the element of small capacity, a connection leading from a portion of the element of small capacity normally containing a relatively large proportion of vapor to liquid to the element of large capacity, a pressure or expansion operated engine in said connection, a by-pass connection from another portion of the element of small capacity to the element of large capacity.

6. A vapor generator according to claim 5, in which the element of large capacity is not subjected to intense heating.

7. A vapor generator according to claim 5, in which the by-pass connection is from a portion of the element of small capacity normally containing a greater proportion of liquid to vapor than that obtaining in the portion of the element of small capacity from which the connection runs to the engine.

8. A vapor generator according to claim 5, in which the by-pass connection is from a portion of the element of small capacity normally containing a greater proportion of liquid to vapor than that obtaining in the portion of the element of small capacity from which the connection runs to the engine, said by-pass element also being provided with a valve, and actuating means which provides a valve opening increasing with decreasing proportion of vapor to liquid in the portion of the element of small capacity from which the by-pass connection leads.

9. In a vapor generator in combination a pressure chamber, at least one tubular heat coil connected at both ends with the pressure chamber, means for heating the coil to generate therein a pressure higher than that in the pressure chamber, liquid forcing means arranged in the connection between one end of the coil and the pressure chamber having its inlet connecting with the pressure chamber and its outlet connecting with the coil, a pressure operated engine arranged in the connection between the other end of the coil and the pressure chamber, adapted to actuate the liquid forcing means, and a by-pass connection from a point between the coil inlet and coil outlet to the pressure chamber.

10. A pressure generator in accordance with claim 9 in which the by-pass connects with the heating coil in a zone thereof normally containing a lower percentage of vapor to liquid than the coil outlet zone.

11. A pressure generator in accordance with claim 9 in which the by-pass connects with the heating coils in a zone thereof normally containing a lower percentage of vapor to liquid than the coil outlet zone, and a pressure actuated valve in said by-pass operated so as to provide a larger valve opening with increasing percentage of liquid to vapor in the portion of the heating coil from which the by-pass leads.

12. A generator according to claim 5 in

which means are provided to prevent reverse circulation.

13. A vapor generator according to claim 9 in which means are provided to prevent reverse circulation.

14. A vapor generator comprising in combination a vapor drum, a liquid and vapor level therein, at least one relatively small tubular element, means for heating said element, a connection between the liquid zone of the drum and one end of the tubular heating element, a liquid force pump in said connection adapted to cause liquid to flow from the drum of the heating element, a connection from the other end of the heating coil to the vapor space of the drum, an engine adapted to be actuated either by vapor or liquid in said connection connected to the liquid pump and arranged so that flow of fluid therethrough from the heating element to the drum actuates the pump to force liquid from the drum to the heating element, and a by-pass connection from the portion of the heating portion intermediate its ends to the vapor space of the drum.

15. A vapor generator according to claim 14, in which a check valve is provided in the connection between the liquid space of the drum and heating element and adapted to check flow from the heating element to the drum.

16. A vapor generator according to claim 14, in which a valve controlled by-pass is provided around the liquid forcing pump.

17. A vapor generator according to claim 14, in which the by-pass is provided with a valve and valve actuating means adapted to increase the valve opening with increasing percentage of liquid to vapor in the heating element.

Signed at Pittsburgh, Pennsylvania, this 20th day of December, 1927.

ROBERT AMES NORTON.