

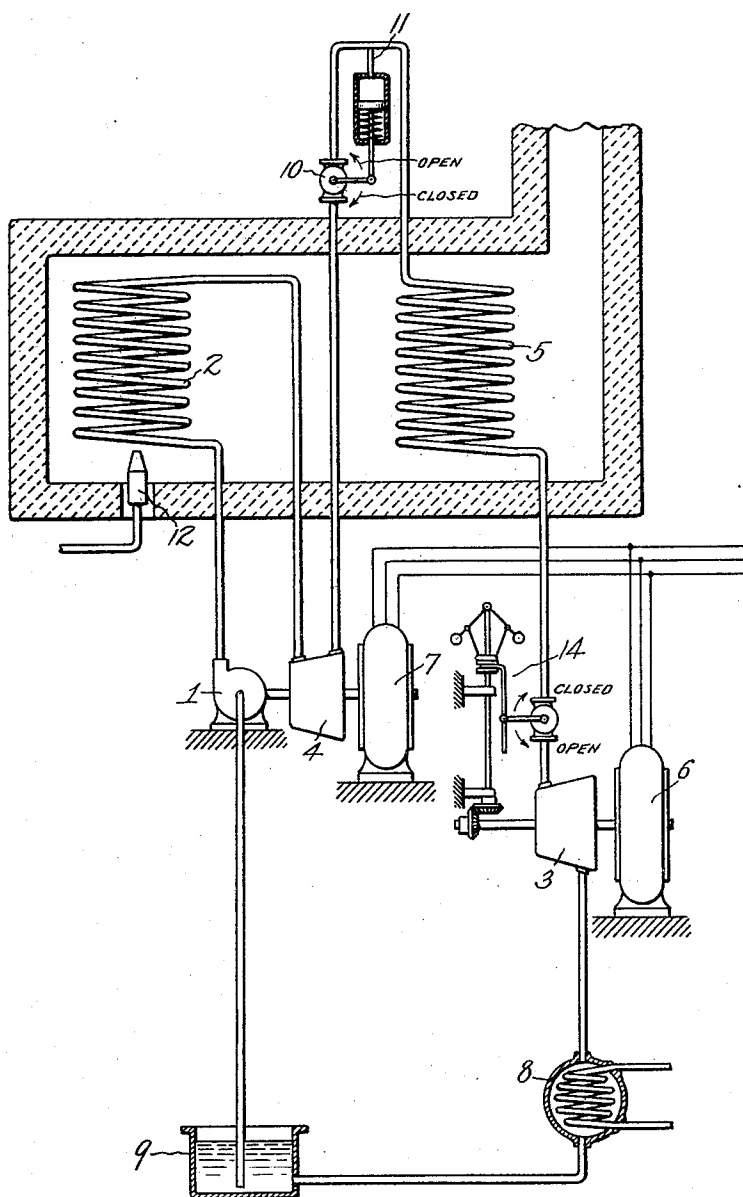
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METHOD OF GENERATING WORKING STEAM

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METHOD OF GENERATING WORKING STEAM

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Our invention relates to a system for the production and use of high pressure steam, especially steam which is produced in the neighborhood of the critical point.

5 It is possible to produce steam without the occurrence of the so-called ebullition phenomenon, by forcing the working medium through a heated pipe system positively by means of a pump, operating at a pressure
10 which is substantially equal to the critical pressure, and heating the working medium at least to the critical temperature. In this process vapor and fluid of equal pressure and equal temperature, but of different physical
15 properties, cannot simultaneously exist together, but the entire mass of liquid which has reached the critical temperature at the critical pressure is converted directly into steam. That is to say, the production of
20 steam occurs without the absorption of latent heat.

Since the pressure of the steam produced in this way is very high, the design of steam engines capable of operating over the entire
25 pressure range from the high pressure to the condenser pressure, involves great difficulties. It has therefore been proposed to throttle the steam thus produced down to the working pressure, and for this purpose
30 the use of a pressure reduction valve has been suggested. Since, however, the throttling in a pressure reduction valve occurs without the equivalent of a mechanical load, it is preferable to use for this purpose a special auxiliary machine in which the drop in pressure
35 can be made useful.

In plants of this nature it is necessary to impart to the water to be evaporated, from the very beginning, that pressure which it
40 should have in the heater when being converted into steam, a pressure which is thus higher than the critical pressure. The feed pump, necessary for this purpose or other similar devices, must adapt themselves very
45 accurately to the prevailing steam consumption since the steam generator pipes have no storage capacity which can serve for equalizing the fluctuations in steam consumption. Above all provisions must be made that at
50 a sudden extra consumption of steam the

pressure cannot drop appreciably below the critical pressure. On the other hand it must be prevented that when the consumption of the steam falls suddenly excessively high pressures (or other operating difficulties)
55 develop. By utilizing the pressure difference existing between the high pressure and working pressure side of the system, for driving the feed pump, it is possible to adapt the output of the feed pump automatically
60 and within a wide range to the prevailing steam consumption in such a manner that the necessary pressure is always maintained in the first stage of the steam generator.

When the output and the steam consumption of the main steam consumer—which may in the present case be a steam turbine with its conventional governing equipment—rises, the circulation of the working medium is accelerated and thereby also raises the output
65 of the feed pump which is operated by the auxiliary steam engine. A condition may occur where the output of the auxiliary steam engine, such as a turbine, does not perfectly adapt itself to the pump output to be covered.
70 In such a case our invention provides an efficient remedy.

According to our invention an electric machine is provided for the equalization or balancing of the outputs between the auxiliary
80 steam engine and the pump, which machine drives the feed pump in parallel with the auxiliary engine at a suitable ratio, for instance directly as shown. This electric machine is connected with the same network as the main generator. Its speed is so proportioned that at normal operation it runs idle and thus neither consumes nor supplies power.
85 Since the feed pump is required to supply more liquid working medium to the steam generator at increased load, in order to immediately replenish the increased amount of steam drawn from the generator, the auxiliary throttling machine as a consequence
90 must carry a heavier load put on it through the increased pump load. This would tend to reduce the speed of the auxiliary machine and thus also the speed of the dynamo electric machine coupled with it to tend to decrease so that the latter now commences to
100

operate as a motor, drawing from the electric power system the additional amount of energy necessary to maintain the speed of the auxiliary throttling machine. If on the other hand owing to a decrease in load of the main prime mover a small amount of steam is drawn from the steam generator, correspondingly less liquid operating medium need be supplied by the pump. As a consequence, the load on the auxiliary throttling machine is decreased which would tend to increase its speed. In that case the dynamo electric machine, whose speed the auxiliary machine would tend to increase thereby now supplies, in running as an electric generator, energy into electric system and thereby put a load upon the auxiliary machine sufficient to prevent the speed to unduly increase. This mode of operating the feed pump can be readily carried out if, as is shown in the drawing and as will be later described, a centrifugal pump is used as a feed pump. This type of pump has the well known characteristic, when operating at substantially constant speed, of decreasing the delivery pressure with increasing output. Therefore, within a reasonable range of maximum and minimum output, and the assumption that a pump size and speed is selected at which at the maximum output the required critical steam generator pressure is still maintained, such a pump may be operated jointly by an auxiliary throttling machine and a coupled dynamo-electric machine as aforementioned and deliver at the same speed the varying quantities of feed water required at the varying steam generator loads.

The single figure of the drawing represents a diagrammatic illustration of our improved system.

Referring to this figure it will be seen that a pump 1, characterized as a centrifugal pump by its symbolic representation in the drawing, forces the working medium through a system of pipes 2 which is heated by a burner 12. Centrifugal pumps, as is well known have, when run at a constant speed, a characteristic curve, with respect to output plotted against pressure, according to which the pressure rises with falling output. Such a pump is, therefore, well adapted to serve in a system such as the present one, as an operating liquid supply means. The pressure within the system of pipes corresponds approximately with the critical pressure (225 atm.), while the temperature is equal to or higher than the critical temperature (374° C.). Steam generating systems of this type, however, do not operate with an absolutely constant generator pressure; the latter may frequently be appreciably higher, only it should not be at any time below the critical pressure. Therefore, if such a centrifugal pump operating at a given constant speed, is able at critical pressure to furnish

the feed water, required at maximum load, it will automatically furnish less feed water, when less steam is required and the steam pressure should rise above the critical value. The main machine is the turbine 3, which in the customary manner is controlled by a speed governor 14. As it is not desired to work with the high pressures prevailing in the pipe system 2, the pressure of the working medium is reduced to the working pressure by a power engine, in this case a turbine 4 while the temperature of the working medium is kept so high in a superheater pipe system 5—which may for instance also be heated by burner 12—that an unsteady separation of steam and water does not occur. This heating may also occur at a later stage of the circulation of the working medium and has no bearing on the present invention. The turbine 3 is coupled with a main electric generator 6 while the turbine 4 is coupled with a dynamo electric machine 7 which serves as a balancing machine for differences in the output of the pump 1. In other words, when at low steam generator load the power of the throttling turbine is insufficient for the pump power required, electric machine 7 will draw current from the power line and furnish as a motor the balance of the required pump power. When the generator load is normal, and the throttling turbine delivers more power than the pump requires, machine 7 is driven as a generator and delivers the surplus energy of turbine 4 into the electric power line. The exhaust of the turbine 3 is condensed in a condenser 8 and conducted into a collecting tank 9 from which the pump 1 draws its supply.

Since the turbine 4 should operate merely as a throttling element interposed between the high pressure and working pressure side of the system, it is necessary that the same pressure is maintained behind the turbine 4, for instance 100 atm. Steam consumption fluctuations of the turbine 3 would, however, also cause fluctuations in the steam consumption of the turbine 4 which in their turn would bring about a change of pressure behind this series machine, i. e. the value of the throttling pressure varies in such arrangements. A further object of our invention is to eliminate such fluctuations in pressure. For this purpose a regulating valve 10 and a pressure responsive device 11 actuating this valve is inserted according to our invention behind the series turbine 4. When the device 11 responds to the pressure fluctuations due to the varying steam consumption of the turbine 3, it acts upon valve 10 and thereby keeps constant the pressure in the exhaust pipe leading from the series machine 4 to the main machine 3, by opening the valve wider at decreasing pressure and by closing it further at increasing pressure. If the steam consumption in the main engine 3 rises, and

the valve 10 opens, further, a larger volume of steam passes through the turbine 4 and the drop of pressure is thereby compensated, while when the consumption of steam drops and the flow through the valve 10 is reduced, the pressure behind the turbine 4 is reduced thereby to the required value, i. e. the turbine 4 operates with variable back pressure and consequently with fluctuating output, the fluctuations in output being balanced by the dynamo electric machine.

Various modifications and changes may be made without departing from the spirit and scope of our invention and we desire, therefore, that only such limitations be placed upon it as are justified by the state of the prior art.

We claim as our invention:—

1. In a speed flow vapor power plant in combination a tube system constituting the vapor generator, a centrifugal pump for forcing a liquid working medium in a continuous stream through said system, means for heating the liquid in a portion of said system to generate vapor at high pressure, a main prime mover operating at a vapor pressure lower than the generating pressure, and means for reducing the pressure of the generated vapor to the pressure required for the main prime mover, said reducing means comprising an auxiliary prime mover operated by said vapor and connected in the supply line to said main prime mover and acting as a vapor throttling element, said auxiliary prime mover operating said pump, and an electric equalizing machine connected to an electric power line and connected in fixed relation to said auxiliary prime mover and said pump, and operating as a motor when the delivered auxiliary prime mover power is below the required pump power, and operating as a generator when the delivered prime mover power is above the required pump power, whereby said auxiliary prime mover acts as a vapor throttling element, and the pump output varies substantially with the amount of vapor produced by said generator.

2. In a speed flow vapor power plant in combination a tube system constituting the vapor generator, a centrifugal pump for forcing a liquid working medium in a continuous stream through said system, means for heating the liquid in a portion of said system to generate vapor at high pressure, a main prime mover operating at a vapor pressure lower than the generating pressure, and means for reducing the pressure of the generated vapor to the pressure required for said main prime mover, said reducing means comprising an auxiliary prime mover, directly connected to the delivery side of said generator, and adapted to pass through it the entire amount of vapor produced in said generator, and acting as a vapor throttling element, said auxiliary prime mover operating

said pump, and an electric equalizing machine connected to an electric power line and connected in fixed relation to said auxiliary prime mover and said pump, and operating as a motor when the delivered auxiliary prime mover power is below the required pump power, and operating as a generator when the delivered prime mover power is above the required pump power, whereby the amount of liquid circulated by said pump is automatically proportioned substantially to the varying output conditions of the generator.

In testimony whereof we affix our signatures.

WILHELM ABENDROTH.
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