April 18, 1939. H. C. EGLOFF 2,155,039

STEAM GENERATOR APPARATUS

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Fig. 1.

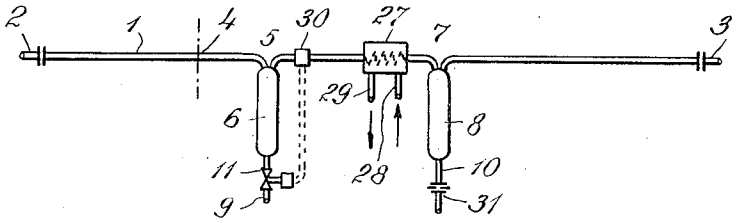


Fig. 2.

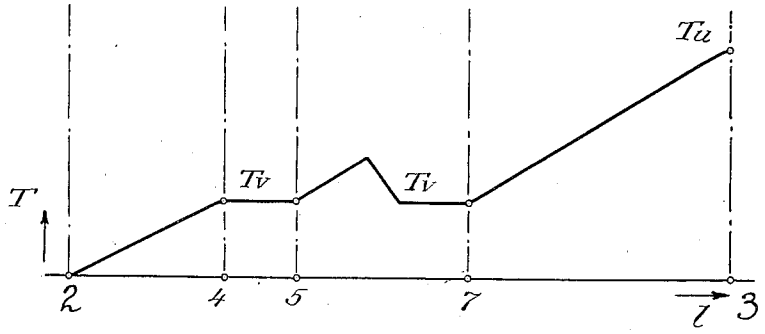


Fig. 4.

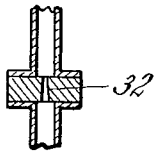
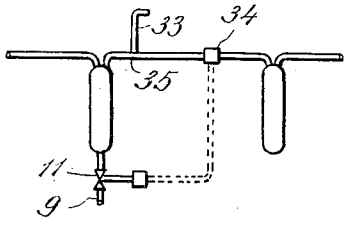


Fig. 5.



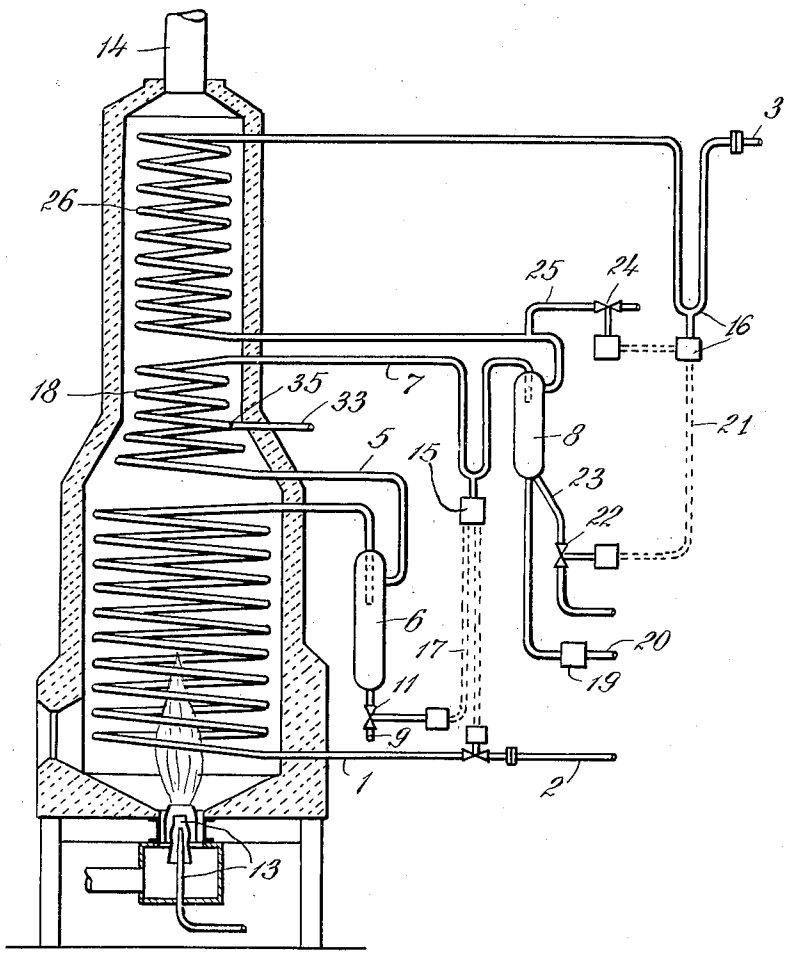
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Fig. 3.



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STEAM GENERATOR APPARATUS

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Application September 22, 1936, Serial No. 101,910
In Switzerland October 12, 1935

2 Claims. (Cl. 122—459)

This invention relates to apparatus for the separation of impurities from a fluid in tubular, continuous-flow steam generators comprising at least two series-connected separators and has for its object the provision of an improved apparatus of this character. More particularly, the invention aims to provide an improved combination of steam generator apparatus comprising a cooling device connected between two separators.

It has been proposed heretofore to provide the tubular system of continuous-flow steam generators with a separating device for removing feedwater impurities from the steam. Separators have been connected in the system where impurities such as salts were still in solution or where the steam was slightly superheated. There are disadvantages inherent in such apparatus due to incomplete separation of enriched salt solution from the steam, or to the accumulation of salt incrustations in the tubing. It has also been proposed to employ a plurality of separators in the tube assembly of a single tube steam generator, but in such apparatus, solid entrained particles can only be removed with great difficulty and incrustations on the tube walls, between the separators, cannot be dissolved, in certain instances, due to the separation of water from the steam in the first separator.

It is an object of this invention to substantially overcome the aforementioned disadvantages and to provide apparatus from which crusts clinging to the tube walls, between the separators, may be removed, and in which impurities entrained in the steam can be separated at a suitable point in the system by means of condensate.

The invention will be better understood if reference is made to the accompanying drawings, taken in conjunction with the following description, in which

Fig. 1 is a diagrammatic illustration (with the tubing straightened out) of a single-tube steam generator in accordance with the invention;

Fig. 2 shows the temperature conditions prevailing in the tubing shown in Fig. 1;

Fig. 3 illustrates another adaptation of apparatus in accordance with the invention, and

Figs. 4 and 5 show details of structure in accordance with the invention.

Into one end of the tubing 1 (Fig. 1) liquid is fed through supply conduit 2 and superheated steam is taken off at the other end and carried by the delivery conduit 3 to the place of consumption. At point 4 in the tube system the liquid begins to evaporate. At point 5 the first separator 6 is connected to the tubing 1 and just beyond, the second separator 8 is connected at point 7. A sludge draw-off is connected to the conduit 9, and to the second separator a sludge draw-off conduit 10 is connected to the separator. The amounts of the sludge thus drawn off can be regulated by means of valves 11 and 31, respectively.

Arranged between the two separators 6 and 8 is a device 27 by means of which the steam flowing from point 5 to point 7 is cooled. The cooling device can, for example, constitute the heating surface of an intermediate superheater, or reheater into which steam to be superheated (for example steam at a lower pressure) is fed through conduit 28. The steam flows from the superheater to the place of consumption through conduit 29. The wet low-pressure steam is thus superheated and the superheated high-pressure steam is saturated.

Inserted on one side of the intermediate superheater is the temperature-responsive device 30 which acts upon the element 11 in the sludge line 9 in such a way that the steam issuing from the separator 6 has its condition maintained about constant. For practical purposes it is advisable to draw off sludge-carrying liquid continuously from the separator 8. For this purpose the valved element 31 in the sludge draw-off line 10 is given the form of a nozzle (32, Fig. 4). The cross-sectional area of the nozzle which controls the amount of liquid passing therethrough is such that the amount of liquid separated in the separator 8 is provided an opportunity to flow therethrough. If for once a smaller amount of sludge should form, in that case steam would blow off together with liquid. But since the weight of the steam that can flow through a nozzle amounts to only one tenth of that of the water flowing therethrough, the loss thus occasioned becomes immaterial.

Fig. 2 shows the temperatures of the fluid medium in the pipe system of Fig. 1. The various points indicated by numerals 2, 4, 5, 7 and 3, correspond to points indicated on the pipe shown in Fig. 1. As shown on the graph, the temperature T of the fluid medium increases from the admission end of the tubing 2 up to the point 4 where it reaches the vaporization temperature T_V. Because of the pressure drop due to friction in the tubular system the vaporization temperature T_V is apt to drop slightly up to point 5. Ahead of the separator 8, the temperature begins to rise in the superheating zone and drops again to the

vaporization temperature T_v due to cooling effects and then rises ahead of point 7 finally to the utilization temperature T_u at point 3.

One consequence of cooling the steam between the separators is that its condition reverts again to the saturation range. During this retrogradation, part of the steam condenses. The fine solid particles suspended in the steam then act as condensation nuclei and are made heavier by the condensate. The particles having thus been made heavier can then be precipitated in the second separator 8 and abstracted from the steam generator together with entrainment liquid.

In the steam generator shown in Fig. 3 the tubular system is heated by means of a firing installation 13. The liquid fed into the tubular system enters it through conduit 2, and the steam is led through conduit 3 to the places of utilization. A first separator 6 is arranged at that point of the tubular system where about 10% of the total amount of the working medium is still liquid. A second separator 8 is mounted in such a manner as to be located in the rear of the place where the impurities precipitating from the liquid residue of the first separator remain adhering to the tube walls.

Inserted between the first separator 6 and the second separator 8 is a temperature-responsive apparatus 15, and on this side of the exit end of the tubing another temperature-responsive apparatus 16. The temperature-actuated device 15 acts by means of conduit 17 upon the control element 11 in the sludge draw-off pipe 9 in such a way that the steam arriving in the separator 8 has already absorbed one third of the superheating heat. A residue amounting to about 3% of the liquid (figured on the total amount of the working medium) then still remains behind in the steam passing into part 18 of the generator tubing. The feed impurities that remain adhering in part 18 of the tubular system can, by increasing from time to time the amount of feed water, be impelled forwardly into the separator in which they are separated from the steam and carried off through the condenser trap 19. The amount of liquid to be fed into the system can be increased by lessening at predetermined intervals the amount of sludge to be taken out of the separator 6 or interrupting the sludging-off altogether.

The temperature-responsive apparatus 16 actuates via conduit 21 an element 22 in the conduit 23. The element 22 is opened whenever the temperature-actuated apparatus 16 indicates too low a temperature, in order thus to prevent liquid from being entrained to the places of consumption. An element 24 in the conduit 25 acts upon the means provided for feeding additional liquid working medium for the purpose of regulating the temperature of the steam. The additional liquid must be purified to such an extent that in part 26 of the tubing connected with the separator 8 deposits of impurities no longer form.

At point 35 additional ("make-up") liquid is admitted through conduit 33, which cools the already superheated steam back again to the vaporization temperature. During this cooling stage the condensing steam attaches itself to the solid impurities acting in the manner of condensation nuclei, so as to increase the weight of said impurities and to permit of separating them from the steam in the next separator 8.

In the apparatus illustrated in Fig. 5, the sludging-off element 11 in the conduit is acted upon by a thermostat 34 arranged ahead of the point of admission 35 of the cooling liquid fed in through conduit 33. The condition of the steam at the point of installation of the temperature-responsive apparatus 34 is thus maintained substantially constant.

I claim:

1. Apparatus for the separation of feed-water impurities from steam in tubular, continuous-flow steam generators which comprises a tube into which feed-water is passed at one place and superheated steam removed at another place, a separator connected to the tube at a point where steam and water flows through the tube, said separator being provided with sludge draw-off conduit whereby sludge may be removed from the separator, a valve in said conduit controlling the discharge of sludge-carrying fluid through said conduit, a second separator connected to the tube beyond the first mentioned separator in the direction of steam flow, means for heating the steam in the tube after it has passed through the second separator, a reheater for low pressure steam connected to the tube between the separators, said reheater and tube being located and arranged to permit heating of the tube between the first mentioned separator and the reheater and to prevent appreciable heating of the tube between the reheater and the second separator whereby the steam may be heated after passing the first mentioned separator, cooled in the reheater and passed to the second separator without appreciable vaporization, and means for drawing off sludge-carrying fluid from said second separator.

2. A tubular continuous-flow steam generator which comprises a reheater connected to the tube at a point where the steam is superheated, said reheater being provided with means for passing low-pressure steam in heat exchange relation with the superheated steam, thereby cooling the steam and effecting a precipitation of condensate, and a separator connected to the tube at a point beyond the reheater in the direction of steam flow for removing condensate together with entrained or suspended impurities from the stem.

HANS CONRAD EGLOFF.