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APPARATUS AND METHOD FOR THE VAPORIZATION OF LIQUIDS IN STEAM-GENERATORS COMPRISING MORE THAN ONE VAPORIZATION SYSTEM

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Fig. 1

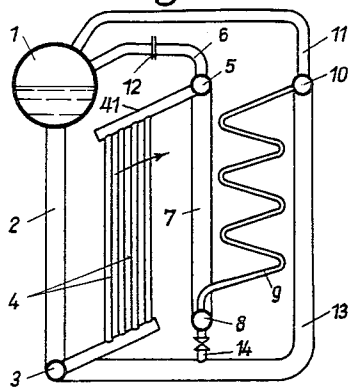


Fig. 2

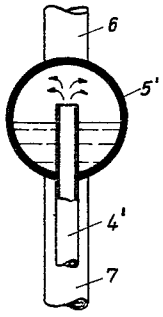


Fig. 3

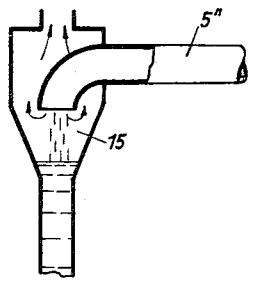


Fig. 5

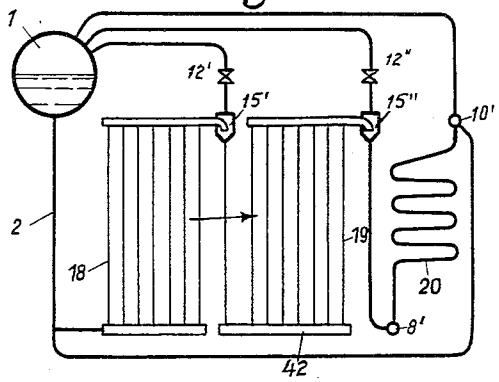


Fig. 4

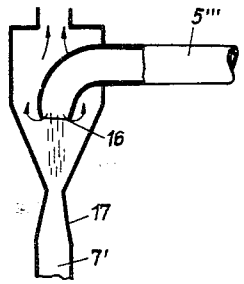


Fig. 6

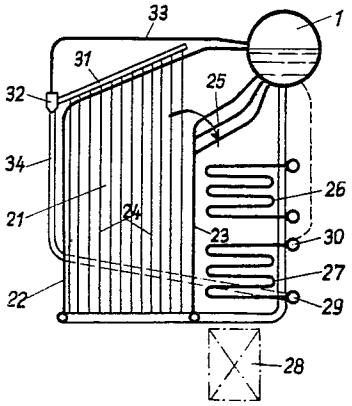
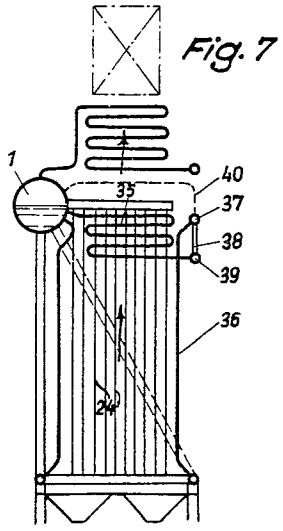


Fig. 7



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APPARATUS AND METHOD FOR THE VAPORIZATION OF LIQUIDS IN STEAM-GENERATORS COMPRISING MORE THAN ONE VAPORIZATION SYSTEM

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3 Claims. (Cl. 122—406)

This invention relates to the vaporization of liquids in steam-generators comprising a steam separator and more than one vaporization system, connected to the steam space of the separator. With steam-generators of this type difficulties are encountered in the construction and sizing of the vaporization heating surfaces due to the smallness of the circulation forces. In order to obtain satisfactory circulation, hitherto structures had to be used which rendered the steam generator assembly costly and spacious.

One object of the invention is the provision of an apparatus and a method which relieves said difficulties.

Another object of the invention is the provision of a device in which the steam-water mixture of one vaporization system is separated and the separated part containing mostly steam is throttled and the separated part containing mostly water is led to the distributor of another vaporization system operating at an input pressure higher than the input pressure of the first mentioned system.

Still a further object of the invention consists in utilizing the circulation forces of one vaporization system to insure the circulation in another vaporization system. This is, of course, only possible with a steam-generator having vaporization systems with circulation forces high enough to render a throttling of the circulation harmless. This is usually the case with radiation heating surfaces which consist of straight, intensely heated tubes and in which the weight of the circulating water is 50 to 60 and more times that of the generated steam. To cool the vaporization tubes sufficiently such a great quantity of water is not necessary and may, without any harm, be reduced to 10 to 20 times the weight of the steam. The circulation forces set free by the reduction of the weight of circulating water may be transformed into pressure.

Accordingly a further object of the invention consists in separating the steam-water mixture generated in one system, wholly or partly, at the end of the heating surface and conducting the separated steam to the separator, while throttling it on its way to the separator with the result that the pressure at the end of the heating surface rises and the quantity of recirculating water will be reduced. The admissible height of pressure is determined by the quantity of circulating liquid necessary for cooling.

Still a further object of the invention is to lead the separated liquid, being thus subject to an increased pressure, as circulating medium to further vaporization heating surfaces in which, owing to their position or construction, the lifting forces generated by heating are insufficient to overcome the resistance to flow. Thereby a greater freedom in designing those heating surfaces is obtained, since the consideration of the circulation, especially with slightly heated succeeding heating surfaces, is not as critical as in usual constructions.

Therefore a further object of the invention consists in employing repeatedly bent sepentine pipes or narrow tubes with the result that in a given space more or larger heating surfaces may be arranged. Therefore a steam-generator of this type may be designed, at least as regards the succeeding heating surfaces, similar to a steam-generator with forced circulation.

Still a further object of the invention consists in throttling the steam conducting pipes, e. g. by initially dimensioning the sectional area for the flow so that throttling occurs, or by providing throttling means reducing the cross-section of the pipes.

A further object of the invention consists in the provision of valves, preferably constant pressure valves, as the mentioned throttling means. Such valves are advantageous because they will maintain the pressure constant at the height predetermined by calculation whereas otherwise the pressure would vary according to fluctuations of the boiler pressure or of the output. If the back pressure is maintained constant the quantity of water circulating in the pipes changes upon fluctuations of the output or of the pressure.

Still a further object of the invention consists in sizing the area and the heat capacity of the succeeding heating surface in a steam-generator of the above type so that the separated water of the antecedent heating surface is sufficient for the cooling of the pipes. Since, as a rule, the succeeding heating surface is only slightly heated the excess water quantity may in some cases be reduced to 5 to 10 times the steam weight without endangering the pipes. In order to prevent steam bubbles from adhering to the inner walls of the pipes, the speed of water circulation must be higher where pipes conducting the water are less inclined than in more steeply inclined pipes.

In some cases, e. g. when the resistance to flow is relatively high in the succeeding heating surface or in steam-generators of low construction, it may happen that the circulating forces of an antecedent vaporization system are not sufficient to obtain the necessary pressure. In that event and according to a further object of the invention two or more vaporization systems of similar structure may be so connected in series that the water, separated from the first system, is led to the second or a further system of the kind described whereby the pressure of the water entering a system may be increased from system to system until a sufficient pressure is obtained at the entrance to the last system.

It is obvious that the quantity of the water decreases system to system corresponding to the evaporated portion and the portion taken along by the steam. If the excess quantity of water is sufficient, this may, without risk, be taken into account. But it is also possible to adapt the cross-section for the flow in each of the systems to the quantity of circulating water therein.

In order to make this invention more clearly understood several examples shall be described, reference being had to the accompanying drawing, in which

Fig. 1 is a diagrammatic view of a steam generator according to the invention,

Fig. 2 is a diagrammatic section of a modified connection of a collector with vaporization tubes,

Figs. 3 and 4 are diagrammatic sections of two other modified collectors, respectively, and

Figs. 5 to 7 are diagrammatic views of other steam generators, respectively, according to the invention.

Referring now to Fig. 1 down pipes 2, connected to a steam separator drum 1, lead to a distributor chest 3. From this distributor chest 3 a heated tubular system 4 leads to the collector chest 5 which is connected to the steam separator 1 by overflow-pipes 6. The collector chest 5 is further connected through pipes 7 to the lower distributor chest 8. Another heated tubing system 9 leads from the chest 8 to a collector chest 10. The chest 10 is connected through pipes 11 to the steam separator 1, and through a down pipe 13 with the distributor 3 and

thus with the water space of the drum 1. The resistance to flow in the pipes 6 is higher than in the pipes 11, for which purpose a throttling means 12 may be provided within the overflow pipes 6.

A valved conduit 14 closed during normal operation of the boiler may be provided so as to connect the distributor 8 to the lowermost portion of the down pipe 13. Conduit 14 serves to drain the system 9 if and when desired. The boiler water flows from the water space of the separator drum 1 through down pipes 2 to the chest 3 and from there into the heated tubular system 4 in which it flows upwardly. The steam-water mixture generated therein will flow through the intermediate collector 41 to the collector 5 where it will be partially separated. The separated steam throttled on its way by means of the device 12 will flow through pipes 6 into the steam space of the separator drum 1. Owing to the increased resistance, the pressure within collector chest 5 will be increased beyond the pressure in the separator drum 1, whereas in the rear of the throttling means 12, i. e. between the latter and the drum 1, the pressure will drop to that prevailing in the drum. The pressure prevailing in collector 5 is that with which the separated water enters pipe 7 on its way down to the distributor 8. In consequence, the pressure in distributor 8 is the sum of the water column in pipe 7 plus the pressure in collector 5. This total pressure aids the circulation in the succeeding tube system 9 with the result that the circulation force therein is higher by the pressure in collector 5 than it would have been without the throttling at 12. The steam-water mixture of system 9 may be led directly into the separator at substantially medium water level (not shown). Alternately the mixture may be subjected to a preceding separation of the steam in order to relieve the steam space of the separator 1. In the latter case the overflow conduit 11 may run into the steam space at a higher point and a higher lift-over may be provided. The separated water returns through steam chest 10, and pipes 13 as well as through pipes 2 into the circulation system. It will be understood that in the operation of the boiler the resistance to the flow of the steam from the antecedent system 4 to the drum 1 must be greater than the resistance to the flow of the steam from system 9 to the drum 1 as otherwise the water cannot be caused to enter system 9 at a pressure higher than that of the water entering the system 4. The manner in which the greater resistance is brought about is immaterial. The invention essentially aims to separate the steam-water mixture as completely as possible. If the circulation speed in said collector chest 5 is not too high, that is, if the cross-section is amply dimensioned, the action of gravity is sufficient for separation. A modified form of the collector design is shown in Fig. 2. In this modification the collector 5' is located horizontal and in the plane of the vaporization tubes, i. e. similar to the arrangement shown in Fig. 5. The vaporization tubes 4' project into collector 5' so far that the discharged steam-water mixture flows against the wall thereof which acts as a baffle. The water particles flow down the wall and collect in the lower part of the collector, the steam occupying the upper part. From collector 5' the overflow steam pipes 6 extend upwardly whereas the water return pipes 7 extend downwardly. It is advisable to connect the pipes 6 and 7 to the collector 5' at the unheated ends of the latter so that steam and water flow parallel to one another within collector 5 over a certain distance and that even the smaller water particles suspended in the steam may precipitate. From the view point of the invention it is important that the separated water is as free of steam as possible, while the moisture content of the separated steam is of subordinate significance.

Another mode of separating steam and water according to the invention is shown in Fig. 3 where the horizontal collecting chest or chamber 5'' is provided with a downwardly directed mouth piece which projects at one or both ends into an enlarged vessel 15. With such an arrangement a higher velocity of the mixture entering vessel 16 is insured, which is desirable since, both the action of gravity and the velocity of the stream itself are utilized for the purpose of separation. As shown in Fig. 3, the water is urged downwardly by the direction of the mouthpiece as well as by gravity whereas the steam is led to the separator in an opposite direction of flow.

The arrangement according to Fig. 4 differs from the afore mentioned one only in that the mouthpiece 16 of collector 5''' is designed like a jet or nozzle which simultaneously acts as a throttling means. Thereby the mixture is accelerated and its pressure reduced substantially to that within the separator. The separation is favoured by the increased velocity. However, since according to the invention only the separated steam but not the water shall be throttled it is necessary to regain the pressure of the separated water by a diffusor-like tubular piece 17 through which the water is fed, to a succeeding heating surface by way of a down pipe 7'.

In the diagrammatic view of Fig. 5 both the vaporization systems 18 and 19 are connected in series so as to anticede the vaporization heating surface 20 in the direction of the flow of the circulating water. The systems 18 and 19 consist of straight, vertical, intensely heated vaporization tubes the water sides of which are connected in series in that the collectors 15' of system 18 are connected to the distributors 42 of the system 19. Consequently their circulation forces are relatively high. By throttling the separated steam the circulating water quantity is reduced and back pressure is increased in each system. Since the separated water flows from system 18 to system 19 already with an increased pressure, a further increase of pressure will occur within the system 19. A high end pressure may be obtained by connecting in series a plurality of systems of this type. The possible number of sequentially connected systems will be limited by the necessary excess of water, decreasing from system to system by the vaporized part.

The circulating water then flows from system 19 into distributor 8' of the succeeding heating surface 20 provided with the collector 10'. As the pressure of the water entering the heating surface 20 is relatively high owing to the series connection of the water passages of the systems 18 and 19, the suceeding heating surface 20 may be regarded as a heating surface operated at forced circulation. The design and arrangement of the succeeding heating surface 20 depends on the pressure which may be obtained.

In Fig. 5 the succeeding heating surface 20 consists of several sepentine tubes connected in parallel in which the heated medium flows upwards only. Consequently, there exists also a lifting force acting in the same direction as the pressure of the circulating water and there exists also a buoyancy acting in the same direction. This buoyancy or lifting power causes a uniform distribution of the circulating water according to the heat absorption. Alternately it is possible, as known with boilers with forced circulation, to distribute the circulating water among the tubes forcibly by throttling. However, in that event the throttling pressure and the admissable resistance of the tubes will not be as high as usual in boilers with mechanically supplemented forced circulation.

Fig. 6 shows an example of a tubular system of a steam-generator with radiation heating surfaces as well as convective heating surfaces. The radiation heating surfaces are arranged at the walls of the furnace space 21 and consist of the front wall and ceiling tubes 22, the rear wall tubes 23 and the side wall tubes 24. Adjacent to the furnace space the convective heating surfaces are arranged in a downwardly directed flue. By subdividing the rear wall tubes 23 a tubular bundle 25 is formed leading directly to the steam separator 1. Succeeding it in the direction of the flowing flue-gases a superheater 26 and a vaporization heating surface 27 are arranged. As

indicated in dotted lines, a preheater 28 may be provided. The vaporization heating surface 27 consists of serpentine tubes connected in parallel and joined to a distributor 29 and a collector 30. Such a heating surface can be constructed simply and with little costs.

However, the natural circulation forces are not sufficient to overcome the resistance in those relatively long serpentines tubes 27, with the result that the heating surfaces would not be cooled sufficiently. To obtain a sufficient circulation according to the invention a further heating surface with higher circulating forces is to be connected antecedent said heating surface 27 when considering the flow of the water. In this example the side wall tubes 24 are chosen for that purpose. The steam-water mixture generated in said tubes flows into the collector 31 and from there into the separating vessel 32. From that vessel a part mostly consisting of steam flows through conduit 33 into the steam separator 1. The conduit 33 has to be dimensioned so that the overflowing steam passing through it will be throttled. A special throttling means may be provided for the same purpose. A part, mostly consisting of water flows through conduit 34, through the distributing device 29 and through the vaporization heating surface 27 to the separator 1. The resistance of the overflow conduit 33 is to be made so high that a quantity of water sufficient for cooling the heating surface 27 may flow through said heating surface to separator 1.

Fig. 7 shows a tubular system of a steam-generator of the single-draught-type. The combustion space has a substantially square cross-section and is relatively high. It is especially adapted for coal dust firing. The water conduit of the convective evaporator 35 is connected in series so as to succeed the radiation heating surface 36. The water separated in the collector 37 flows through conduit 38 to the distributor 39 of the convective heating surface 35, the steam flowing through the overflow pipes 40 to separator 1. Since in this case the convective heating surface 35 is exposed to high temperatures and additionally is irradiated, its resistance to the flow is relatively high. Consequently a high circulating force in tubes 36 is required. If that force alone is not sufficient, further radiation heating surfaces may be provided similar to those of the diagrammatic Fig. 5, e. g. the side wall tubes 24', may be connected in series with heating surface 35 so as to antecede the latter. It is an advantage of the construction shown that the convective evaporator may be arranged in a narrow space and that the total height of the structure can be relatively small.

Having now described the nature of the invention and in what manner it may be performed it is obvious to those skilled in the art that many variations may be made within the scope of this invention.

What I claim is:

1. A steam generator comprising a steam separator drum having a water space and a steam space, and at least two tubular evaporating units, each unit including a distributor and a collector, a first conduit connecting the collector of the first one of said units to said steam space of said drum, a second conduit connecting the collector of said second unit to said steam space, the resistance to the flow of the steam through said first conduit being higher than that of said second conduit, the distributor of said first unit being connected to said water space of said drum, and the distributor of said second unit being connected to the collector of said first unit.

2. A steam generator as claimed in claim 1, further comprising a throttling element in said first conduit.

3. A steam generator as claimed in claim 1, said second unit consisting of serpentine tubes.

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