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INDIRECT GENERATING OF SUPERHEATED STEAM

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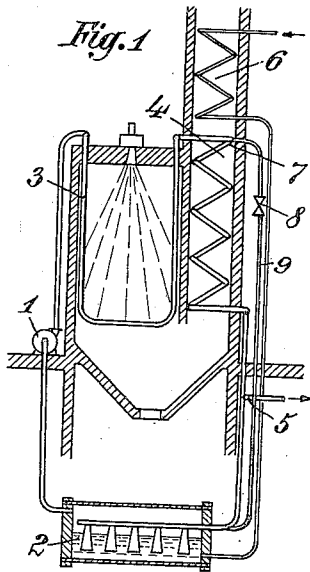


Fig. 2

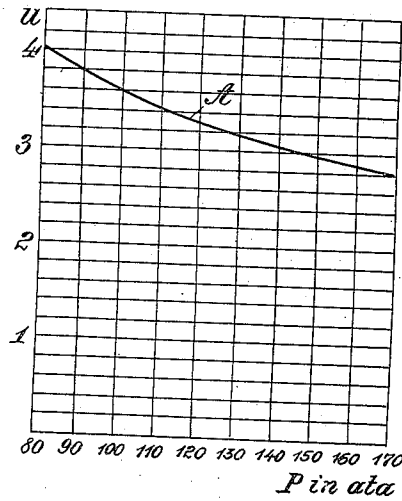


Fig. 4

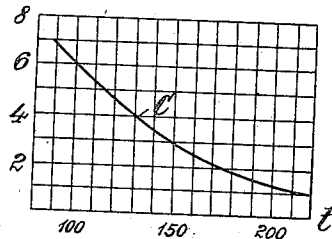


Fig. 5

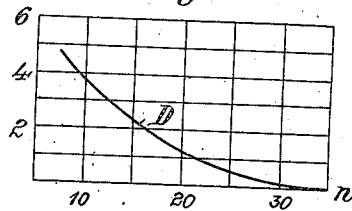
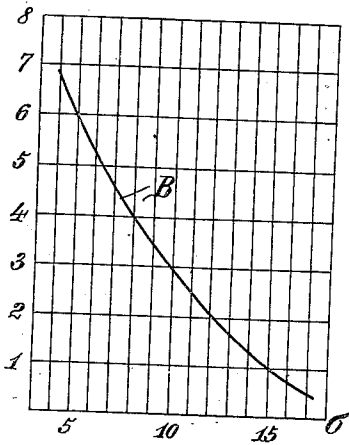


Fig. 3



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UNITED STATES PATENT OFFICE

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INDIRECT GENERATING OF SUPERHEATED STEAM

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3 Claims. (Cl. 122—31)

This invention relates to a process for the indirect generating of superheated steam in the high pressure steam boilers known as Löffler boilers, in which the steam is taken by means of a pump out of an unheated boiler drum, superheated in a radiation superheater and then in a convection superheater, and blown into the water space of the said boiler drum in positive circulation, the steam for utilization being taken from this circuit at a point beyond the steam circulating pump. Such a process and such a boiler are described for example in United States patents Löffler, Nos. 1,740,254, 1,812,966.

Such a boiler with certain modifications according to my invention is diagrammatically illustrated by way of example in Figure 1 of the accompanying drawing, in which the steam drum is denoted by 2, the radiation superheater by 3, the convection superheater by 4, the pump by 1, the preheater or economizer by 6, a by-pass connection from a point intermediate of the superheaters and beyond the outlet of the radiation superheater to the boiler drum by 9, a throttle valve in the by-pass by 8 and the point at which the steam is withdrawn for further use by 5.

In the economy of such a boiler plant, the demand for power made by the pump that effects the circulation of the steam plays an important part. The magnitude of this demand is determined by the so-called circulation ratio, that is to say, the ratio of the quantity of steam to be pumped round the circuit to the quantity of steam generated and by the resistance to flow in the superheater tubes and in the remainder of the piping. This circulation ratio, at a given pressure, is conditioned by the temperature of superheat of the circulating steam, and by the preheating of the feed water, and the higher the temperature of superheat and the preheating of the feed water, the smaller is the circulation ratio.

It has therefore hitherto been believed that by suitably designing the boiler plant for a definite given steam pressure with as small as possible a quantity of steam to be pumped round the circuit, that is, with as high a temperature of superheat as possible of the steam serving as a heat carrier, and with as high a preheating of the feed water as possible, the power consumption of the pump that circulates the steam could be reduced to a minimum. For instance a boiler for a steam pressure of 130 atmospheres, with a desired superheat of 500° C., would be built, according to the view hitherto held, in such a way that the circulation ratio, that is to say, the ratio of the quantity of steam pumped round the

circuit to the quantity of steam generated, would be brought, by increasing the preheating of the feed water, almost to the value 2.675, which is yielded upon preheating the feed water right up to the saturated steam temperature, and which can be further reduced if an evaporation economizer is employed.

Now this invention is based upon the discovery that assuming sufficient safety of the superheater tubes against burning, a boiler with a low circulation ratio, that is to say, with high feed water preheating, as compared with a boiler with lower feed water preheating, and likewise a boiler with higher superheating temperature as compared with a boiler with lower superheating temperature, has a greater power consumption for the circulation of the steam. This new discovery implies that for the attainment of the minimum pumping power it is not the maximum permissible temperature of superheat and the maximum attainable feed water preheating that are decisive, but the quantity of steam to be heated in the radiation superheater, the most favorable conditions being yielded not by the smallest possible quantity of steam being pumped round the circuit but by a substantially larger quantity.

This arises from the following consideration: In any boiler plant there must be delivered to the radiation heating surface a quantity of heat which is not determined according to the requirements of the steam circuit but according to the condition of the furnace, as for example the properties of the coal and of the clinker, the temperature of the combustion air, and so forth. A boiler with a small circulation ratio therefore yields a higher steam temperature in the radiation superheater than a boiler with a larger circulation ratio. In order to regulate the circulation a valve 8 is placed in the by-pass 9 and by operation of this valve the circulation ratio is regulated through the regulation of the quantity of steam passing through the by-pass.

For the purpose of maintaining the safety of the superheater tubes, and for the protection of the latter against burning, a boiler with a low circulation ratio must consequently be designed, as compared with a boiler having a greater circulation ratio, with a greater steam velocity, in order that the requisite cooling may be obtained. This raising of the velocity of the steam, however, yields a substantially increased frictional resistance in the pipe coils, and therefore an increase in the back pressure that the pump has to overcome.

The demands for power made by the pump for this cause is hereby made so great that it is more

economical, as the present inventor has ascertained, to work with a greater circulation ratio than had hitherto been assumed to be correct.

According to the invention, therefore, by maintaining a substantially greater circulation ratio, a diminution in the demand for power arising from the smallest possible circulation ratio for the circulation of the steam is obtained and the lowest limit thereof lies at the values of the circulation ratio that are equal to or greater than the values represented in the curve A in Figure 2 of the accompanying drawing.

The invention therefore consists in establishing, as contrasted with the opinion hitherto held, those substantially higher values of the circulation ratio at given pressures which are represented in the curve A in Figure 2, and which if the circulation ratio does not fall below the said values, require a smaller amount of power for the circulating pump, whereas it has hitherto been assumed that the power consumption could only be diminished by reducing the circulation ratio below the values represented by the curve at the same pressures. Therefore according to the invention the temperature of superheat of the steam serving as a heat carrier and the preheating of the feed water, are also so dimensioned that the circulation ratio has a value according to the curve A in Figure 2 or a greater value. In this curve, u denotes the circulation ratio in kilogrammes of steam circulated to the steam generated as ordinates, and the boiler pressure p in atmospheres as abscissae. The upper limit for the circulation ratio is here directed not according to the question of the power consumption for the steam circulation but according to purely structural points of view, which are primarily obtained in the construction of the superheaters from the magnitude of the quantity of steam to be circulated.

Now since the velocity of the steam in the superheaters which is necessary to protect them against burning is determined from the creep-stress of the constructional material of the superheater tubes, particularly those parts of the superheaters that receive the radiation, and that are exposed to the maximum furnace gas temperatures, the power demand for circulating the steam is less with structural materials of higher creep stress in every case than with structural materials of lower creep stress. With the former on the assumption of equal safety, a higher temperature of the tube wall is permissible, and accordingly the minimum demand for power for the steam circulation is yielded when the values denoted by the curve A for the minimum circulation ratio undergo according to the invention an addition according to the curve B of the accompanying drawing. This curve yields the requisite addition in percentage of the circulation ratio u of the curve A in dependence upon the creep-stress (indicated in kilogrammes per square millimetre at 550° C.) for the steels here contemplated as structural material, the creep stress of which are represented in Figure 3 by 3 to 18, since the lower and higher creep stresses need not be considered.

The minimum circulation ratio according to the invention is however also dependent upon the temperature t at which the feed water enters the economizer, and is to be increased, as compared with the values according to the curve A, by the additions shown by the curve C in Figure 4. In this curve this addition is again marked in percentages of the circulation ratio u of the curve A

as a function of the feed-water supply temperature t in degrees centigrade. The temperatures coming into consideration in practice for the feed-water supply, ranging from 80 to 220° C., are here used as a basis.

The demand for power for the steam circulation is of course furthermore dependent upon the steam velocities w in the external pipes of the boiler, that is to say, the collecting pipes between the boiler drum, the steam circulating pump and the superheater. The circulation ratio, which is to be maintained according to the invention at least at the values shown in the curve A, is therefore also varied by those additions to the values of the curve A, which are shown by the curve D in Figure 5. These additions are there indicated in percentages of the circulation ratio u of the curve A in dependence upon the mean steam velocity w in the external pipes of the circuit, which for the values that come into consideration in practice, range from 5 to 35 metres per second.

With a boiler according to the above example the circulation ratio for the attainment of the minimum demand for power for circulating the steam would therefore not approach the value 2.675, which corresponds to the former opinion, but assuming for the superheaters an ordinary low-alloy molybdenum steel, which at 550° C. has a strength of 8 kilogrammes per square millimetre, and a feed-water supply temperature of 130° C., according to the curves A, B and C for example (curve D not being here taken into consideration) would be at least:

$$3.15 + \frac{4(3.15)}{100} + \frac{4(3.15)}{100} = 3.4,$$

which corresponds, with a superheating temperature of 500°, to a feed-water temperature of 239°.

According to the disclosures of this invention, therefore, the preheating of the feed water, in order to obtain the minimum possible expenditure of power for circulating the steam, is to be chosen smaller, the higher the superheating of the steam.

The construction shown in Figure 1 enables us to employ a higher preheating of the feed water, if desired, particularly when a high superheating of the utilization steam is desired, and according to the present development the superheat temperatures adopted will be still further increased. Such an increase in the feed-water preheating to be permitted at a desired high superheat of the utilization steam is rendered possible according to the invention by lowering the temperature of the steam entering the boiler drum as heat-carrier by an admixture of steam drawn off at 7 between the radiation superheater 3 and the convection superheater 4 through an adjustable throttle member 8, shown in Figure 1, in a quantitative ratio which remains constant at all loads. Here the advantages inherent in the Löffler process are fully maintained. By the aid of this step a vaporization economizer can also easily be adopted, and under special circumstances for the purpose of obtaining a minimum power consumption for the steam circulation, a vaporization economizer may become necessary.

The advantages of the invention are not dependent upon whether the steam serving as heat-carrier is only mixed with the water to be vaporized in the boiler drum.

What I claim is:

1. A high pressure steam generating steam circulating system comprising a boiler drum, radiation and convection superheaters respectively in

series, a steam circulating pump for withdrawing steam from the boiler drum conveying the same through the said superheaters and reintroducing it as a heat carrier into the boiler drum, a by-pass connection from a point intermediate of the superheaters to the boiler drum, means in this connection for regulating the flow of steam there-through, and means for withdrawing the useful steam from the circuit at a point beyond the steam circulating pump.

2. A high pressure steam generating steam circulating system comprising a boiler drum, radiation and convection superheaters respectively in series, a circulating pump for withdrawing steam from the boiler drum conveying the same through the said superheaters and reintroducing it as a heat carrier into the boiler drum, a by-pass connection from a point intermediate of the superheaters beyond the outlet of the radiation superheater to the boiler drum, means in this connection for the regulation of the flow of the steam therethrough, and means for withdrawing the useful steam from the circuit at a point between the convection superheater and said drum.

3. A high pressure steam generating steam circulating system comprising a boiler drum, radiation and convection superheaters respectively in series, a circulating pump for withdrawing steam from the boiler drum conveying the same through the said superheaters and reintroducing it as a heat carrier into the boiler drum, a by-pass connection from a point intermediate of the superheaters to the boiler drum, means for preheating the feed water, means for withdrawing the useful steam at a point between the convection superheater and the boiler drum, and means in said connection for regulating the ratio of the bypassed steam in relation to the superheat of the heat carrier steam and the preheat of the feed water in such manner, that at a given steam pressure the ratio u of the quantity of steam to be delivered by the said pump to the quantity of steam generated is equal or greater than the figures represented by the curve A (Figure 2) of the annexed drawing.

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