July 15, 1941. H. SIMMON 2,249,301

FLUE GAS HEAT EXCHANGER

Filed June 15, 1936 2 Sheets-Sheet 1

Fig.1

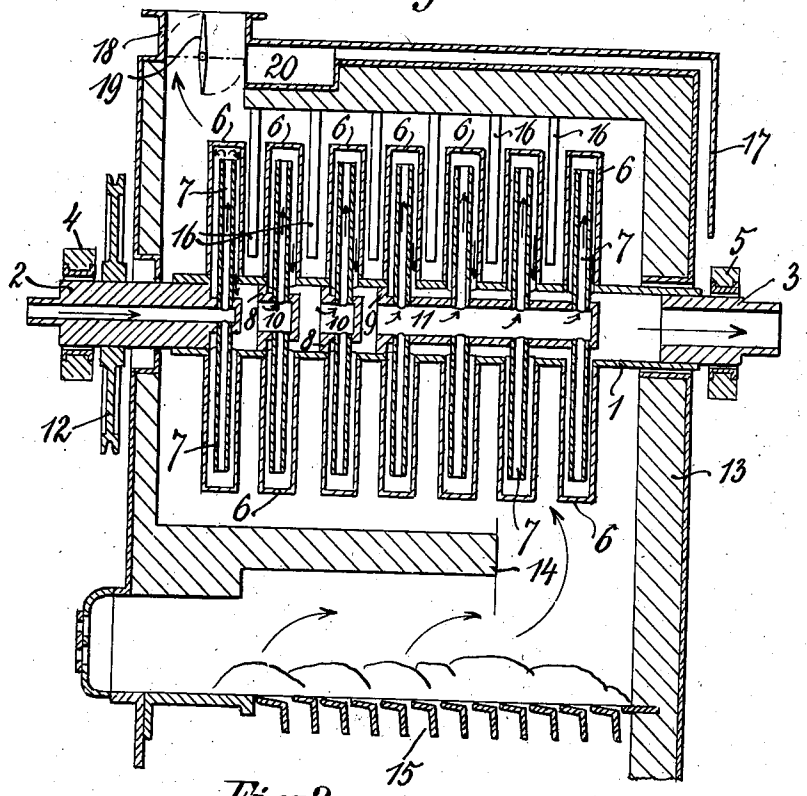


Fig.2

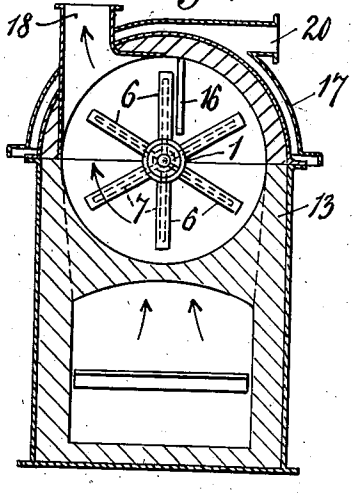
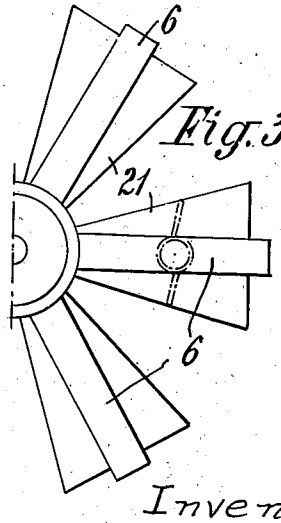


Fig.3



Inventor:
Hans Simmon
By Emil Bönebyche
Attorney

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Fig. 4

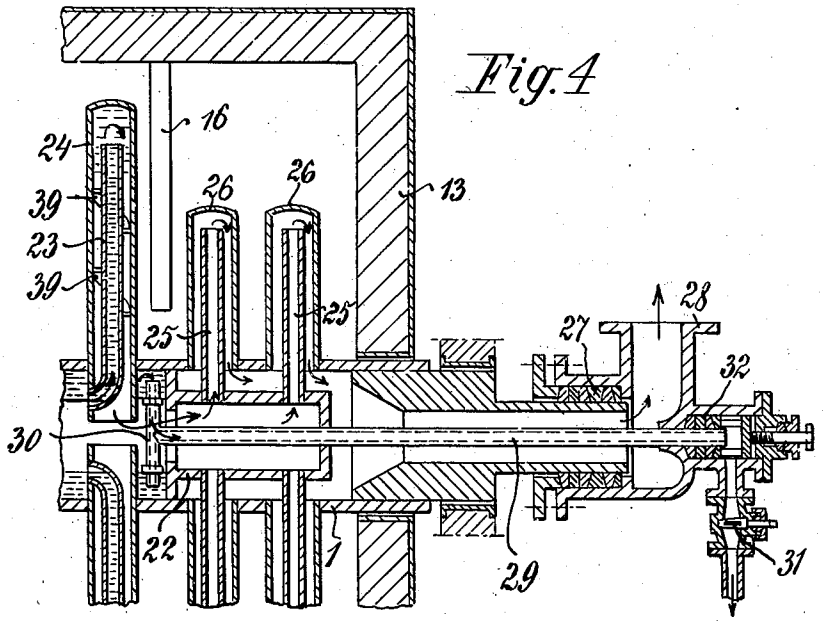
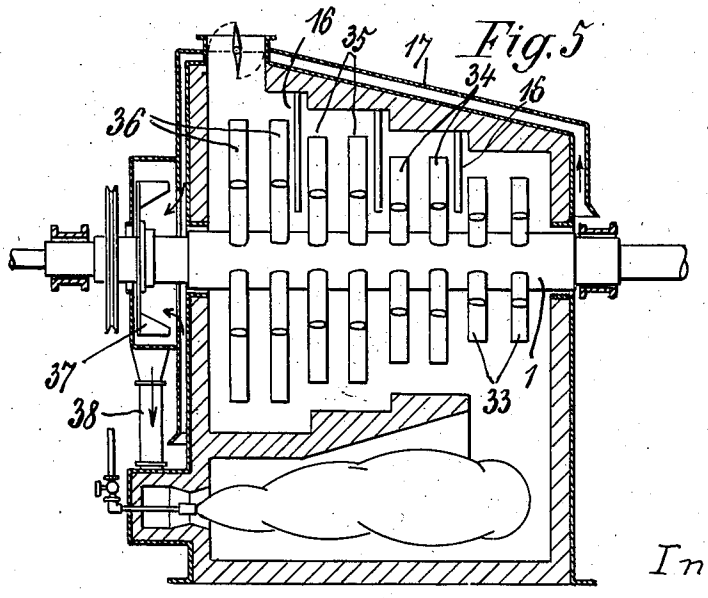


Fig. 5



Inventor:
Hans Simmon
By Emil Römelyche
Attorney

Patented July 15, 1941

2,249,301

UNITED STATES PATENT OFFICE

2,249,301

FLUE GAS HEAT EXCHANGER

Hans Simmon, Vienna, Austria

Application June 15, 1936, Serial No. 85,387
In Austria June 28, 1935

7 Claims. (Cl. 122—11)

This invention relates to rotary flue gas heat exchangers for feed-water pre-heating, steam generation, and steam superheating, and has for its object to provide improved apparatus of this description.

The known heat exchangers with revolving exchange vessel in which the cooler medium moved outwards by centrifugal force displaces the already heated medium thereby causing the latter to move inwards, are of complicated construction, and are therefore difficult and expensive to manufacture. Moreover, since the different sections of the revolving exchange vessel are exposed to different temperatures this vessel is subjected to very great strains, so that it is hardly possible to keep the same permanently fluid-tight.

The present invention relates to a rotary flue gas heat exchanger for pre-heating feed-water, generating steam, and superheating steam, the exchanging elements of which consist of a plurality of heating tubes closed at their outer end, and connected with their inner ends to a hollow shaft in such a manner that they are disposed radially or after the manner of spokes and communicate with the exit end of the bore of the hollow shaft to form an outlet system. The invention further consists in providing in the interior of the heating tubes admission pipes which extend almost up to the closed end of the heating tubes, and which are either connected into a length of tube disposed with clearance in the hollow shaft so as to admit of the inflow of the medium to be heated or otherwise adapted to communicate with the entry end of the hollow shaft to form an inlet system communicating with the outlet system only through the said admission pipes and heating tubes. In the intermediate space formed between the admission pipe and the heating tube there may be provided (as is known in connection with stationary heat exchangers) inclined blades which on the one hand hold the admission pipe fast in a central position, and which, on the other hand, may be adapted to impart an additional rotary motion to the medium to be heated in the revolving heat exchanging vessel, with the result that the rate of heat transmission is increased, such blades being shown by way of example, at **39**, in Fig. 4 of the accompanying drawings. Such blades preferably extend or are distributed over substantially the whole length of the said intermediate space. In order to still further increase the thermal efficiency there may be provided in the casing a rake the prongs of which constitute a baffle for the flue gases carried along by the heating tubes, so that these gases are constantly eddied, with the result that not only is effective heat delivery obtained but in addition the formation of an insulating deposit of soot and flue ash is prevented. At a part of the system at which the flue gases have become greatly cooled down the tubes may be provided with ribs which enable the total area of the heating surface to be increased, and which, if they be disposed obliquely, can also be arranged to act as blower fans to accelerate the movement of the flue gases. In order to prevent an excessive increase in the salt content of the water due to evaporation there is provided a salt-eliminating pipe which is in permanent communication with the water space inside the hollow shaft, and the bore of which is regulable to suit the rate of water discharge. To avoid loss of heat by radiation, the casing surrounding the rotary exchanger is preferably enclosed by a jacket beneath which (as is known in connection with furnace plant) there is a hollow space for an insulating layer of air, from which space the air, as it becomes heated, may be fed, with the aid of a blower, as pre-heated air for combustion, to the furnace. The favorable co-operation of all these measures makes it possible for the apparatus to be built with very small heating surfaces, which is of importance from the economic point of view, more particularly in conjunction with very high pressure boilers.

Forms of construction embodying the invention are shown, by way of example, in the accompanying drawings, in which:

Fig. 1 shows a heat exchanger in accordance with the invention, in vertical longitudinal section.

Fig. 2 is a vertical transverse section of the same heat exchanger, on a reduced scale.

Fig. 3 shows one half of a heat exchanging member in accordance with the invention, as seen in an axial direction, on an enlarged scale.

Fig. 4 shows a part of a modified form of construction, in vertical longitudinal section.

Fig. 5 shows a further modification, in a similar view.

In the form of construction of the appliance according to the invention shown in Figs. 1 and 2 the hollow shaft **1** of the exchanger is supported with its ends **2**, **3** in bearings **4**, **5**. The shouldered pipe connections at the ends of the shaft fit in stuffing-boxes pertaining to the pipes (not shown in Fig. 1) for the feeding in and discharg-

ing of the water and/or steam. The heat exchanging elements consist of heating tubes 6 disposed radially in the manner of spokes, closed at their outer ends, and communicating with the interior of the hollow shaft 1. Within each of the heating tubes 6 there is a smaller bore admission pipe 7 the outer end of which extends almost up to the closed end of the heating tube 6, while the inner end, in the case of the first of the star-shaped sets of tubes, adjoins a closed tubular extension at the end 2 of the shaft 1 and communicates, through the bore of this extension, with the water feed pipe, and in the case of the remaining sets of tubes adjoins a length of tube 10 or 11 which is inserted in the hollow shaft 1 within which it fits tightly by means of a flange 8 and 9, respectively, and which is closed at its end. Each of the lengths of tube 10 carries a set of tubes for pre-heating and steam generation, while to the length of tube 11 there are connected a plurality of such sets of tubes serving for the superheating of steam. At the end 2 of the hollow shaft 1 there is secured a cord pulley 12 which can be driven from a source of power. The rotary exchanger is enclosed in a casing 13 beneath which there is located a fire arch 14 and a grate 15. The furnace may alternatively be situated at the side, it being merely necessary that the casing be interposed in the path of flow of the flue gases coming from a furnace. In the upper part of the casing there are provided bars 16 which constitute a rake engaging between the sets of tubes, to prevent flue gases from becoming carried round with the heating tubes 6, and to effect through eddying of these gases. The casing 13 is made from heat-insulating material, or jacketed with such material, and it is in addition enclosed within a shell 17 which is spaced a certain distance from the casing to form an intervening air space, so that an insulating layer of air is situated beneath this shell. The flue pipe connection 18 on the casing contains an adjustable damper 19 which serves to regulate the rate of gas escape, and which if desired may be automatically controlled in dependence on the steam pressure. The shell 17 is provided with a pipe connection 20 through which the heated air may be drawn off and fed to the furnace as preheated air for combustion. In a region less exposed to the action of the flue gases the heating tubes may be provided with ribs 21 (Fig. 3) which, as indicated by the transverse section shown in chain-dotted lines on the right in Fig. 3, may if desired be obliquely disposed, so that they act as blower blades, to accelerate the flow of the flue gases.

The mode of operation of the heat exchanger shown in the drawings is as follows:

The flue gases rise from the furnace, and are caught up by the rapidly revolving heating tubes 6 and thoroughly eddied. At the same time these gases are moved forward helically in an axial direction while being gradually cooled off. Finally, the gases are forced out through the outlet 18. Water entering at the end 2 of the hollow shaft passes into the first set of admission pipes 7, and is carried by centrifugal force to the ends of the heating tubes 6 of this set, where it becomes heated, and in consequence of its lower specific gravity this water is displaced by the inflowing cold water into the interior of the hollow shaft 1. Thence, while gradually evaporating, the water passes through the length of tube 10 into the second set of admission pipes 7 and heating tubes 6, then through the next length of tube 10 into the third set of admission pipes 7 and heating tubes 6. After complete evaporation of the water the resulting steam passes into the length of tube 11 through which it enters a plurality of sets of heating tubes simultaneously, to become superheated. As will be clear from this description and the drawings, pre-heating and evaporation are effected in the first of the sets of tubes, which come in contact with the flue gases after the latter have become more or less cooled down, while in the sets of tubes which are exposed to the flue gases at their hottest the superheating of the steam is effected.

In the form of construction shown in Fig. 4 the saturated steam generated can be continuously converted into superheated steam, for which purpose means for eliminating salt from the feeding water must be provided, in order to prevent the salt content of the water from exceeding the admissible limit. The hollow shaft 1 is divided into two chambers by means of the flange pertaining to an inserted member 22 which is closed at one end, one of these chambers being in communication with the water feed pipe, while the other is situated at the side at which the steam flows out. The admission pipes 23, which conduct the water outwards under the action of centrifugal force, have their entry ends fitted in the wall of the closed-ended heating tubes 24 in which the evaporation takes place, so that the steam escapes at the inner ends and passes through the hollow space in the inserted member 22 into the admission pipes 25 associated with the superheating tubes 26. Thence the steam passes out through a stuffing-box 27 into the steam discharge connection 28. For the elimination of excess salt there serves a salt-eliminating pipe 29 the T-shaped end 30 of which dips with its two inlet orifices into the annular body of water forming on the inlet side of the hollow shaft 1 during rotation. A closure member 31 enables the quantity of water conducted away to be regulated, so that the desired salt content of the water can be kept constant. The end of the salt-eliminating pipe 29 is rotatably mounted in a stuffing-box 32. Between the admission pipe 23 and the heating tube 24 there are inserted obliquely set blades 39 which serve on the one hand to hold the admission pipe in the middle of the heating tube, and on the other hand to impart a supplementary rotary movement to the medium to be heated, thereby intensifying the heat transmission.

In the form of construction shown in Fig. 5 the heating tubes 33, 34, 35, and 36 are of graduatedly reduced length, the arrangement being such that the tubes are shortest where the gases are hottest, and longest where the gases have been cooled down most and where the strongest eddying is required. Fig. 5 also shows a blower 37 mounted on the hollow shaft 1, which blower feeds the air heated beneath the shell 17 by the shortest route, through an air conduit 38, to the combustion chamber of the furnace.

The economy of working of the described heat exchanger is due to the fact that it can be used both as a water pre-heater, as a steam generator, and as a steam superheater, and can at the same time be made to serve in addition for the conveying of the combustion gases and also of the air for combustion.

I claim:

1. A rotary flue gas heat exchanger for the pre-heating of water, generating of steam, and superheating of steam, comprising in combination a chamber adapted to be interposed in the path

of flow of flue gases from a furnace, a hollow shaft freely rotatable in the said chamber and extending out clear of said chamber through opposite walls thereof, means for introducing a medium to be heated at one end of the said rotary hollow shaft and for discharging the heated medium at the other end thereof, heating tubes radially connected to the said hollow shaft and communicating with the outlet end thereof, the said tubes being closed at the outer end, hollow positioning means within the said hollow shaft communicating with the inlet end and closed off from the discharge end of the said shaft, open-ended admission pipes fitted with their inner ends in the said positioning means and severally extending, with clearance, into the said heating tubes to a point near the closed outer end of the said tubes, means on the shaft for continuously rotating the assembly consisting of said shaft, heating tubes, positioning means, and admission pipes at high speed, independently of the operation of the said furnace, to exert centrifugal force upon said medium, the said positioning means for the first set of admission pipes consisting of a closed extension on the entry end of the said hollow shaft, and for the remaining sets of admission pipes of lengths of tube flanged to fit within the said hollow shaft at the end towards the entry end of the said shaft and closed at the other end, the said lengths of tube being associated partly with single sets of admission pipes and partly with a plurality of such sets.

2. A rotary flue gas heat exchanger for the pre-heating of water, generating of steam, and superheating of steam, comprising in combination a chamber adapted to be interposed in the path of flow of flue gases from a furnace, a hollow shaft freely rotatable in the said chamber and extending out clear of said chamber through opposite walls thereof, means for introducing a medium to be heated at one end of the said rotary hollow shaft and for discharging the heated medium at the other end thereof, heating tubes radially connected to the said hollow shaft and communicating with the outlet end thereof, the said tubes being closed at the outer end, hollow positioning means within the said hollow shaft communicating with the inlet end and closed off from the discharge end of the said shaft, open-ended admission pipes fitted with their inner ends in the said positioning means and severally extending, with clearance, into the said heating tubes to a point near the closed outer end of the said tubes, means on the shaft for continuously rotating the assembly consisting of said shaft, heating tubes, positioning means, and admission pipes at high speed, independently of the operation of the said furnace, to exert centrifugal force upon said medium, and a rake associated with the inner wall of the said chamber and consisting of bars extending inwards between the sets of the said radially disposed heating tubes, for the purpose of increased eddying of the flue gases.

3. A rotary flue gas heat exchanger for the pre-heating of water, generating of steam, and superheating of steam, comprising in combination a chamber adapted to be interposed in the path of flow of flue gases from a furnace, a hollow shaft freely rotatable in the said chamber and extending out clear of said chamber through opposite walls thereof, means for introducing a medium to be heated at one end of the said rotary hollow shaft and for discharging the heated medium at the other end thereof, heating tubes radially connected to the said hollow shaft and communicating with the outlet end thereof, the said tubes being closed at the outer end, hollow positioning means within the said hollow shaft communicating with the inlet end and closed off from the discharge end of the said shaft, open-ended admission pipes fitted with their inner ends in the said positioning means and severally extending, with clearance, into the said heating tubes to a point near the closed outer end of the said tubes, means on the shaft for continuously rotating the assembly consisting of said shaft, heating tubes, positioning means, and admission pipes at high speed, independently of the operation of the said furnace, to exert centrifugal force upon said medium, an outer shell surrounding the said chamber in spaced relation thereto, for the provision of a layer of heated air between the chamber and shell, and a blower mounted on the said hollow shaft and communicating with its suction side with the said layer of air, and with its delivery side with the combustion chamber of the furnace, for the purpose of feeding pre-heated air to support combustion in the said furnace.

4. A rotary flue gas heat exchanger for the pre-heating of water, generating of steam, and superheating of steam, comprising in combination a chamber adapted to be interposed in the path of flow of flue gases from a furnace, a hollow shaft freely rotatable in the said chamber and extending out clear of said chamber through opposite walls thereof, means for introducing a medium to be heated at one end of the said rotary hollow shaft and for discharging the heated medium at the other end thereof, heating tubes radially connected to the said hollow shaft and communicating with the outlet end thereof, the said tubes being closed at the outer end, hollow positioning means within the said hollow shaft communicating with the inlet end and closed off from the discharge end of the said shaft, open-ended admission pipes fitted with their inner ends in the said positioning means and severally extending, with clearance, into the said heating tubes to a point near the closed outer end of the said tubes, means on the shaft for continuously rotating the assembly consisting of said shaft, heating tubes, positioning means, and admission pipes at high speed, independently of the operation of the said furnace, to exert centrifugal force upon said medium, the said sets of heating tubes being of graduatedly varied length, the said tubes being shortest where the flue gases are hottest, and longest where the said gases are most cooled and where therefore maximum eddying is desired.

5. A rotary flue gas heat exchanger for the pre-heating of water, generating of steam, and superheating of steam, comprising in combination a chamber adapted to be interposed in the path of flow of flue gases from a furnace, a hollow shaft freely rotatable in the said chamber and extending out clear of said chamber through opposite walls thereof, means for introducing a medium to be heated at one end of the said rotary hollow shaft and for discharging the heated medium at the other end thereof, heating tubes radially connected to the said hollow shaft and communicating with the outlet end thereof, the said tubes being closed at the outer end, hollow positioning means within the said hollow shaft communicating with the inlet end and closed off from the discharge end of the said shaft, open-ended admission pipes fitted with their inner ends in the said positioning means and severally extending, with clearance, into the said heating

tubes to a point near the closed outer end of the said tubes, means on the shaft for continuously rotating the assembly consisting of said shaft, heating tubes, positioning means, and admission pipes at high speed, independently of the operation of the said furnace, to exert centrifugal force upon said medium, and a salt-eliminating pipe having a T-shaped end provided with two inlet orifices adapted to dip in the annular body of medium formed in the said hollow shaft when rotated, the said pipe being provided with a closure member adapted to admit of regulating the inside cross-sectional area of flow through the said pipe.

6. A rotary flue gas heat exchanger for the pre-heating of water, generating of steam, and superheating of steam, comprising in combination a chamber adapted to be interposed in the path of flow of flue gases from a furnace, a hollow shaft freely rotatable in the said chamber and extending out clear of said chamber through opposite walls thereof, means for introducing a medium to be heated at one end of the said rotary hollow shaft and for discharging the heated medium at the other end thereof, heating tubes radially connected to the said hollow shaft and communicating with the outlet end thereof, the said tubes being closed at the outer end, hollow positioning means within the said hollow shaft communicating with the inlet end and closed off from the discharge end of the said shaft, open-ended admission pipes fitted with their inner ends in the said positioning means and severally extending, with clearance, into the said heating tubes to a point near the closed outer end of the said tubes, means on the shaft for continuously rotating the assembly consisting of said shaft, heating tubes, positioning means, and admission pipes at high speed, independently of the operation of the said furnace, to exert centrifugal force upon said medium, some of the said heating tubes, namely those furthest removed from the point of entry of the flue gases into the said casing, being provided with fins for the purpose of increasing the total heat-absorbing surface of the said tubes.

7. A rotary flue gas heat exchanger for the pre-heating of water, generating of steam, and superheating of steam, comprising in combination a chamber adapted to be interposed in the path of flow of flue gases from a furnace, a hollow shaft freely rotatable in the said chamber and extending out clear of said chamber through opposite walls thereof, means for introducing a medium to be heated at one end of the said rotary hollow shaft and for discharging the heated medium at the other end thereof, heating tubes radially connected to the said hollow shaft and communicating with the outlet end thereof, the said tubes being closed at the outer end, hollow positioning means within the said hollow shaft communicating with the inlet end and closed off from the discharge end of the said shaft, open-ended admission pipes fitted with their inner ends in the said positioning means and severally extending, with clearance, into the said heating tubes to a point near the closed outer end of the said tubes, means on the shaft for continuously rotating the assembly consisting of said shaft, heating tubes, positioning means, and admission pipes at high speed, independently of the operation of the said furnace, to exert centrifugal force upon said medium, some of the said heating tubes, namely those furthest removed from the point of entry of the flue gases into the said casing, being provided with fins disposed obliquely after the manner of fan blades, for the purpose of increasing the total heat-absorbing surface of the said tubes while at the same time accelerating the movement of the said flue gases through the said casing.

HANS SIMMON.