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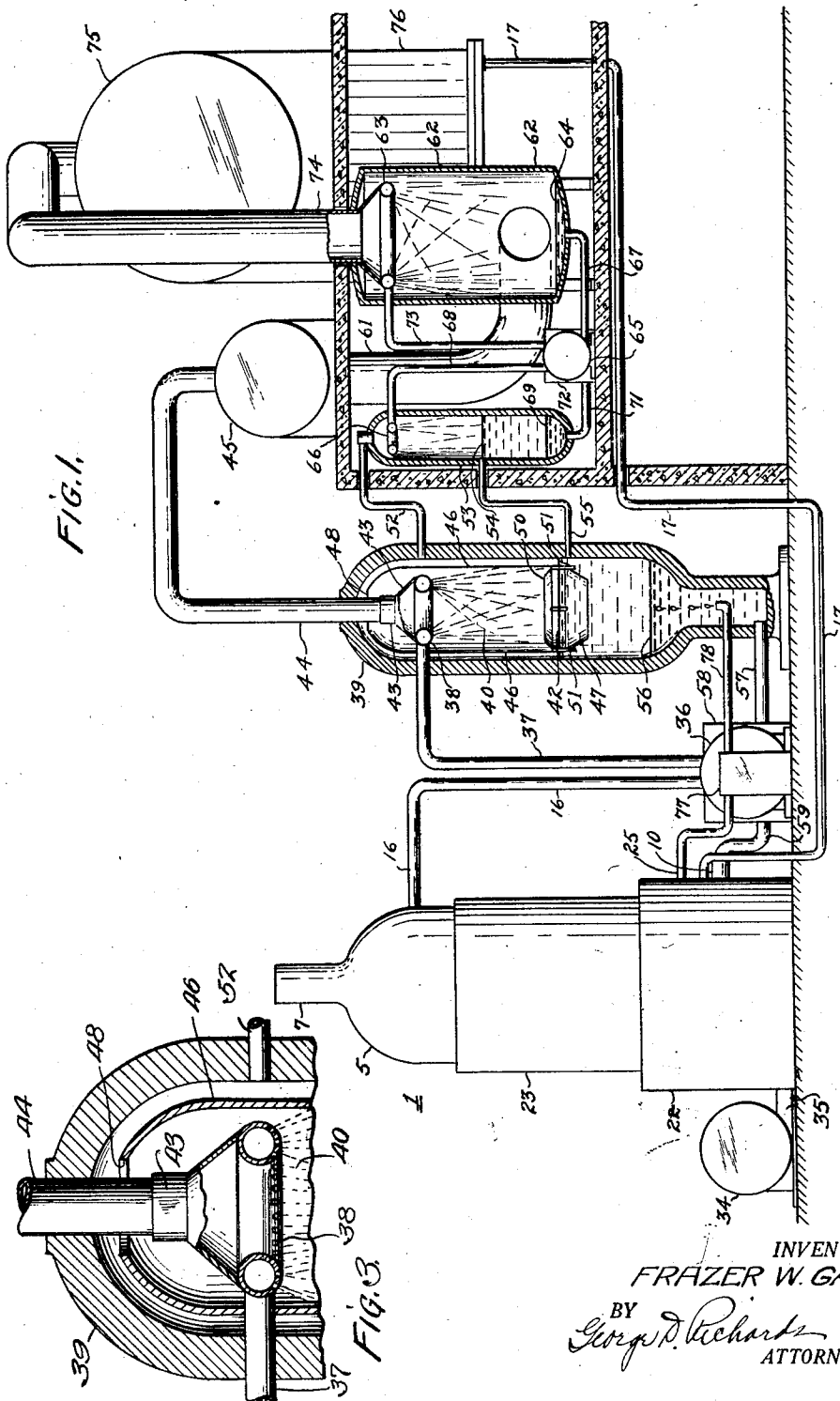
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STEAM GENERATING SYSTEM

Filed April 12, 1929

2 Sheets-Sheet 1



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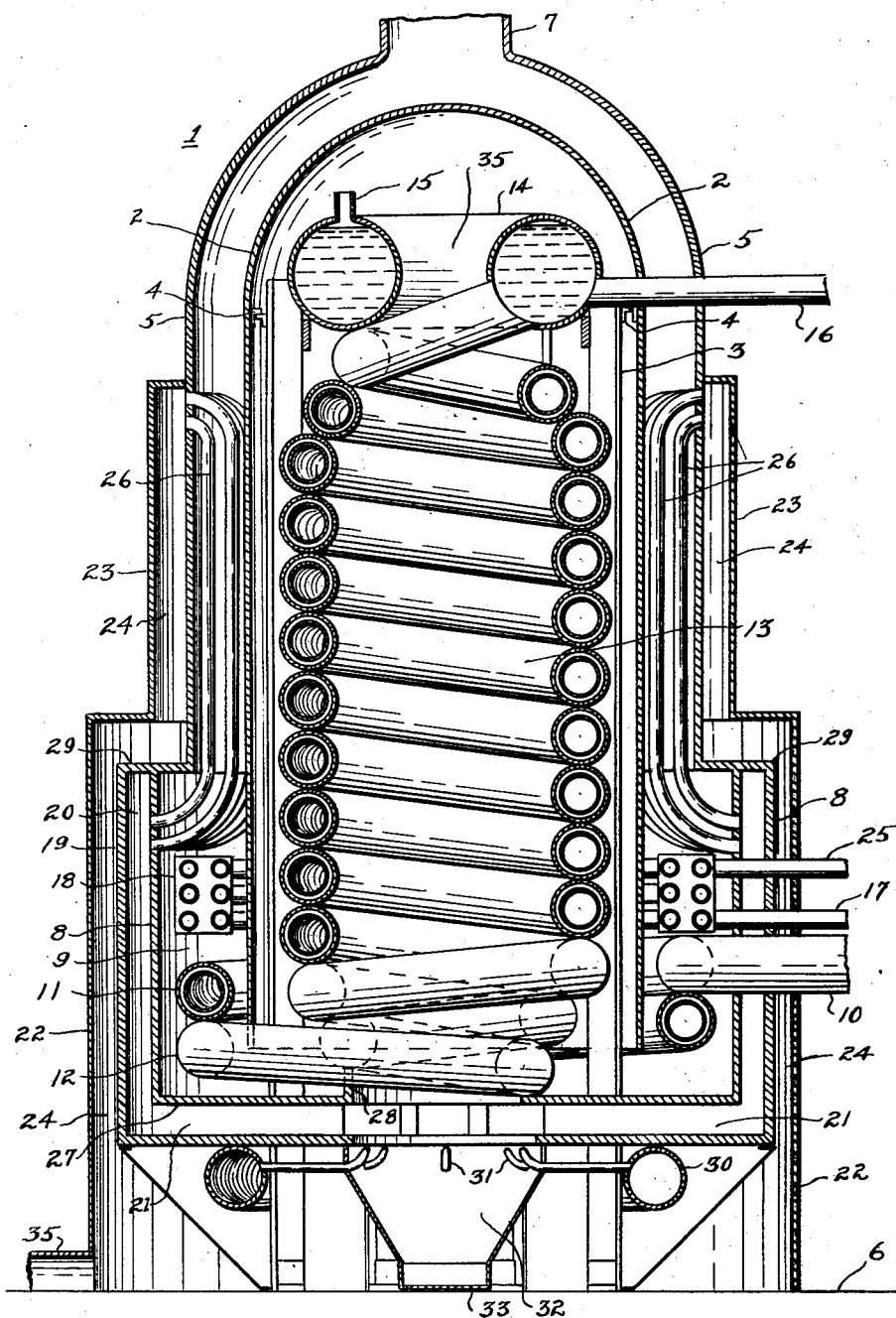


FIG. 2

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STEAM GENERATING SYSTEM

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This invention relates, generally, to the generation of steam; and the invention has reference, more particularly, to a novel steam generating system especially adapted for generating and superheating high pressure steam.

The rapid increase in boiler pressures in recent years has resulted in the relatively common installation of boilers with pressures lying above one thousand pounds per square inch and employing high superheat temperatures. Boilers commonly used for such high pressure installations are not only expensive, owing to the relatively great areas of high pressure tubing required, but are also somewhat dangerous in use. Also, the great area of high pressure superheater pipes necessary for adequately superheating such steam, adds greatly to the cost of the steam generating installation. For effectively superheating the steam, the temperature of the superheater pipes must be much higher than that of the steam, and when operating with maximum superheat, the steel temperature is so high as to materially weaken the superheater pipe strength. This results in the necessity for closely controlling boiler conditions so as to prevent overheating of superheater pipes and their consequent damage.

It is the principal object of the present invention to provide a novel steam generating system capable of a safely and cheaply producing superheated steam of any desired working pressure, and wherein fused metal or metallic alloy is heated at substantially atmospheric pressure and is employed as the heat conveying means for effecting the vaporization and superheating of steam.

In carrying out the invention, a fused alloy is circulated through tubes suitably located in a furnace. The alloy is subjected to atmospheric pressure only and the maximum pressure obtaining in the furnace is that due to the static head of the alloy. In use, the alloy in a cooled condition enters the furnace near the bottom thereof and rises as it is heated and is taken out at the top of the furnace in a highly heated condition to be used for producing steam having the desired superheat. Since the maximum static pres-

sure in the furnace tubes is in the lowermost tubes, and as the cooled alloy enters at the bottom of the furnace, these tubes are never very hot so that their strength is not weakened by the furnace temperature. The alloy, as it moves upwardly through the furnace is heated more and more, while at the same time the static head on the successive tubes is decreasing, so that at no time are the tubes subjected to combined high pressure and high temperature. The fused alloy delivered from the top of the furnace is forced by means of suitable alloy circulating pumps into the top of a boiler and sprayed therein so as to fall upon the water in the boiler evaporating the same and superheating the steam as it rises in the boiler. The cooled alloy collects in the bottom of the boiler and is allowed to run out of the boiler and thence through a pump engine which functions to supply driving power to the alloy circulating pumps. Additional motor means is used for supplying any additional power that may be necessary for operating the alloy circulating pumps. From the pump engine, the alloy passes back into the bottom of the furnace to be reheated therein, preliminary to another passage through the boiler.

Additional superheater means are adapted to be employed between the various stages of the turbines so as to maintain a high superheat in the steam as it passes through the turbines. These additional superheater means may utilize either high pressure steam as a source of heat, which steam will not be over approximately 700° F. or alloy may be tapped from the top of the furnace and sprayed into the low pressure steam superheating the same. In the latter case the cooled alloy will be pumped into the bottom of the furnace as before.

It is well known that in steam turbine operation, the portion of the heat energy that is put into water to change it into the vaporous state, i. e. the latent heat of vaporization is largely lost in the condensers when the steam is again recondensed. Only that portion of the heat energy that is used to superheat the steam is efficiently converted into mechanical work and hence high degrees

of superheat are desirable. In the superheating of low pressure steam, fusible alloy may first be sprayed through a body of high pressure steam which serves to heat the alloy and the alloy may then be sprayed into the low pressure steam superheating the same. Owing to the finely divided condition of the alloy and consequent enormous surface area of the same, as it is thus sprayed, it rapidly absorbs heat from the high pressure steam and almost as rapidly gives it up to the low pressure steam. The pressure energy of the alloy leaving the high pressure steam chamber may be used in part to pump the cooled alloy back into the high pressure steam chamber for reheating.

Other objects of this invention not at this time more particularly enumerated, will be clearly understood from the following detailed description of the same.

The invention is clearly illustrated in the accompanying drawings, in which:—

Fig. 1 is a diagrammatic elevational view partly in section of the novel steam generating system of this invention, and

Fig. 2 is an enlarged part sectional view of the alloy furnace used in the generating system.

Fig. 3 is an enlarged fragmentary view of a portion of the structure shown in Fig. 1.

Similar characters of references are employed in all of the hereinabove described views to indicate corresponding parts.

Referring to the figures of the drawings, the reference numeral 1 designates a furnace that is adapted to heat a suitable metallic alloy, such as an alloy of lead, bismuth and tin, which alloy is used for vaporizing and superheating steam. The furnace 1 comprises an inner shell 2 of substantially cylindrical shape having a dome shaped closed upper end and an open lower end. The shell 2 is supported from metal uprights 3 as by brackets 4. The metal uprights 3 extends vertically within the furnace 1 and have their lower ends supported upon the furnace foundation 6. A substantially cylindrical outer shell 5 surrounds and is spaced from the inner shell 2. The outer shell 5 also has a dome shaped upper end which terminates in a stack or chimney 7. The lower portion of the outer shell 5 is outwardly enlarged at 8 so as to provide an enlarged annular chamber 9, extending between the inner and outer shells.

The furnace 1 is illustrated as having a substantially continuous spirally arranged furnace tube 10 comprising an outer and inner pipe providing an annular space therebetween through which space the alloy circulates in its passage through the furnace. The furnace tube 10 enters the boiler in the lower right hand side thereof, as especially shown in Fig. 2, and is illustrated as having two outer coils or convolutions 11 and 12 posi-

tioned within the annular chamber 9. From the chamber 9 the furnace tube extends into the inner shell 2 and is wrapped spirally within this shell so as to extend from the bottom to the top thereof and comprising a plurality of successive inner convolutions forming an interior combustion chamber 13. A number of the convolutions at the upper and lower end portions of the tube 10 within the inner shell 2 are of progressively reduced diameters and as each successive overlying convolution has its periphery contacting with the next adjacent lower convolution, the combustion chamber 13 is closed at its sides and has reduced ends which provide a desirable space for completing the combustion of the fuel used in the furnace and for holding the heat produced by such combustion so that the same is conducted through the walls of the tube convolutions and absorbed by the alloy within the furnace tube.

The upper end of the furnace tube 10 terminates in an annular reservoir 14. The annular reservoir 14 has a vent pipe 15 which connects the interior of this reservoir with the interior of the inner shell 2. An outlet pipe 16 connects with the annular reservoir 14 and extends exteriorly of the furnace 1. The successive convolutions of the furnace tube 10 within the inner shell 2 and the annular reservoir 14 are supported upon the metal uprights 3.

An economizer 18 is illustrated as positioned within the chamber 9 above the coil 11 of the furnace tube. The economizer 18 has an inlet pipe 17 and an outlet pipe 25. The enlarged portion 8 of the outer shell is exteriorly surrounded by an annular wall 19, thereby providing an air passage 20 extending between the outer surface of the portion 8 and the inner surface of the annular wall 19. This passage is closed at its upper end by an end wall 29. Air ports 21 extend between the metal uprights 3 and connect the passage 20 to the interior of the furnace. A hollow cylindrical casing forms the greater portion of the exterior wall of the furnace and has an upper portion 23 surrounding the intermediate portion of the outer shell 5 and an enlarged lower portion 22 surrounding the annular wall 19. This cylindrical casing provides an annular air duct or chamber 24 extending from the bottom of the furnace toward the top thereof. A plurality of circumferentially arranged preheater tubes 26 are positioned within the annular space provided between the inner and outer shells and these tubes have their upper ends connected to the air duct 24 near the top of this duct and their lower ends connected to the air passage 20.

The enlarged portion 8 of the outer shell is partially closed at its lower end by an annular base plate 27. The inner periphery of the base plate 27 is provided with an up-

standing flange 28 which conforms to the lowermost convolution of the furnace tube 10 positioned within the inner shell. The base plate 27 together with its flange 28 acts in conjunction with the air ports 21 to conduct air inwardly of the furnace and into the combustion chamber 13. The furnace 1 is illustrated as being supplied with liquid fuel passing into an annular pipe 30 from which it is fed through burners 31 to an ignition chamber 32. The ignition chamber 32 is provided at its lower end with a trough 33 which is adapted to collect refuse material falling from the interior of the furnace.

Air is adapted to be driven into the furnace 1 by means of a blower 34. Air from blower 34 passes through a conductor 35 into the bottom of the duct or chamber 24. This air passes upwardly within this chamber and into the preheater tubes 26. Passing down through these preheater tubes, the air then enters air passage 20 and from thence it passes through air ports 21 into the ignition chamber 32. In the ignition chamber, this air combines with the burning fuel supplied from the burners 31 and the gaseous mixture passes into the combustion chamber 13 where combustion is completed and great heat developed, which heat causes the heating of the furnace tube 10 and its contained alloy. The hot gaseous mixture passes up through combustion chamber 13 and through the interior aperture 35 in the reservoir 14, which aperture serves as the furnace throat. From the throat 35 the gases pass around the upper surface of reservoir 14 and down between the exterior of the inner convolutions of the furnace tube 10 and the interior surface of the inner shell 2. Passing under the lower end of the inner shell 2, this gaseous mixture then passes up and around the outer convolutions 11 and 12 of the furnace tube, around the economizer 18 and up between the inner and outer shell and the preheater tubes 26 and finally out of the chimney 7.

The hot gases within the combustion chamber 13 serve to heat the alloy within the inner convolutions of the furnace tube to a high temperature. The passage of the gases around the reservoir 14 and down along the outer surfaces of the inner convolutions of the furnace tube serves to further heat the alloy within these members. The somewhat cooled gaseous mixture then passes over the outer convolutions 11 and 12 of the furnace tube. Since the alloy within the convolutions 11 and 12 has just entered the furnace, such alloy is relatively cool and consequently extracts considerable heat from this partly cooled gaseous mixture. The economizer extracts still more heat from the gaseous furnace fumes and the preheater tubes 26 finally extract an additional quantity of heat from these fumes so that when the fumes finally pass out of this chimney 7 they are relatively

cool. It will be noted that the outer shell 5 as well as the preheater tubes 26 absorb heat from the furnace gases, thereby preheating the incoming air supply. Thus the furnace 1 is extremely economical in operation and secures a maximum heating effect per cubic volume of combustible fuel.

It is to be understood that the specific furnace disclosed is illustrated by way of example only and though suitable as shown for small installation, this furnace would doubtless be constructed in sections for larger units. Also it will be apparent that other forms of furnaces may be employed for heating the alloy, such for example as the common types of steam boilers and it is therefore not intended to limit the invention to the form of furnace shown.

The alloy within the furnace tube 10 rises in the furnace 1 as it is heated and absorbs more and more heat as it progresses upwardly through this furnace so that by the time it reaches the outlet pipe 16 this alloy is very hot. Inasmuch as the alloy in the lower furnace tube convolutions is relatively cool, the tube walls of these lower convolutions are also cool and can well carry the higher static pressure head to which such convolutions are subjected.

The hot alloy leaving the furnace 1 flows through pipe 16 to a pump 36 which pumps this alloy through a pipe 37 that connects with an annular spray ring 38 positioned within the upper portion of a substantially cylindrical heavy walled high pressure boiler 39. The spray ring 38 has a plurality of circumferentially arranged small spray apertures through which apertures the hot alloy is sprayed in a cloud of small droplets. The sprayed alloy passes through a superheating space 40 provided in the boiler 39 and falls upon the water 42 contained within this boiler. The alloy gives up its heat to the water 42 evaporating the same and as the steam so formed rises into the superheating space 40 the hot incoming alloy acts to superheat this steam to the desired temperature, depending upon the temperature of the alloy leaving the spray ring which may be controlled as desired. The spray ring 38 is carried by the apron 43 that is secured to the lower end of the high pressure steam outlet pipe 44. The pipe 44 is adapted to supply superheated steam to the high pressure turbine 45.

The high pressure boiler 39 is provided with a substantially cylindrical baffle plate 46 which is spaced inwardly slightly from the inner walls of the boiler and has its lower end portion, which projects into the water 42, constricted somewhat at 47. The upper portion of baffle plate 46 is dome shape and is provided with a central aperture 48 through which the outlet pipe 44 extends. The aperture 48 is somewhat larger than pipe 44 so that saturated steam passing up be-

tween the baffle plate and the inner wall of the boiler may pass down through this aperture 48 and into the superheating space 40. The baffle plate 46 is provided interiorly with a circumferentially extending trough 50 which is positioned somewhat above the surface of the water 42. A plurality of pipes or conduits 51 are connected with the trough 50 and extend downwardly through apertures provided in the constricted portion 47. The trough 50 is adapted to catch a portion of the alloy sprayed from the spray ring 38 and especially such alloy as runs down the inner sides of the baffle plate 46. The alloy thus collected by the trough 50 is conducted by pipes 51 to the water lying between the constricted portion 47 and the inner walls of the boiler 39. The alloy thus delivered between the constricted portion 47 and the inner walls of the boiler 39 produces a rapid evaporation of steam from the surface of the water extending between the baffle plate and the inner boiler walls, the constricted portion 47 aiding in directing steam to such water surface. This saturated steam rises upwardly between these members and serves to keep the temperature of the boiler walls at that of the saturated steam, thereby protecting these walls from the high superheat temperature obtaining in the superheating space 40. A portion of this saturated steam is adapted to pass through a feeder pipe 52 into the top of an auxiliary boiler 53. This saturated steam passing into the auxiliary boiler 53 is adapted to condense in a manner to be further described, and the water of condensation 54 so formed is adapted to collect in the bottom of the auxiliary boiler. Excess condensate is returned to high pressure boiler 39 by way of pipe 55. The portion of the saturated steam passing up between baffle plate 26 and the inner walls of the boiler 39 which is not supplied to the auxiliary boiler 53, passes through aperture 48 and down into the superheating space 40 where it is superheated and finally passes out through outlet pipe 44 to be consumed by the high pressure turbine 45. The alloy sprayed within boiler 39 collects in the bottom of this boiler at 56 and owing to the high fluid pressure in this boiler, is gradually forced outwardly of the boiler through the pipe 57 and into a pump engine 58 which acts to drive the pump 36. The alloy leaves the pump engine 58 by way of exhaust pipe 59 which connects to the furnace tube 10 to be recirculated through the furnace 1 for further heating. Any additional torque which may be required to drive pump 36 may be supplied by any suitable motor not shown.

The exhaust steam from high pressure turbine 45 passes through a conduit 61 into a reheater 62. The reheater 62 is a hollow cylindrical vessel closed at its ends and is provided with a spray ring 63 which is similar to the spray ring 38. The spray ring 63 is adapted to be supplied with hot alloy from the auxiliary boiler 53. This alloy is adapted to be pumped from the sump 64 in the bottom of reheater 62 by a pump 65 to a spray ring 66 provided in the upper portion of auxiliary boiler 53. This alloy flows from sump 64 through a pipe 67, through pump 65 and a pipe 68 into the spray ring 66 positioned within the upper portion of auxiliary boiler 53. The alloy thus sprayed by spray ring 66 falls downwardly within boiler 53 and is heated by the saturated steam therein. This alloy collecting at 69 in the bottom of the auxiliary boiler is gradually forced outwardly of this boiler by the pressure of the saturated steam therein. This alloy passes through a pipe 71 and into a pump engine 72. The pump engine 72 acts to drive the pump 65. From the pump engine 72, this alloy passes through pipe 73 and into spray ring 63 provided in the reheater 62. The hot alloy sprayed downwardly within reheater 62 serves to superheat the relatively low pressure exhaust steam coming from turbine 45. This superheated steam rises within the reheater 62 and passes through outlet pipe 74 thereof into low pressure turbine 75, thereby operating this turbine. The turbine 75 exhausts directly into a condenser 76. Condensate formed within the condenser 76 is conducted by a pipe 17 to the economizer 18 provided in furnace 1. After being heated within economizer 18, this condensate passes through a boiler feed pump 77 and by way of a pipe 78 into the bottom of high pressure boiler 39. This condensed water while passing up through the alloy 56 into the bottom of this boiler is greatly heated thereby, so that by the time this feed water reaches the body of water in the boiler it is substantially at the boiling point.

It will be noted that with the exception of outlet pipe 44 which may be of relatively short length, no high pressure, high temperature piping is used in the novel steam generating system of this invention, which is not only conducive of safety and economy but which enables the present system to produce exceedingly high degrees of superheat.

Also, the actual physical contact of the metal alloy with the boiler water and generated steam produces a rapid transfer of heat between these substances and enables a small plant installation to have a relatively great steam generating capacity.

The use of a baffle means for protecting the high pressure boiler walls from the high temperature of the incoming alloy and its superheated steam is a valuable innovation as it greatly enhances the pressure capacity of the boiler with relative safety.

The use of the pressure energy of the alloy for assisting in circulating the same is

conductive of operating economy as is also the continuous recirculation of the same alloy which in effect operates in a closed system.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:—

1. A steam generating system comprising in combination, a furnace for heating a fluid circulating alloy while at substantially atmospheric pressure and out of contact with furnace gases, a high pressure boiler, and pump means for pumping the hot circulating alloy from said furnace into said boiler to generate superheated steam therein, said boiler being so constructed and arranged that the highly superheated steam generated therein does not contact with the walls of said boiler.

2. A steam generating system comprising in combination, a furnace, a high pressure steam boiler having means to protect its walls against dangerously high temperatures and means comprising a circulating metal for conveying heat from said furnace to said boiler for generating and superheating steam therein, said protecting means contained within said boiler serving to retain hot alloy and superheated steam away from the walls of said boiler.

3. A steam generating system comprising in combination, a furnace, a high pressure steam boiler, means comprising a circulating metal for conveying heat from said furnace to said boiler, said furnace serving to heat said circulating metal at substantially atmospheric pressure and while out of contact with furnace gases, and means for spraying said circulating metal into said boiler for generating and superheating steam therein, said superheated steam passing upwardly through said metallic spray and out at the top of said boiler without contacting with the walls thereof.

4. A steam generating system comprising in combination, a furnace, a high pressure steam boiler, means comprising a circulating metal for conveying heat from said furnace to said boiler, means for spraying said circulating metal into said boiler for generating and superheating steam therein, and baffle means for protecting the boiler walls from contact with the superheated steam therein.

5. In a generating system, in combination, means for heating liquid metallic alloy, and a boiler, said boiler having a lower internal liquid space and an upper internal vapor space, means for spraying the hot metallic alloy supplied from said heating means into

said boiler, for evaporating the liquid in said liquid space and for superheating the vapor in said vapor space, and means for protecting the walls of said boiler from the great heat of said hot metal and the superheated vapor.

In testimony, that I claim the invention set forth above I have hereunto set my hand this 9th day of April, 1929.

FRAZER W. GAY.

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