April 13, 1943. J. E. LOEFFLER 2,316,522

ROTARY VAPOR GENERATOR

Filed Sept. 9, 1939 3 Sheets-Sheet 1

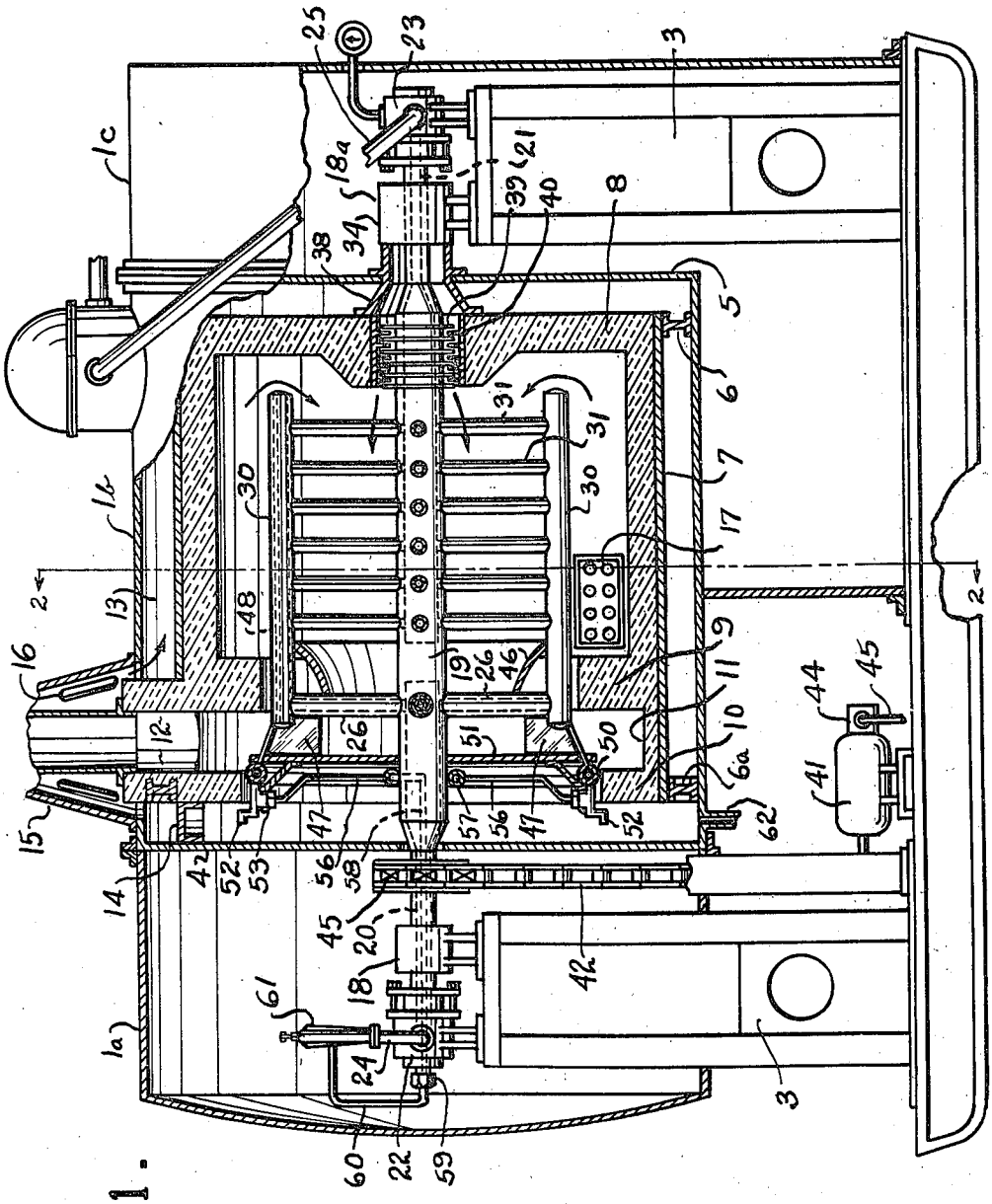


Fig. 1.

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ROTARY VAPOR GENERATOR

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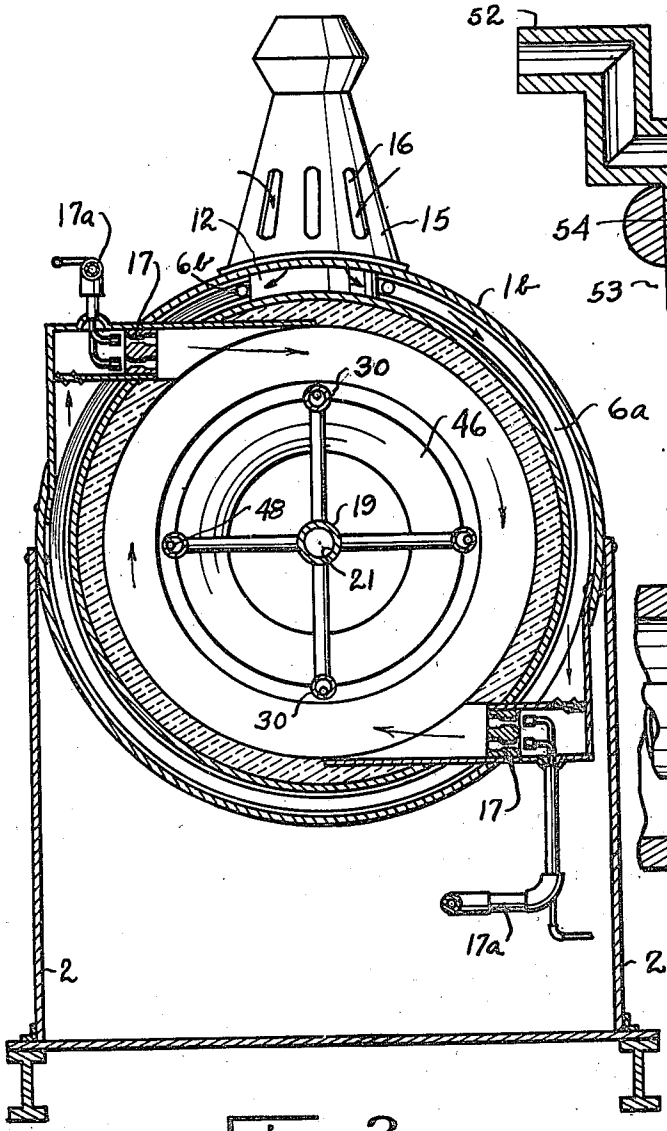


Fig. 2.

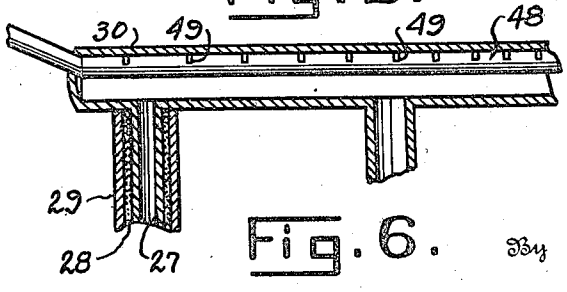


Fig. 6.

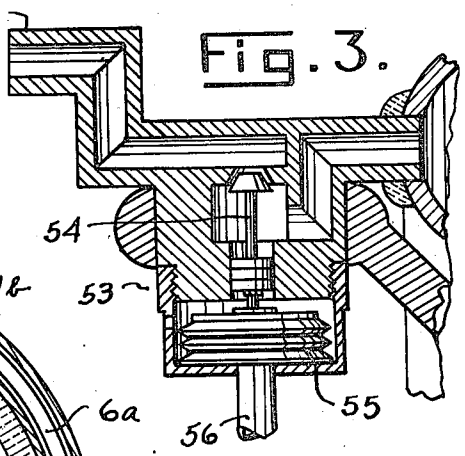


Fig. 3.

Fig. 4.

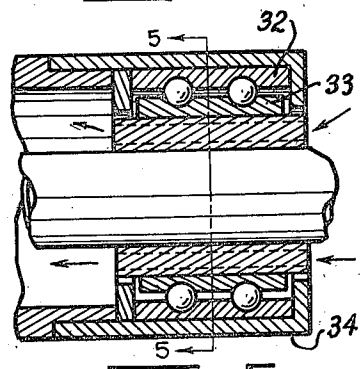
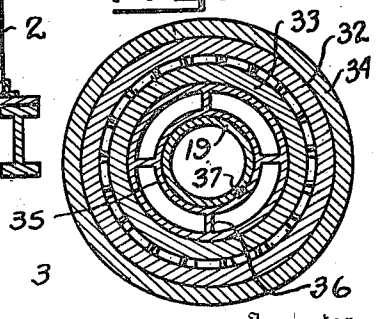


Fig. 5.



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ROTARY VAPOR GENERATOR

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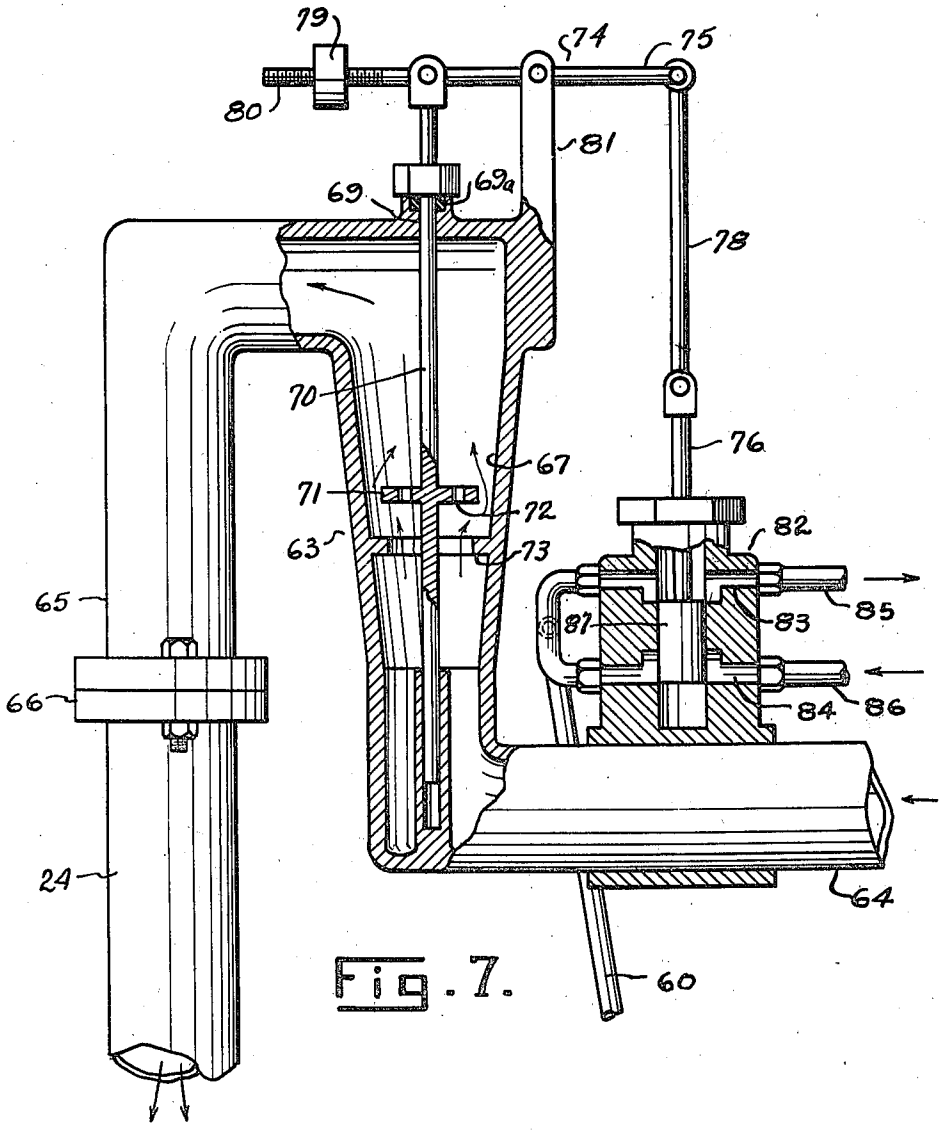


Fig. 7.

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2,316,522

UNITED STATES PATENT OFFICE

2,316,522

ROTARY VAPOR GENERATOR

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Application September 9, 1939, Serial No. 294,077

6 Claims. (Cl. 122—11)

This invention relates to a rotary vapor generator.

An object of the invention is to provide a vapor generator in which the vapor generating tubes are rotated and which is preferably adapted to be used for the generation of steam; however, the generator may be generally used for converting liquid to vapor.

Another object of the invention is to provide a vapor generator in which the vapor generating tubes are rotated, to secure recurrent contact between the combustion gases and said tubes, which recurrent contact of the tubes with the gases is effective to reduce the heating surface required to transfer the heat from gases through the tubes, to liquid in the tubes.

Another object of the invention is to provide a vapor generator in which the vapor generating tubes are rotated at high speed through the combustion gases to decrease the thickness of the insulating gas film around said tubes which results in an increase in the overall coefficient of heat transfer between said gases and said tubes and thence to the liquid in the tubes. By thus passing the tubes through the gases rather than the gases around the tubes, the necessary velocity of the combustion gases through the furnace is decreased and more time is allowed for combustion so that less excess air is required. The reduced amount of excess air used results in less unutilized heat passing out of the furnace because of said excess air.

Another object of the invention is to provide a vapor generator in which rotating steam manifold tubes communicate with the liquid source by means of centrally terminating hollow water legs connected to and rotating with said tubes. The speed of rotation of said legs is made sufficient to cause the centrifugal forces exerted by the water columns in the legs to balance the opposite forces exerted by the steam pressure, thus eliminating the necessity of a boiler feed pump.

Another object of the invention is to provide a vapor generator having rotating manifolds in which condensate containing boiler scale forming substances and other impurities, separated by chemical means, is collected by centrifugal settling and is removed from said manifolds by an automatically controlled blow-down system which operates in conjunction with the feed water supply so as to blow-down a predetermined percentage of the entering feed water.

Another object of the invention is to provide a vapor generator with rotating steam tubes and manifolds mounted in a novel furnace in which the hot combustion gases are directed by means of the pressure wall caused by said rotating manifolds, are drawn around the steam tubes thereby superheating the vapor, and are then forced out of the furnace by means of an internal fan which is connected to and rotates with the vapor generating assembly.

A further object of the invention is to provide a vapor generator having rotating radial steam tubes through which the steam is conducted radially inwardly so that centrifugal force will act on the steam, which force is effective to prevent entrainment of moisture in the steam to thereby allow only dry or superheated steam to leave the tubes.

A still further object of the invention is to provide a vapor generator with rotating vapor generating tubes mounted in a novel furnace, the walls of the furnace being surrounded by and spaced from a sheet metal shroud forming therebetween a heating chamber through which the air is passed and is preheated before being used to support the combustion in the furnace.

With the above and other objects in view, the invention has particular relation to certain novel features of construction, operation and arrangement of parts, an example of which is given in this specification and illustrated in the accompanying drawings, wherein:

Figure 1 shows a vertical, sectional view of the apparatus taken along the longitudinal axis thereof.

Figure 2 shows a vertical, sectional view of the apparatus taken along the line 2—2 of Figure 1.

Figure 3 shows an enlarged sectional view of the blow-down nozzle valve.

Figure 4 shows a sectional view of a novel shaft bearing employed in the apparatus.

Figure 5 shows a sectional view taken along the line 5—5 of Figure 4.

Figure 6 shows an enlarged, fragmentary sectional view of the blow-down system, and

Figure 7 shows a sectional view of the control valve for the blow-down system.

Referring now more particularly to the drawings wherein like numerals of reference designate the same parts in each of the figures, the numeral 1 designates a sheet metal covering or shroud which comprises a forward end section 1*a*, an intermediate section 1*b* and a rear section 1*c*, which sections are detachably secured together. As shown in Figures 1 and 2 the shroud has depending sides 2, 2 at the rear end by which the shroud is substantially supported. Mounted in the forward and rear sections 1*a*, 1*c* of the shroud

are the upstanding pedestals 3, 3 which serve as supports for the rotating shaft 19.

The center section 1b of the shroud is circular in vertical transverse cross-section and is closed at the end by front and rear plates 4, 5, respectively.

A furnace is mounted within the center section and is supported therein by I-beams 6, 6a which are suitably secured therein by welding or riveting. Seated on the inner peripheries of the I-beams is the tubular sheet metal furnace sheathing 7 which forms a support for the refractory material of the furnace. The refractory material is shaped to form a furnace which is closed at the rear end by a wall 8 and the furnace is open at the forward end thereof. Adjacent the forward end of the furnace, the refractory material extends radially inwardly to form an annular, intermediate baffle 9 and also a similar end baffle 10 is formed therein leaving an annular trough 11 between the baffles as more particularly shown in Figure 1. At the forward end of the furnace a stack 12 is constructed which connects with the trough 11.

It will be noted that the I-beam 6a forms a partition which separates the annular chamber 13 from the forward end of the furnace. Also positioned around the stack 12 is a channel 14 which forms a partition around the stack. The I-beam 6a is perforated by holes 6b (Figure 2) so that an air connection may be made between the frusto-conical jacket 15 around the stack and the annular chamber 13. The jacket 15 is provided with suitable openings 16 therein.

Positioned tangentially to the inner surface of the furnace wall are the burners 17, 17 of a suitable type, but preferably that type of burner shown and which is more accurately described in United States Patent No. 2,136,449 issued on the 15th day of November, 1938. Fuel is conducted to the burners 17, 17 by the fuel pipes 17a, 17a.

Rotatably mounted in bearings 18, 18a which are supported on the pedestals 3, 3 is the generator shaft 19. The generator shaft has bores 20, 21 which do not communicate with each other. Also mounted on the pedestals are the glands 22, 23 which communicate with the bores 20, 21, respectively. A water feed pipe 24 is connected to the gland 22 and a steam outlet pipe 25 is connected to the gland 23 which pipes conduct fluid through the glands and bores. Attached to the shaft 19 are the water legs 26, 26, the construction of which is more particularly shown in Figure 6. Each leg comprises an inner pipe 27 surrounded by an insulating material 28 and the insulating material is protected by a tubular sheet 29. Each of the legs connect the manifolds 30, 30 with the bore 20 of the shaft 19. As shown in Figure 1 the manifolds 30 are connected with the bore 21 of the shaft 19 by means of the series of steam tubes 31, 31.

Due to the fact that hot steam is carried by the shaft 19 in the bore 21, the bearing 18a must be cooled, which is accomplished by air passing through the novel bearing more particularly shown in Figures 4 and 5. The bearing 18a comprises an outer bearing race 32 and an inner bearing race 33, the outer race 32 being suitably mounted in the bearing housing 34 which is mounted on the pedestal 3. The inner race 33 is mounted on a sleeve 34 which is maintained in spaced relation with the inner sleeve 35 by means of supporting vanes 36, 36 whereby air may be allowed to pass between the sleeves 34, 35. The sleeve 35 is keyed to the shaft 19 by means of the key 37. As shown in Figure 1 air passes through the bearing assembly 18a into the furnace through the funnel 38 and baffles 39, 40 mounted on the shaft and wall 8, respectively.

The shaft 19 is rotated by the motor 41, chain 42 and sprocket 43 mounted on the shaft. The motor 41 is preferably a conventional rotary vapor engine having an adjustable governor 44 controlling the feed of motive fluid thereto from the line 45. This motor may be driven by high pressure gas until steam pressure is built up in the generator and then steam from the generator will be used to drive the motor, which connections are not shown.

Connected to the manifolds 30 and water legs 26 is the outwardly diverging, annular baffle 46. Mounted on the forward side of the legs 26 are blades 47, 47 which form a blower.

The novel blow-down system hereinafter described, is more effective in this rotary generator, but is also adapted to be used in conjunction with any type of vapor generator. The system includes a collector 48 mounted longitudinally in the manifolds 30. The collectors are tubular in shape and closed at the rear end and have slots 49, 49 therein. It can be noted from an inspection of Figure 6 that the slots are positioned more closely at the rear end of the collectors 48 and manifolds 30. The collectors extend beyond the forward ends of the manifolds 30, diverging outwardly with respect to the shaft 19 and terminating in a tubular sludge ring 50.

The collectors are welded to the manifolds at the point of exit therefrom so that no water can escape from the manifolds 30, 30 around the collectors 48, 48. Mounted on the shaft 19 is the disc 51 which closes the end of the furnace and also serves as a support for the sludge ring 50. Leading from the sludge ring 50 are a plurality of spray nozzles 52, 52. The flow of fluid through the spray nozzles is controlled by a suitable valve assemblies 53, 53 which comprise balanced valves 54 which are actuated by bellows 55, 55, which communicate with the pipes 56, 56.

The pipes 56 terminate in an annular tube 57 which is mounted on the shaft 19. A pressure connection is established between the annular tube and an external source of pressure by means of a pipe 58 in the bore 20 of the shaft 19 terminating at one end in the annular tube 56 and at the other end in the gland 59 which is mounted in the end of the shaft 19. A tubing 60 is connected between the gland 59 and the blow-down valve assembly 61.

A drain tube 62 is connected into the lower side of the shroud below the nozzles 52, 52. The blow-down valve assembly 61 is of a conventional type of proportioning mechanism as shown in Figure 7. This assembly includes a casing 63 one end of which 64 is connected to a suitable supply of water for the generator (not shown) and the other end 65 of which is connected to the water feed pipe 24 by means of the flange connection 66.

Reciprocably mounted in the upwardly and outwardly diverging throat 67 by means of a guide 68, bearing 69 and gland 69a is the stem 70. A piston 71 having ports 72 is positioned on the stem 70 so that it will contact the stop 73 mounted in the throat when in the lowermost position. The upper end of the stem is pivotally connected to the balance arm 74. The lever arm 75 of the balance arm 74 is connected to the valve stem 76 by means of the link 78. A weight 79 is movably mounted on the weight arm 80 of the

balance arm 74. The balance arm is suitably mounted, at a point intermediate the link 78 in the stem 70, upon an upstanding support 81 on the casing. The valve 82 comprises a valve casing mounted on the end 64 of the casing 63 and has a valve chamber therein. Leading from the valve chamber are the flowways 83, 84 one end of the flowways commonly communicating with the tubing 60 and the other end of the flowways 83, 84 communicate with the bleed lines 85 and inlet lines 86, respectively. A piston valve 87 positioned in the valve chamber is arranged to close one flowway when the other flowway is completely open; and also when one flowway is partially open the other flowway will be partially closed. The inlet line is connected to a suitable supply of pressure fluid, as gas, and the bleed line terminates in the furnace or atmosphere. The line 60 terminates in the gland 59 as hereinabove stated.

In starting, the water legs 26, manifolds 30 and steam tubes 31 are substantially filled with water. A motive fluid is then delivered to the motor 41 to rotate the shaft 19 and generator assembly at a predetermined R. P. M. The burners 17 are then ignited to heat the furnace. The hot gases flowing through the furnace will heat the manifolds 30 and steam tubes 31 to form steam therein which steam will cause a rise in pressure. This pressure rise will practically force all the water into the manifold 30, from generating tubes 31 into the water legs 26 thereby forming substantially a U-tube having water in one side and steam pressure in the other side. In order to balance the steam pressure, the water tubes and manifolds are rotated at sufficient velocity so that the centrifugal force caused by the rotating columns of water in the water legs 26 will balance the steam pressure acting on said columns. As hereinbefore stated the water legs are insulated so that no steam is formed therein which might unbalance the system. As the steam pressure is balanced by pressure resulting from the centrifugal force of the column of water in the legs no check valve or feed pump is required to force water into the bore 20 which communicates with the water legs 26. The maximum operating pressure of the generator is therefore determined by the R. P. M. of the shaft and water legs which R. P. M. determines the centrifugal force exerted by the column of the water in said legs.

It is contemplated that the burners will be closely regulated in accordance with the steam required from the generator in a conventional manner. The generator will have substantially no reserve capacity, the variation in steam required from the generator being taken care of by close regulation of the burners 17, the reserve or residual heat in the refractory material being just enough to keep the motor 41 supplied with an operating vapor, so that when the burners are cut off, due to a reduction in steam required from the generator, there will be only enough heat in the furnace to supply steam to the motor 41.

It can also be seen that the high velocity required to give the above centrifugal effect to the water columns in the legs 26 will also be beneficial as there will be a scrubbing effect of the furnace gases on the manifolds 30 and vapor tubes 31 due to said high velocity. As is common in boiler practice, this scrubbing effect is very necessary in order to secure efficient heat transfer between the gases and generating tubes, but the relative velocity between the gases and boiler tubes is ordinarily attained by high velocity of combustion gases through the furnace. The high velocity gases require much excess air in order to secure complete combustion of fuel injected into the furnace. In this generator the velocity of the gases through the furnace may therefore be low, without losing the scrubbing effect above described, so that less excess air is required. Less excess air is beneficial as there is less wasted heat for heating the excess air, furnace temperatures are higher, which higher furnace temperature gas makes greater heat drop between the manifolds, steam tubes and the furnace. As the heat transfer between two tubes is dependent upon the temperature differences of the objects, the high furnace temperature will raise the amount of heat transfer and therefore raise the efficiency of said transfer.

As shown in Figures 1 and 2, the shroud 1 forms an annular chamber 13 around the furnace which chamber is necessarily very warm due to its proximity to the outer surface of the furnace wall. This chamber serves as an air preheater as hereinafter described. Air is admitted into the chamber 13 through the opening 16 in the jacket 15 around the stack and into said chamber. The channel 14 forms a partition around the stack 12 so that air is not admitted into the forward end of the furnace, and the I-beam 6a also performing the same function.

As shown in Figure 2 air from the chamber 13 is admitted to the burners 17, which burners discharge tangentially with respect to the walls of the furnace.

The high velocity of the manifolds 30 is also beneficial in controlling the flow of the hot gases through the furnace as the rotation of the manifolds forms a pressure wall through which the hot gases cannot penetrate so that they must flow into the rear end of and through the tube assembly around the steam tubes 31. Mounted in the forward end of the tube assembly adjacent the water legs are the blades 47 which form a suction blower to suck the gases through the assembly and force them out the stack 12 through the channel 11. The disc 51 adjacent the blades and the annular baffle 46 mounted on the manifold and water legs aid in directing the flow of the hot gases. It can therefore be seen that the manifolds will act as disengaging surfaces wherein the steam is formed from the water as these manifolds are subject to radiant heat of the furnace which is obviously the hottest area therein. The hot gases through the assembly around the steam tubes will further heat the steam and cool the gases so that the gases when passing the water legs 26 are at their lowest temperature thereby maintaining the relative positions of the water in the water legs 26 and the steam in the manifolds and steam tubes so that the balance between the pressure resulting from the centrifugal force of the water columns of the legs 26 and the steam pressure in the manifolds is maintained.

It is also beneficial that the manifolds 30 are the disengaging surfaces for the correct function of the blow-down system as hereinafter described. If water is used which contains scale forming impurities therein, it is very necessary that these impurities be removed in some manner as the disengaging surface is so small. The manifold tubes will act as an evaporator to distill water from the solution leaving the impurities behind. The impurities will not precipitate out

of the solution until a certain concentration point of the solution is reached. In order to prevent the scale from forming on the manifolds 30 this concentrated solution of impurities and water is removed before the solution becomes concentrated enough to allow precipitation. Due to the high rotative velocity of the manifolds this concentrated solution is collected by centrifugal force in the outer portions of the manifold. The concentrated solution is drained from the manifolds by the collector 48 into the sludge ring 50 thence into the forward end of the furnace through the nozzles 52. A large portion of the liquid released will flash into the steam and will go out of the stack and the remainder will drain out of the drain tube 62. As shown in Figure 6 the slots 49 and collector 46 are positioned closer together at the rear end of the manifold, than at the forward end thereof so that the concentrated solution is caused to flow forwardly in the collectors. Also the sludge ring has a greater radius with respect to the shaft 19 than that of the manifolds 30 so that centrifugal force is greater at the sludge ring to aid in causing the concentrated solution to flow out of the manifolds.

It is desirable that a certain proportion of the water entering the generator be drained from the nozzles 52 in order to reduce the loss of heat which is lost with the solution from the nozzles. This control is accomplished by means of the nozzle valve 53 which comprises a valve stem operated by the bellows 55 which bellows is expanded by pressure through the pipe 56 as shown in Figure 4. The valve 53 may be of any conventional construction which is slightly unbalanced to cause the valve 54 to tend to open at all times.

As hereinbefore described the pipe 56 is connected with the tubing 60 by means of the annular tube 56, pipe 58 and gland 59. Between the pipe 58 and the shaft 59 adjacent the tubular ring 57 will be a suitable seal as a threaded connection or similar construction so that there is no leakage from the bore 20 around the pipe 58.

The proportioning mechanism shown in Figure 7 is merely an illustrated form as any type may be used. This proportioning mechanism functions to release pressure from the bellows 55 to allow the valve 54 to open as the quantity of water entering the generator increases. As the velocity of water through the throat 67 is increased the piston 71 and stem 70 will be raised causing the piston valve 87 to be lowered. The piston 71 and piston valve 87 will be in the position shown for maximum flow of water into the generator. Here pressure from the bellows 55 is released through the pipe 56 and 58 and tubing 60, flowway 83 and out the bleed line 85, the pressure or inlet connection to the tubing 60 from the inlet line 86 being closed at the same time. Then as less water enters the generator the piston 71 and stem 70 will be allowed to fall connecting the tubing 60 with the pressure inlet 86 through the flowway 84 so that the bellows 55 is actuated. If no water is entering the generator then the piston 71 falls to its lowest position on the stop 73 and the bleed line 85 is closed and cut off from the tubing 60 by the piston valve 87 so that the valve 54 of the nozzle valve 53 is completely closed by the bellows 55 and there is no blowdown. Thus the nozzle valve 53 is opened and closed to vary the amount of solution being released from the columns 48 so that a predetermined percentage of the water entering the generator is released from the nozzles 52.

The high rotative speed of the tubing assembly is also beneficial in causing the steam discharged from the generator to be of very high quality. As hereinbefore described the steam released from the water therein travels radially inward through the steam tubes 31 to the bore 21 and shaft 19. Centrifugal force acting on the particles of vapor in these steam tubes 31 will prevent heavy particles of vapor from travelling through the steam tubes 31 to the bore 21. As the hot gases also pass around these tubes the combination of the centrifugal operating effect combined with the heating effect of the gases will cause the vapor to be of very high quality.

While the vapor generator is more particularly described with reference to use as a steam generator, the same apparatus may be used to convert mercury and other liquids to vapor for power generation.

Although the preferred position of the shaft and furnace is horizontal, the generator will function properly when the shaft is in a vertical position or at any angular position intermediate vertical and horizontal positions.

What I claim is:

1. A rotary vapor generator comprising a furnace, means for heating the furnace, a rotatable shaft in the furnace, radial tubular legs on the shaft, radial tubes on the shaft, manifolds connecting said legs and tubes in series, an annular funnel shaped baffle extending radially inwardly from the manifolds and a fan at the end of the funnel for creating a draft through the furnace, a liquid inlet conduit communicating with the legs and a vapor outlet conduit communicating with the tubes.

2. A rotary vapor generator comprising a furnace, means for heating the furnace, a rotatable shaft in the furnace, radial tubular water legs on the shaft, radial steam tubes on the shaft, manifolds at the radially outer ends of the legs connecting said legs and tubes in series, a water inlet communicating with the legs, a vapor outlet conduit communicating with the tubes and a valve controlled conduit leading from the manifolds effective to relieve condensate from the water in the manifolds.

3. A rotary vapor generator comprising a furnace, means for heating the furnace, a rotatable shaft in the furnace, radial tubular water legs on the shaft, radial steam tubes on the shaft, manifolds connecting said legs and tubes in series, a water inlet communicating with the legs, a vapor outlet conduit communicating with the tubes and a valved conduit means for blowing down the manifolds while the tubes are rotating.

4. A rotary vapor generator comprising a furnace, means for generating heat in the furnace, a rotary shaft, a series of tubular radial fluid conductors on the shaft in the furnace, a manifold connecting the ends of the conductors, a liquid inlet conduit communicating with one of the conductors of the series and a vapor outlet conduit leading from the other conductors of the series, means for relieving a predetermined amount of the water entering the liquid inlet conduit from the manifolds to blow-down the generator.

5. A rotary vapor generator comprising a furnace, means for heating the furnace, a rotatable shaft in the furnace, radial insulated tubular water legs on the shaft, radial steam tubes on the shaft, manifolds connecting said legs and tubes in series, a water inlet communicating with the

legs, a vapor outlet conduit communicating with the tubes, means for rotating the shaft at high speed so that the centrifugal force of columns of water in said water legs will prevent said columns of water from being forced out of the water legs by steam pressure in the steam tubes and manifolds and means including a baffle and current generator for creating a draft through the furnace.

6. A rotary vapor generator comprising a furnace, means for generation of heat in the furnace, a rotary shaft, a series of tubular radial fluid conductors on the shaft in the furnace, manifolds extending longitudinally of the furnace and connecting the outer ends of the conductors, said shaft, radial conductors and manifolds forming a tube assembly, a liquid inlet conduit communicating with one of the conductors of the series and a vapor outlet conduit leading from the other conductors of the series, means for rotating the shaft at high speed, said manifolds being adapted to form a wall of high velocity air as the assembly is rotated, the furnace having an exhaust at the forward end and being spaced from the rear end of and also radially from the manifolds, a baffle in the forward end of the furnace co-acting with the wall of air to prevent movement of gases between the furnace and the tube assembly past the forward end of the assembly, said wall of air preventing passage of gases radially past the manifolds, blades mounted on the forward end of the shaft to form a blower effective to suck air forwardly through the assembly, whereby air is sucked from outside of the assembly, around the rear end of the manifolds, through the assembly and out the exhaust at the forward end of the furnace.

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