

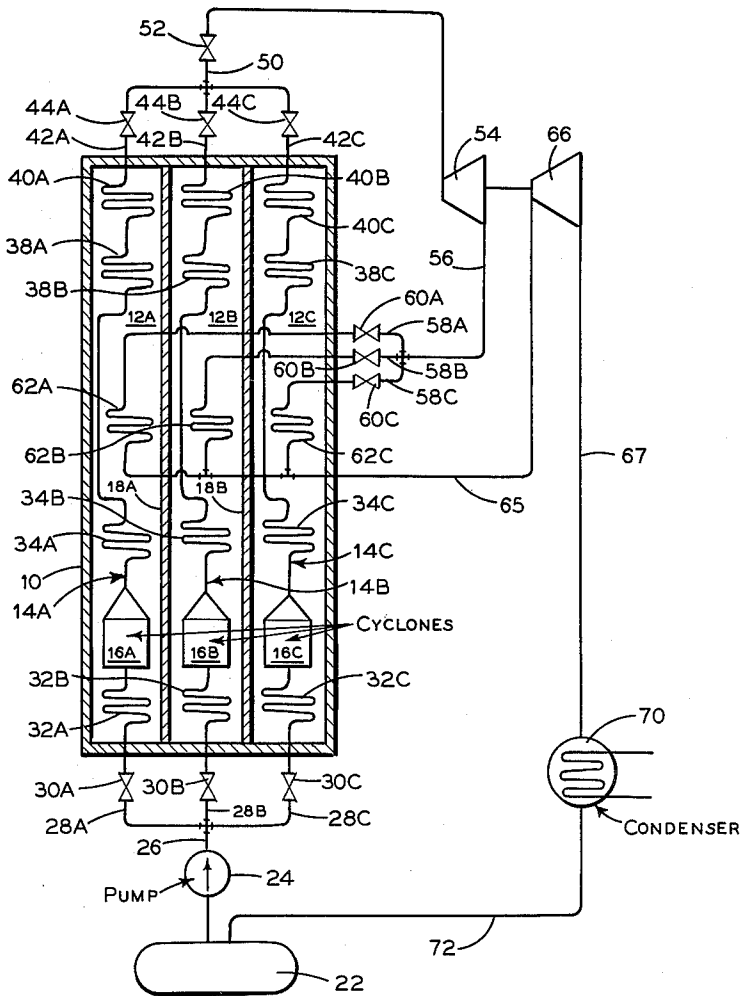
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K. DEITLHAÜSER

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ONCE-THROUGH VAPOR GENERATOR

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INVENTOR.

Karl Deitlhaüser

BY

J. P. Moran

ATTORNEY

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ONCE-THROUGH VAPOR GENERATOR

Karl Deitlhauser, Munich, Germany, assignor to Durrwerke Aktiengesellschaft, Ratingen, Germany, a corporation of Germany

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This invention relates in general to improvements in forced flow, once-through vapor generators and more particularly to the construction and operation of a plural chambered, cyclone furnace fired, forced flow, once-through vapor generator designed for wide load range operation.

There are certain disadvantages which limit the use of cyclone furnaces in firing forced flow, once-through vapor generators where wide load range operation is required. An important feature of cyclone furnace operation is the entrainment of ash in a liquid slag which in turn flows from the furnace to a slag tank. It is essential to maintain the temperature within the cyclone furnace above the ash fusion temperature and thereby keep the slag liquid. If the slag freezes it will prevent proper furnace operation. Because of this inherent limiting characteristic cyclone furnaces have a load range on the order of 3 to 1.

Additionally, in forced flow once-through vapor generators there are certain vaporizable fluid velocity limitations which affect the width of its control range. The amount of heat input to the tube system demands that certain minimum tube flow velocities be maintained regardless of vapor generator load to prevent tube burn-out. In turn, the maximum load to which any given flow circuit can be operated is determined by the pressure drop that can be economically tolerated by the overall vapor generating system. These considerations dictate a controlled velocity range of approximately 3 or 4 to 1 which is similar in scope to the load range required for cyclone furnace firing.

In order to use a cyclone furnace fired, forced flow, once-through vapor generator for wide load range operation the limitations on load range caused by the use of a cyclone furnace and by the need to prevent tube burn-out must be overcome. It has been known to use a forced flow, once-through vapor generator fired by a plurality of cyclone furnaces. While this arrangement permits an increased load range for the combustion system in once-through vapor generators of conventional construction it, nevertheless, results in overheating and failure of the tube system because the flow velocities fall below the permissible limits to properly cool the tubes.

Therefore, it is the purpose of the present invention to provide a once-through vapor generator fired by a plurality of cyclone furnaces which operates over a wide load range. The setting of the unit in the present invention is separated by division walls into individual heating gas chambers. Each of the individual chambers is provided with a separately fired cyclone furnace and with tube means forming an individual forced flow, once-through vapor generating and superheating system. Each of the vapor generating and superheating systems receives a vaporizable liquid from a common source. The superheated vapor generated within the individual vapor generating and superheating systems is delivered to a common discharge point.

The various features of novelty which characterize the

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invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which a certain specific embodiment of the invention is illustrated and described.

Referring to the drawing, which shows a schematic diagram of an embodiment of the invention, a setting 10 for a forced flow, once-through vapor generator is separated by division walls 18A, 18B into individual heating gas chambers 12A, 12B, 12C. Each of the individual chambers 12A, 12B, 12C has a once-through vapor generating tube system 14A, 14B, 14C and a separately fired cyclone furnace 16A, 16B, 16C. The arrangement of the cyclone furnace as embodied in the invention is disclosed in Patent No. 2,594,312. A vaporizable liquid is supplied to each of the vapor generating tube systems 14A, 14B, 14C at a substantial positive pressure by a single feed pump 24. The pump 24 receives its supply of vaporizable liquid from a feed liquid storage tank 22.

The liquid to be vaporized is delivered by the pump 24 to a conduit 26 which is trifurcated and forms the flow passageways 28A, 28B, 28C. Valves 30A, 30B, 30C are located in the flow passageways 28A, 28B, 28C and control the flow of vaporizable liquid to the separate once-through vapor generating tube systems 14A, 14B, 14C. If the valves 30A, 30B, 30C are open the vaporizable liquid enters the once-through tube systems and passes first through the economizer sections 32A, 32B, 32C where the vaporizable liquid receives a substantial amount of the heat necessary to raise it to the saturated steam temperature. The vaporizable liquid upon leaving the economizer sections then flows serially through tubes which form the walls of the separately fired cyclone furnaces 16A, 16B, 16C and through final vapor generating tube sections 34A, 34B, 34C.

In flowing through the wall tubes of the cyclone furnaces and the final vapor generating tube sections the vaporizable liquid receives the final heat required for vaporization. The vaporized fluid next passes in succession through primary superheaters 38A, 38B, 38C and secondary superheaters 40A, 40B, 40C wherein it receives the final degree of superheat.

The superheated vapor then passes from the once-through vapor generating tube systems 14A, 14B, 14C within the individual chambers 12A, 12B, 12C and flows through the parallel conduits 42A, 42B, 42C external of the setting 10, to a common high pressure vapor outlet line 50. Valves 44A, 44B, 44C are located in the conduits 42A, 42B, 42C to control the flow of vapor there-through. A main cut-off valve 52 is provided in the common vapor outlet line 50. The superheated vapor flows through the common discharge line to a high pressure turbine 54 wherein it expands to do work and leaves at a reduced pressure and temperature. The reduced pressure vapor passes from the high pressure turbine through a flow passageway 56. The flow passageway 56 is trifurcated to form parallel flow passageways 58A, 58B, 58C which reenter the individual chambers 12A, 12B, 12C. Valves 60A, 60B, 60C are located in the passageways 58A, 58B, 58C to control the flow of vapor therethrough. The reduced pressure vapor passes through the flow passageways 58A, 58B, 58C to reheaters 62A, 62B, 62C located within the individual heating gas chambers 12A, 12B, 12C where the vapor is again heated. The reheated vapor leaves the reheaters 62A, 62B, 62C through a common low pressure outlet line 65 and is delivered to a low pressure turbine 66. The reheated vapor does further work within the low pressure turbine and then flows to a condenser 70 through a conduit 67.

After the vaporized fluid is condensed it is returned to the feed liquid storage tank 22 by way of a conduit 72.

The embodiment of the invention as illustrated in the drawing shows three individual heating gas chambers 12A, 12B, 12C within a single setting 10 each having its own separately fired cyclone furnace 16A, 16B, 16C and forced flow, once-through vapor generating tube system 14A, 14B, 14C. As has already been stated a single cyclone furnace fired vapor generator operates on a load range of 3 to 1, however, the embodiment illustrated widens the load range of a cyclone furnace fired vapor generator to 9 to 1 without the previously encountered limitations.

At full load the three separately fired cyclone furnaces and their companion once-through vapor generating tube systems operate at maximum output. As the demand on the vapor generating unit decreases the firing rate of the individual cyclone furnaces must be either reduced or one or more of the cyclone furnaces taken out of operation. Since a single feed pump 24 supplies the vaporizable fluid to all of the once-through vapor generating tube systems 14A, 14B, 14C the velocity of the vaporizable fluid in each of the operating tube systems is uniform. Therefore, since the flow velocities are uniform the firing rate of the cyclone furnaces 16A, 16B, 16C must be kept uniform, where more than one cyclone furnace is being operated, so that vapor is generated at a uniform temperature and pressure. For example, if the vapor generating unit is operating at 75% of its maximum output the three cyclone furnaces each deliver heating gases to the system at 75% of their maximum load and in turn the feed pump is adjusted to deliver vaporizable liquid to the tube systems at a velocity sufficient to generate vapor at the temperature and pressure required. As the demand decreases below two-thirds of the maximum output of the vapor generating unit, it becomes possible to cut out one of the once-through vapor generating tube systems, and so too when the demand further decreases to below one-third, it is possible to cut-out a second vapor generating tube system.

To illustrate reduced operation of the vapor generating unit if it is operating at say 60% of its maximum output two cyclone furnaces 16A, 16B can be kept in operation while the third cyclone furnace 16C is shut down. To achieve an overall vapor generating output of 60% of maximum the two cyclone furnaces must deliver heating gas to the individual chambers 12A, 12B at 90% of their maximum load. The feed pump is adjusted to supply the vaporizable liquid to the tube system 14A, 14B at 60% of its full load capacity and at a velocity required by the vapor generating tube systems 14A, 14B to operate at 90% of their full load. The valves 30C and 44C are closed to shut off the vapor generating tube system 14C and the valve 60C is closed to cut out the reheater 62C. Accordingly, the vapor generator described herein will satisfy any load requirement within a range of 9 to 1 by controlling the operation of the feed pump and the firing of the separate cyclone furnaces. In addition, though the load range is widened the range of flow velocities in the tube systems will remain unchanged due to the novel vapor generating tube system arrangement.

Therefore the construction of the present invention provides a means for using a cyclone furnace fired, forced flow, once through vapor generator where a wide load range is desired. By dividing a once-through vapor generating unit into separate individual systems it is possible to widen the load range as a direct function of the number of individual systems which compose the vapor generating unit. Each of the individual systems has its own cyclone furnace firing means and vapor generating system though they all have a common source of vaporizable liquid and a common point of discharge. Therefore, the novel construction of the present invention permits the usual load range of 3 to 1 of a cyclone furnace fired once-through vapor generator to be increased in direct relation

to the number of individual heating gas chambers which make up the vapor generating unit. Though, the construction of the present invention permits the load range to be increased the velocity range is not affected and remains the same for each individual vapor generating tube system thereby avoiding the problem of tube failure due to overheating.

Therefore, the present invention permits a much wider load range in the use of a cyclone furnace fired, forced flow, once-through vapor generating system without the usually accompanying problem of tube failure at lower loads which result from reduced flow velocities.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a forced flow once-through vapor generating and superheating unit adapted for wide load range operation, walls defining a setting, division walls arranged to divide said setting into separate individual adjoining heating gas chambers, a separately fired cyclone furnace for each of said chambers arranged to supply heating gases only to its corresponding chamber, tube means forming separate parallel forced flow once-through vapor generating and superheating flow paths in each of said chambers for effecting a continuous parallel flow of liquid through said flow paths as the liquid is vaporized and superheated, means for supplying a vaporizable liquid to all of said parallel flow paths from a common supply, individual valve means to control the flow of vaporizable liquid through each of said flow paths, said valve means located exteriorly of said setting, and means for delivering the vapor superheated in said parallel flow paths to a common discharge point.

2. In a forced flow once-through vapor generating and superheating unit adapted for wide load range operation, walls defining a setting, division walls arranged to divide said setting into separate individual adjoining heating gas chambers, a separately fired cyclone furnace for each of said chambers arranged to supply heating gases only to its corresponding chamber, tube means forming separate parallel forced flow once-through vapor generating and superheating flow paths in each of said chambers for effecting a continuous parallel flow of liquid through said flow paths as the liquid is vaporized and superheated, said tube means for each of said flow paths comprising an economizer section, a fluid heating section a portion of which forms the walls of said cyclone furnace, a primary superheater and a secondary superheater, means for supplying a vaporizable liquid to all of said parallel flow paths from a common supply, individual valve means to control the flow of vaporizable liquid through each of said flow paths, said valve means located exteriorly of said setting, and means for delivering the vapor superheated in said parallel flow paths to a common discharge point.

3. In a forced flow once-through vapor generating, superheating and reheating unit adapted for wide load range operation, walls defining a setting, division walls arranged to divide said setting into separate individual adjoining heating gas chambers, a separately fired cyclone furnace arranged for each of said chambers to supply heating gases only to its corresponding chamber, tube means forming separate parallel forced flow once-through vapor generating, superheating and reheating flow paths in each of said chambers for effecting a continuous parallel flow of liquid through said flow paths as the liquid is vaporized superheated and reheated, means for supplying a vaporizable liquid to all of said parallel flow paths from

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a common supply, individual valve means to control the flow of vaporizable liquid through each of said flow paths, said valve means located exteriorly of said setting, a first common outlet line arranged to receive and to deliver the vapor superheated in said parallel flow paths to a first common discharge point, and a second common outlet line arranged to receive and to deliver the vapor reheated in said parallel flow paths to a second common discharge point.

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