Aug. 8, 1961 P. H. KOCH 2,995,119

APPARATUS FOR SHUT-DOWN OF A FORCED FLOW VAPOR GENERATING UNIT

Filed July 17, 1958

FIG. 1

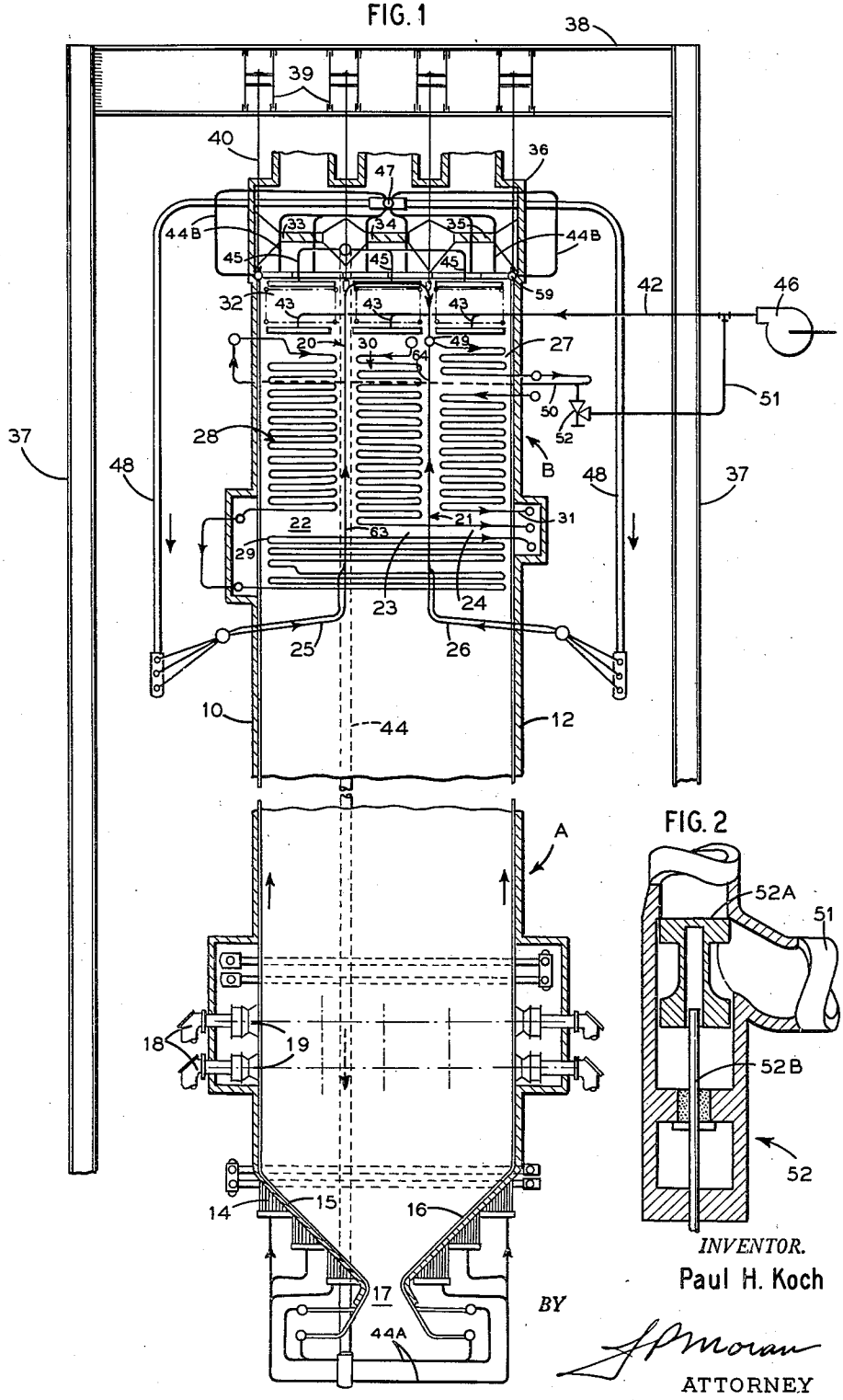

FIG. 2

INVENTOR.
Paul H. Koch

BY

ATTORNEY

United States Patent Office 2,995,119 Patented Aug. 8, 1961

2,995,119

APPARATUS FOR SHUT-DOWN OF A FORCED FLOW VAPOR GENERATING UNIT

Paul H. Koch, East Orange, N.J., assignor to The Babcock & Wilcox Company, New York, N.Y., a corporation of New Jersey

Filed July 17, 1958, Ser. No. 749,123
9 Claims. (Cl. 122—406)

The present invention relates in general to the construction and operation of a forced circulation once-through vapor generating and superheating unit and more particularly to apparatus for and a method of shutting down a forced circulation once-through vapor generating and superheating unit.

In a unit of the character described feed water is pumped into one end of a continuous flow path, along which heat is supplied and from which superheated steam is discharged. It is common practice to provide this type of unit with a fluid recirculation system for start-up and for normal and emergency shut-downs. The recirculation system normally includes a turbine by-pass system which is used primarily in starting the unit; and a superheater by-pass system which is used for by-passing the superheater and turbine during start-up of the unit from a cold condition and from a hot bottled condition and during normal and emergency shut-downs. The superheater by-pass system is employed during shut-downs to prevent rapid cooling of the high temperature superheater and to maintain a recirculating flow of fluid through the unit to absorb the residual heat in the furnace on termination of firing, the heat content of hot slag on the walls of the furnace, and heat radiated by hot refractory. The discharge from these systems subsequently flows to a condenser, then to a feed pump for return to the fluid heating unit. While this recirculation system protects the superheater from thermal shock and the furnace wall tubes from overheating during normal and emergency shut-downs, the heat loss from the working fluid in flowing through the condenser is of a magnitude necessitating an extended firing period to return the fluid to a condition suitable for restarting the turbine. This is particularly disadvaneageous if the operating upset causing an emergency shut-down can be corrected with dispatch or when it is desired to remove the unit from service temporarily but to resume load at a later time with minimum delay. Moreover, this recirculation system is entirely dependent on the feed water pump. If the feed water pump fails, fluid flow through the unit ceases. While provisions are made for immediate suspension of firing on loss of the feed water pump, the furnace wall tubes are subject to overheating or high localized rates of heat input from hot slag at temperatures up to 2800° F., refractory radiation and residual heat in the furnace, thereby presenting the danger of tube failure and creating differential expansion stresses in the furnace wall-forming components.

I have found that these disadvantages may be overcome by providing for natural circulation of fluid through a portion of the fluid flow path during normal and emergency shut-downs if the feed water pump is rendered inactive or fails. The invention is embodied in a forced flow once-through fluid heating unit having a gas flow path normally fired with a fluid fuel; a once-through fluid flow passage in the gas flow path receiving a vaporizable fluid at one end and discharging superheated vapor at the other end; a high heat capacity economizer in a relatively low temperature portion of the gas flow path at an elevation above and discharging fluid to the inlet of the fluid flow passage; and a pump normally supplying fluid under pressure to the inlet of the economizer. In accordance with the invention, a valve-controlled conduit is connected to an intermediate portion of the fluid flow passage and to the inlet side of the economizer to provide natural circulation of fluid through a portion of the fluid flow path during shut-downs and on inactivation of the fluid supply pump. With this arrangement the naturally circulating fluid absorbs residual heat in the gas flow path on discontinuance of firing, heat from the hot slag on walls of the gas flow path when a slag-forming fuel is fired, and heat radiated by hot refractory, then passes the absorbed heat to the relatively low temperature high heat capacity economizer for absorption by the tube metal thereof. This arrangement minimizes heat loss by the fluid during shut-downs, thereby permitting resumption of load by the unit with minimum delay; prevents overheating of the tubes constituting the fluid flow path; and minimizes differential expansion stresses in the walls forming the gas flow path.

The various features of novelty which characterize the 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 drawings and descriptive matter in which certain specific embodiments of the invention are illustrated and described.

Of the drawings:

FIG. 1 is a partially diagrammatic sectional elevation of a forced circulation once-through vapor generating and superheating unit embodying the invention; and

FIG. 2 is an enlarged view of the inverted stop-check valve of FIG. 1.

In the drawings the invention has been illustrated as embodied in a top-supported forced flow once-through steam generating unit designed for furnace operation under internal gaseous pressures above atmospheric pressure and for the production of superheated steam at pressures and temperatures in excess of the critical pressure of 3206 p.s.i. and the critical temperature of 705° F., a unit of this general construction being disclosed and claimed in a co-pending U.S. application of Paul H. Koch, Serial No. 685,119, filed September 20, 1957.

It will be understood that the shut-down system and method of operation hereinafter described can also be advantageously used in a forced flow once-through fluid heating unit designed for sub-critical pressures and temperatures.

The forced circulation steam generating unit illustrated includes a vertically elongated setting of substantially rectangular horizontal cross-section having a furnace chamber A and a superjacent convection gas cooling chamber B defined in most part by a front wall **10**, a rear wall **12** and opposing side walls **14** (of which only one is shown). Each boundary wall includes fluid heating tubes, the arrangement of which is disclosed in the aforesaid application Serial No. 685,119, having their intertube spaces closed by metallic webs to provide a gas-tight enclosure and their outer faces covered by suitable insulation. The lower portion of the furnace chamber is formed by a hopper having inclined front **15** and rear **16** wall portions converging downwardly from the lower ends of the front and rear walls **10** and **12**, respectively, to define a rectangular throat passage **17** for discharging ash into an ash pit, not shown, positioned therebelow.

The furnace chamber A is fired by two vertically spaced rows of horizontally extending burners **18** arranged to direct pulverized fuel and air in mixing relationship into the furnace chamber through corresponding burner ports **19** in the lower portion of the front, rear and side walls.

Upright gas-tight baffles **20** and **21**, each of which includes fluid heating tubes having their intertube spaces

enclosed by metallic webs, cooperate with the enclosure walls **10**, **12** and **14** to define three parallel gas passes **22**, **23** and **24** in the chamber B. Gas passes **22** and **24** are separated from the furnace chamber A by slag screens **25** and **26**, respectively, formed by continuations of the baffle tubes projecting downwardly and outwardly therefrom. The parallel gas passes are occupied by economizer surface and steam superheating and reheating surface or sections in the form of return bend horizontally arranged tubes having their opposite ends connected to headers, most of which are arranged externally of the chamber B. The upper central portion of the gas pass **24** is occupied by an initial primary superheater **27**, the central portion of the gas pass **22** by a final primary superheater **28**, the lower portion of all gas passes by a secondary superheater **29**, which also includes a section disposed subjacent the entrances to the parallel gas passes; the central portion of the gas pass **23** by a first stage reheater **30**; the central portion of the gas pass **24** by a second stage reheater **31**; and the upper portion of all the parallel gas passes by an economizer **32**. The economizer **32** includes three sections arranged for parallel flow of fluid therethrough, respectively disposed in the gas passes **22**, **23**, **24**, and connected to a common supply conduit **42** by tubes **43** and to an unheated downcomer **44** by tubes **45**. Dampers **33**, **34** and **35** control gas flow to the gas passes **22**, **23** and **24**, respectively. Breeching **36** receives gases flowing from the parallel gas passes and passes them to other heat exchange apparatus, not shown. Thus, the gaseous products of combustion passing from the furnace chamber are regulably divided into three parallel streams beyond the screens **25**, **26** and simultaneously flow over the superheating, reheating and economizer surfaces located in the respective passes.

The steam generator setting is top-supported by structural steel members including upright members **37**, cross beams **38**, and beams **39** from which hangers support all walls.

For the sake of clarity, FIG. 1 shows by arrows the flow path of the working fluid during normal operation. Feed water at a pressure of 4500 p.s.i. is delivered by a feed pump **46** through the conduit **42** and tubes **43** to the economizer **32** wherein it is partially heated. The heated fluid then flows through the tubes **45**, the downcomer **44** and supply tubes **44A** to the fluid heating tubes lining the boundary walls of the chambers A and B, then passes through the boundary wall tubes and riser tubes **44B** to a header **47**. Thereafter the fluid passes in parallel through downcomers **48** for flow through the tubes forming the screens **25**, **26** and baffles **20**, **21**, then discharges to a header **49**. The fluid then successively passes through the initial primary superheater **27**, the final primary superheater **28** by way of a conduit **50**, and the secondary superheater **29** to the high pressure stage of a turbine, not shown. Thus the wall tubes of the chambers A and B, the screen and baffle wall tubes and the superheaters cooperate to form a once-through fluid flow passage of which the predominant portion is located in the high gas temperature zones of the furnace and parallel gas passes. Partially expanded steam from the turbine passes through the reheater **30** from which it flows to the intermediate stage of the turbine. After the intermediate expansion stage, the steam flows through the reheater **31** from which it returns to the turbine for final expansion.

In accordance with the invention, the conduit **50** from the outlet of the primary superheater **27** and the inlet conduit **42** to the economizer **32** are interconnected by a conduit **51** having an inverted piston type stop and check valve **52**, as shown in FIG. 2. During normal operation of the fluid heating unit, the valve **52** is held closed due to the difference of fluid pressure between the feed pump side of the piston **52A** and the opposite or primary superheater side thereof, while the stem **52B** of the valve is positioned to permit downward movement of the piston. Fluid flow with the valve **52** closed is in the order above described for normal operation of the unit. If the feed water supply system for the unit is rendered inactive or fails, interlocks (not shown) trip out the turbine and shut down the fuel firing equipment, while the piston of the valve **52** automatically moves downward to its open position because of its weight and the difference in the density of the fluid flowing between the furnace wall tube inlets and the valve **52** and the fluid flowing between the inlet side of the economizer and the furnace wall tube inlets. A natural flow of fluid is induced by this difference in fluid density from and to the furnace wall tube inlets by way of a flow passage comprising the fluid heating tubes lining the boundary walls of the chambers A and B, the initial primary superheater **27**, the conduits **50**, **51** and **42**, the economizer **32**, the downcomer **44** and the supply tubes **44A**. Thus the recirculating fluid by-passes the final primary superheater **28** and the secondary superheater **29**. There is no flow in these superheaters or in the reheaters after trip-out of the turbine and feed water pump. These surfaces are capable of enduring the stresses occasioned by absence of fluid flow therein during shutdown because, compared to the boundary and baffle wall tubes of the unit, they are less susceptible to hot slag accumulations, are constituted by tubes of higher metal quality, are subject to a lesser degree of support stress, and are less restrained to expand and contract. The initial primary superheater **27** also has these stress enduring qualities even though fluid flows therethrough during shut-downs. In this regard, though the conduit **51** preferably has its inlet end connected to the discharge from the primary superheater **27** and its outlet connected to the inlet side of the economizer **32**, substantially the same benefits of the invention may be obtained by connecting the inlet end of this conduit to the inlet side of the primary superheater, the outlet side of the secondary superheater **29** or to any suitable portion of the fluid flow path therebetween.

The economizer **32** is located at the low temperature end of both the gas and fluid flow paths, is proportioned to provide high heat absorbing capacity by the tube metal thereof, and is positioned at an elevation high enough above the furnace wall tube inlets to assure natural circulation of fluid in the manner described. The naturally circulating flow thus established is enhanced by absorption of residual heat from the chambers A and B on discontinuance of firing; heat from the hot slag on the walls of the chambers A and B, particularly from high temperature slag accumulation on the wall portions adjacent the burners and on the hopper walls; and heat radiated by hot refractory. The heat so absorbed by the fluid is passed to the economizer **32** wherein a substantial portion of the heat is absorbed by the tube metal thereof due to its heat capacity and location at the low temperature end of the gas and fluid flow paths, thereby minimizing heat loss from the fluid flow path. The surface of the economizer is of sufficient magnitude to absorb the heat passed to it by the naturally circulating fluid without overheating. Recirculation of fluid will continue until all the tubes in the natural circulation flow path reach substantially the same temperature or until the unit is restarted, whichever is sooner.

Thus naturally circulating fluid through the unit during emergency and normal shutdowns, in accordance with the invention, permits shutdowns without the use of a feed pump; minimizes differential temperatures between adjacent tubes of the boundary walls of the chambers A and B, thereby preventing undue thermal stresses in the wall-forming components; assures protection of the tubes constituting the fluid flow path against overheating, particularly the tubes subject to high temperature slag accumulations; and minimizes heat loss by the fluid during shutdowns, thereby allowing resumption of load by the unit with minimum delay, if so desired.

When the unit is restarted from a hot condition, the piston **52A** of the valve **52** is returned to its closed posi-

tion by upward movement of the valve stem 52B and the feed water pump 46 is started. Then fluid flow is established through the unit by means of superheater and turbine by-pass recirculation systems of the type hereinbefore described, the stem of the valve 52 is positioned to allow downward movement of the piston, and firing is commenced. Interlocks (not shown) are provided to prevent firing unless the valve piston is in its closed position and the valve stem is in its open position. When the steam at the turbine throttle reaches the desired condition, the fluid recirculation systems are closed, while the turbine throttle is opened, and then the turbine is loaded. Since the fluid heat loss is held to a minimum during shut-down by use of the invention, the firing required during a hot restart of the unit to raise the temperature of the fluid to a condition suitable for starting the turbine is relatively short. While starting up with the turbine by-passed, the reheaters 30 and 31 have no steam flow for cooling. To avoid tube metal overheating the gas temperature entering the reheaters is maintained below a predetermined maximum.

While in accordance with the provisions of the statutes I have illustrated and described herein a specific 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 the invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a forced circulation once-through vapor generating and superheating unit, walls defining a gas flow path, means normally supplying heating gases to said gas flow path, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of said gas flow path and arranged to receive fluid at one end and discharge superheated vapor at its opposite end, an economizer of high heat absorbing capacity located in a relatively low temperature portion of said gas flow path and connected for series flow of fluid to and disposed above the inlet end of said fluid flow passage, means including a pump normally supplying a vaporizable fluid to said economizer under a substantial pressure, and means responsive to inactivation of said vaporizable fluid supply means for effecting a natural circulation of fluid through a portion of said fluid flow passage while the supply of heating gases to said gas flow path is discontinued, said last named means including a valve-controlled conduit arranged to pass fluid and the heat absorbed thereby from an intermediate portion of the fluid flow passage to the inlet side of the economizer wherein a substantial portion of the heat picked up by the fluid in passing through said portion of said fluid flow passage is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

2. In a forced circulation once-through vapor generating and superheating unit, walls defining a gas flow path, fluid fuel firing means normally supplying heating gases to said gas flow path, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of said gas flow path and arranged to receive fluid at one end and discharge superheated vapor at its opposite end, a high heat capacity economizer located in a relatively low temperature portion of said gas flow path and connected for series flow of fluid to and disposed above the inlet end of said fluid flow passage, means including a pump normally supplying a vaporizable fluid to said economizer under a substantial pressure, and means responsive to inactivation of said vaporizable fluid supply means for effecting a natural circulation of fluid through a portion of said flow passage during shut-down of the unit including a conduit connecting an intermediate part of the fluid flow passage to the inlet side of said economizer, and a normally closed valve in said conduit arranged to open upon inactivation of said vaporizable fluid supply means to pass the fluid flowing through said portion of the fluid flow passage to the economizer wherein a substantial portion of the heat picked up by the fluid in passing through said portion of said fluid flow passage is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

3. In a forced circulation once-through vapor generating and superheating unit, walls defining a gas flow path, fluid fuel firing means normally supplying heating gases to said gas flow path, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of said gas flow path and arranged to receive fluid at one end and discharge superheated vapor at its opposite end, said fluid flow passage comprising a plurality of fluid heating tubes in one of said walls arranged for parallel flow of fluid therethrough, and a vapor superheating section in said gas flow path connected for series flow of fluid from said fluid heating tubes, a high heat capacity economizer located in a relatively low temperature portion of said gas flow path and downstream gas-wise of said vapor superheating section and connected for series flow of fluid to and disposed above the inlet ends of said fluid heating tubes, means including a pump normally supplying a vaporizable fluid to said economizer under a substantial pressure, and means responsive to inactivation of said vaporizable fluid supply means for effecting a natural circulation of fluid through a portion of said fluid flow passage during shut-down of the unit including a conduit connecting an intermediate part of the vapor superheating section of said fluid flow passage to the inlet side of said economizer, and a normally closed valve in said conduit arranged to open upon inactivation of said vaporizable fluid supply means to pass the fluid flowing through said portion of the fluid flow passage to the economizer wherein a substantial portion of the heat picked up by the fluid in passing through said portion of said fluid flow passage is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

4. In a forced circulation once-through vapor generating and superheating unit, walls defining a vertically elongated gas flow path, fluid fuel firing means normally supplying heating gases to the lower portion of said gas flow path, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of said gas flow path and arranged to receive fluid at one end and discharge superheated vapor at its opposite end, said fluid flow passage comprising a plurality of upwardly extending fluid heating tubes in one of said walls arranged for parallel flow of fluid therethrough, and a vapor superheating section in the upper portion of said gas flow path connected for series flow of fluid from said fluid heating tubes, a high heat capacity economizer located in a relatively low temperature portion of said gas flow path and downstream gas-wise of said vapor superheating section and connected for series flow of fluid to and disposed above the inlet ends of said fluid heating tubes, means including a pump normally supplying a vaporizable fluid to said economizer under a substantial pressure, and means responsive to inactivation of said vaporizable fluid supply means for effecting a natural circulation of fluid through a portion of said fluid flow passage during shut-down of the unit including a conduit connecting an intermediate part of the vapor superheating section of said fluid flow passage to the inlet side of said economizer, and a normally closed valve in said conduit arranged to open upon inactivation of said vaporizable fluid supply means to pass the fluid flowing through said portion of the fluid flow passage to the economizer wherein a substantial portion of the heat picked up by the fluid in passing through said

portion of said fluid flow passage is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

5. In a forced circulation once-through vapor generating and superheating unit, walls defining a vertically elongated gas flow path, fluid fuel firing means normally supplying heating gases to the lower portion of said gas flow path, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of said gas flow path and arranged to receive fluid at one end and discharge superheated vapor at its opposite end, said fluid flow passage comprising a plurality of upwardly extending fluid heating tubes in each of said walls arranged for parallel flow of fluid therethrough, and a vapor superheating section in the upper portion of said gas flow path including a primary vapor superheater connected for series flow of fluid from said fluid heating tubes and a secondary vapor superheater connected for series flow of fluid from said primary vapor superheater, a high heat capacity economizer located in a relatively low temperature portion of said gas flow path and downstream gas-wise of said vapor superheating section and connected by an unheated conduit for series flow of fluid to and disposed above the inlet ends of said fluid heating tubes, means including a pump normally supplying a vaporizable fluid to said economizer under a substantial pressure, and means responsive to inactivation of said vaporizable fluid supply means for effecting a natural circulation of fluid through a portion of said fluid flow passage during shut-down of the unit including a conduit connecting the fluid flow passage at a position between the primary and secondary vapor superheaters to the inlet side of said economizer, and a normally closed valve in said conduit arranged to open upon inactivation of said vaporizable fluid supply means to pass the fluid flowing through said portion of the fluid flow passage to the economizer wherein a substantial portion of the heat picked up by the fluid in passing through said portion of said fluid flow passage is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

6. In a forced flow once-through vapor generating and superheating unit having walls defining a gas flow path normally fired by a fluid fuel, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of the gas flow path and arranged to receive a vaporizable fluid at one end and discharge superheated vapor at its opposite end, a high heat capacity economizer in a relatively low temperature portion of said gas flow path discharging fluid to and disposed above the inlet end of said fluid flow passage and normally receiving a vaporizable fluid under substantial pressure from a feed water supply system including a pump, and a valve-controlled conduit connecting an intermediate portion of the fluid flow passage to the inlet side of the economizer and normally closed to the flow of fluid, the method of shutting-down the unit when the pressure in the feed water supply system fails which comprises discontinuing the flow of superheated vapor from the opposite end of said fluid flow passage, discontinuing the firing of said gas flow path, opening the valve in said conduit in response to inactivation of said feed water supply system, and naturally recirculating fluid through said fluid flow passage to said conduit, and thence through said conduit and the economizer to the inlet of said fluid flow passage so that a substantial portion of the heat picked up by the fluid in passing from the inlet of said fluid flow passage to said conduit is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

7. In a forced flow once-through vapor generating and superheating unit having walls defining a gas flow path normally fired at the lower portion thereof by a fluid fuel, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of the gas flow path and arranged to receive a vaporizable fluid at one end and discharge superheated vapor at its opposite end, a high heat capacity economizer in a relatively low temperature portion of said gas flow path discharging fluid to and disposed above the inlet end of said fluid flow passage and normally receiving a vaporizable fluid under substantial pressure from a feed water supply system including a pump, and a valve-controlled conduit connecting an intermediate portion of the fluid flow passage to the inlet side of the economizer and normally closed to the flow of fluid, the method of shutting-down the unit when the feed water pump is rendered inactive which comprises discontinuing the flow of superheated vapor from the opposite end of said fluid flow passage, discontinuing the firing of said gas flow path, opening the valve in said conduit in response to inactivation of said feed pump, and naturally recirculating fluid through said fluid flow passage to said conduit, and thence through said conduit and the economizer to the inlet of said fluid flow passage so that a substantial portion of the heat picked up by the fluid in passing from the inlet of said fluid flow passage to said conduit is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

8. In a forced flow once-through vapor generating and superheating unit having walls defining a gas flow path normally fired by a fluid fuel, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of the gas flow path and arranged to receive a vaporizable fluid at one end and discharge superheated vapor at its opposite end and comprising fluid heating tubes in one of said walls arranged for parallel flow of fluid therethrough, and a vapor superheating section in said gas flow path receiving fluid at one end from said fluid heating tubes and normally discharging superheated vapor at its opposite end, a high heat capacity economizer in a relatively low temperature portion of said gas flow path discharging fluid to and disposed above the inlet ends of said fluid heating tubes and normally receiving a vaporizable fluid under substantial pressure from a feed water supply system including a pump, and a valve-controlled conduit connecting an intermediate portion of the vapor superheating section of the fluid flow passage to the inlet side of the economizer and normally closed to the flow of fluid, the method of shutting-down the unit when the pressure in the feed water supply system fails which comprises discontinuing the flow of superheated vapor from the discharge end of said vapor superheating section, discontinuing the firing of said gas flow path, opening the valve in said conduit in response to inactivation of said feed pump, and naturally recirculating fluid through said fluid heating tubes to said conduit, and thence through said conduit and the economizer to the inlets of said fluid heating tubes so that a substantial portion of the heat picked up by the fluid in passing from the inlet of said fluid flow passage to said conduit is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

9. In a forced flow once-through vapor generating and superheating unit having walls defining a gas flow path normally fired at the lower portion thereof by a fluid fuel, a once-through fluid flow passage disposed in most part within a relatively high temperature portion of the gas flow path and arranged to receive a vaporizable fluid at one end and discharge superheated vapor at its opposite end and comprising fluid heating tubes in each of said walls arranged for parallel flow of fluid therethrough, and a vapor superheating section in said gas flow path receiving fluid at one end from said fluid heating tubes and normally discharging superheated vapor at its opposite end, a high heat capacity economizer in a relative-

ly low temperature portion of said gas flow path discharging fluid to and disposed above the inlet ends of said fluid heating tubes and normally receiving a vaporizable fluid under substantial pressure from a feed water supply system including a pump, and a valve-controlled conduit connecting an intermediate portion of the vapor superheating section of the fluid flow passage to the inlet side of the economizer and normally closed to the flow of fluid, the method of shutting-down the unit when the feed water pump is rendered inactive which comprises discontinuing the flow of superheated vapor from the discharge end of said vapor superheating section, discontinuing the firing of said gas flow path, opening the valve in said conduit in response to inactivation of said feed pump, and naturally recirculating fluid through said fluid heating tubes to said conduit, and thence through said

conduit and the economizer to the inlets of said fluid heating tubes so that a substantial portion of the heat picked up by the fluid in passing from the inlet of said fluid flow passage to said conduit is absorbed by the tube metal of the economizer due to its heat capacity and location in a low temperature portion of the gas flow path.

References Cited in the file of this patent

UNITED STATES PATENTS

2,614,543	Hood	Oct. 21, 1952
2,849,989	Vorkauf	Sept. 2, 1958
2,901,887	Buri	Sept. 1, 1959

FOREIGN PATENTS

857,965	Germany	Dec. 4, 1952