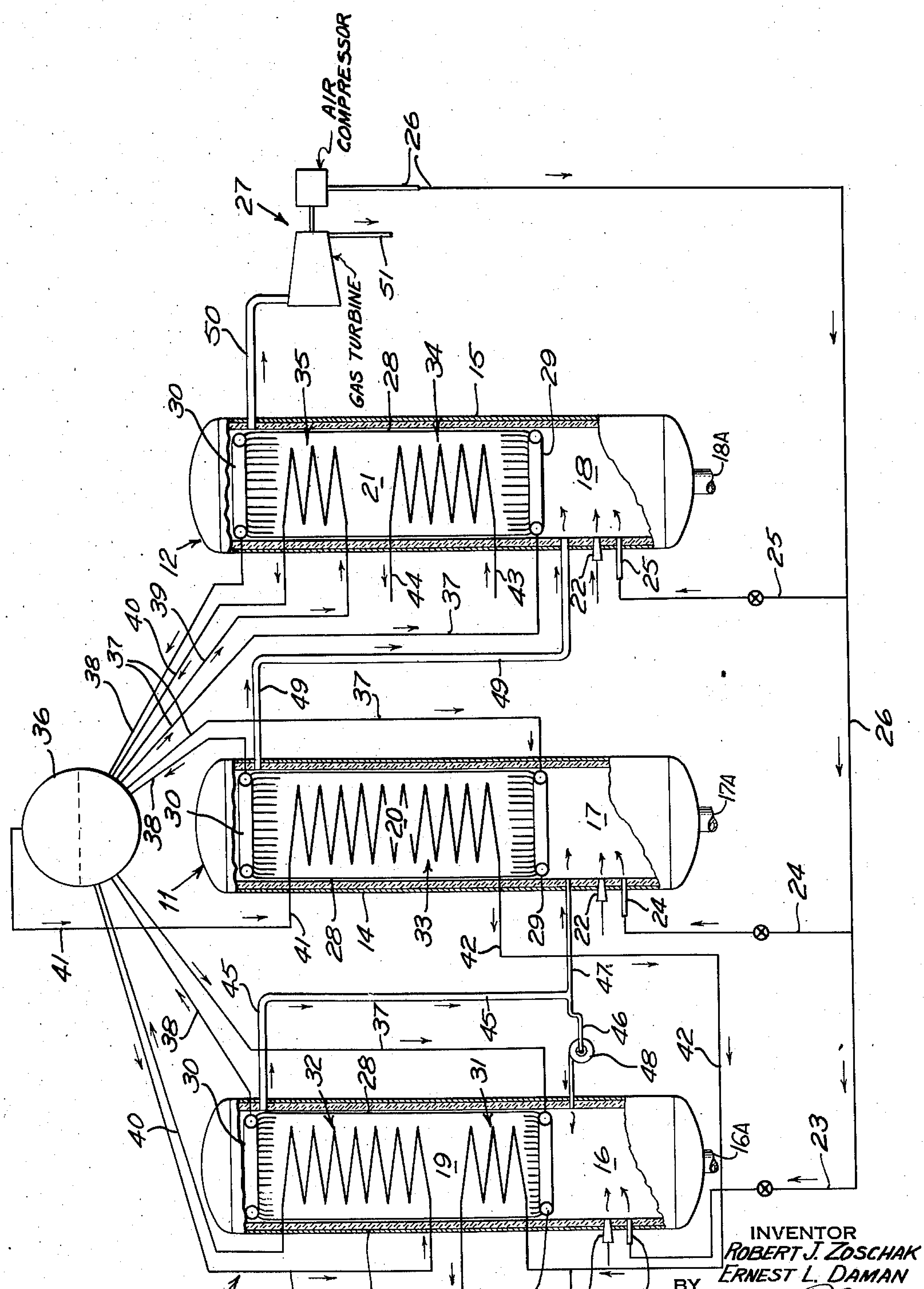
Jan. 17, 1961 R. J. ZOSCHAK ET AL 2,968,288

METHOD OF BURNING SLAG FORMING FUEL IN FURNACES

Filed March 18, 1959



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2,968,288
Patented Jan. 17, 1961

2,968,288

METHOD OF BURNING SLAG FORMING FUEL IN FURNACES

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Filed Mar. 18, 1959, Ser. No. 800,214
8 Claims. (Cl. 122—240)

This invention relates to steam generators, more particularly to the method of burning slag forming fuels in large capacity supercharged vapor generating power plants.

In large capacity supercharged vapor generating power plants, it is commercially impractical to provide all the necessary heat transfer elements in a single shell because of the construction problems arising from the fact that combustion gas pressures in supercharged vapor generating plants are in the order of 60 to 80 p.s.i.g. Therefore, large capacity supercharged vapor generating plants comprise a plurality of separate shells or sections, each of which contains heat transfer elements and is independently fired to generate vapor and superheat vapor and/or reheat vapor. The combustion gas generated in each of the plurality of sections is conducted from each of the shells to a common flue, and thence to a gas turbine-compressor assembly. These sections are gas or oil fired to obviate the problem of non-combustible matter which is entrained in the combustion gas adhering to the surfaces of the heat transfer elements in the convection zone, which problem exists where slag producing fuels are burned. It is well known in the boiler art that slagging on the convection elements may be obviated where a slagging fuel, such as pulverized coal, is burned by recirculating combustion gas from a point, with respect to the combustion gas flow, after the economizer of a boiler into the combustion zone or furnace chamber to reduce the temperature of the combustion gas in the combustion zone so that the combustion gas is below the fusion point of the ash before it reaches the convection elements. However, recirculation of combustion gas after the economizer section in a supercharged boiler is not economically feasible since the combustion gas must first pass through a gas turbine where the combustion gas pressure is substantially reduced so that recirculation of combustion gas after the economizer would require an exceptionally large recirculation compressor which results in a substantial loss in overall efficiency of the power plant.

It is therefore one of the objects of this invention to provide a method of burning a slag forming fuel in a multi-section supercharged vapor generator plant without a slagging condition occurring on the heat transfer elements in the convection zones of the sections. Another object of this invention is to provide a method of burning a slag forming fuel in a supercharged multi-section vapor generating plant whereby plant efficiency is superior to conventional non-supercharged vapor generators of comparable capacity.

Accordingly, the present invention contemplates, in a multi-section supercharged vapor generating plant, a method of burning a slag forming fuel wherein a slag forming fuel is burned in a first combustion zone to produce a combustion gas at a temperature above the fusion point of the non-combustible material in the combustion gas so that the non-combustible material is in a molten state, and then, flowing the first combustion gas from said

first combustion zone into indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool said first combustion gas. Thereafter, pumping a portion of the cooled first combustion gas into the first combustion zone and into admixture with the first combustion gas generated in the combustion zone to produce a first resultant combustion gas having a temperature below the fushion point of the non-combustible material entrained in the resultant combustion gas so that the entrained molten non-combustibles are solidified before the latter gas passes into indirect heat exchanger relationship with said relatively cool fluid. In a second combustion zone, burning a slag forming fuel to produce a second combustion gas having a temperature above the fusion point of the non-combustible material in the second combustion gas so that the non-combustible material is in a molten state. Thereafter, passing the other portion of the cooled first combustion gas into said second combustion zone and into admixture with said second combustion gas to produce a second resultant gas having a temperature below the fusion point of the non-combustible material entrained in said second resultant combustion gas so that the entrained molten non-combustibles are solidified before passing from said second combustion zone. From the second combustion zone, the second resultant combustion gas is passed in indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool the second resultant combustion gas. In a third combustion zone, burning a slag forming fuel to produce a third combustion gas having a temperature above the fusion point of the non-combustible material in the third combustion gas so that the non-combustible material is in a molten state. Thereafter passing the cooled second combustion gas into said third combustion zone and into admixture with the third combustion gas to provide a third resultant combustion gas having a temperature below the fustion point of the non-combustibles entrained in the third resultant gas so that the entrained molten non-combustibles solidify before the latter combustion gas is passed from the third combustion zone. The third resultant combustion gas is then passed into indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool the third resultant gas. After the third resultant gas is cooled, it is passed to a place of use, such as a turbine-compressor assembly, wherein the gas functions to turn the turbine which in turn operates the compressor to compress the combustion air which is fed to the first, second and third combustion zones.

The invention will be more fully understood from the following description when considered in connection with the accompanying drawing.

In the drawing, a supercharged vapor generating power plant according to this invention is somewhat diagrammatically shown. For illustration purposes the power plant is shown as comprising three separate sections or boilers **10**, **11** and **12** although it is contemplated that the power plant may comprise two boilers or more than three sections or boilers without departing from the spirit and scope of this invention.

The boilers **10**, **11** and **12** comprise cylindrical settings **13**, **14** and **15**, respectively, having in the lower portions thereof high temperature combustion zones or furnaces **16**, **17** and **18**, respectively, and in the upper portions thereof convection zones or sections **19**, **20** and **21**, respectively. Each of the boilers **10**, **11** and **12** is provided with suitable fuel burners **22** which are connected to receive from a suitable source thereof (not shown) a slag forming fuel, as for example, pulverized coal, and are adapted to introduce the fuel into combustion zones **16**, **17** and **18** of the boilers. Combustion air for supporting combustion of the fuel is introduced under pressure into each of the combustion zones **16**, **17** and **18**, by way of valved lines 23, 24 and 25, respectively. Valved lines 23, 24 and 25 are each connected to a main combustion air supply line 26 which is connected to receive compressed air from a gas turbine-compressor assembly 27. In the convection zones or sections 19, 20 and 21 of the boilers, vapor generating tubes 28 may be arranged around the inner surfaces of the settings, which tubes may be connected at one end to annular inlet headers 29 and at the opposite ends to outlet headers 30.

As shown, boiler 10 is provided, in convection section 19, with a secondary superheater tube bank 31 and, above the latter, a vapor generating tube bank 32. In convection section 20 of boiler 11, a primary superheater tube bank 33 is provided, while, in convection section 21 of boiler 12, a reheater tube bank 34 and a convection vapor generating tube bank 35 are disposed. It is to be understood that while convection vapor generating tube banks 32 and 35, superheater tube banks 31 and 33, and reheater tube bank 34, are shown in the form of a helical coil, they may be constructed and arranged within the convection sections in any other suitable manner.

The boilers 10, 11 and 12 are interconnected, as hereinafter described, to a single vapor-liquid drum 36 although two or more vapor-liquid drums may be provided without departing from the spirit and scope of this invention.

Vapor generating tubes 28 of each of the boilers 10, 11 and 12 are connected through inlet headers 29 and downcomers 37 to vapor-liquid drum 36 to receive liquid from the latter. The liquid flows through tubes 28 and in indirect heat exchange relationship with products of combustion flowing through convection sections 19, 20 and 21 of the boilers whereby saturated vapor is generated. The tubes 28 are connected, through outlet headers 30 and risers 38, to vapor liquid drum 36 to pass the saturated vapor to the latter. Convection vapor generating tube banks 32 and 35 of boilers 10 and 12 are connected to vapor-liquid drum 36 by way of downcomers 39. The liquid flows through tube banks 32 and 35 and in indirect heat exchange relationship with combustion gas flowing through the respective convection sections 19 and 21 of boilers 10 and 12 to produce saturated vapor. Vapor generating tube banks 32 and 35 are connected by risers 40 to vapor-liquid drum 36 to pass the saturated vapor to the latter.

Primary superheater tube bank 33, in convection section 20 of boiler 11, is connected through line 41 to receive vapor from vapor-liquid drum 36, the vapor in flowing through the primary superheater passes in indirect heat exchange relationship with combustion gas flowing through convection section 21 and is thereby heated. Tube bank 33 is connected by line 42 to secondary superheater tube bank 31, in convection section 19 of boiler 10, to conduct the superheated vapor to superheater tube bank 31. In secondary superheater tube bank 31, the superheated vapor is heated to a final predetermined superheat temperature by passing in indirect heat exchange relationship with combustion gas flowing through convection section 19 of boiler 10. The superheated vapor is conducted from secondary superheater tube bank 31 to a high pressure stage of a vapor turbine, not shown.

Reheater tube bank 34, in convection section 21 of boiler 12, is connected through a line 43 to an intermediate pressure stage of a vapor turbine (not shown) to receive vapor therefrom. The vapor is heated in reheater tube bank 34 to a predetermined temperature by passing in indirect heat exchange relationship with combustion gas flowing through convection section 21. The reheated vapor is conducted from reheater tube bank 34 by way of line 44 to a low pressure stage of a vapor turbine, not shown.

As previously described, each of the boilers 10, 11 and 12 are provided with fuel burners 22 which are adapted to burn a slag forming fuel in the respective combustion zones 16, 17 and 18 of boilers to thereby produce, in each of the combustion zones, a combustion gas having a temperature above the fusion point of the non-combustible material in the fuel. To obviate slagging of the non-combustible material entrained in the combustion gas on the heat transfer elements which are disposed in convection sections 19, 20, 21 of the boilers, the boilers are serially interconnected for the flow of cooled combustion gas into their respective combustion zones as hereinafter described.

A line or duct 45 is connected at one end to the top portion of boiler 10 and in communication with convection section 19 to receive from the latter combustion gas which has been cooled by flowing over secondary superheater tube bank 31, vapor generating tube bank 32, and adjacent vapor generating tubes 28, duct 45 being connected at its other end to two branch ducts 46 and 47. Duct 46 communicates through a recirculation fan or blower 48 with combustion zone 16 of boiler 10, while duct 47 communicates with combustion zone 17 of boiler 11. Recirculation blower 48 draws a portion of the cooled combustion gas, through ducts 45 and 46, and forces a sufficient amount of the cooled combustion gas into combustion zone 16 and into admixture with the combustion gas generated within the combustion zone to produce a combustion gas mixture having a temperature below the fusion point of the molten non-combustible material in the combustion gas so that the entrained non-combustible material solidifies before the combustion gas mixture passes into convection section 19 of boiler 10. The other portion of the cooled combustion gas flows through ducts 45 and 47 into combustion zone 17 of boiler 11 and into admixture with the combustion gas generated in combustion zone 17 to produce a combustion gas mixture having a temperature below the fusion point of the molten non-combustible materal in the combustion gas so that the entrained non-combustible material solidifies before the combustion gas mixture passes into the convection section 20 of boiler 11.

A duct 49 is provided to pass the combustion gas mixture which has been cooled in passing in indirect heat exchange relationship with the vapor generating tubes 28 and primary superheater tube bank 33 in convection section 20 of boiler 11, from the top portion of convection section 20, into combustion zone 18 of boiler 12 and into admixture with the combustion gas generated in combustion zone 18 to produce a combustion gas mixture having a temperature below the fusion point of the molten non-combustible material in the combustion gas so that the entrained non-combustible material solidifies before the combustion gas mixture passes into convection zone 21. A duct 50 is provided to conduct the combustion gas which has been cooled by passing in indirect heat exchange relationship with the fluid in vapor generating tubes 28, vapor generating tube bank 35 and reheater tube bank 34, from the top portion of convection section 21 to gas turbine-compressor assembly 27, the combustion gas driving the turbine which in turn drives the compressor.

By the relative adjustment of the valves in valved lines 23, 24 and 25 to control flow of combustion air into the respective combustion zones of boilers 10, 11 and 12, and by differential firing of the boilers, a lower combustion gas pressure is maintained in boiler 11 than in boiler 10 and a still lower combustion gas pressure in boiler 12 than in boiler 11. By maintaining a combustion gas pressure differential between boiler 10 and boiler 11 and between boiler 11 and boiler 12, cooled combustion gas will flow from convection section 19 of boiler 10 through ducts 45 and 47, into combustion zone 17 of boiler 11, without the need for a circulating fan or blower. Likewise, combustion gas will flow from convection section 20 of boiler 11 into combustion zone 18 of boiler 12 through duct 49 without the need for a circulating fan or blower because of the differential combustion gas pressure which is maintained between boilers 11 and 12. A blower 48 is required to effect recirculation of a portion of the combustion gas from convection section 19 into combustion zone 16 through ducts 45 and 46 since there is a small pressure drop through convection section 19 of boiler 10 and duct 45.

However, while it is desirable to maintain a combustion gas pressure differential between boilers 10, 11 and 12, it is essential for maximum efficiency of the supercharged vapor generating power plant to maintain as small differential combustion gas pressure as possible between the boilers, as for example, a combustion gas pressure differential between boiler 10 and boiler 12 within the range of 2 to 4 p.s.i.g.

In operation of the supercharged vapor generating power plant above described, a slag forming fuel, such as pulverized coal, is fired in the respective high temperature combustion zones 16, 17 and 18 of boilers 10, 11 and 12 by fuel burners 22 to generate combustion gas having a temperature within the range of 2,600° F. to 3,000° F., at which temperature the non-combustible materials in the fuel are in a molten state. While only one burner is shown in each of the boilers, it is contemplated that a plurality of burners may be employed which are arranged and directed to produce a cyclonic effect in combustion zones 16, 17 and 18.

A substantial amount of the molten non-combustible material separates from the gaseous products of combustion in combustion zones 16, 17 and 18 and flows downwardly along the walls of the combustion zones and out of the bottom of the boilers through an opening therein, not shown, and outlet means 16A, 17A and 18A of the respective boilers 10, 11 and 12. The combustion gas in each of the combustion zones 16, 17 and 18 passes upwardly into the respective convection sections 19, 20 and 21 and in indirect heat exchange relationship with the fluids flowing through the heat transfer elements disposed therein to heat the latter and cool the combustion gas as hereinbefore described. Secondary superheater tube bank 31, vapor generating tube bank 32 and vapor generating tubes 28 in convection section 19 of boiler 10 are constructed and arranged in relation to combustion gas temperature and flow rates, to provide a rate of heat transfer sufficient to cause the combustion gas flowing through convection section 19 to be cooled to a temperature of approximately 900° F., while primary superheater tube bank 33 and vapor generating tubes 28 in convection section 20 of boiler 11 are constructed and arranged in relation to combustion gas temperature and flow rates, to provide a rate of heat transfer sufficient to cause the combustion gas passing through convection section 20 to be cooled to a temperature of 1,000° F. In convection section 21 of boiler 12, reheater tube bank 34, convection vapor generating tube bank 35 and vapor generating tubes 28 are constructed and arranged to provide a heat transfer rate in relation to the combustion gas temperature and flow rates, which will cool the combustion gas, flowing through convection section 21 to a temperature of 1,400° F.

To prevent slagging of the molten non-combustible material entrained in the combustion gas, a portion of the cooled combustion gas flows from convection section 19 of boiler 10 by way of duct 45 and is pumped by blower 48 into the combustion zone 16 of boiler 10 by way of line 46, while the other portion of the cooled combustion gas flows through duct 47 into the combustion zone 17 of boiler 11. At the same time, the cooled combustion gas passes from convection section 20 of boiler 11 through duct 49 into combustion zone 18 of boiler 12.

To insure optimum mixing of the cooled combustion gases with the high temperature combustion gases in the respective combustion zones 16, 17 and 18 of boilers 10, 11 and 12, so that substantially all of the non-combustible material entrained in the combustion gases is solidified prior to passage into the respective convection zones 19, 20 and 21, each of the ducts 46, 47 and 49 may be connected to manifolds or gas plenum chambers (not shown) which are disposed adjacent the combustion zones so that the cool combustion gases enter the combustion zones at various spaced points and at such angles as to achieve complete mixing with the high temperature combustion gases.

The cooled combustion gases from convection zone 21 of boiler 12 pass through duct 50 into the turbine of turbine-compressor assembly 27 and, after discharge from the turbine, pass to a suitable economizer and/or air heater (not shown) through line 51.

From the foregoing description, it can be readily seen that a novel method of gas recirculation has been provided in a multi-boiler supercharged vapor generating power plant whereby a slag forming fuel may be burned without slagging of non-combustible material on the heat transfer elements in the convection section of the boilers. It is a method of recirculating cool combustion gases into the combustion zones of the boilers where only one recirculation fan or blower of relatively small size is required.

Although but one embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes may be made in the design and arrangement of parts without departing from the spirit and scope of the invention, as the same will now be understood by those skilled in the art.

What is claimed is:

1. In a supercharged vapor generating plant having a plurality of combustion zones, the method of firing a slag forming fuel comprising the steps of burning a slag forming fuel in a first combustion zone to produce a first combustion gas, passing said combustion gas into indirect heat exchange relationship with heat transfer elements whereby heat is absorbed from said gas, recirculating a portion of said first combustion gas after it is cooled into the first combustion zone and into admixture with the combustion gas generated in said first combustion zone by the burning of slag forming fuel, burning a slag forming fuel in a second combustion zone to produce a second combustion gas, passing the other portion of the cooled first combustion gas into said second combustion zone and into admixture with said second combustion gas, passing the admixed first and second combustion gases into indirect heat exchange relationship with heat transfer elements whereby heat is absorbed from said gases, burning a slag forming fuel in a third combustion zone to produce a third combustion gas, flowing the cooled first and second combustion gas admixture into said third combustion zone and into admixture with said third combustion gas, passing the first, second and third combustion gas admixture in indirect heat exchange relationship with heat transfer elements whereby heat is absorbed from said combustion gas admixture and thereafter passing the cooled first, second and third combustion gas admixture to a place of use.

2. In a supercharged vapor generating plant, the method of burning a slag forming fuel comprising the steps of burning a slag forming fuel in a first combustion zone to produce a first combustion gas, passing said first combustion gas in indirect heat transfer relationship with relatively cool fluid to heat the latter and cool said first combustion gas, recirculating a portion of said cooled first combustion gas into said first combustion zone and into admixture with the combustion gas generated in said first combustion zone by the burning of slag forming fuel, burning a slag forming fuel in a second combustion zone to produce a second combustion gas, passing the other portion of said cooled first combustion gas into said second combustion zone and into admixture with said second combustion gas, then passing the admixture of said first and second combustion gases into indirect heat transfer relationship with a relatively cool fluid to heat the latter and cool said combustion gas admixture, burn-

ing a slag forming fuel in a third combustion zone to produce a third combustion gas, flowing the cooled first and second combustion gas admixture into said third combustion zone and into admixture with said third combustion gas, passing the first, second and third combustion gas admixture in indirect heat transfer relationship with a relatively cool fluid, and thereafter passing the cooled first, second and third combustion gas admixture to a place of use.

3. In a supercharged vapor generating power plant, the method comprising the steps of burning a slag forming fuel in a first high temperature combustion zone to produce a first combustion gas at a temperature above the fusion point of the non-combustibles in said slag forming fuel, passing said first combustion gas in indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool the first combustion gas, recirculating a portion of said cooled first combustion gas into said first combustion zone and into admixture with sadi first combustion gas to provide a first resultant combustion gas having a temperature below the fusion point of the non-combustibles in said slag forming fuel so that substantially all of the molten non-combustibles entrained in said resultant combustion gas mixture are solidified, burning a slag forming fuel in a second high temperature combustion zone to produce a second combustion gas a temperature above the fusion point of the non-combustibles in said slag forming fuel, passing the other portion of said cooled first combustion gas into said second combustion zone and into admixture with said second combustion gas to provide a second resultant combustion gas mixture having a temperature below the fusion point of the non-combustibles in said slag forming fuel to solidify substantially all of the molten non-combustibles in the second resultant combustion gas mixture before it passes from said second combustion zone, passing the second resultant combustion gas mixture into indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool the second resultant combustion gas mixture burning a slag forming fuel in a third high temperature combustion zone to produce a third combustion gas at a temperature above the fusion point of the non-combustibles in said slag forming fuel, passing said cooled second resultant combustion gas mixture into said third combustion zone and into admixture with said third combustion gas to provide a third resultant combustion gas mixture having a temperature below the fusion point of the non-combustibles in the slag forming fuel to solidify substantially all of the molten non-combustibles in the third resultant combustion gas mixture, passing the third resultant combustion gas mixture into indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool the third resultant combustion gas mixture, and thereafter passing said cooled third resultant combustion gas mixture to a place of use.

4. In the supercharged vapor generating power plant, the method of burning slag forming fuel comprising the steps of burning a slag forming fuel in a first high temperature combustion zone to produce a first combustion gas at a temperature above the fusion point of the non-combustibles in said fuel, passing said first combustion gas from the first combustion zone into indirect heat exchange with fluid to heat the latter and cool said first combustion gas, recirculating a portion of cooled first combsution gas into said first combustion zone and into admixture with said first combustion gas at a point before the latter passes into indirect heat exchange relationship with said fluid to produce a first resultant combustion gas having a temperature below the fusion point of the non-combustibles in said fuel so that the entrained non-combustibles are solidified before passing from said first combustion zone, burning a slag forming fuel in a second high temperature combustion zone to produce a second combustion gas at a temperature above the fusion point of the non-combustibles in said fuel, passing the other portion of said cool first combustion gas into said second combustion zone at a point before the second combustion gas passes from said second combustion zone and into admixture with the latter to produce a second resultant combustion gas having a temperature below the fusion point of the non-combustibles in said fuel so that the entrained non-combustibles are solidified before passing from said second combustion zone, flowing said second resultant combustion gas from said second combustion zone into indirect heat exchange relationship with a fluid to heat the latter and cool said second resultant combustion gas, burning a slag forming fuel in a third high temperature zone to produce a third combustion gas at a temperature above the fusion point of the non-combustibles in said fuel, passing said cooled second combustion gas into said third combustion zone at a point before the third combustion gas passes from said third combustion zone and into admixture with the latter to produce a third resultant combustion gas having a temperature below the fusion point of the non-combustibles in the fuel so that the entrained non-combustibles are solidified before passing from said third combustion zone, passing the third resultant combustion gas from said third combustion zone into indirect heat exchange relationship with a fluid to heat the latter and cool said third resultant combustion gas, passing the cooled third resultant combustion gas to a place of use.

5. In a supercharged vapor power plant having a plurality of combustion zones, the method of burning pulverized fuel in each of said zones comprising the steps of burning a pulverized fuel in a first high temperature combustion zone to produce a first combustion gas at a temperature above the fusion point of the non-combustibles in said fuel, passing said first combustion gas in indirect heat exchange relationship with a fluid to heat the latter and cool said first combustion gas, recirculating a portion of said first combustion gas into said first high temperature combustion zone and into admixture with further first combustion gas generated in said combustion zone by the burning of additional quantities of pulverized fuel, the recirculation of said portion of said first combustion gas into admixture with said further first combustion gas to produce a first resultant combustion gas having a temperature below the fusion point of slag in said fuel so that the entrained molten slag is solidified before passing in indirect heat exchange relationship with said relatively cool fluid, passing said first resultant combustion gas in indirect heat exchange relationship with fluid to heat the latter and cool said first resultant combustion gas, passing a portion of said cooled first resultant combustion gas into said first combustion zone, burning pulverized fuel in a second high temperature combustion zone to produce a second combustion gas at a temperature above the fusion point of the slag in said fuel, passing the other portion of said cooled first resultant combustion gas into said second high temperature combustion zone and into admixture with said second combustion gas to produce a second resultant combustion gas having a temperature below the fusion point of slag in said fuel to solidify the entrained molten slag before said second resultant combustion gas passes from said second combustion zone, flowing said second resultant combustion gas from the second combustion zone into indirect heat exchange relationship with a fluid to heat the latter and cool said second resultant combustion gas, burning pulverized fuel in a third high temperature combustion zone to produce a third combustion gas at a temperature above the fusion point of slag in said fuel, passing said cooled second resultant combustion gas into said third combustion zone and into admixture with said third combustion gas to produce a third resultant combustion gas having a temperature below the fusion point of said fuel so that said third resultant combustion gas is below the fusion point of said slag to solidify the entrained molten slag before pass-

ing from said third combustion zone, flowing said third resultant combustion gas into indirect heat exchange relationship with a fluid to heat the latter and cool said third resultant combustion gas, and passing said cooled third resultant combustion gas to a place of use.

6. In a supercharged vapor generating plant having a plurality of boilers each of which has a combustion zone and a convection zone disposed thereabove, the method of burning a slag forming fuel in each of said boilers comprising the steps of burning a slag forming fuel in a first combustion zone of a first boiler to produce a first combustion gas at a temperature above the fusion point of the non-combustibles in said fuel so that the non-combustibles are in a molten state, passing said first combustion gas from the first combustion zone into indirect heat exchange relationship with a fluid in a first convection zone of said boiler to heat the fluid and cool said first combustion gas, passing the cooled first combustion gas from the first convection zone, passing a portion of said cooled first combustion gas into said first combustion zone and into admixture with the first combustion gas to produce a first resultant combustion gas having a temperature below the fusion point of the non-combustibles in said fuel so that when the first resultant combustion gas enters the first convection zone the entrained molten non-combustibles are solidified, burning a slag forming fuel in a second combustion zone in a second boiler to produce a second combustion gas having a temperature above the fusion point of non-combustibles in said fuel so that the non-combustibles are in a molten state, flowing the other portion of said cooled first combustion gas into said second combustion zone of said second boiler to produce a second resultant combustion gas having a temperature below the fusion point of the non-combustibles in said fuel so that the entrained non-combustibles are solidified, passing said second resultant combustion gas in a second convection zone in said second boiler and into indirect heat exchange with a fluid to heat the latter and cool said second resultant combustion gas, and passing said cooled second resultant combustion gas to a place of use.

7. In a supercharged steam generating plant having a plurality of boilers each of which have a combustion zone and a convection zone disposed thereabove, the method of burning a slagging fuel in each of said boilers comprising the steps of burning a slag forming fuel in a first combustion zone of a first boiler having a relatively high predetermined combustion gas pressure to produce a first combustion gas having a temperature above the fusion point of the non-combustibles in said combustion gas so that the non-combustibles are in a molten state, passing said first combustion gas from said combustion zone into a first convection zone in said boiler and into indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool said first combustion gas, passing said cooled first combustion gas from the first convection zone and dividing said cooled first combustion gas into two streams, pumping one stream into said first combustion zone and into admixture with the first com-

bustion gas generated in said first combustion zone to produce a first resultant combustion gas having a temperature below the fusion point of the non-combustibles in said first combustion gas so that said entrained molten non-combustibles are solidified before the first resultant combustion gas passes into said first convection zone, burning a slag forming fuel in a second high temperature combustion zone of a second boiler having a combustion gas pressure lower than the predetermined pressure in said first boiler to produce a second combustion gas having a temperature above the fusion point of the non-combustibles in said combustion gas so that the non-combustibles are in a molten state, flowing the other stream of said cooled first combustion gas into said second combustion zone and into admixture with said second combustion gas to produce a second resultant combustion gas mixture having a temperature below the fusion point of the non-combustibles in the fuel so that the entrained molten non-combustibles are solidified before said second resultant combustion gas passes from said second combustion zone, passing said second resultant combustion gas from said second combustion zone into a second convection zone of said second boiler and into indirect heat exchange relationship with a relatively cool fluid to heat the latter and to cool said second resultant combustion gas, burning a slag forming fuel in a third high temperature combustion zone of a third boiler having a combustion gas pressure lower than said second boiler to produce a third combustion gas having a temperature above the fusion point of the non-combustibles in said fuel so that the non-combustibles are in a molten state, passing the cooled second resultant combustion gas from the second convection zone into said third combustion zone and into admixture with the third combustion gas generated therein to produce a third resultant combustion gas having a temperature below the fusion temperature of the non-combustibles in the fuel so that the entrained molten non-combustibles are solidified before said third resultant gas passes from said third combustion zone, passing said third resultant combustion gas from the third combustion zone into a third convection zone and into indirect heat exchange relationship with a relatively cool fluid to heat the latter and cool the third resultant combustion gas, and thereafter flowing the cooled third resultant combustion gas from said third convection zone to a place of use.

8. The method of claim 7 wherein the molten non-combustibles not entrained in the combustion gases in each of the combustion zones are withdrawn from the combustion zones in a molten state.

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UNITED STATES PATENT OFFICE
CERTIFICATION OF CORRECTION

Patent No. 2,968,288 January 17, 1961

Robert J. Zoschak et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 8, for "fushion" read -- fusion --; line 37, for "fustion" read -- fusion --; column 4, line 35, for "materal" read -- material --; column 7, line 20, for "sadi" read -- said --; line 65, for "combsution", first occurrence, read -- combustion --.

Signed and sealed this 6th day of June 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents