March 3, 1959 H. G. STALLKAMP 2,875,736

GAS RECIRCULATION METHOD AND AUTOMATIC APPARATUS FOR SUPERHEAT CONTROL

Filed Oct. 26, 1955 2 Sheets-Sheet 1

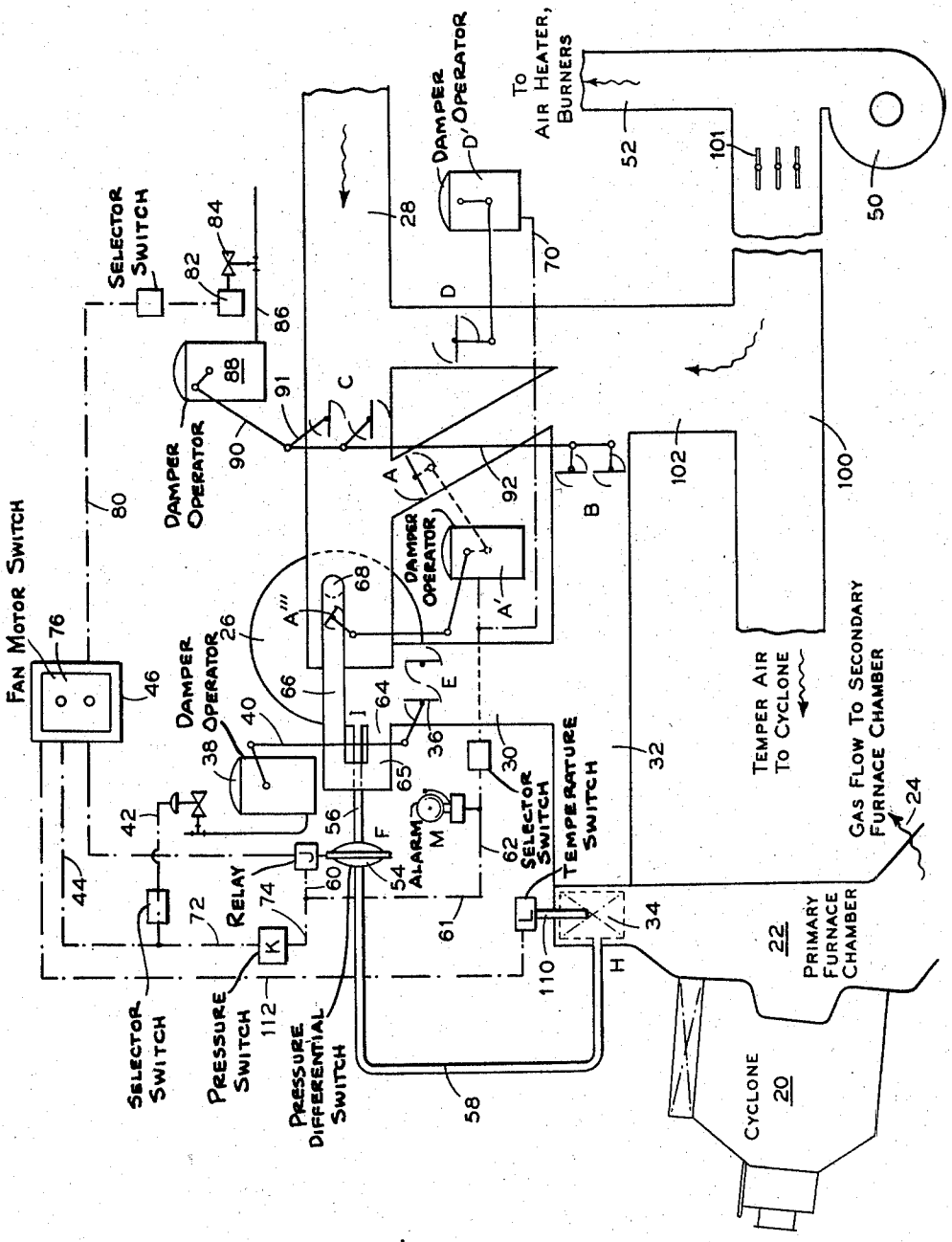


FIG. 1.

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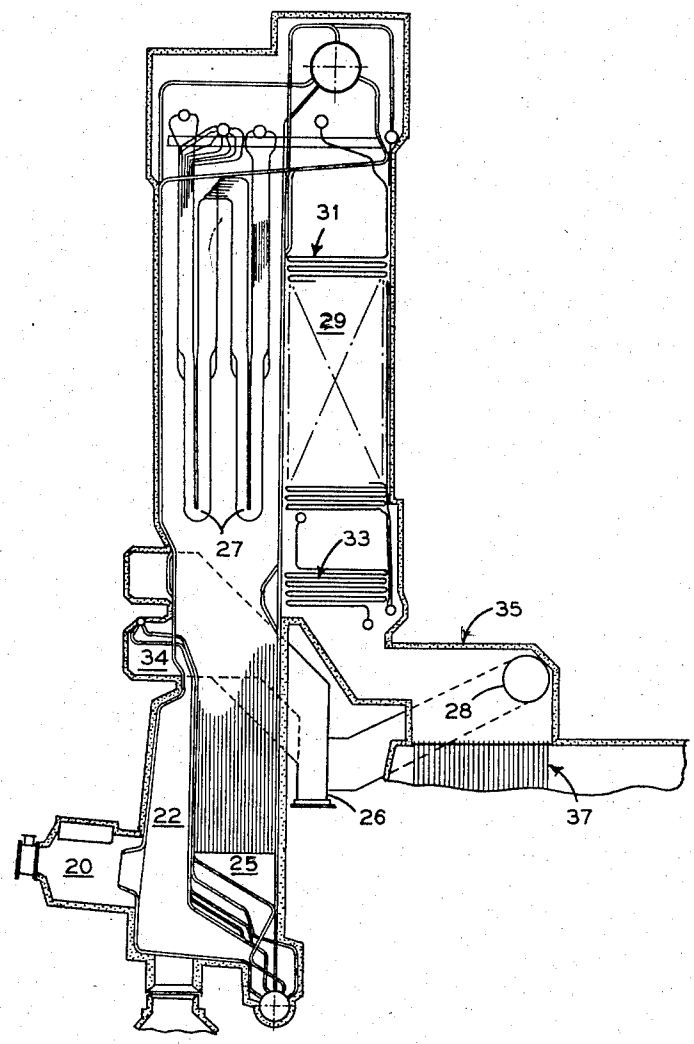
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2 Sheets-Sheet 2

FIG. 2



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2,875,736

GAS RECIRCULATION METHOD AND AUTOMATIC APPARATUS FOR SUPERHEAT CONTROL

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Application October 26, 1955, Serial No. 542,926

16 Claims. (Cl. 122—479)

The invention is exemplified in a steam generating and superheating unit involving a furnace, the walls of which include steam generating tubes in which at least a predominant portion of the total generated steam is generated as a result of radiant heat transmission from the furnace gases, the furnace being provided with high temperature gases by a coal burning means operating at temperatures above the fusion temperature of the incombustible in the coal. The heating gases pass from the furnace over a convection superheater, and a recirculated gas system withdraws lower temperature gases from a position in the gas stream beyond the superheater and introduces the gases into the furnace in increasing volume percentage-wise as the steam generating rate decreases. In the operation of such a unit, fused or semi-fused particles of slag, from the fuel, may accumulate upon the screen tubes and different sections of the convection heating means such as the superheater, and such accumulations may increase to such an extent that the draft loss through the furnace is materially increased. Under such circumstances the total draft resistance may be built up to such an extent that it exceeds the maximum static abiilty of the gas recirculating fan. When this occurs, the fan may be ruined within a few minutes because of the reverse flow of gases through the fan. Additionally, there is apt to be a sudden increase in draft loss under conditions wherein the load suddenly changes from, for example, 50 percent load to 100 percent load when, at the same time, the amount of recirculated gas flow called for by the control system of the unit, approaches zero as the load approaches 100 percent load. The draft loss varies as the square of the change in load, and under these circumstances that would mean that the draft loss is increased four times. This situation is apt to cause a reversal of flow of the recirculated gas through the fan and likewise increase the liability of ruining the fan in the manner above indicated. This invention involves a method of, and means for, preventing the above indicated type of damage to the fan without increasing the size of the fan or increasing the power requirements for operating the fan. According to the invention, when the recirculated gas flow to the furnace decreases to such an extent that the fan outlet static pressure approaches, to a predetermined degree the gas pressure within the furnace, gas is bled from the fan exit and recirculated to the fan inlet, this flow of bled gases being controlled in such a manner that the minimum amount of gas handled by the fan wheel does not drop below that required for the maximum static pressure peak of the fan. According to the invention all of the gas would be recirculated around the wheel of the fan at maximum boiler load when the flow of recirculated gases into the furnace is zero, and no bled gas would be recirculated around the fan wheel at boiler loads requiring recirculated gas flow in excess of that delivered at fan static peak. The flow of bled gases recirculating about the fan wheel may, within the scope of the invention, be controlled manually or automatically.

The invention also involves the control of gas recirculation about the fan wheel from the fan exit to the fan inlet in such a manner that the amount of gas so bled and recirculated about the fan wheel is greater than that required at maximum fan static peak, to attain an upward characteristic of fan static at maximum boiler loads.

The invention also involves a method and apparatus for obtaining the above indicated results, wherein the fan static pressure is increased at low loads by the introduction of cool air or gas into the fan inlet, thus increasing the static of the fan. According to this method of the invention the cool air or gas flow into the fan inlet is automatically regulated or modulated to control the temperature as required in order to give predetermined statics at low flow rates.

The invention also involves control means for, and a method of effecting the above indicated results, involving both the controlled inlet of cold air to the inlet of the recirculating gas fan, and the bleeding of gas from the outlet of the recirculating gas fan to its inlet at low rates of flow of recirculated gas, in order to maintain the fan static at, or near, its peak.

The invention involves an automatic control system functioning to automatically increase the flow of cold air from the forced draft fan of the unit into the inlet side of the recirculated gas fan, and to automatically increase the flow of bled gases from the outlet of the recirculated gas fan to its inlet as the flow rate of recirculated gas into the furnace decreases (such changes in air flow and gas flow may be simultaneous), and also to provide for means for protecting the fan by automatically insulating the fan from gas or air connection with the furnace when the pressure differential between the fan outlet and furnace falls below a predetermined amount, for example 1½" of water. In this automatic system pressure connections are added to the fan outlet and the furnace inlet to measure the pressure differential between the duct from the fan outlet and the furnace inlet, which is restricted in such a manner that the predetermined resistance is achieved. As the pressure differential remains well above 1½" of water, the flow of recirculated gases to the furnace is automatically controlled or modulated from such variables as steam temperature and rate of vapor generation. As the pressure differential decreases and approaches 1½" of water, a damper is automatically opened to permit cold air from the forced draft fan to enter the recirculating fan inlet. The amount of this opening is adjusted as required to allow sufficient cold air to enter and lower the total temperature of the recirculating gas, thus maintaining a 1½" pressure differential between the recirculating fan outlet and the furnace inlet. The automatic system preferably operates so that, if the differential pressure continues to fall, which would be a sign that the furnace resistance is increasing, and the cold air damper reaches its wide open position so that no further margin may be gained, then the system operates to render the fan motor inoperative. At the same time inlet and outlet dampers on the inlet and outlet sides of the fan are closed and cold air dampers upstream and down-stream of the inlet and outlet dampers are opened so that the fan is completely surrounded with cold air. A second precaution involved in the automatic control system involves a temperature switch at the recirculating fan outlet. If the temperature rises in this outlet, which would indicate a reversal of flow of hot gases toward the fan, the motor is automatically stopped and the fan is automatically insulated as previously described. In addition to these features of the automatic system an alarm is also provided in this circuit which warns the operator

that the furnace resistance is dangerously high when the pressure differential approaches 1½" of water.

The invention will be concisely set forth in the claims, but for a complete understanding of the invention, its uses and advantages, recourse should be had to the following description which refers to a preferred embodiment illustrated in the accompanying drawings.

Of the drawings:

Fig. 1 is a diagrammatic representation of a gas recirculation system embodying the invention and associated with a vapor generating and superheating unit; and

Fig. 2 is a vertical sectional view of the vapor generating and superheating unit with which the gas recirculation system of Fig. 1 is associated.

In Fig. 1 there is diagrammatically illustrated a cyclone furnace **20** burning a slag forming fuel and discharging high temperature furnace gases into a primary furnace chamber **22**, from the lower part of which the gases flow upwardly as indicated at **24** into a vertically elongated secondary furnace chamber **25**, the walls of which include steam generating tubes. This secondary furnace chamber, the succeeding convection section including the steam superheater, and the pertinent recirculated gas system for control of superheated steam temperature over a wide range of rate of vapor generation, are constructed and arranged in the manner shown and described in the pending patent application Serial No. 278,872, filed March 27, 1952, by P. H. Koch, and belonging to the same assignee. As disclosed in said application and illustrated in Fig. 2, the products of combustion pass upwardly through the secondary furnace chamber **25** and over a secondary superheater **27** to a downflow convection gas pass **29**, then successively contact a primary superheater **31** and an economizer **33**, and then flow into a duct **35** leading to an airheater **37**. In communication with the duct **35** is the inlet of a duct **28** of a heating gas recirculation system.

In the illustrative steam generating and superheating unit of Fig. 2 the elements of the superheater **27** are arranged as pendent superheater platens disposed within the vertically elongated secondary furnace chamber **25** receiving the combustion products from the cyclone furnace, the latter being an example of fuel burning means. Parts of the dependent superheater platens are disposed in a part of the secondary furnace chamber receiving combustion products including high temperature heating gases with particles of fused slag suspended therein. In the illustrative unit there is a recirculated gas system including a fan and duct work having its inlet downstream in a gas-flow sense from the superheater, and having its gas outlet in communication with the upper part of the primary furnace chamber **22**. This gas recirculation system and its associated controls operate to maintain the temperature of the superheated steam at a predetermined value over a wide load range, and to accomplish this the flow of recirculated gas to the primary furnace chamber is increased as the load decreases, in a lower part of the load range. The recirculated gas system also functions to decrease the ratio of furnace absorbed heat to the total heat absorbed in superheating the vapor, as the steam demand decreases, this action also involving an increase in a proportion of the total heat absorbed by the superheater.

Referring further to the system shown in Fig. 1 as being a part of such a unit as that shown in the above identified pending patent application, the recirculated gas system includes a recirculating gas fan **26**, preferably operated by an appropriate electric motor and receiving partially cooled heating gases through the duct **28**, the inlet of which is in communication with the gas flow of the unit at a position beyond the superheater. The outlet of the fan **26** is connected by the duct work components **30** and **32** to an outlet **34** communicating with the primary furnace chamber **22**.

As the rate of steam demand decreases toward a low load value, and as the rate of firing of the cyclone furnace **20** is decreased, the dampers **36**, disposed in the duct work component **30** are open and controlled or modulated to increase the recirculated gas flow through the opening **34** into the primary furnace chamber **22**. The dampers **36** may be operated throughout a wide load range by appropriate control mechanism including a damper operator **38** appropriately connected to the dampers **36** by linkage **40**. The damper operator **38** is intended to respond to changes in pneumatic loading pressure in the control line **42** and the connected control line **44**, leading from a controller **46** in which, or connected with which, there are suitable and known control devices for varying the loading pressure in the lines **42** and **44** in response to the conjoint influences of a plurality of variables such as load or rate of vapor generation, and superheated steam temperature.

The controls above referred to may be considered as the normal operative controls for maintaining final steam temperature substantially at a predetermined value and, in practice, these controls may be such as those shown and described in the pending application to Paul S. Dickey, Serial No. 260,357 and filed on December 7, 1951, or in the pending patent application of Charles S. Smith, Serial No. 199,406 filed on December 6, 1950, or appropriate gas recirculation control components such as those indicated in the patent application of Durham and Weaver, Serial No. 322,646 filed on November 26, 1952. All of these applications are assigned to The Babcock & Wilcox Company and/or its wholly owned subsidiary, The Bailey Meter Company.

In general, the pertinent normal operative controls of the flow of recirculated gas operate to increase the flow of recirculated gas as the vapor generating load decreases toward a predetermined low load, with a minimum flow of recirculated gas at a relatively high load value.

The type of unit with which the pertinent controls of recirculated gas flow are associated is one in which the fuel burning means such as the cyclone furnace **20** operates under a positive, or super-atmospheric pressure created by such means as the forced draft fan **50**, the outlet of which includes duct work **100** having air flow control dampers **101** and duct work **52** leading to the air inlet of an air heater from which the air flows by appropriate duct work to the air inlet of the fuel burning means **20**. Thus there normally is a relatively high gas pressure at the position of the recirculated gas outlet **34** into the primary furnace chamber **22**, which gas pressure must be overcome by the operation of the recirculated gas fan **26** in order for the recirculated gas to flow from the fan into the primary furnace chamber. In practice, it has been determined that there must be a pressure differential between the position H, or the outlet **34** of the recirculated gas system into the primary furnace chamber, and the position I adjacent the outlet of the fan **26** of a value of the order of 1½" of water, and to effectively utilize the actual pressure differential between these points the pressure differential controller F, or **54** has opposite sides of its diaphragm connected by the lines **56** and **58** to the outlet side of the fan **26**, and to the upper part of the primary furnace chamber, respectively, at positions I and H, respectively. This pertinent pressure differential may be decreased by an increase in draft loss through the furnace occasioned by abnormal slagging of the screen and various convection sections, and by a sudden increase in the rate of vapor generation. When due to such conditions, the pressure differential at F is decreased below the predetermined value, there is apt to be a reverse flow of the high temperature heating gases from the upper part of the primary furnace chamber **22** and through the duct components **32** and **30**, and through the fan **26**. Such a reverse flow of gases would ruin the fan within a matter of minutes to

cause great economic loss not only to operators of the electric generating station with which the steam generating unit is associated but also to the users of the power developed thereby. Such a contingency is prevented by the present invention.

When the differential pressure between the points I and H, measured by the differential pressure controller **54** approaches or drops below 1½" of water, which means that the gas flow is approaching a dangerous condition, so changes the pneumatic loading pressure in the line components **60—62** that the alarm M is sounded and, simultaneously as a result of the signaling of the relay J through the change in loading pressure in said line components, opens the damper A through the agency of the damper operator A', sufficiently to permit such flow of the gases from the duct opening **64** in the outlet of the fan **26** and through the communicating ducts **65** to and through the duct **66** and the opening **68** in the duct **28** or in the inlet box of the fan **26** that the pressure differential between H and I is restored to a value well above 1½" of water.

If the differential pressure between the position H and I continues to fall below 1½" of water while the damper A''' is wide open then the pressure switch K picks up the influence or impulse through the lines **60** and **74** from the relay J; and through the lines **72** and **74**, turns off the fan motor switch **76**; closes the dampers E through the intermediacy of the damper operator **38** and its connections; closes the dampers C and opens the dampers B through the agency of the loading line **80**, the control components **82** and **84**, the line **86**, the damper operator **88** and its connections **90—92**; to insulate the fan **26** and permit the relatively high pressure cold air from the outlet of the forced draft fan **50** to flow through the duct components **100**, **102** and **32** directly into the primary furnace chamber through the opening **34**.

As an additional safety factor, if other controls fail, the temperature switch L, having the element **110** responsive to gas temperatures within the opening **34** or the upper part of the primary furnace chamber operates, upon a dangerous rise in temperature, through the agency of the loading line **112** to stop the fan motor, close dampers C and E and open the dampers B through their connections which are illustrated.

The dampers which are shown in the drawing are preferably arranged so that they may be alternatively, manually or automatically operated through the use of selector switches indicated in one of the above identified pending applications, and thus, for the insulation of the recirculating gas fan other than that above referred to the operator may manually open the damper D and the dampers B to permit cold air to flow to the primary furnace and to the inlet side of the fan, and to close the dampers A, C and E, thus providing for bodies of cold air on both inlet and outlet sides of the fan, after the fan motor is stopped.

Although the invention has been described with reference to a preferred embodiment thereof, it is to be appreciated that the invention is not necessarily limited to all of the details of that embodiment. The invention is, rather, to be taken as of a scope commensurate with the scope of the sub-joined claims.

What is claimed is:

1. In a steam generating and superheating unit of the water tube type, wall means including steam generating tubes and defining a furnace chamber, means normally supplying said chamber with high temperature heating gases, a convection steam superheater including tubes receiving the generated steam and externally subject to the gas flow from the furnace chamber, a recirculated gas system including a fan and connected fan inlet ductwork communicating with gas flow downstream of the superheater for normally withdrawing a percentage of the heating gases after loss of heat therefrom in the superheating and having fan outlet ductwork through which the withdrawn gases are introduced into the furnace chamber, means rendered effective when the pressure differential between the furnace chamber and the fan outlet falls below a predetermined value to increase gas flow around the fan rotor and thereby restore said pressure differential to a value at least as high as said predetermined value; said last named means including a pressure differential controller having one side connected to the recirculated gas fan outlet and its other side communicating with the gas space in the furnace chamber, said differential controller being adapted to detect the pressure differential between the furnace chamber and the outlet side of the fan, dampered additional ductwork leading from the fan outlet ductwork to the inlet side of the fan, and automatic means increasing the flow of gas through said additional ductwork when the differential pressure measured by said controller drops to or below said predetermined value.

2. In a steam generating and superheating unit of the water tube type, wall means including steam generating tubes and defining a furnace chamber, means normally supplying said chamber with high temperature heating gases, said last named means including a fuel burner and a forced draft fan supplying combustion supporting air through an air duct to the burner, air ductwork connecting the outlet of the forced draft fan to said furnace chamber, a convection steam superheater including tubes receiving the generated steam and externally subject to the gas flow from the furnace chamber, a recirculated gas system including a fan and connected fan inlet ductwork communicating with the gas flow downstream of the superheater, and fan outlet ductwork connected to the furnace chamber, said system adapted to normally withdraw a percentage of the heating gases after loss of heat therefrom in the superheating and to introduce the withdrawn gases into the furnace chamber, a damper in the gas fan outlet ductwork, a damper in the gas fan inlet ductwork, and means rendered effective when the pressure differential between the furnace chamber and the gas fan outlet falls below a predetermined value to automatically increase gas flow around the fan rotor and to introduce cold air into the gas fan inlet ductwork to restore said pressure differential to a value at least as high as said predetermined value, said last named means including a differential pressure controller and a pressure switch operatively connected in a control sense to provide for the flow of cold air from the forced draft fan through said air ductwork to the furnace chamber in the event that said pressure differential continues to fall after increasing gas flow around the gas fan rotor and introducing cold air into the gas fan inlet ductwork, the differential controller detecting a change in gas pressure differential between the furnace chamber and the gas fan outlet.

3. In the generation and superheating of high pressure vapor, generating high temperature heating gases by effecting combustion at super-atmospheric pressure, transmitting heat predominantly by radiation to enclosed streams of a vaporizable liquid, superheating the generated vapor by the predominantly convection transfer of heat to enclosed streams of the vapor subject to heat exchange conditions relative to the heating gases after the loss of heat from the latter in vapor generation, withdrawing an automatically controlled percentage of the heating gases after loss of heat therefrom in the superheating, introducing the withdrawn gases into the zone of radiant heat transmission by establishing a predetermined pressure differential between the point of withdrawal of the heating gases and their point of introduction into the radiant heat transmission zone, automatically controlling and varying the flow of introduced heating gases from a maximum flow at a predetermined low load to a minimum flow at a predetermined higher load, detecting the pressure differential between the point of initiation of the withdrawal flow and the point in the

combustion zone to which the recirculated gases are introduced, and increasing the flow of gases through the gas fan by recirculating an automatically controlled percentage of the withdrawn gases in a portion of the path of gases flowing from the point of withdrawal to the point of introduction into the radiant heat zone in response to a decrease in said pressure differential below a predetermined value to re-establish the required pressure differential for flow of gases to the point of introduction into the radiant heat zone.

4. In a vapor generating and superheating unit, wall means including vapor generating tubes normally receiving heat predominantly by radiant heat transfer from high temperature furnace gases within a furnace chamber formed by the wall means, fuel burning means in the form of a cyclone furnace supplying the furnace chamber with high temperature heating gases, a forced draft fan and associated ductwork normally supplying the cyclone furnace with super-atmospheric pressure combustion supporting air, a convection superheater including spaced tubes internally receiving the generated vapor and subject externally to the flow of said heating gases after loss of heat therefrom in the vapor generating zone, a recirculated gas system including a fan and fan inlet ductwork communicating with the heating gas flow downstream of the superheater and having fan outlet ductwork communicating with the furnace chamber, dampered shunt ductwork having an inlet connected with the gas space on the outlet side of the recirculating gas fan, said shunt ductwork having its outlet connecting with the gas space on the inlet side of the fan, a differential pressure controller having a diaphragm separating two pressure chambers, a duct communicating with one of said pressure chambers and the fan outlet, ductwork communicating with the other of said pressure chambers and with the furnace chamber, and control means operatively activated automatically by a departure of said pressure differential below a predetermined value to open the damper in said shunt ductwork to provide for recirculation of the gases around the rotor of the recirculated gas fan to establish said pressure differential at a value above said predetermined value.

5. In a steam generating and superheating unit, wall means including steam generating tubes defining a furnace chamber normally receiving high temperature furnace gases and transmitting heat for the generation of steam predominantly by radiant heat transfer to the steam generating tubes, fuel burning means supplying the furnace chamber with high temperature heating gases, a convection superheater receiving the generated steam and subject externally to the flow of heating gases after a loss of the heat therefrom in said steam generation, a gas recirculating system including a gas recirculating fan and fan inlet ductwork establishing communication with gas flow beyond the superheater and the inlet side of the fan, said system including fan outlet ductwork establishing communication between the outlet side of the fan and the furnace chamber, means varying the flow of recirculated gas into the furnace chamber relative to the variation in the rate of vapor generation, pressure differential means measuring the pressure differential between the fan outlet and the furnace chamber, a shunt duct leading from the outlet side of the gas fan to the inlet side thereof, a damper in said shunt gas duct, a forced draft fan normally supplying combustion supporting air to the fuel burning means, means responsive to change in pressure differential determined by said pressure differential means to control flow of recirculating gas through said shunt ductwork by-passing the rotor of the recirculating gas fan, fan insulating ductwork leading from the air flow from the forced draft fan to the fan inlet ductwork of the recirculating gas fan, and a recirculated gas fan insulating damper disposed within said insulating ductwork, said pressure differential responsive means also simultaneously opening said recirculated gas fan insulating damper to permit the flow of relatively low temperature air from the forced draft fan and its communicating ductwork to the recirculating gas fan inlet ductwork when the pressure differential falls below a predetermined value.

6. The combination of claim 5 further characterized by a damper in said gas fan outlet ductwork, a damper in said gas fan inlet ductwork, a pressure switch responsive to the fall of the pressure differential below a predetermined value, and automatic control connections whereby, when the differential pressure falls below a predetermined value, the operation of the recirculated gas fan is stopped, the damper in said insulating ductwork is opened, and the dampers in the recirculated gas fan inlet and outlet ductwork are closed.

7. The combination of claim 5 further characterized by the inclusion in said control means of a temperature switch responsive to temperature changes within the gas fan outlet ductwork, and automatic control connections associated with said temperature switch whereby, when the gas temperature within the gas fan outlet ductwork rises above a predetermined value, the operation of the recirculated gas fan is stopped and the damper in said insulating ductwork is opened simultaneously with the closing of the damper within the recirculated gas fan outlet ductwork and the damper within the recirculated gas fan inlet ductwork.

8. The combination of claim 5 further characterized by an alarm operatively associated with said pressure differential means and responsive to a fall in the differential pressure below a predetermined value for audibly signaling said fall of differential pressure.

9. In a steam generating and superheating unit, wall means including steam generating tubes defining a furnace chamber normally supplied with high temperature heating gases from which heat is predominantly radiantly transmitted to said tubes to generate steam therein, fuel burning means for supplying high temperature gases to said furnace chamber, a convection superheater receiving the generated steam and subject to the heat of the gases after loss of heat therefrom in the steam generating zone, a recirculated gas system normally withdrawing a percentage of the heating gases from the heating gas flow path downstream of the superheater and introducing a controlled percentage of those gases into the furnace chamber at an increasing rate as the rate of vapor generation decreases over a lower part of its load range, said recirculated gas system including a fan, fan inlet ductwork establishing communication between the gas fan and the heating gas flow path at a position beyond the superheater, and fan outlet ductwork establishing communication between the gas fan and said furnace chamber, means conjointly responsive to load changes and to changes in superheated steam temperature for controlling the flow of recirculated gases to maintain the superheated steam temperature substantially at a predetermined value, control means involving a differential pressure device having a diaphragm separating two pressure chambers, a conduit connecting one of said pressure chambers with the outlet of the recirculating gas fan, another conduit connecting the other of said pressure chambers with said furnace chamber, a shunt by-pass duct leading from the outlet side of the recirculated gas fan to the inlet side of the recirculated gas fan, a damper in said shunt duct, a forced draft fan and associated ductwork supplying the fuel burning means with combustion supporting air, a branch air duct leading from the associated ductwork of the forced draft fan to the recirculating gas fan inlet ductwork, an air control damper in said branch air duct, and control means automatically responsive to a falling off of the differential pressure measured by said pressure differential device below a predetermined value to open said branch air duct damper to permit the flow of cold air through said branch air duct and to simultaneously open the shunt duct damper to provide for increasing the

circulation of gas flow through said shunt ductwork around the fan rotor until the pressure differential is established at a value above said predetermined value.

10. In a steam generating and superheating unit, wall means defining a furnace chamber, means including a fuel burner and a forced draft fan with connected fan outlet ductwork normally supplying said furnace chamber with high temperature heating gases, a tubular vapor superheater subject to the gas flow from the furnace chamber, a recirculated gas system including a fan with connected fan inlet ductwork and dampered fan outlet ductwork normally withdrawing a percentage of the heating gases after loss of heat therefrom in the superheating and introducing the withdrawn gases into the furnace chamber, an air duct communicating at one end with the forced draft fan and at its opposite end with the gas fan inlet, a shunt duct leading from the outlet of the gas fan to the inlet thereof and an automatic control system functioning to automatically increase the flow of cold air from the forced draft fan through said air duct into the inlet side of the recirculated gas fan and to automatically increase the flow of bled gases from the outlet of the recirculating gas fan to its inlet by way of said shunt duct as the flow rate of recirculated gas into the furnace decreases.

11. The combination of claim 10 further characterized by a differential pressure controller having one of its chambers communicating with the gas fan outlet and its other chamber communicating with the furnace to measure the pressure differential between the gas fan outlet and the furnace, said automatic control system acting to automatically admit cold air from the forced draft fan to the inlet of the recirculating gas fan when the pressure differential measured by said differential controller attains or falls below 1½" of water.

12. The combination of claim 11 further characterized by means for rendering the recirculated gas fan inoperative when the differential pressure measured by said differential pressure controller continues to fall after the damper in said branch air duct reaches its wide open position.

13. In a method of preventing the destruction of a recirculated gas fan in the operation of a steam generating and superheating unit including a fuel fired furnace, a steam superheater subject to the heating gas flow after loss of heat therefrom in steam generation, and a recirculated gas system including a fan having dampered inlet ductwork and dampered outlet ductwork associated therewith, the method comprising withdrawing heating gases through said fan inlet ductwork from a position downstream of the superheater and discharging the withdrawn gases through said fan outlet ductwork into said furnace chamber, automatically controlling the percentage of heating gases so withdrawn, and measuring the pressure differential between the gases in the furnace and in the gas space at the outlet side of the gas fan and increasing the flow of gases through the gas fan in response to a decrease in said pressure differential below a predetermined value, while maintaining the rate of flow of recirculated gases into said furnace chamber substantially constant.

14. In a method covered by claim 13 further characterized by the automatic introduction of cold air into the recirculated gas fan inlet ductwork when said measured pressure differential falls below the predetermined value.

15. The combination of acts specified in claim 13 further characterized by the increasing of gas flow through the recirculated gas fan by withdrawing a percentage of the gases from the outlet side of said fan and conducting those gases to the inlet side of the fan in such degree that the measured pressure differential will rise above said predetermined value.

16. The combination of acts specified in claim 13 further characterized by the increasing of gas flow through the recirculated gas fan when said measured pressure differential falls below said predetermined value, by introducing cold air into the ductwork at the inlet side of the recirculated gas fan, and simultaneously conducting a percentage of the gases exiting from the fan rotor to the inlet side of the fan rotor, and continuing such introduction of cold air and bled gases around the fan rotor until said measured pressure differential increases to a value above said predetermined value.

References Cited in the file of this patent

UNITED STATES PATENTS

2,086,812 Luty ---------- July 13, 1937

OTHER REFERENCES

B & W Bulletin G74 of 1954, page 24.