March 8, 1938. R. M. E. O. NORGUET 2,110,422

BOILER FURNACE

Filed June 27, 1935 4 Sheets-Sheet 1

FIG. 1

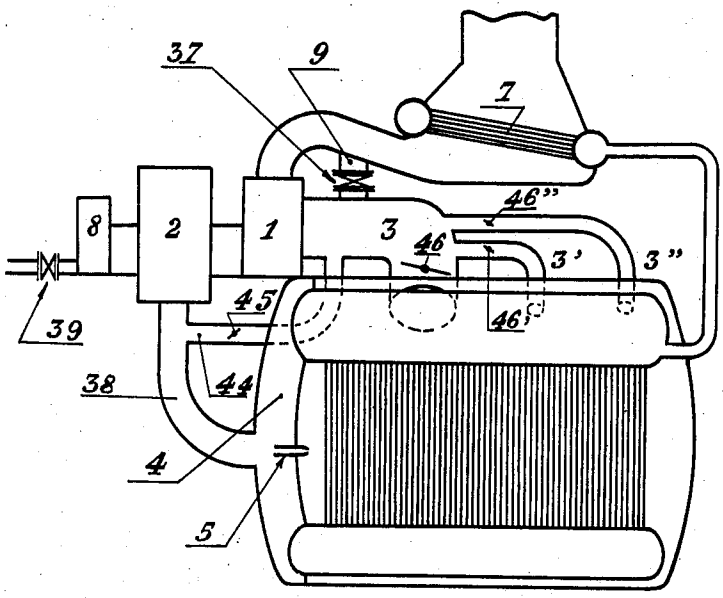


FIG. 2

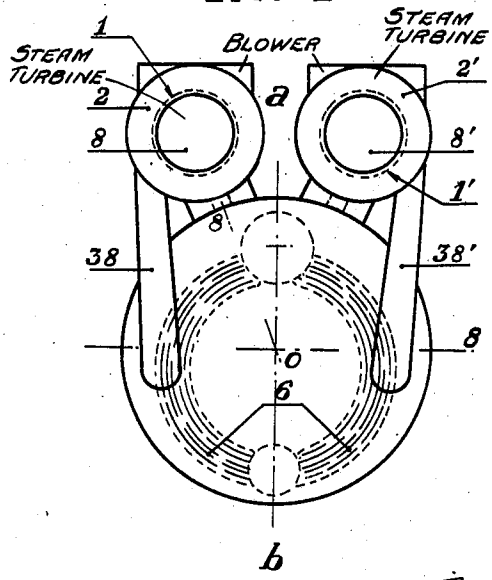
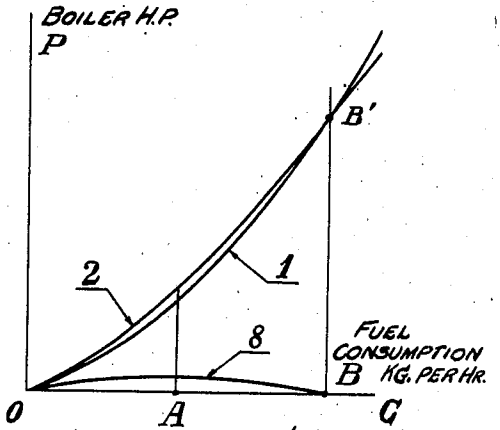


FIG. 3



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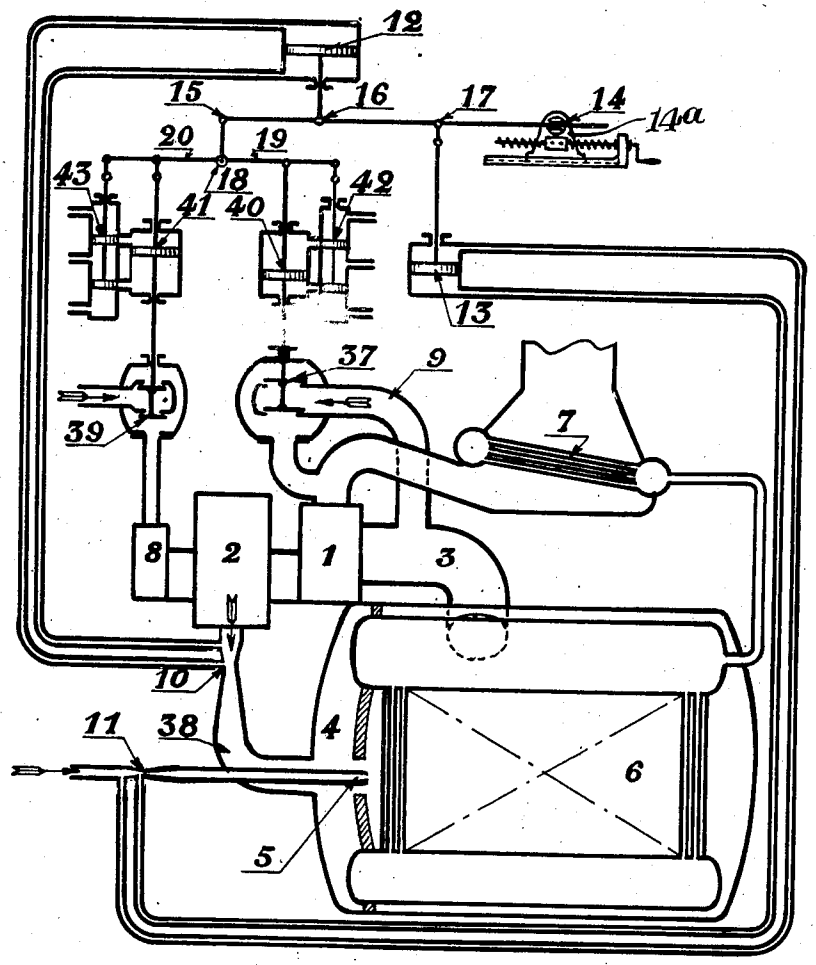
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Fig. 4.



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FIG. 8.

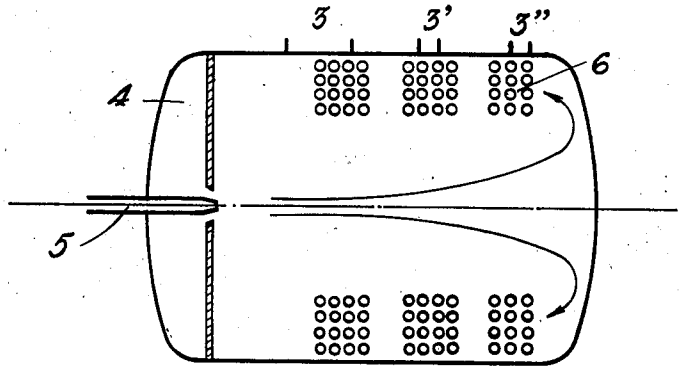


FIG. 5

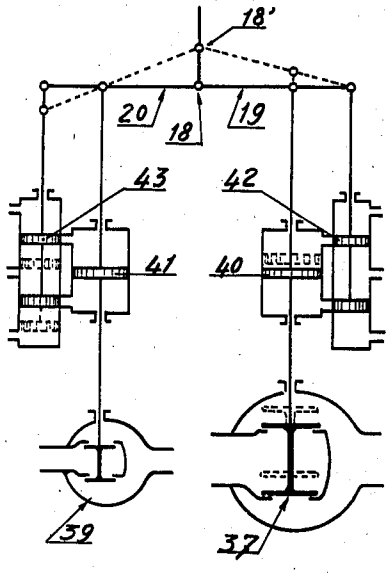
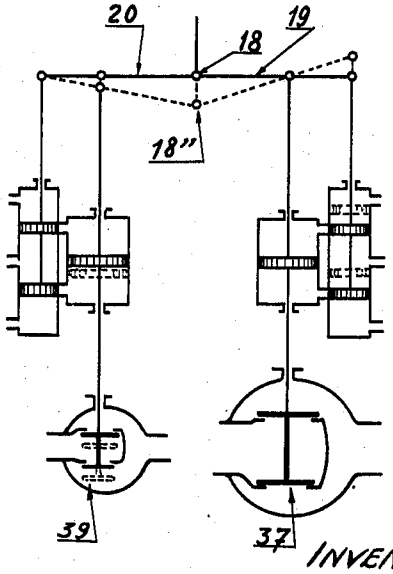


FIG. 6



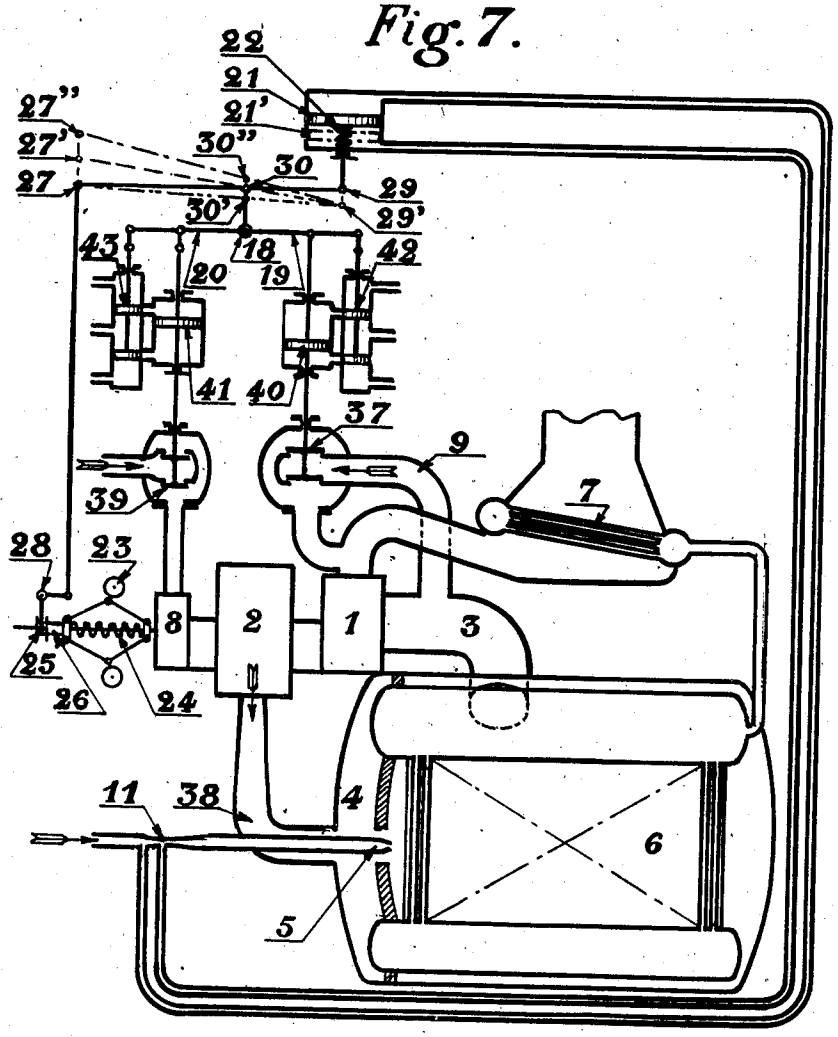
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Fig. 7.



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UNITED STATES PATENT OFFICE

2,110,422

BOILER FURNACE

René Marie Emile Omer Norguet, Paris, France

Application June 27, 1935, Serial No. 28,757
In France September 22, 1934

6 Claims. (Cl. 122—24)

The present invention relates to systems of the type including a boiler and means for feeding air at a suitable rate to the furnace of said boiler, said means including an air blower, compressors or the like, connected with the air inlet of the furnace and operated by a turbine driven by the expansion of the combustion gases from said furnace.

The object of the present invention is to provide a system of this type which is better adapted to meet the requirements of practice than systems of this type used up to the present time.

According to an important feature of the present invention, the boiler is divided into at least two sections (for instance two groups of tubes) through which the combustion gases from the furnace flow, and the turbine above referred to is driven by the combustion gases flowing from one boiler section to the other, said combustion gases being fed to the intake of said turbine from different points of the path of travel of the gases through the first mentioned boiler section, at will.

According to another feature of the present invention, the two boiler sections are connected together by at least two passages, the gas turbine above mentioned being mounted across one of said passages, and the system further includes a steam turbine for driving said blower in parallel with the gas turbine, means, responsive to the rate of flow of air fed by said blower to said furnace and to the rate of flow of fuel to the furnace, being provided for controlling the steam turbine and the section of flow through the second passage above referred to.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described, with reference to the accompanying drawings, given merely by way of example, and in which:

Figure 1 represents diagrammatically, in elevation and section, along line *a—b* of Figure 2, the complete arrangement of a boiler according to the invention; Figure 2 is an end elevation thereof; Figure 3 is a diagram of the curves representing the variations in the power of the blower, gas turbine and steam turbine (employed for driving the blower); Figure 4 shows an arrangement in which the control is effected by the supplies of air and fuel; Figures 5 and 6 represent, in two different positions, the steam valve and the gas draw-off valve, in combination with the control device shown in Figure 4; Figure 7 shows an arrangement in which the control is effected by the supply of fuel and the speed governor; whilst Figure 8 shows a section of the boiler along line 8—8—8 of Figure 2.

As diagrammatically shown by Fig. 1, a system according to the present invention includes a boiler the furnace of which is shown at 4 and which is provided with fuel burners of any suitable type, for instance an oil burner (especially intended to use mazout, that is to say the brownish black liquid remaining after the distillation of benzine and kerosene from Russian petroleum) 5. Air under pressure for combustion of said fuel is fed to said furnace through conduit 38. This air is supplied by a blower 2 operated by a turbine 1. Said turbine is driven by the combustion gases from furnace 4.

According to the present invention, the boiler tubes are divided into two groups, to wit groups 6 and 7, and turbine 1 is inserted in the path of travel of the combustion gases flowing through the passage extending from group 6 to group 7. This arrangement permits of obtaining a sufficient driving power from the combustion gases, by suitably choosing the relative numbers and dimensions of the tubes of these two groups 6 and 7.

However, it should be well understood that, if the whole is designed in such manner as to obtain from the combustion gases thus employed a driving power sufficient for working the turbine, and consequently the blower, at the proper rate for feeding the right amount of air to the boiler furnace, when said boiler is working under average conditions, that is to say with an averag rate of feed of fuel to burner 5, the same is not true when the working conditions of the boiler are modified. When fuel is fed to burner 5 at a rate lower than the average rate in question, the amount of air delivered by blower 2 is too small. On the other hand, when the fuel feed to burner 5 is higher than the average rate, the amount of air fed by blower 2 is too large.

According to the present invention, these drawbacks can be obviated by making use of the following arrangements, employed separately or in combination.

At low outputs of the boiler, that is to say when the rate of feed of fuel to burner 5 is low, the power for driving blower 2 is supplied, at least partly, by an auxiliary steam turbine 8, keyed on the shaft of the turbo-blower 1, 2 and supplied with steam through a valve 39. Its power is usually small. Advantageously, according to the present invention, the working of said

steam turbine (for instance the feed of steam thereto) is regulated in such manner (see for instance the device of Fig. 4) that the power of said steam turbine increases with the rate of feed of fuel to burner 5 up to a certain value of said rate of feed, then gradually decreases when said rate of feed further increases, and finally becomes zero for a certain value of said rate of feed (corresponding for instance to one half of the normal value of the power of the boiler). The curve 8 in Figure 3 shows this variation in the power of the steam turbine 8, the power P being expressed by ordinates and the fuel feed C to burner 5 by abscissae. The power output of the blower 2 is represented by the curve 2, and that of the gas turbine 1 by the curve 1.

Beyond the output at which the power of the gas turbine is equal to that of the blower—point B', Figure 3—the power of said turbine becomes more than sufficient. In order to prevent racing and excess of air, a draw-off, or by-pass 9, for the combustion gases, controlled by a valve 37 (Figure 1), connects the group of tubes 6 with the group of tubes 7 in such a way as to cause a portion of the combustion gases that have flown around the tubes of group 6 to pass directly to the tubes of group 7 without passing through gas turbine 1. This operation may be performed by hand, or by means of an automatic control of the kind hereinafter described.

The boiler may also be equipped with a second turboblower unit, indicated by 1', 2' in Figure 2. At low outputs, it will be simpler, and in some cases more economical—to put only one of the units in operation, the two functioning in parallel at higher outputs.

In these circumstances, a single machine will be able to supply the boiler with the requisite air up to an output exceeding half the maximum power, since the pressure and temperature will be lower, for the corresponding supply, than if the two machines were in parallel (losses of charge in the sheaves, and nozzles being lower). Consequently, neither the blower nor the turbine will be exposed to maximum centrifugal or thermal stress.

If the number and size of the tubes of group 6 has been chosen suitably, it is thus possible to work with a single turbo-blower unit for instance unit 1—2, up to an output such that the two turbo-blower units 1—2 and 1'—2', afterwards set in parallel operation, will no longer require any supply of power.

The arrangement will function in the following manner:

The boiler is started by means of an appropriate burner or mazout heater, as in ordinary boilers. When steam has been generated, one of the turbo-blower units 1, 2, or 1', 2' is set in operation, its power being supplemented by that of the steam admitted to the auxiliary turbine 8. As the output increases, the power of this latter turbine 8 increases, passing a maximum and then falling to zero, the power of the turbo-blower unit being sufficient. As this output further increases, the by-pass 9 is opened in a corresponding manner, these conditions of working permitting to obtain an output corresponding to one-half of the full output of the boiler.

When it is desired to still further increase the output, combustion gases from portion 6 of the boiler furnace are gradually admitted to the second turbo-blower unit. The by-pass 9 is again closed. The rates of feed of the combustion gases to turbines 1, 1' is increased as the output further increases.

If possible, one may, at outputs for which the gas turbine is more than sufficient, draw off a portion of the cold air furnished by the blower, towards the intake of the turbine, for example, with the object of lowering the temperature of the gases and therefore the wear and tear of the turbine rotor. This is illustrated in Figure 1 by the branch pipe 44 connecting the delivery pipe 38 with the gas conduit 3 a valve 45 being placed in said pipe 44.

The method which consists in setting a single unit in operation at low outputs, in order to lessen the auxiliary power to be supplied, may be replaced, or supplemented, by the following means.

Conduits, such as 3, 3', 3'' (Figures 1 and 8) branching off at different points in the path of the gases, beyond the furnace, and provided with throttles or valves 46, 46', 46'' in such a manner as to draw-off the gases at points nearer the furnace in proportion as the rate of combustion diminishes, thereby compensating the lowering of the gas temperature. This measure also reduces the losses of pressure resulting from the passage in the sheaves of tubes, and thereby again increasing the power available in the gas turbine.

Since the additional power to be supplied in the steam turbine, between no-load and that corresponding with operating with the gas turbine alone, varies with the load on the boiler, the admission of the steam can be controlled by an automatic device.

The variations in the power of the steam turbine can be obtained by controlling the admission of the steam by means of a throttle 39. Said throttle, and also that of the by-pass 9, can be actuated automatically by means of a control device enabling proportionality to be maintained between the supplies of air and fuel necessary for obtaining good combustion under all loads.

In Figure 4, 10 is a Venturi tube through which passes the air from the delivery pipe 38 (Figure 1) of the blower. 11 is a second Venturi tube through which the supply of fuel is passed, and 12 and 13 are pistons subjected respectively to the negative pressures set up in the two Venturi tubes 10 and 11. The pistons 12 and 13 act on points 16 and 17, respectively, of a lever L, mounted on a pivot 14, so that said lever is balanced by the opposed actions of the respective suctions of the two Venturi tubes 10 and 11 corresponding to the feeds of air and fuel, these respective actions depending upon the values of lever arms 14—16 and 14—17.

These values can be modified by modifying the position of pivot 14, which is, for example, carried by a sliding support 14a, the result being to change the ratio of the lever arms 14, 16 and 14, 17. In this manner, the excess of air can be controlled according to the higher or lower density and fluidity of the fuel.

Every modification of the supply of air or fuel displaces the lever 14, 15 which acts on the aperture of the steam valve 39, or of the throttle 37 on the gas by-pass 9 (Figure 1).

An increase in the rate of fuel feed which is controlled through any conventional means produces either the closing of the gas by-pass, or the opening of the steam valve 39, according as the group works on one side or the other of the state of equilibrium (illustrated by point B in Figure 3).

The speed of the blower is then accelerated, increasing the rate of air feed and tending to restore the desired proportionality. Conversely, the increase in the air feed rate leads to the closing of the steam valve 39, or the opening of by-pass 9, which reduces the speed of blower 2 and therefore tends to reduce said air feed rate, thus restoring the desired proportionality.

Thus, any modification of the air feed (reduction or increase) sets up a variation in the operation of the group, in the direction tending to restore the proportionality between air and fuel feed. Once this result has been obtained, all action on the control members ceases, lever 14, 15 being again balanced.

The control of steam throttle 39 and by-pass throttle 37, initiated by the displacements of point 15, Figure 4, may be effected through any means which, in the conditions represented in that figure are capable of insuring the following results:

In the case of a downward displacement of point 15 (increase of fuel supply or decrease of air supply), by-pass 9 is closed and then valve 39 is opened.

In the case of an upward displacement of point 15 (decrease of fuel supply or increase of air supply), the valve 39 is closed and then by-pass 9 is opened.

The arrangement shown in Figures 5 and 6 gives an example of such a device. Point 18 corresponds with the same point as in Figure 4.

The position shown in full lines is the starting position, members 37 and 39 being then closed.

At 18', steam throttle 39 is closed, and the gas by-pass throttle 37 wide open (positions indicated, in Figure 5 by broken lines). From 18' to 18, throttle 37 closes, throttle 39 remaining closed. Said throttles are preferably controlled by pistons 40, 41 actuated by the distributor of servo-motors 42 and 43, connected with rods 19, 20, pivoted at 18.

From 18 to 18'' (Figure 6) the gas throttle remains closed, and the steam throttle 39 opens, becoming wide open at 18''. The corresponding positions of the throttles and their servomotors are indicated by broken lines.

Any other arrangement producing those successive opening and closing movements may be utilized.

Figure 7 shows another control arrangement for successively opening and closing the steam throttle, and opening the gas by-pass throttle, so as to obtain a variation of the power of the steam turbine approximating as nearly as possible that represented by the curve 8, Figure 3.

With that object, the opening of the steam valve is effected by the partial vacuum created in a Venturi tube and by the supply of fuel, and continues up to the load corresponding with the maximum power of the steam turbine, beyond which moment the throttle is gradually closed by the action of a centrifugal governor. When the steam has been shut off completely, the governor gradually opens the by-pass.

Referring to Figure 7, the partial vacuum set up in the Venturi tube 11 by the fuel feed acts on a piston 21 against the action of a spring 22 which is adjusted in such a manner that, for the feed corresponding with the load for which the power of the steam turbine is maximum (indicated by the point A on the power diagram, Figure 3), the piston 21 occupies the position 21', determined by a stop.

On the other hand, the centrifugal governor 23 driven by the turbine is provided with a spring 24, or any equivalent, which does not allow the collar 25 to leave the stop 26 unless the speed of said machine exceeds a predetermined value. The spring 24 is adjusted so that said speed will be precisely that corresponding with the boiler output indicated by A' (Figure 3).

The arrangement functions in the following manner: For boiler loads comprised between O and A, the governor is inactive, the point 27 remaining fixed (the point 28 of the lever connected with the collar 25 being a fixed point). On the contrary, the end of the rod of the piston 21 moves from 29 to 29' and the point 30 from 30 to 30'. From that moment, and for all higher loads, the piston 21 is stopped at 21', and 29' becomes a fixed point.

The centrifugal governor then begins to act. An increase on the amount of fuel obtained through any conventional means raises the temperature of the gases, thereby accelerating the unit, the point 27 moving to 27', and the point 30' from 30' to 30 and 30''.

The movements of the point 30 are transmitted to the throttle members, starting with 18, by a device similar to that of the first system, for example as shown in Figure 4.

Various modifications in the arrangements described may be effected without departing from the spirit of the invention and the scope of the claims.

What I claim is:

1. A system of the type described which comprises, in combination, a furnace for producing hot gases, a boiler including at least two sheaves of tubes and passages for leading the gases from said furnace through both of said sheaves of tubes successively, at least one turbine mounted in the passage between said two sheaves of tubes, means for directly connecting with the intake of said turbine different points of the path of travel of the gases through the first sheaf of tubes, at will, whereby said turbine is actuated by said gases, and a blower driven by said turbine for feeding air under pressure to said furnace.

2. A system of the type described which comprises, in combination, a furnace for producing hot gases, a boiler including two distinct boiler sections and passages for leading the gases from said furnace through both of said boiler sections successively, at least one turbine mounted in the passage between said two boiler sections, means for directly connecting with the intake of said turbine different points of the path of travel of the gases through the first boiler section, at will, whereby said turbine is actuated by said gases, and a blower driven by said turbine for feeding air under pressure to said furnace.

3. A system of the type described which comprises, in combination, a furnace for producing hot gases including an air intake and a fuel inlet, a blower adapted to feed air under pressure to said air intake, a boiler including two sheaves of tubes, passages connecting said furnace and said two sheaves of tubes in series, with the passage between the two sheaves of tubes subdivided into two parts, a gas turbine, mounted in one of said parts so as to be operated by the gases flowing therethrough, valve means in the other part for controlling the flow therethrough, a steam turbine, both of these turbines being arranged to drive said blower in parallel, and means, responsive both to the rate of flow of the air fed by said blower and to the rate of flow of fuel through

said fuel inlet, for controlling said steam turbine and said valve means.

4. A system of the type described which comprises, in combination, a furnace for producing hot gases including an air intake and a fuel inlet, a blower adapted to feed air under pressure to said air intake, a boiler including two sheaves of tubes, passages connecting said furnace and said two sheaves of tubes in series, with the passage between the two sheaves of tubes subdivided into two parts, a gas turbine mounted in one of said parts so as to be operated by the gases flowing therethrough, valve means in the other part for controlling the flow therethrough, a steam turbine, both of these turbines being arranged to drive said blower in parallel, and means, responsive both to the rate of flow of the air fed by said blower and to the rate of flow of fuel through said fuel inlet, for controlling said steam turbine and said valve means, said controlling means including a centrifugal governor operative by said gas turbine and adapted to control the feed of said steam turbine, so as to gradually reduce the output thereof, and, when said steam turbine is brought out of action, to open said valve means.

5. A system of the type described which comprises, in combination, a furnace for producing hot gases including an air intake and a fuel inlet, a blower adapted to feed air under pressure to said air intake, a boiler including two distinct boiler sections, passages connecting said furnace and said two boiler sections in series, with the passage between the two boiler sections divided into two parts, a gas turbine mounted in one of said parts so as to be operated by the gases flowing therethrough, valve means in the other part for controlling the flow therethrough, a steam turbine, both of these turbines being arranged to drive said blower in parallel, and means, responsive both to the rate of flow of the air fed by said blower and to the rate of flow of fuel through said fuel inlet, for controlling said steam turbine and said valve means.

6. A system according to claim 5 in which said last mentioned means include a centrifugal governor operative by said gas turbine, and operatively connected with said steam turbine, so as to gradually reduce the feed thereof, said governor being also operatively connected with said valve means so as to open said valve means when said steam turbine has been brought out of action.

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