

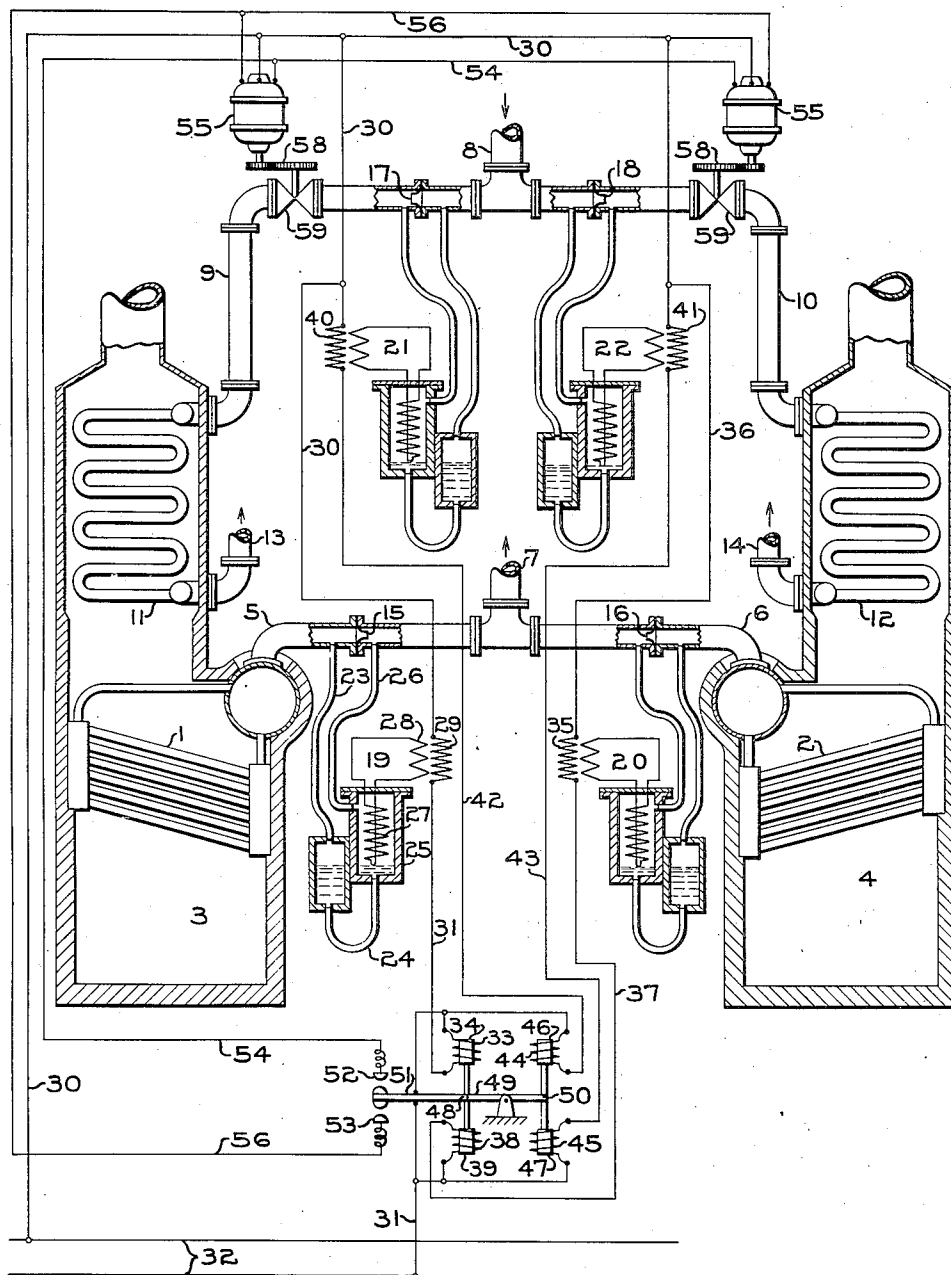
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METHOD OF AND APPARATUS FOR PROPORTIONING FLOWING FLUIDS

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METHOD OF AND APPARATUS FOR PROPORTIONING FLOWING FLUIDS

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This invention relates to the control of flowing fluids, and in particular to the proportioning of the several flows of a divided fluid, through and in accordance with the available heat of a plurality of heaters for the heating of the fluid.

It has as its primary object to provide a method and an apparatus for distributing or proportioning a flowing fluid through a number of heaters in accordance with the available heat supplied to the heaters.

A further object is to so proportion the fluid to be heated between the heaters that sufficient cooling of the heaters will result to prevent damage to them.

Still another object is to so proportion the fluid that as nearly a uniform temperature of the fluid will be obtained at the exit of the heaters, as is possible.

In order to make clear my invention I have chosen to illustrate and will describe a preferred embodiment in connection with the reheating of steam after it has passed through a relatively high pressure turbine and prior to passing through a relatively lower pressure turbine. I preferably cause the steam to flow through heat exchangers heated by the waste gaseous products of combustion of steam generating boilers, and wherein the amount and heat content of the gases for heating varies with the rate of operation of the boilers. I proportion the flow of steam through these heaters in accordance with the available heat, considering the rate of operation of the boiler or rate of flow of steam generated by the boiler as an index of the amount of available heat in the waste products of combustion.

In the drawing, which is a diagrammatic representation of apparatus embodying the invention, I have illustrated two steam generating boilers 1 and 2 heated by the combustion of a suitable fuel in the furnaces 3 and 4 respectively, and discharging steam through the pipes 5 and 6 to a header 7. The header 7 may supply steam to a turbine or other steam utilizing apparatus (not shown) from which exhaust steam is desirably reheated before going to other steam utilizing apparatus (not shown). I have assumed that the steam exhausted from the first mentioned steam utilizing apparatus is available through a header 8, and I desire to proportion this steam from the header 8 through the pipes 9 and 10 to the waste gas heat exchangers 11 and 12. The heat exchangers 11 and 12 being positioned in the path of discharge from the boilers 3 and 4 of the waste gaseous products of combustion of the boilers, for

the heating of the exhaust steam flowing through the exchangers by the heat available in the waste gases. The reheated steam leaves the heater 11 through a pipe 13, and leaves the heater 12 through a pipe 14, the pipes 13 and 14 leading to further steam utilizing apparatus (not shown).

I find that the rate of discharge of steam through the pipes 5 and 6 serves as an accurate index of the rate of operation of the boilers, and of the availability of total heat per unit of time in the waste products of combustion passing the heaters 11 and 12. To measure the rate of flow of steam leaving the boiler through the pipe 5, I have inserted in the pipe between convenient flanges, a flow nozzle 15 across which will occur a pressure difference bearing a known relation to the rate of flow of steam through the nozzle. I have shown similar flow nozzles 16, 17, 18 positioned in pipes 6, 9, 10 respectively for causing a pressure drop across the respective flow nozzles, which pressure drop I may employ as a measure of the flow of steam through the respective pipes.

Generally indicated at 19, 20, 21 and 22 are rate-of-flow meters of the steam flowing through the pipes 5, 6, 9 and 10 respectively. The meters 30 are similar in construction and operation, and while their capacities may vary, as well as the conditions of the steam being measured, etc., which would change constants one from the other, I feel that it is unnecessary to describe in detail the construction and operation of more than one of the similar meters, and propose to avoid duplication and repetition by describing only the meter indicated at 19.

Connected to the pipe 5, at the inlet side of the flow nozzle 15, is a pressure pipe 23 joining and transmitting pressure to the high pressure leg of a mercury sealed U-tube 24, of which 25 indicates a low pressure leg connected by a pressure pipe 26 to the pipe 5 at the outlet side of the nozzle 15. When steam is flowing through the pipe 5, past the nozzle 15, a pressure difference will exist due to the temporary increase in velocity of the steam through the nozzle, and will be effective through the pipes 23, 26 upon the U-tube 24, to the end that the mercury level will tend to lower in the high pressure leg of the U-tube and rise within the low pressure leg 25 of the U-tube, the difference in elevation being a measure of the pressure difference.

Within the chamber 25 and around one leg of a transformer core (not shown) is arranged a primary winding 27, having conductors leading through the cover plate of the chamber 25 to connect to a transformer winding 28 external of the

flow meter. Transformer winding 28 forms the secondary winding of a step-down or insulating transformer which has its primary winding 29 connected by the conductors 30, 31 to a source of alternating current, of constant potential, indicated by the power lines 32. Primary winding 27 is thus connected to a source of alternating current 32 through the intermediary of the step-down transformer comprising the windings 28 and 29. It is desirable that a voltage of comparatively small value be impressed on the winding 27, while the voltage ordinarily met with is of 110 volts or more, and the purpose of the step-down transformer is to provide a voltage for the winding 27 of suitable value.

The U-tube 24, upon which is effective a pressure difference resulting from a flow of steam through the flow nozzle 15, is sealed with mercury which is a conductor of electricity. The relatively high pressure at the inlet to the flow nozzle forces the mercury downward in the high pressure leg of the U-tube, and upward in the chamber 25 around the winding 27, the difference in elevation of the mercury being a measure of the pressure difference and of the flow. The mercury in rising forms a ring around the lower end of the transformer 27, comprising a closed secondary winding of a single turn for the transformer whose primary winding is 27, and the resistance of which varies in accordance with the depth of the mercury ring.

The current flowing in the primary winding 27 will be proportional to the resistance of the secondary winding formed by the mercury ring, so that as the mercury rises and falls in the casing 25, the current flowing in the primary winding 27 and hence in the circuit comprising conductors 30, 31, will vary in accordance with the depth of the mercury ring, and consequently with the rate of flow of steam through the pipe 5.

In the circuit comprising the conductor 31 is a suitable solenoid coil 33 adapted to vary in effect upon a core 34, for positioning the same vertically, in dependence upon, or proportional to, the current flowing through the conductor 31.

Similarly, a flow meter 20 serves to vary the current flowing through a transformer primary 35 connected by conductors 36, 30 and by conductors 37, 31 to the power lines 32. Interposed in the conductor 37 is a solenoid winding 38 similar to the solenoid winding 33 and effective to position a core 39 in proportion to the current flowing through the conductor 37.

The flow meters 21 and 22 are similarly provided with transformer primaries 40 and 41 respectively, through each of which flows a current proportional to the pressure difference existing across the flow nozzle to which the respective flow meters are connected. The transformer primary 40 connected at one terminal through the conductor 30 to the power lines 32 and at the other terminal through the conductor 42. The transformer primary 41 is connected at one terminal by conductors 36, 30 to the power lines 32 and at the other terminal by a conductor 43 to the power lines. Positioned in the conductors 42 and 43 respectively are solenoid windings 44 and 45, respectively effective in positioning the solenoid cores 46 and 47.

I have shown the four solenoids, namely 33, 38, 44 and 45, as arranged in close proximity for cooperation thereof, and will now explain in detail the desirable cooperation of the solenoids for accomplishing a proportioning of the flow of the steam in the pipe 8 through the pipes 9 and

10 in proportion to the steam flowing through the pipes 5 and 6. The solenoid cores 34 and 39 are oppositely positioned across and connected to, at a common pivot point 48, a fulcrumed beam 49. Similarly positioned, and pivoted to a common point 50 of the fulcrumed beam 49 are the solenoid cores 46 and 47, the arrangement being such that the beam 49 is fulcrumed intermediate the points 48 and 50, and either at a point equidistant from the points 48, 50, or otherwise as desired, depending upon the capacities of the flow meters and the desired proportionality to be maintained between the various flows.

It will be seen that the arrangement of the fulcrumed beam 49 with the solenoid cores 34, 39, 46 and 47 forms a balancing system wherein the beam 49 will be positioned in a clockwise or counterclockwise direction around its fulcrum, depending upon the balance or preponderance of forces in the various solenoid coils. Thus if the current flowing through the solenoid 33 as an indication of the rate of flow of steam through the pipe 5, is equal to the current flowing through the solenoid 38 as an indication of the rate of flow of steam through the pipe 6, then equal forces will be effective upon the point 48 through the solenoid cores 34 and 39, whereas if the rate of flow of steam through the pipe 5 predominates that through the pipe 6, and correspondingly the current flowing through the solenoid 33 predominates that flowing through the solenoid 38, then the beam 49 will tend to move, for example, in a clockwise direction around its fulcrum. Similarly, should the current through the solenoid 44, as an indication of the rate of flow of steam through the pipe 9 predominate the current through the solenoid 45, as an indication of the rate of flow of steam through the pipe 10, then the pull of the solenoid 44 upon the point 50 will be greater than the pull of the solenoid 45 upon the same point, and the beam 49 will tend to rotate in a counter-clockwise direction about its fulcrum.

If, however, the preponderance of the rate of flow of steam through the pipe 5 over that through the pipe 6 is in the same amount or proportion as the preponderance of the flow of steam through the pipe 9 is over that flowing through the pipe 10, then the force tending to rotate the bar 49 in a clockwise direction will be equal to and balanced by the force tending to rotate it in a counterclockwise direction, and the bar 49 will not rotate about its fulcrum. This due to the fact that the rate of flow of steam through the pipes 9 and 10 is in desired proportion to that through the pipes 5 and 6. If, however, the proportionality is other than desired, and for example, the counterclockwise force is greater than the clockwise force, then the bar 49 will tend to rotate in a counterclockwise direction around its fulcrum, as might result from the rate of flow through the pipe 9 being greater in proportion to the rate of flow of steam through the pipe 10, than the proportion of flows through the pipes 5 and 6.

Through my invention, the rotation of the bar 49 effects a correcting of the proportion of the flow of steam through the pipes 9 and 10, whereby in the example given, the flow through the pipe 9 would be decreased, and that through the pipe 10 would be increased, until the proportion of flows between the pipes 9 and 10 would be the same as that through the pipes 5 and 6. I have shown as an extension of the bar 49, a contact arm 51 adapted upon rotation of the bar 49 around its fulcrum in a clockwise direction

to engage and contact with a point 52, and upon rotation in a counter-clockwise direction to engage a contact 53. The contact 52 is shown as connected by a conductor 54 with reversible means indicated as reversible electric motors 55, whereas the contact 53 is connected through a conductor 56 with the motors 55. A return line 30 joins the motors 55 to the power lines 32; the contact arm 51 being connected through the conductor 31 to the power lines 32. The motors 55 are similar and rotate together, each motor connected through gearing 58 to a valve 59. One valve 59 is positioned in pipe 9 and the other in pipe 10, the motors 55 being connected to the conductors 30, 54, 56 oppositely in a manner such that simultaneous rotation of the motors 55 results in opposite rotation of the gearing 58, to the end that one valve 59 will be opened while the other is closed.

The arrangement illustrated and described, contemplates the dividing and proportioning of a fluid to be heated, in accordance with the heat available at the heaters through which the fluid is to pass in divided flow. The heat available will depend upon the rate of operation of the boilers, and as an index of the rate of operation, I measure the rate of steam output from the boilers. By comparing the steam flow from the boilers, I obtain a relationship which I may use as a guide to the proportioning of the fluid to be heated.

It will be readily understandable that the type of flow meter illustrated and described is not necessarily the only type usable in my invention, as I may equally as well employ the invention in connection with float actuated or liquid sealed bell or other types of meters. Nor do I desire to be limited to the use of my invention in connection with steam generating boilers and waste gas heat exchangers. In fact, while I have illustrated and described a preferred embodiment of my invention, I desire it to be distinctly understood that I am not to be limited thereby other than by the claims in view of prior art.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The method of proportioning the flows of a plurality of streams of a fluid to be heated in accordance with the available heat supplied to heaters through which the streams of the fluid are separately passed, which consists in indicating the rate of flow of each stream, determining the ratio of said rates of flow, indicating for each heater the value of a factor bearing a functional relation to the heat available at the heater, determining the ratio of said values, comparing said ratios, and subjecting the streams to rate control in accordance with the departure of said comparison from a predetermined value.

2. The method of proportioning the flows of a plurality of streams of a fluid to be heated in accordance with the available heat supplied to heaters through which the streams of the fluid are separately passed, which consists in obtaining a measure of the proportionality of the flowing streams, obtaining a measure of the proportionality of the available heat at the heaters, determining the relation between said proportionality, and subjecting at least one of the streams to rate control in accordance with the departure of said relation from a predetermined value.

3. In combination, a pipe for the flow of a fluid to be heated, branches to said pipe for joining the pipe to a plurality of heat exchangers, said heat exchangers each having available the heat

contained in a second fluid flowing therethrough in heat conducting relation with the first fluid, valve means for proportioning the distribution of the first fluid from the pipe to said branches, means for indicating for each heater the value of a factor bearing a functional relation to the heat available at the heater, and common means for determining the proportionality between said values for positioning said valve means.

4. In combination, a plurality of furnaces, a heat exchanger for each furnace and having available for heating the waste gaseous products of combustion of said furnace, a pipe for the flow of a fluid to be heated, branches to said pipe for joining the pipe to each heater, valve means for proportioning the distribution of the fluid through the branches, means for indicating for each heater the value of a factor bearing a functional relation to the heat available at the heater, and common means for determining the proportionality between said values for positioning said valve means.

5. In combination, a plurality of vapor generating boilers, a waste heat exchanger for each boiler and having available for heating the waste gaseous products of combustion of the boiler, an inlet pipe for each heater for the flow of a fluid to be heated, valve means in each inlet pipe to regulate the flow of said fluid, a measuring means of the rate of fluid flow through each pipe, means for comparing said rates of flow for determining the ratio thereof, indicating means of the value of a factor of the operation of each boiler, means for comparing said values for determining the ratio thereof, means for comparing said ratios, and means positioned by said last-named means for actuating said valve means.

6. In combination, a plurality of vapor generating boilers, a waste heat exchanger for each boiler and having available for heating the waste gaseous products of combustion of the boiler, an inlet pipe for each heater for the flow of a fluid to be heated, valve means in each inlet pipe to regulate the flow of said fluid, means in connection with each inlet pipe which produces a flow of current which is a measure of the fluid flow therethrough, a discharge pipe for each boiler for the flow of vapor from the boiler, means in connection with each discharge pipe which produces a flow of current which is a measure of the vapor flow therethrough, and a balanced relay connected to said two last-named means responsive to the proportionality between the rates of flow of vapor discharged from the boilers and the rates of flow of vapor to said heat exchangers for affecting movement of said valve means.

7. In combination, a plurality of steam generating boilers, a waste heat exchanger for each boiler and having available for heating the waste gaseous products of combustion of the boiler, a pipe for the flow of fluid to be heated, branches from the pipe to the heat exchangers, control means for proportioning the fluid to be heated to the heaters, a flow meter for each branch which produces a flow of current which is a measure of the fluid flowing through the branch, a flow meter for each boiler and which produces a flow of current which is a measure of the rate of boiler output, and a balanced relay connected to said flow meters, said balanced relay effective to actuate said control means.

8. In combination, a plurality of vapor generating boilers, a waste heat exchanger for each boiler and having available for heating the waste gaseous products of combustion of the boiler, an

- inlet pipe for each heater for the flow of a fluid to be heated, valve means in each inlet pipe to regulate the flow of said fluid, a flow meter for each inlet pipe which indicates the rate of fluid flow therethrough, a discharge pipe for each boiler for the flow of vapor from the boiler, a flow meter for each discharge pipe which indicates the rate of vapor flow therethrough, a balance means to which the flow meters are connected, and means responsive to the balance of measurements for effecting movement of said valve means.
9. The method of proportioning the flows of a plurality of streams of fluids in accordance with the availability of a variable to each of said plurality of streams, which comprises indicating the rate of flow of each stream, determining the ratio of said rates of flow, indicating the value of a factor bearing a functional relation to the availability of said variable to each stream, determining the ratio of said values, comparing said ratios, and subjecting the streams to rate control in accordance with said comparison.
10. The method of proportioning the flows of a plurality of streams of a fluid in accordance with the ratio between the rates of flow of a second plurality of streams of a fluid, which comprises indicating the rate of flow of each stream, determining the ratio between the rates of flow of said first plurality of streams, determining the ratio between the rates of flow of said second plurality of streams, comparing said ratios, and subjecting the first plurality of streams to rate control in accordance with the departure of said comparison from a predetermined value.
11. The method of heating a plurality of fluid streams each flowing through a heat exchange, which comprises measuring the rate of flow of each stream, determining the proportionality for each heat exchanger between the rate of flow of the related stream and the available heat for heating same, and subjecting at least one of said streams to rate control from said proportionality.
12. The method of controlling the flow of steam to a heater having available for heating the steam the gaseous products of combustion from the furnace of a steam generator, which includes regulating the flow of steam to said heater in accordance with the flow of steam from said generator, the flow of steam to the heater being independent of the flow of steam from the generator.
13. The method of controlling the flow of a vapor to a heater having available for heating the vapor the gaseous products of combustion from the furnace of a vapor generator, which includes regulating the flow of the vapor to the heater in accordance with the flow of vapor from the generator, the flow of vapor to the heater being independent of the flow of vapor from the generator.
14. In combination, a vapor generator and a furnace for heating the same, a vapor heater wherein is available the gaseous products of combustion from said furnace, and means responsive to variations in vapor outflow from the generator controlling the flow of vapor through the heater, the flow of vapor to the heater being independent of the flow of vapor from the generator.
15. The method of proportioning the flows of a plurality of streams of a first fluid in accordance with the ratio between the rates of flow of a plurality of streams of a second fluid, which comprises indicating the rate of flow of each stream, determining the ratio between the rates of flow of the plurality of streams of the first fluid, determining the ratio between the rates of flow of the plurality of streams of the second fluid, comparing said ratios, and subjecting the first plurality of streams to rate control in accordance with departure of said comparison from a predetermined value.
16. The combination with a plurality of fluid heaters each having a furnace disposed in heat exchange relation thereto, means for producing effects respectively representative of the flow of fluid through each of said heaters, means sensitive to the difference in said effects, and means controlled by said last-named means for changing the rate of flow of fluid through at least one of said heaters.
17. The combination with a plurality of furnace chambers, a vapor generator and a fluid heater arranged in heat conducting relation to each of said furnace chambers, means associated with each of said fluid heaters for producing an effect representative of the rate of flow of fluid therethrough, means associated with each of said vapor generators for producing an effect representative of the rate of flow of vapor therefrom, means sensitive to said effects, and means for changing the ratio between the rates of flow of fluid from said heaters controlled by said last-named means.
18. The combination with a plurality of furnace chambers, a vapor generator and a fluid heater arranged in heat conducting relation to each of said furnace chambers, an electric circuit associated with each of said fluid heaters, means for producing an electrical current in each of said circuits bearing a functional relation to the rate of flow of fluid through the associated heater, an electrical circuit associated with each of said vapor generators, means for producing an electrical current in each of said last-named circuits bearing a functional relation to the rate of flow of vapor from the associated vapor generator, a movable member, an electro-magnetic winding connected in each of said circuits for exerting a force on said movable member, valve means for controlling the rate of flow of fluid through each of said heaters, electrical means for controlling said valve means, a source of current for energizing said electrical means, means for regulating the energization of said electrical means from said source of current controlled by said movable member.

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